Reduction of NOx emissions of medium combustion plants using biomass

Prossergy
Process for clean Energy

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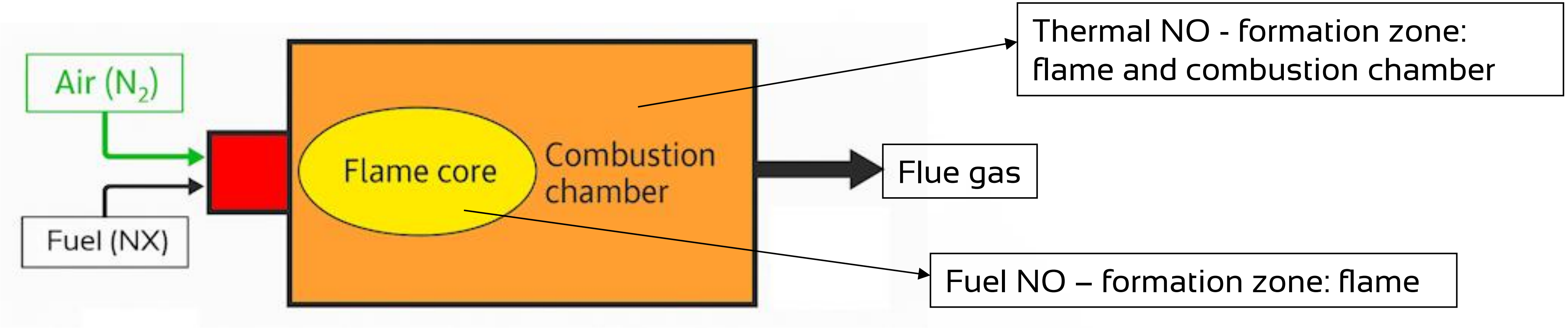
FORMATION OF NOx DURING COMBUSTION



<u>Thermal NO</u>

- Fuels concerned: all fuels
- Parameters governing formation
  - **<u>Temperature</u>**
  - Air excess
  - Residence time of flue gas in combustion chamber

<u>Fuel NO</u>

- Fuels concerned : Coal, Heavy Fuel Oil (HFO), Biomass, process gas containing nitrogenous species (NH_3, HCN, etc,)
- Parameters governing formation:
  - **<u>Nitrogen content of fuel</u>**
  - **<u>Local fuel/air ratio</u>**

NO	HFO	Nat Gas	Biomass
Thermal NO	25 – 35 %	100 %	10 – 20 %
Fuel NO	65 – 75 %	0	80 – 90 %

<u>Biomass fuel, depending on its origin, has a highly variable nitrogen content, ranging from about 0.2% for very clean wood to more than 2% for wood derived from waste materials</u>

NOx REDUCTION TECHNOLOGIES

Primary techniques (preventive)

- Combustion adjustments, reduction of excess air
- Flue gas recycling
- Air staging
- Low-NOx systems (burner, combustion chamber geometry)

Secondary techniques (curative)

- Selective Non Catalytic Reduction (SNCR)
- Selective Catalytic Reduction(SCR)

Increasing investment cost

OBJECTIVES: Compliance with regulations

- NOx limits lower and lower
- Fluctuant fuel quality
- Optimized investment/operating cost
- Reliable and easily usable system

PRIMAIRY TECHNIQUES

OPTIMIZATIONS

- Optimization of combustion settings – reduction of air-excess
- Optimization of fuel distribution parameters
- Reduction of air infiltration (false air)
- Fuel selection

Low-cost solution not to be neglected
Essential first step

LOW NOx SOLUTIONS

- Increase combustion chamber volume / post-combustion zone
- Staged combustion, with multiple air injection points to limit temperature gradients

Not applicable to existing installations in some cases

FLUE GAS RECIRCULATION

- Reduction of the partial pressure of O_2
- Enhanced mixing of the combustion gases
-Risk: increase in CO and unburned compounds

Applicable to existing installations

Primary measures: limited effectiveness on existing installations because the geometry is fixed

