The European Experience for NOx-removal from WTE process gas – SNCR or SCR

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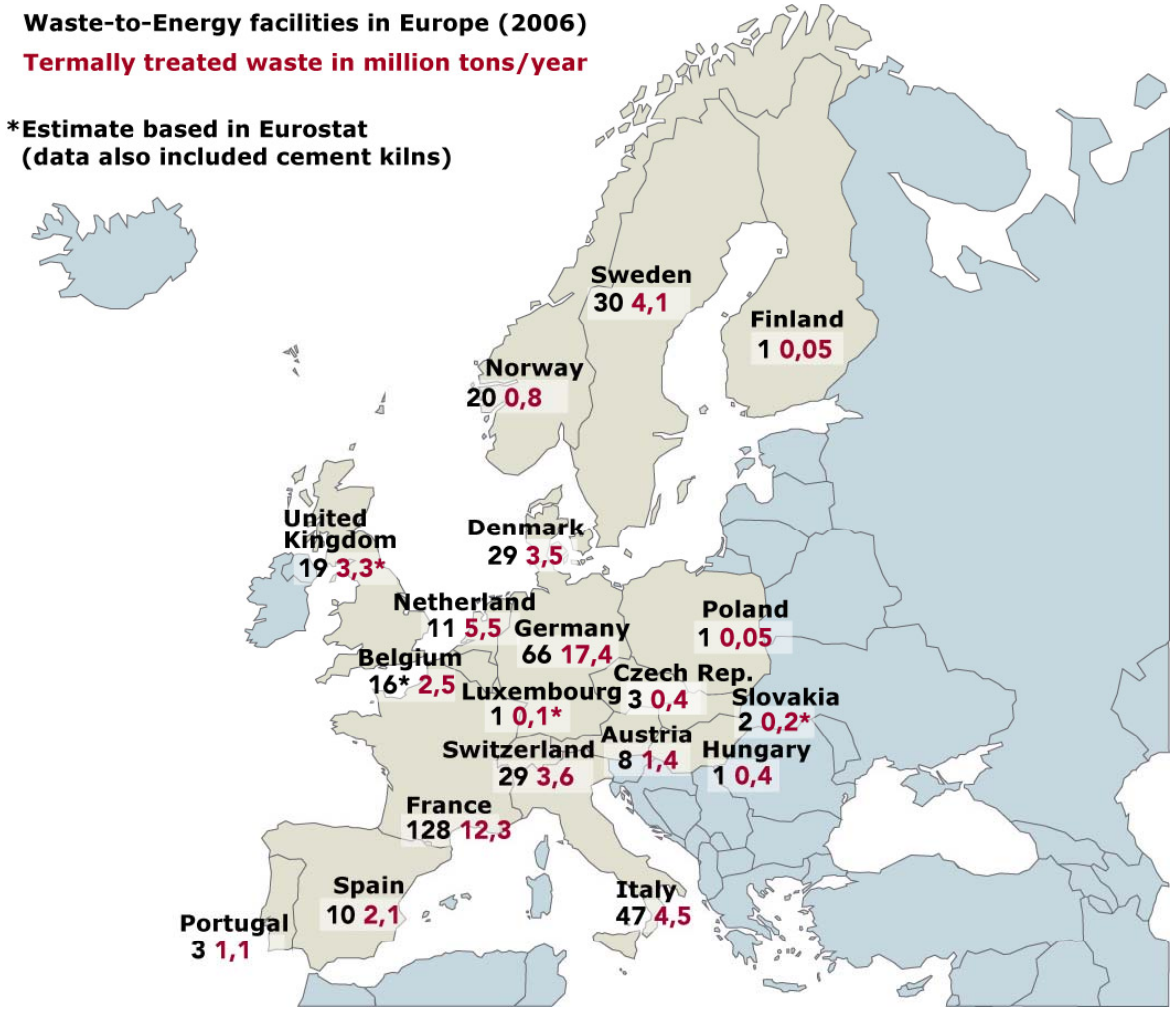
Rambøll Denmark

- Established i 1945
- Ramboll consulting group: more than 8,500 employees
- Leading waste-to-energy consultant with >50 specialists within WtE
- Long track record of waste-to-energy plant projects – on-going > 30 WtE projects.
- Independent consulting services

