TT3: Emissions, Air Quality, Fuel and Ash Logistic
Webinar, 02/12/2020

Basics of flue gas cleaning

ENTRAIN |AEE INTEC| Harald Schrammel, Christian Ramerstorfer

CONTENT

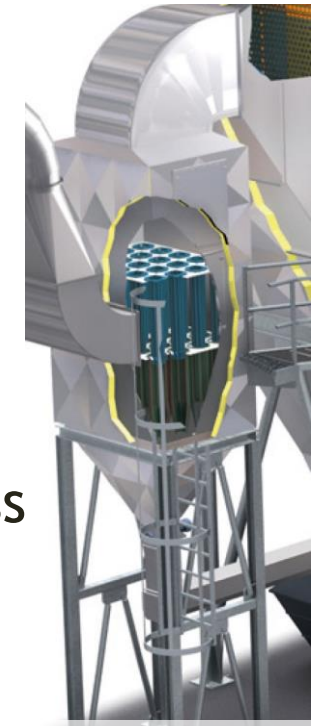
Particle removal (dust precipitation)	Flue gas condensation	Nitrogen oxides reduction (De-NOx)
➢ (Multi-)cyclone ➢ Electrostatic precipitator (ESP) ➢ Baghouse filter		➢ Selective non catalytic reduction (SNCR) ➢ Selective catalytic reduction (SCR)

CYCLONE/MULTI-CYCLONE

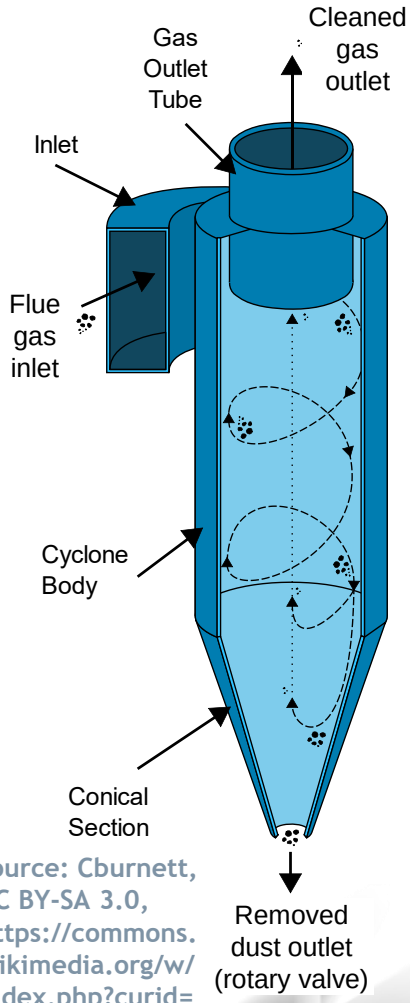
Cyclone

- Centrifugal separator
- Coarse fly ash precipitation (particles > 5 µm)
- Wide operation window (temperature up to > 1000°C)
- Usually designed as multi-cyclone
- Dust load downstream < 150 mg/Nm³ possible