SECONDARY TECHNIQUES

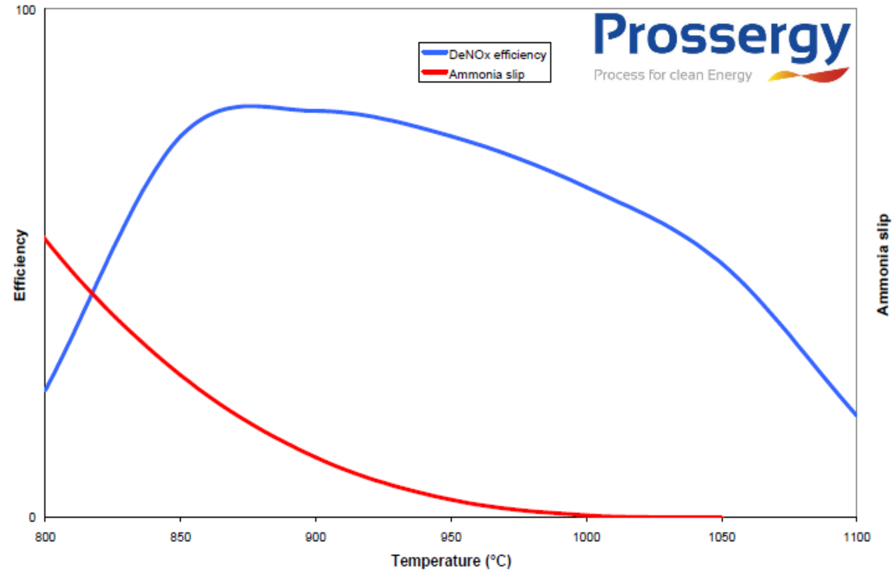
1 MAIN REACTION : $4\ NH_3 + 4\ NO + O_2 \Rightarrow 4\ N_2 + 6\ H_2O$

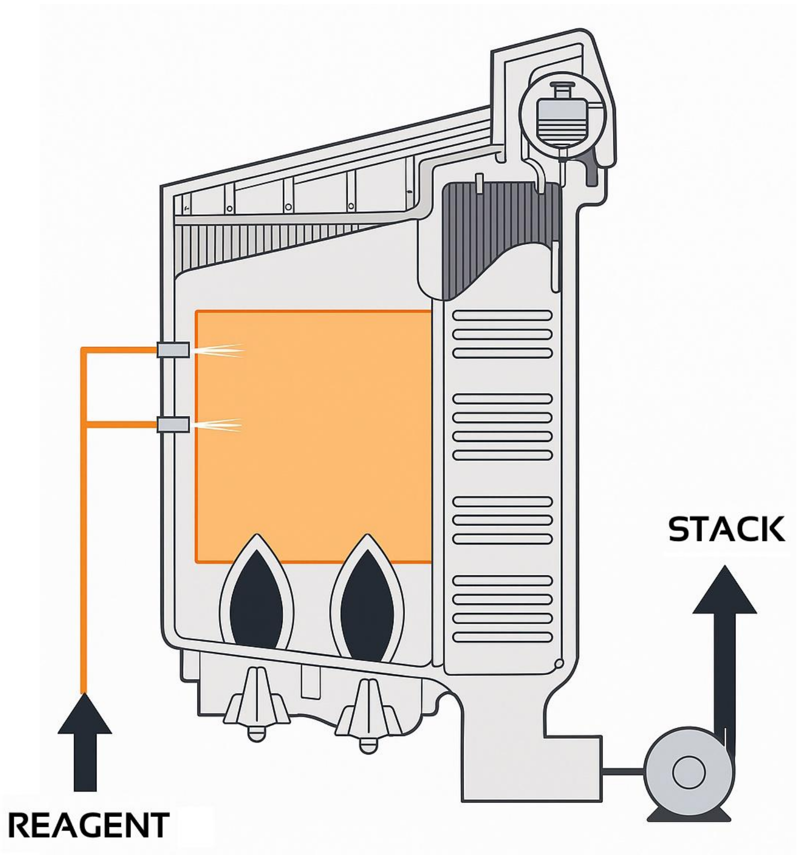
	SNCR	SCR
Catalyst	No	Yes
Temperature	850 – 1 050 °C	180 – 450 °C
Reagent	Ammonia or Urea (liquid or solid)	Mainly ammonia Could be urea
Efficiency	30 – 60 %	Until more than 95%
Investment	1	6 to 12