Waste-to-energy plant references - Rambøll

Status - WtE in Europe

- Total number of plants: ~450
- Total treated waste in million tonnes/year: ~60



WTE in Europe

Company	Number of Plants	Total capacity tpd	Average capacity tpd
Martin (2000-2010)	53	27900	526
Von Roll (2000-2011)	40	23130	578
Fisia Babcock (2000-2011)	24	14750	615
Babcock & Wilcox Vølund (2002-2011)	20	7080	354
Total	**137**	**72860**	**532**

NOx Emission Level in Europe

EU Directive 2000/76/EF on Waste Incineration

- 135 ppmv, 7% O2 (200 mg/Nm3, 11% O2)
- 48 ppmv, 7% O2 (70 mg/Nm3, 11% O2), the Netherlands
- 54 ppmv, 7% O2 (80 mg/Nm3, 11% O2), Austria and Switzerland
- Tax-system!
- New directive is under preparation – NOx emission limit most likely to be tightened (Germany expects 70 pmm (100 mg/Nm3) in year 2013)

- Raw gas typical 175 – 250 ppmv, 7% O2 (250-350 mg/Nm3) with modern combustion control

DeNOx

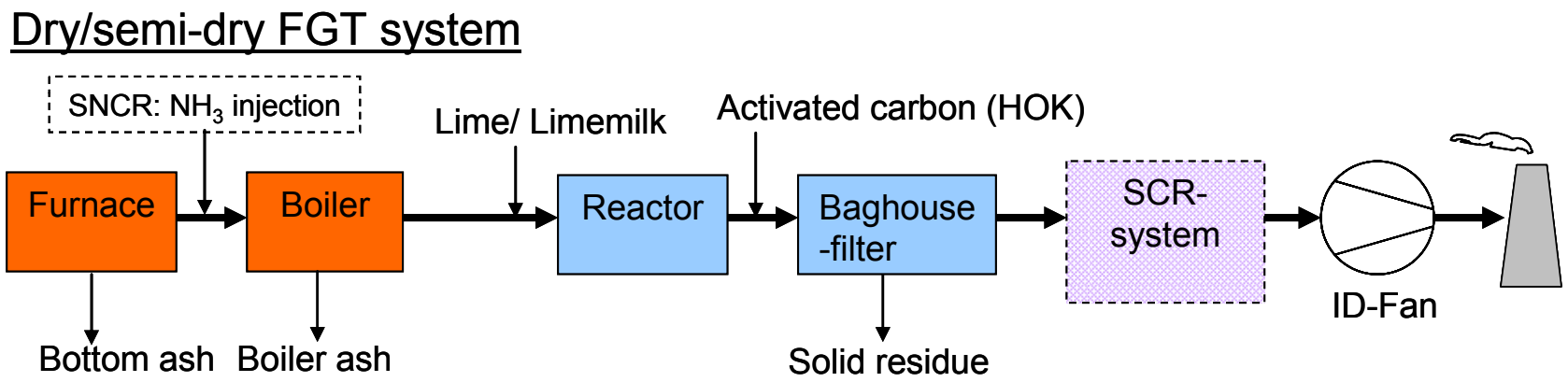
$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$

$6\ NO_2 + 8\ NH_3 \rightarrow 7\ N_2 + 12\ H_2O$

Stoichiometric consumption 1,5 kg 25% NH_3/kg NOx (as NO_2)

(or urea $(NH_2)_2CO$)