State of the art for industrial biomass combustion plants



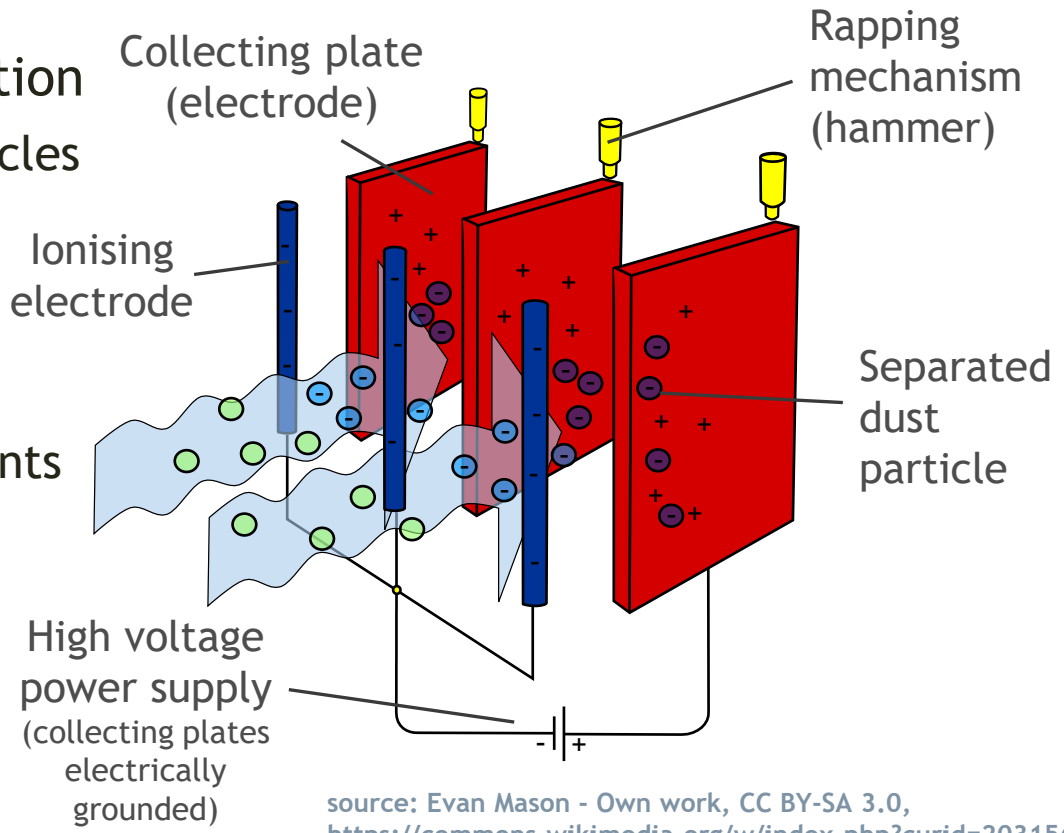
source: multi-cyclone from Scheuch at Holzwärme Grindelwald (CH) in Focus Technik, Ausgabe 1, 2011, Schmid energy solutions



source: Cburnett, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1887330 (modified)

ELECTROSTATIC PRECIPITATOR (ESP) OVERVIEW

- Electrostatic particle separation
  - Suitable for very small particles (≥ 1 µm)
- Dry (dESP) or wet (wESP) operation possible
  - dESP state of the art for plants which have to meet dust emissions < 50 mg/Nm³
  - wESP for application downstream flue gas condensation unit



source: Evan Mason - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=20315619

- About 120 °C minimum operation temperature
- Safety measures regarding high voltage operation (in the range of 20 to 100 kV) have to be considered