The reaction occurs in gas phase, without production of residues

SNCR PROCESS

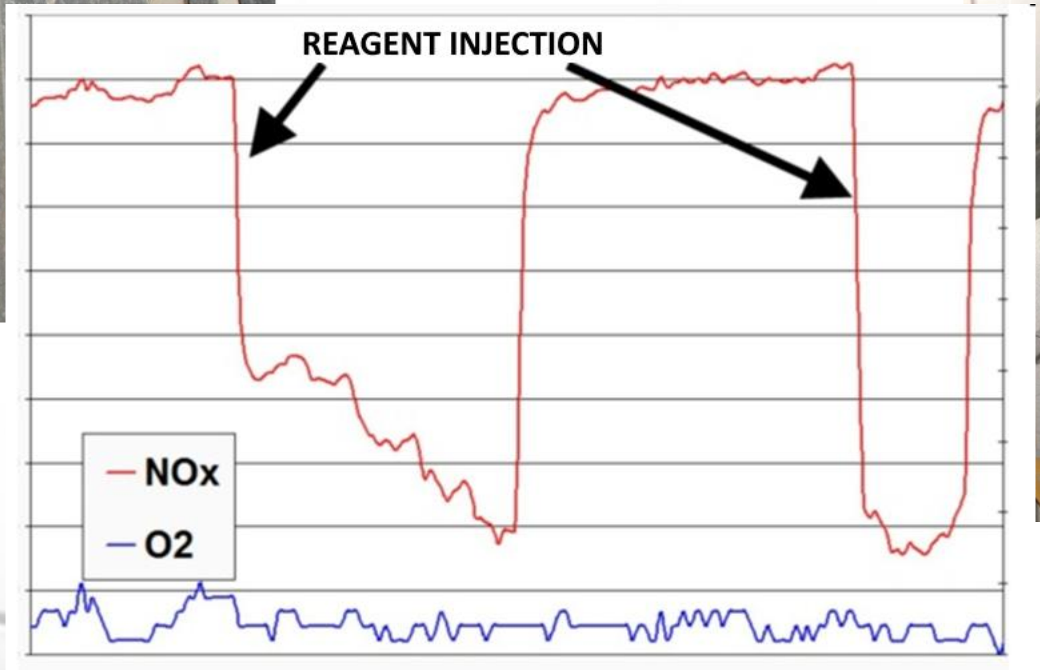
- Reagent injection between 850 and 1050 °C
- Minimum residence time 0.5 sec
- Reagent :
    - Urea liquid solution 33 to 44% w
    - Ammonia water 20 to 24.5% w
- **<u>Stœchiometry from 1,5 to 5</u>**
- Several injection zones to follow temperature and thermal load variations
- NOx reduction up to 60% and more
- Beware of Ammonium Busilfate (ABS) deposit, due to ammonia slip

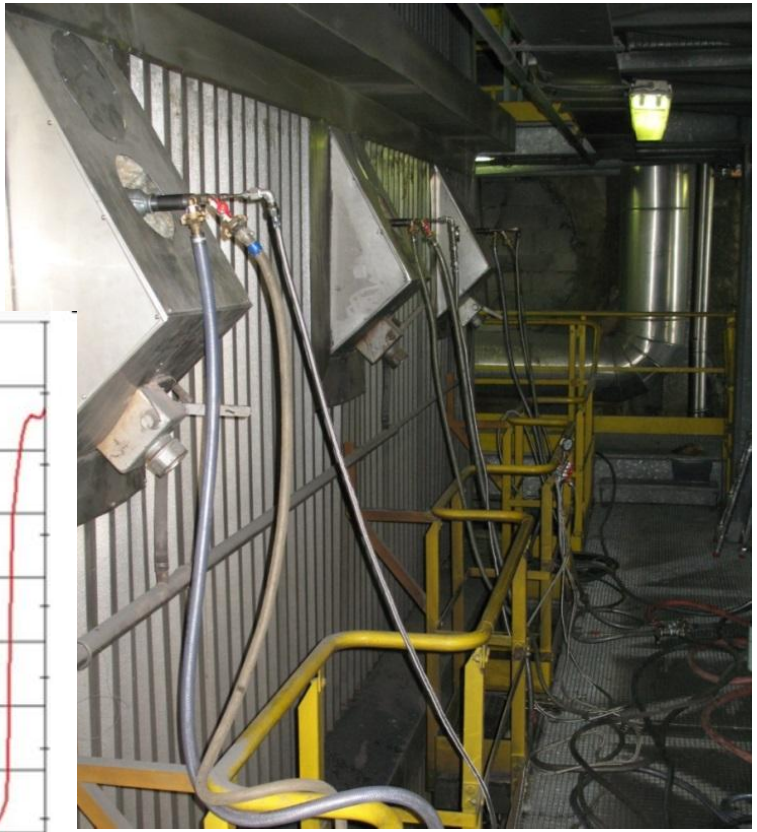




SNCR PROCESS

<u>DIAGNOSIS IS VERY IMPORTANT:</u> temperature mapping and reagent injection tests to validate performance, position of injection points and NH_3 slip