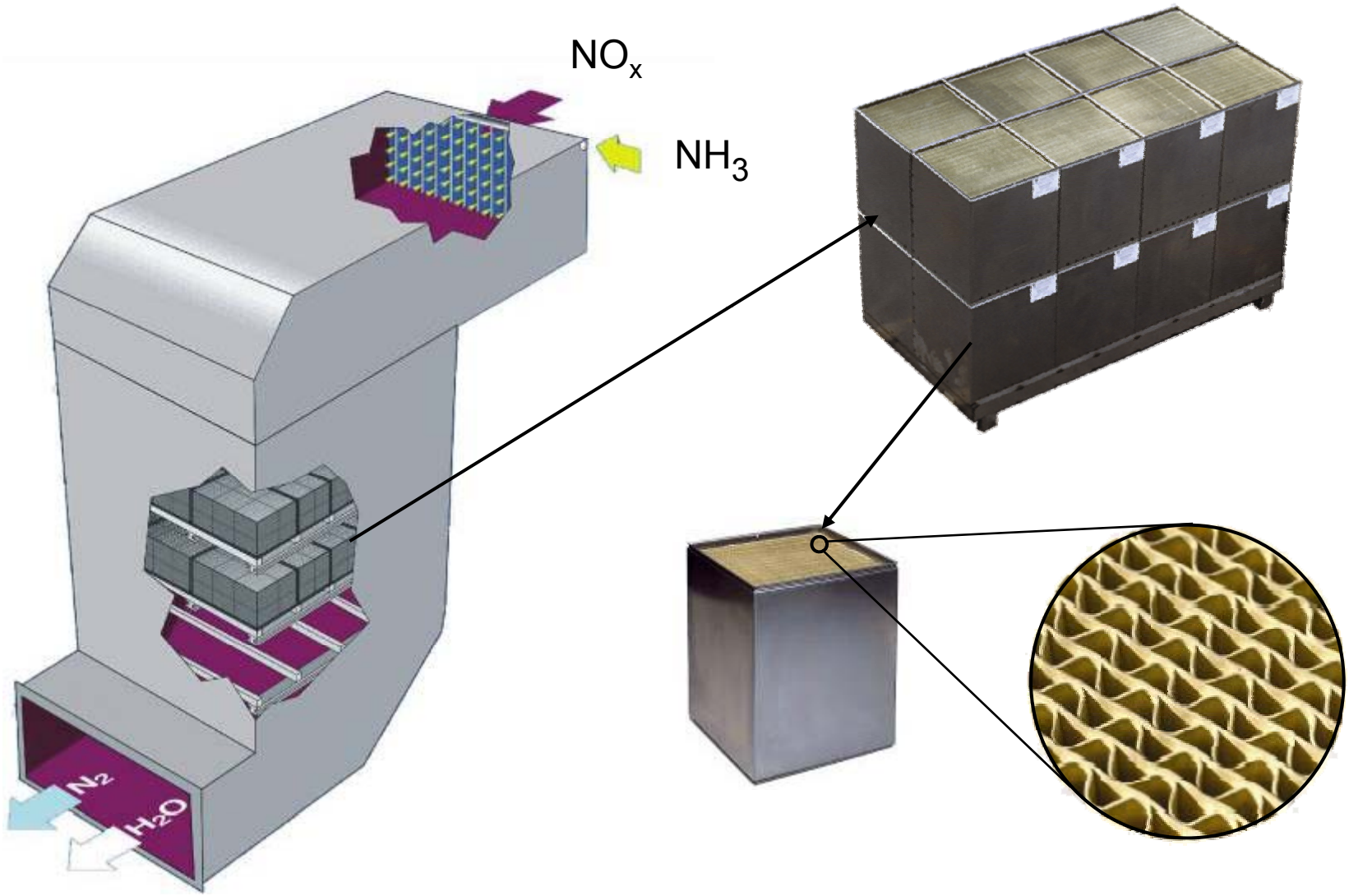
Process – options



Selective Non Catalytic Reduction (SNCR)

- Injection in the boiler at a temperature window at 1560°F – 1650°F (850-900°C)
- 2-3 nozzle layers
- 2- 2,5 times stoichiometric consumption
- Vendors guarantees easily 100 ppm NOx (150 mg/Nm3)
- 70-100 ppm NOx depending on inlet data and restrictions for ammonia slip (100-150 mg/Nm3)
- <70 ppm NOx (<100 mg/Nm3) considerable ammonia slip
- Typical ammonia slip limits 18 ppm (10 mg/Nm3) (Austria 9 mg/Nm3 (5 mg/Nm3))