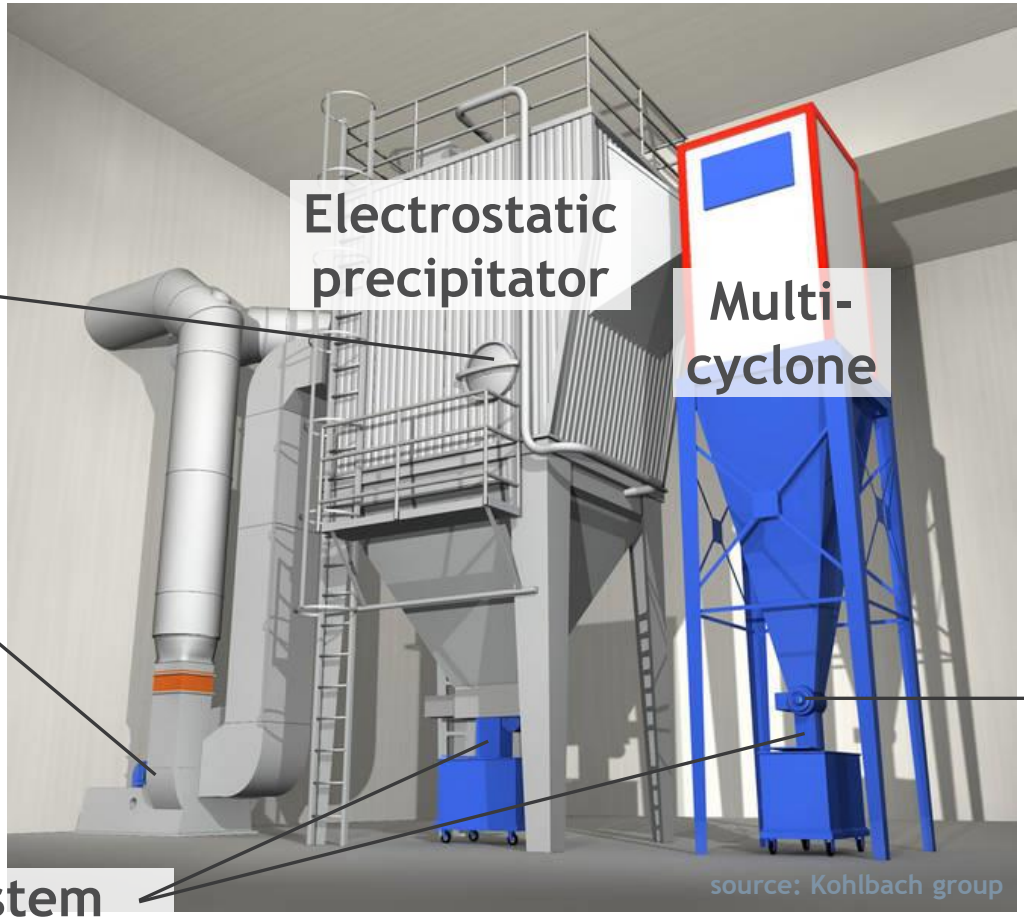
ELECTROSTATIC PRECIPITATOR EXAMPLES

source: Scheuch Electrostatic Precipitators (product folder)

- ESP at the biomass district heating plant (4 MW) in Maria Gugging (Lower Austria)

source: Ulrichulrich in German Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=10748610