SNCR PROCESS

Important technical parameters

- Boiler geometry: residence time and temperature
- Boiler load variation: injection must occur at the correct temperature regardless of the load. **Important limitation of SNCR efficiency**
- Beware of NH_3 slip: ammonia limit and formation of ammonium salt deposits

Parameters influencing cost :

- Size of the installation and reagent storage
- Unloading and storage characteristics
- Tank volume and material
- Civil engineering requirements for the unloading and storage containment area
- Number of injection lances
- Type of reagent

SNCR PROCESS

Small size boiler (P < about 7 MW)

- Implementation of SNCR is challenging due to small size and short residence time
- Limited load variation
- One injection lance
- Use of urea, indoor installation protected from freezing
- Small storage capacity: supplied in 1 m^3 containers

Medium size boiler (7 MW < P < 12-15 MW):

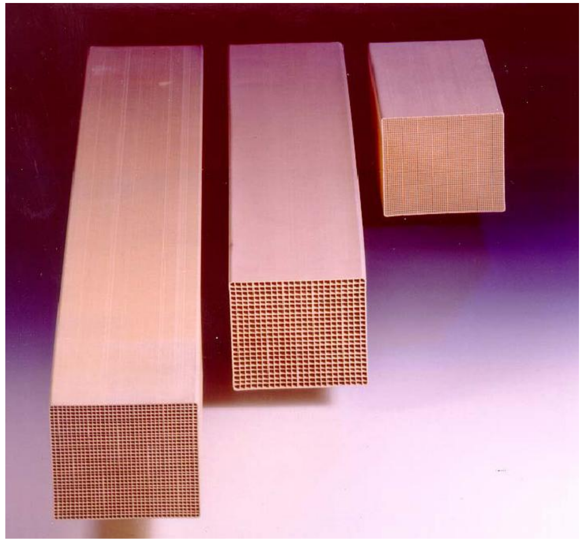
- Higher reagent flow rate
- One or several injection lances, with multiple possible zones
- Use of urea
- Storage in containers or tanks from 10 to 20 m^3
- Supply by tanker truck

Large scale boiler (P> 12-15 MW): :

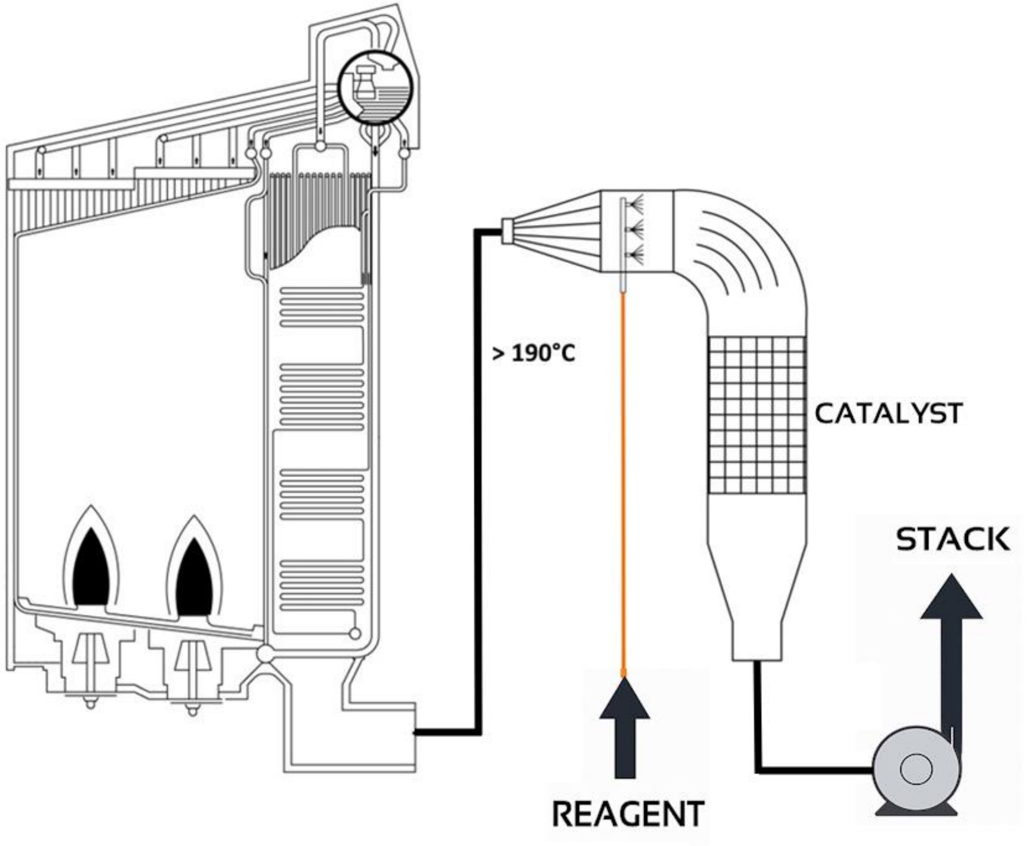
- Water-tube boilers with large combustion chamber volume
- Several injection zones depending on the load
- Possibility to use urea or ammonia water
- Storage in tanks of 30 m^3 or more