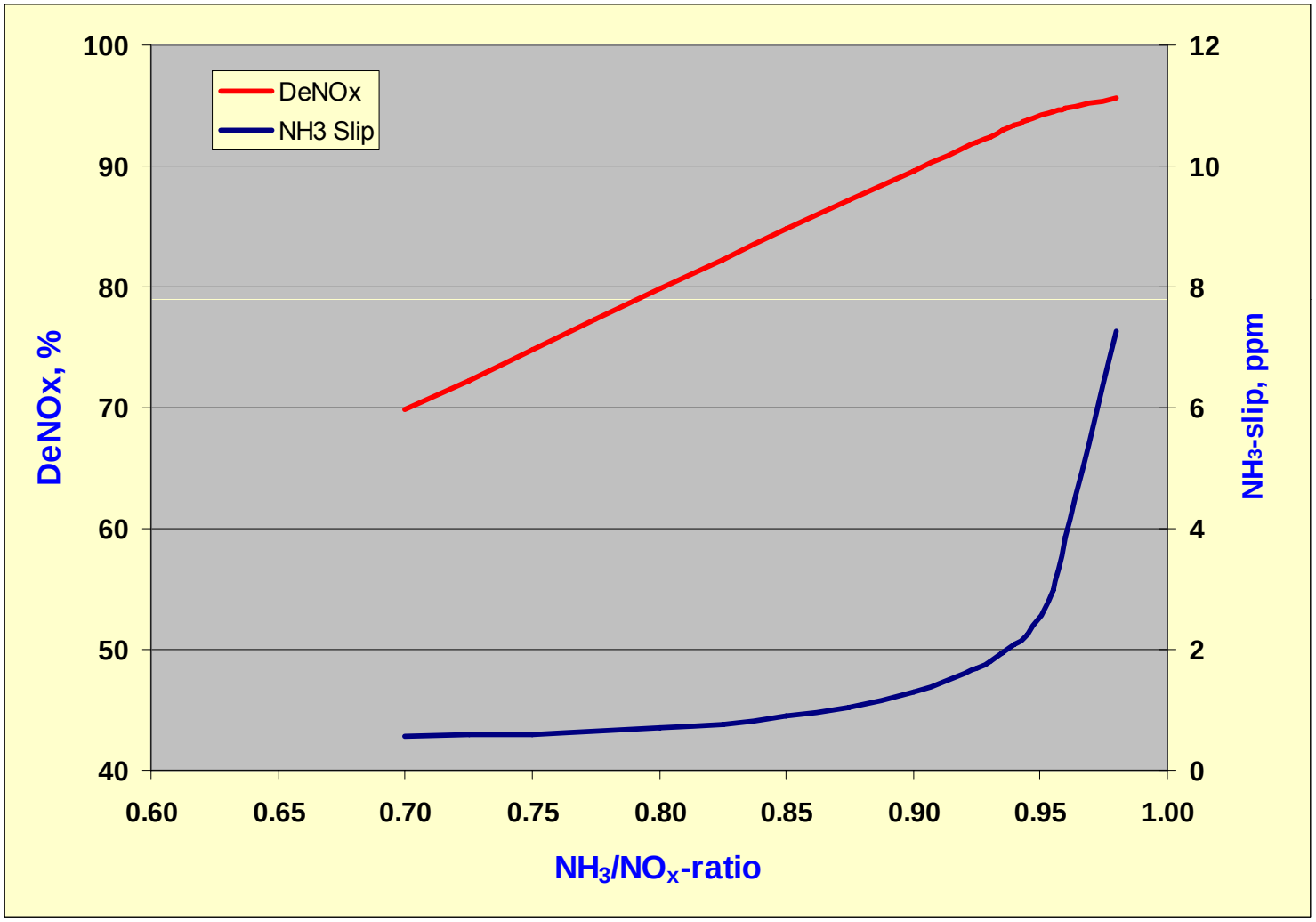
Selective Catalytic Reduction (SCR) - Reactor



Selective Catalytic Reduction (SCR)

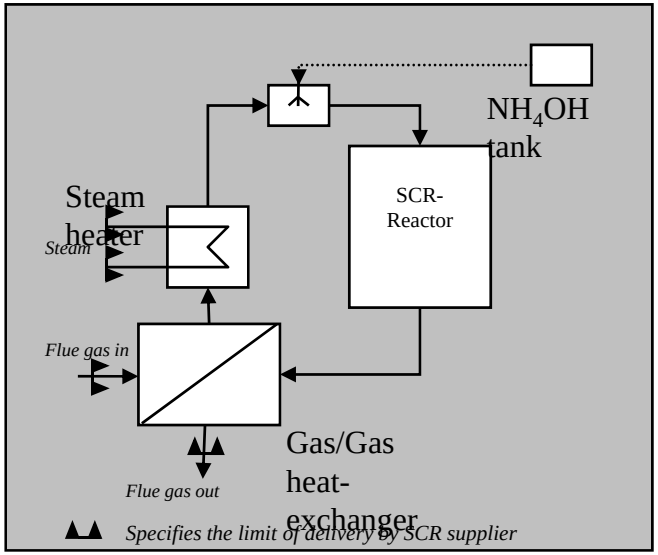
- 430°F - 480°F (220-250°C)
- Close to stoichiometric consumption – low NH3 slip
- Active component V2O5
- By-effect – dioxin removal (oxidation)
- Clocking – ammoniumbisulphate, (SO2<10-12 ppm/20-40 mg/Nm3)
- Emission typically 15-70 ppmv NOx (20-50 mg/Nm3)
- 5 years guarantee (lifetime >10 years) if low SO2, K, Pb, As