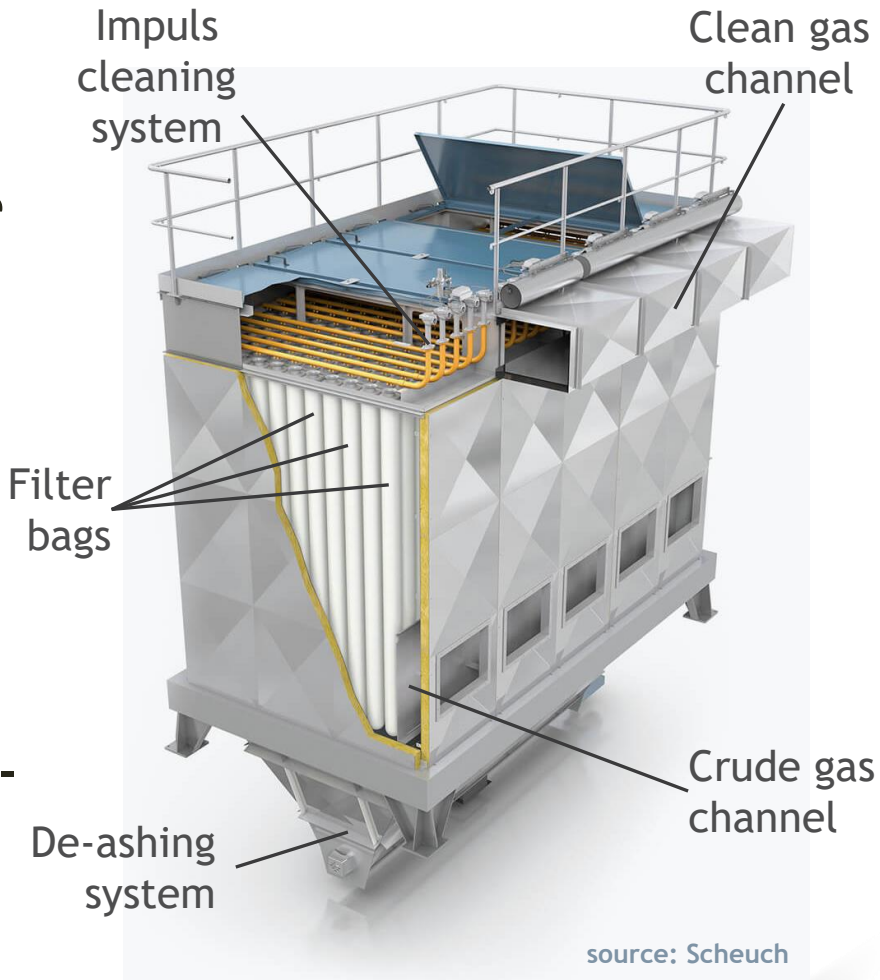
EXAMPLE FLUE GAS CLEANING SYSTEM WITH MULTI CYCLONE AND ESP



- separated ash fractions for cyclone/ESP

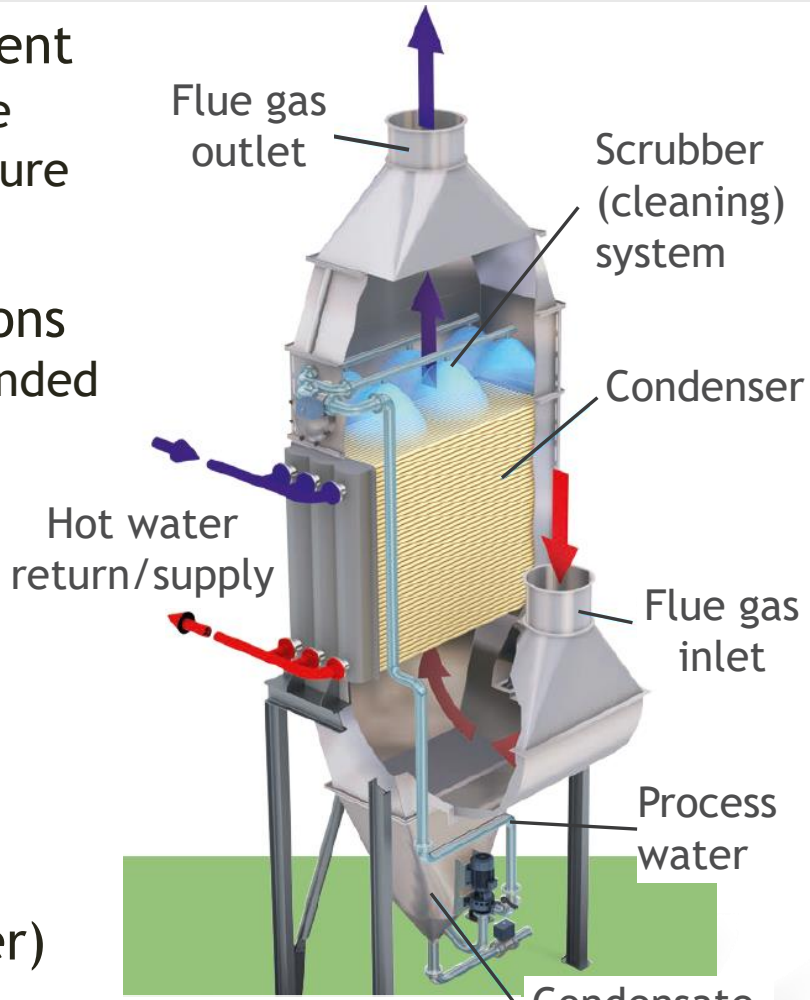
BAGHOUSE FILTER

- Fabric filter (adhesion separator)
- Almost 100 % dust removal efficiency (independent of particle size)
- Dust load cleaned gas < 5 mg/Nm³
- About 180 °C minimum operation temperature
- Dust removal from filter bags into de-ashing system by frequent back-pulsing with compressed air (impuls cleaning system)
- Beyond state of the art (applied for waste wood comb.)