SCR PROCESS

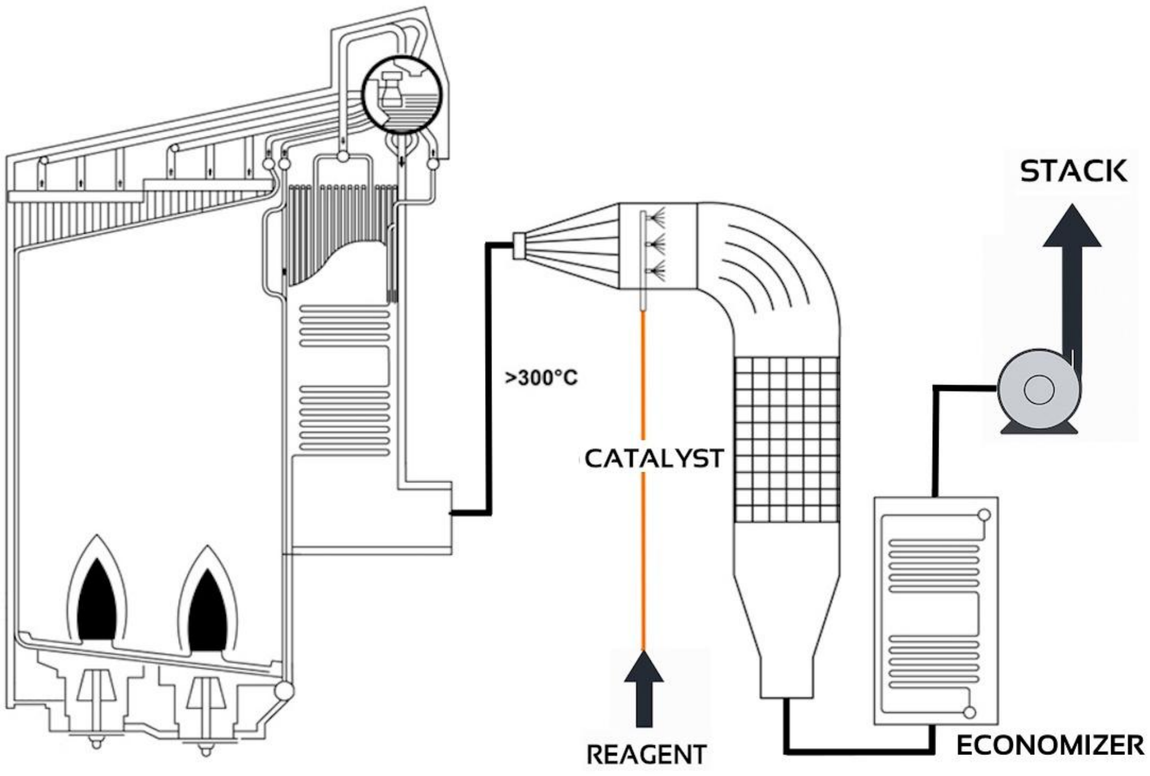
- Use of a catalyst to increase the reduction efficiency and lower the reaction temperature to approximately 190 - 350°C.
- Reduction to 95% and more
  - Capex not very dependent on performance until 80-90% reduction
- Reagents:
  - Mainly NH_3 as liquid (ammonia water) or gas
  - Urea for high temperature only (> 300°C)
- **Stoichiometry: approximately 1**
- Importance of catalyst position:
  - Before / After dust filtering: poisoning
  - Before / After SO_2 treatment: ammonium salt deposits
- Monitoring of catalyst aging is important