FLUE GAS CONDENSATION (SCRUBBERS)

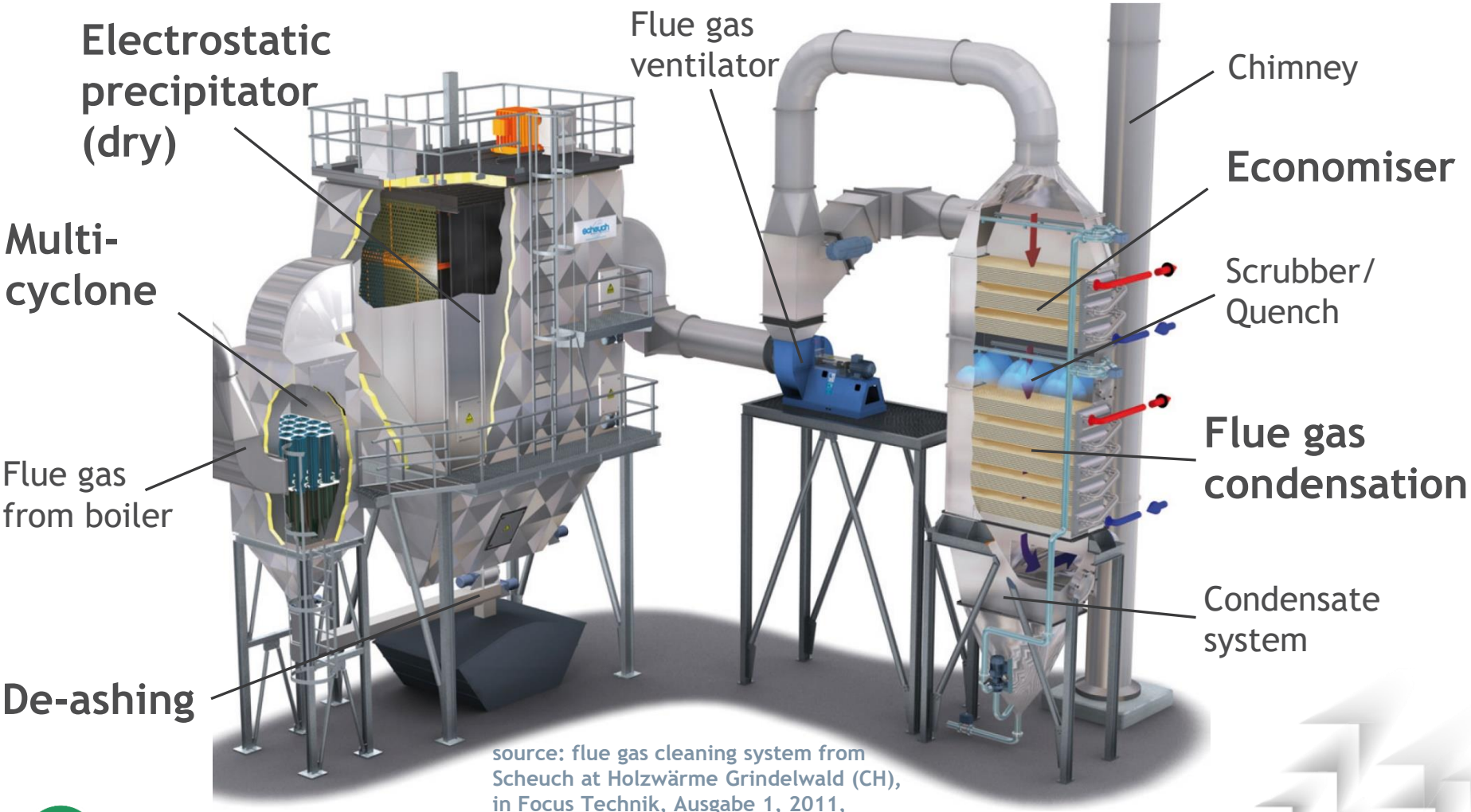
- Primarily heat recovery (sensible and latent heat – feasibility mainly depends on moisture content of the fuel and return flow temperature from the district heating grid)
- Additional positive effect on dust emissions precipitation of fly ash upstream is recommended (dESP) in order to reduce problems regarding condenser corrosion and condensate composition
- Dust load gas outlet < 50 mg/Nm^3 (without ESP upstream)
- Almost 100 % coarse fly ash removal (particle size > 1 µm)
- Stainless steel heat exchanger (condenser)
- Periodic cleaning of the heat exchanger with process water/option for scrubber (quench)



source: Scheuch ERCS Type 01 (Energy Recovery & Cleaning System)

EXAMPLE FLUE GAS CLEANING SYSTEM WITH ESP AND FLUE GAS CONDENSATION

- Plant with 5 MW heat output (incl. condensation)

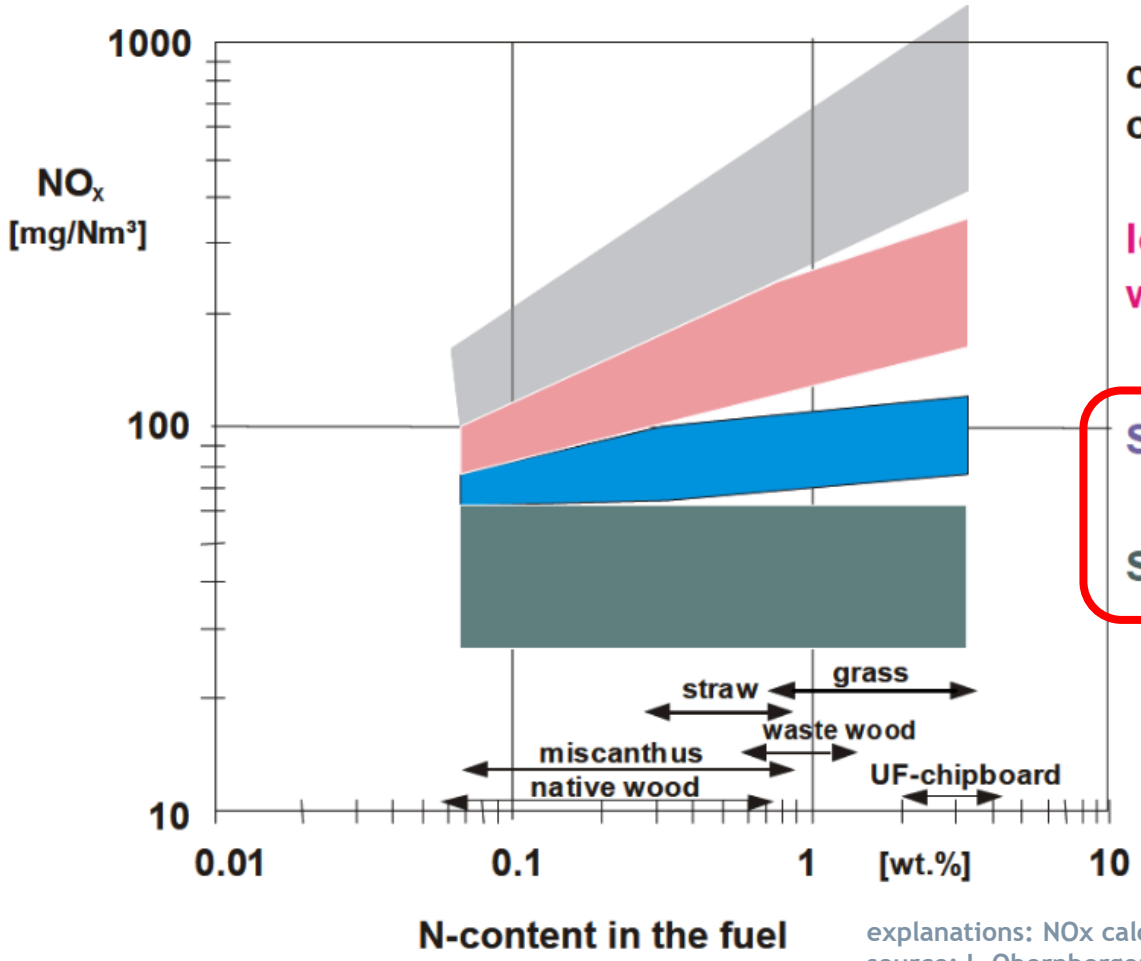


source: flue gas cleaning system from Scheuch at Holzwärme Grindelwald (CH), in Focus Technik, Ausgabe 1, 2011, Schmid energy solutions