SCR PROCESS



WITHOUT SO_2

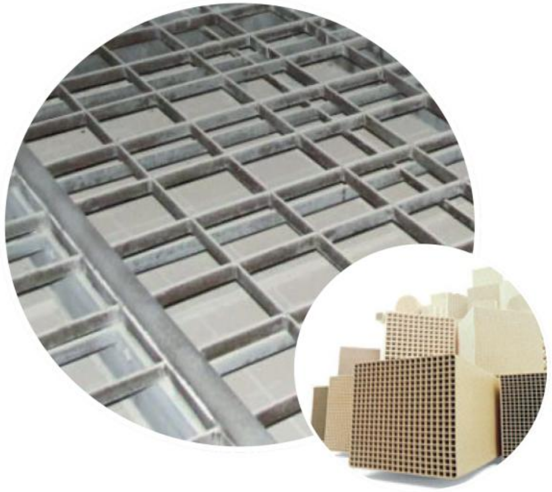


WITH SO_2

SCR PROCESS

Types of catalyst support:

- Pellets: Smaller catalyst volume, excellent Performance/Temperature compromise
- Monolith: Low pressure loss, dust resistance



Fouling

- Limitation of dust content – cleaning system

Ammonium bisulphate deposit

- NH_3 and SO_3 combine in the gas phase and form Ammonium Sulfate and Bisulfate whith solidification temperatures are respectively 280 and 150 °C.
- SO_2 content > 50-60 mg/Nm^3: Operation above 250°C
- SO_2 content < 50 mg/Nm^3: Operation between 190 and 250°C depending on the SO_2 content
- Possibility of regenerating the catalyst in situ or ex situ

Chemical poisoning

- Pb, As, P, Hg, Na, K … etc.
- Be careful to biomass fuels

COMPARISON SNCR / SCR

SNCR	
Advantages	**Disadvantages**
- Low investment cost - Limited space requirement - Well suited for target NOx reductions of about 30–60%	- Solution not always applicable if furnace temperature is too high or residence time too short - Efficiency depends on the boiler type and configuration - Efficiency also depends on boiler load - Monitoring of NH_3 slip required

SCR	
Advantages	**Disadvantages**
- Up to over 99% reduction efficiency - Low reagent consumption - Efficiency independent of boiler load - Applicable to all types of installations - No issues with NH_3 slip	- Higher investment cost - In some cases, flue gas reheating may be required - Installation can sometimes be difficult - Monitoring of catalyst fouling and poisoning is necessary

HYBRID DeNOx

Hybrid DeNOx solution developed by PROSSERGY

- Combining an optimized DeNOx SNCR and a small SCR
- The best of both technologies
- Optimized thermal efficiency

SNCR

- Revamping of an existing SNCR or installation of a new SNCR with an efficiency > 60%
- Controlled production of NH_3 slip to supply the SCR process

SCR

- Installation of an optimized SCR with reduced catalytic volume, downstream of the FGT and filtration system, allowing easy installation into the existing system
- No heating or regeneration system
- Continuous monitoring upstream NH_3 and/or NOx
- Easy assembly/disassembly of the catalytic charge

THERMAL EFFICIENCY

- If necessary, modification of the thermal installation to make the catalyst work in the correct temperature range
- Addition of an economizer downstream of the SCR to improve energy efficiency

HYBRID DeNOx

BENEFITS

- Limited cost: easy layout (small catalyst volume optimized with high SNCR efficiency)
- Possibility of adapting the type of catalyst to the application
- Possibility of installing an economizer under the catalyst at lower cost – increased thermal efficiency
- Catalyst downstream filtration: no chemical poisoning compared to "High dust" SCR solutions
- Possibility of using urea, without switching to ammonia water, unlike a classic SCR, which strongly limits the CAPEX
- Effective ex-situ regeneration:
    - No pollution problems on site
    - Control of the process unlike online regenerations
    - No fuel usage and limited maintenance

DeNOx ON BIOMASS BOILER

SNCR small Boiler

- 3 – 7 MW boiler
- Mini DNX urea system
- Cost: 50 – 180 k€

SNCR Medium Boiler

- One or several boilers > 7 MW
- Opti DNX urea system
- Cost: 200 – 700 k€

SCR Large scale boiler

- SCR with low dust catalyst after baghouse filter
- Cost: 1 – 6 M€

PROSSERGY

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