OVERVIEW DUST PRECIPITATION TECHNOLOGIES

	Cyclones	ESP (dry)	Baghouse filter	Flue gas condensation
Particle size	> 5 µm	≥ 1 µm	all	≥ 1 µm
Dust content cleaned gas [mg/Nm^3, 11% O_2]	120 - 200	5 - 50	1 – 5	25 - 50
Operation temperature min (max) [°C]	(> 1000)	120 – 130 (300)	180 – 220 (280)	(40 – 60)
Pressure loss [mbar]	6 - 15	1.5 - 3	10 - 20	
Options	multi-cyclone	wet ESP	dry sorption (HCl, SOx, Hg, dioxins)	scrubber (quench)

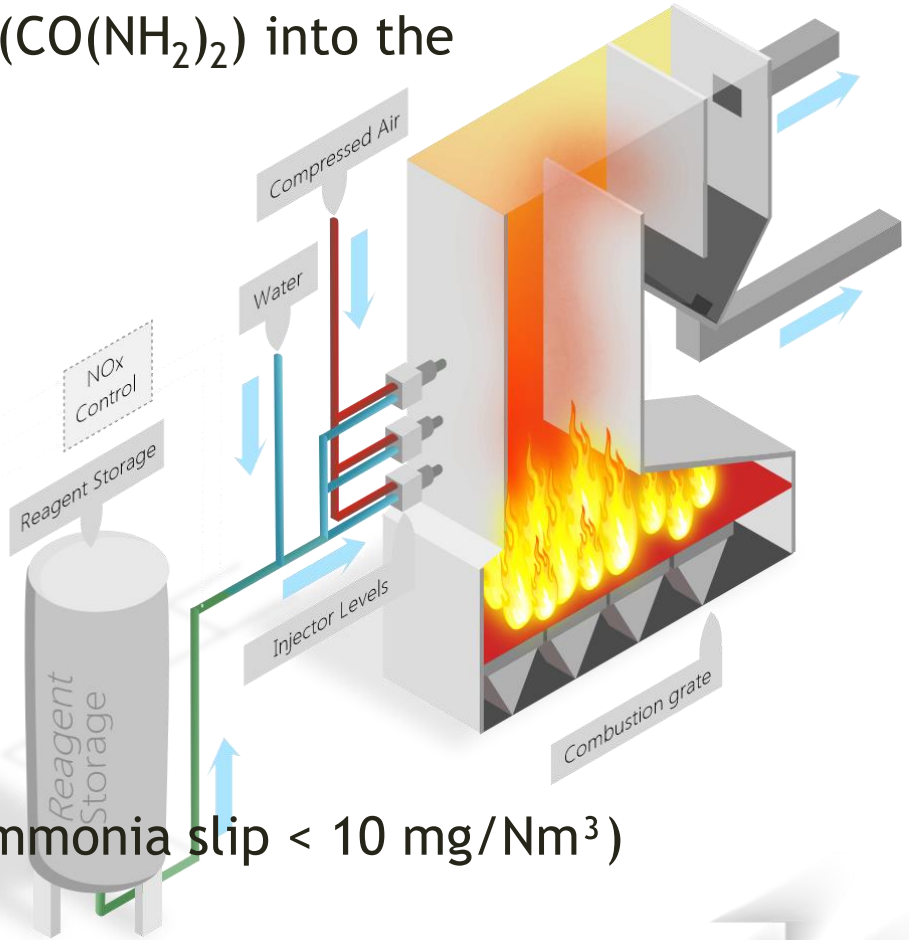
FUEL NITROGEN - NOX IN THE FLUE GAS DENOX TECHNOLOGIES



explanations: NOx calculated as NO_2 (d.b., 11 vol-% O_2)
source: I. Obernberger, THE PRESENT STATE AND FUTURE DEVELOPMENT OF INDUSTRIAL BIOMASS COMBUSTION FOR HEAT AND POWER GENERATION, Figure 24

SELECTIVE NON CATALYTIC REDUCTION (SNCR)

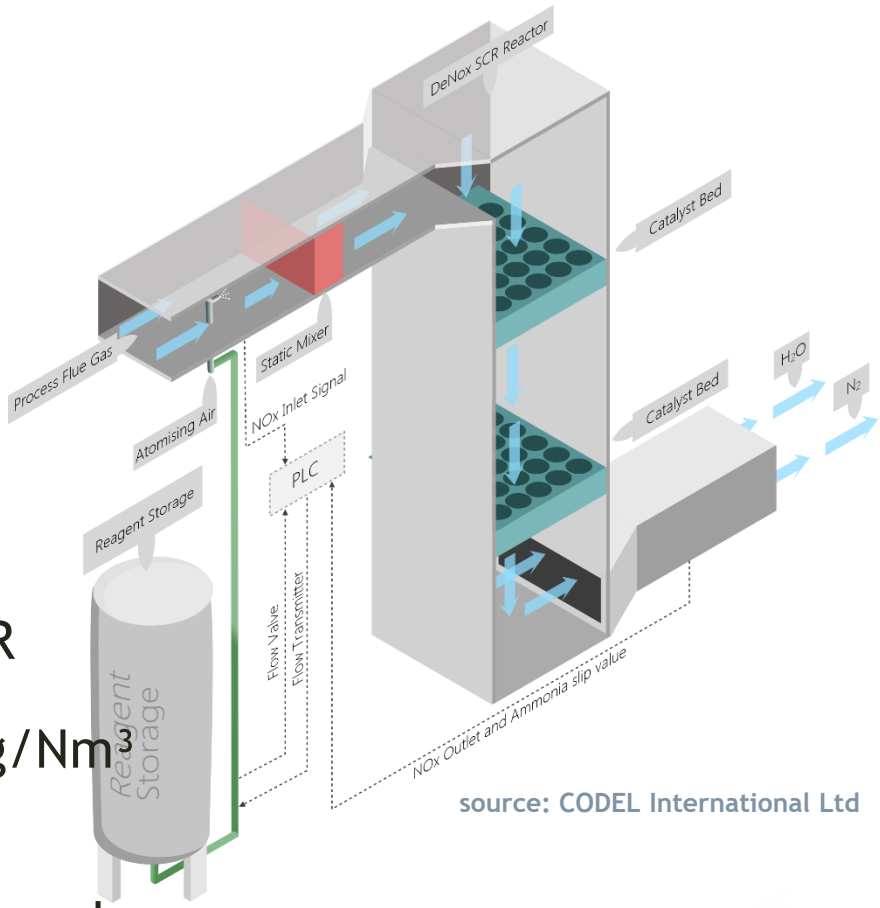
- Injection of Ammonia (NH_3) or Urea ($CO(NH_2)_2$) into the secondary combustion zone
- Reaction of nitrogen oxides (with injected reducing agent) to N_2 directly in the flue gas; by-products: H_2O (and CO_2)
- Temperature range 850°C to 950°C
- Reduction efficiencies of 60 to 70 %
- NOx downstream < 100 mg/Nm³
- Non-reacted Ammonia is emitted (ammonia slip < 10 mg/Nm³)
- Cost effective solution



source: CODEL International Ltd

SELECTIVE CATALYTIC REDUCTION (SCR)

- (similar to NOx reduction technology applied for Diesel engines in cars)
- Reduction of NOx with Ammonia using a catalyst material
- Temperature range 170°C to 450°C
- Reduction efficiencies of 80 to 95 %
- NOx downstream lower than with SNCR
- Ammonia slip in the range of 1 to 5 mg/Nm^3
- Issues with catalyst deactivation for biomass combustion (due to potassium and other alkali compounds in the flue gas)



source: CODEL International Ltd

SUMMARY

- Flue gas cleaning is an important plant component
  - Authority, operating permit
  - Public acceptance
- It requires special attention and profound planning
  - Evaluation of local legal emission limits
  - Selection of suitable technology
  - Consider space demand and costs

THANK YOU!

Harald Schrammel, Christian Ramerstorfer
AEE INTEC
Feldgasse 19, A-8200 Gleisdorf

www.interreg-central.eu/entrain

h.schrammel@aee.at, c.ramerstorfer@aee.at

+43 3112 5886-232, +43 3112 5886-262

@ENTRAIN_project
@AEE_INTEC