NOx Reduction and NH_3 Slip

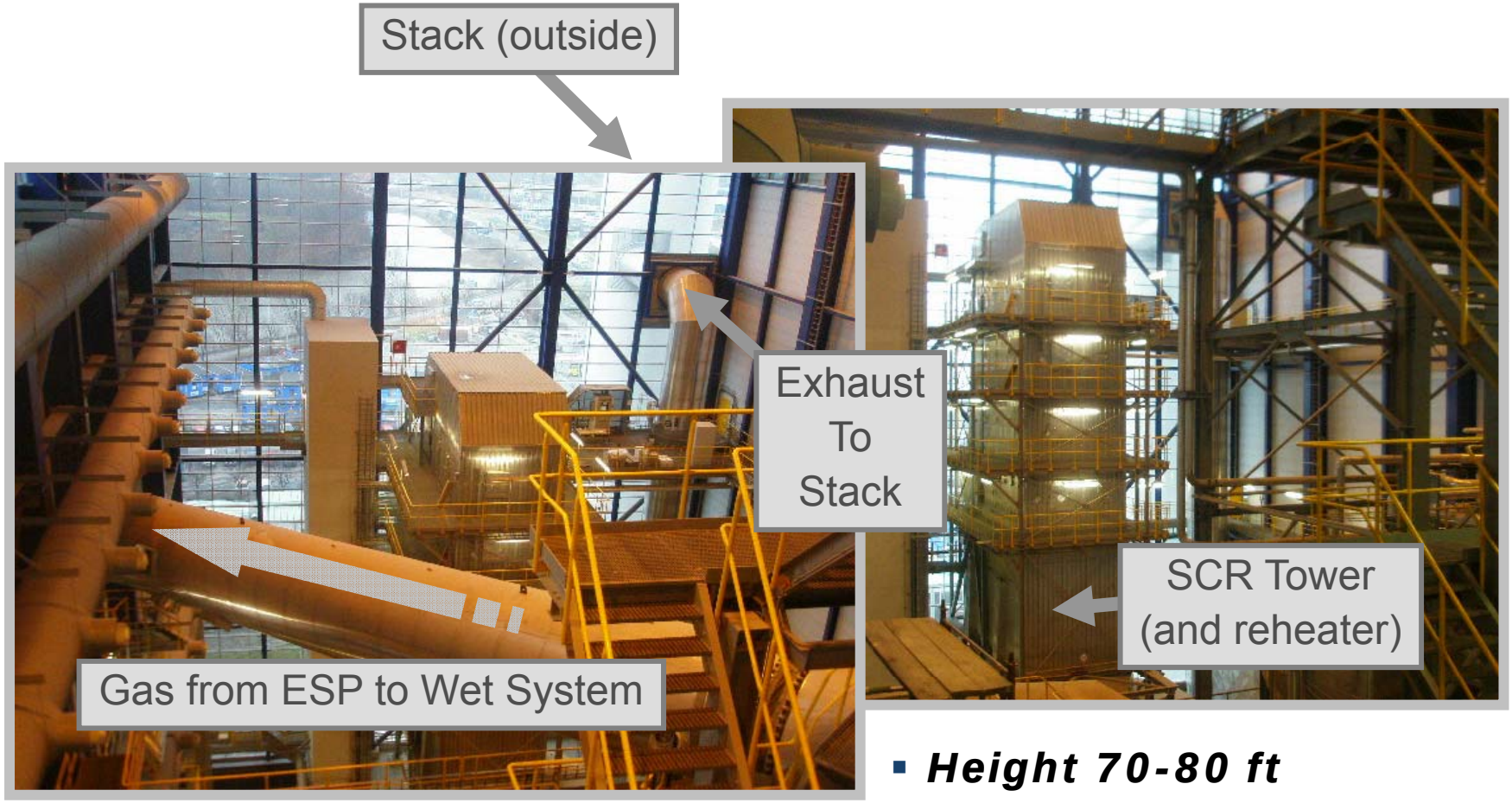


SCR Systems

- High dust (between superheater and economizer) – min 540°F (280°C) to prevent clocking, reduced lifetime, less efficient
- Traditional tail-end solutions, reheat to 430°F-480°F/220-250°C (gas/gas heat exchanger and drum steam)
- Low temperature tail-end solutions, reheat to 360°F-390°F/180-200°C, only with very low SO2 or with on-line high temperature regeneration (4-18 hours at > 540°F/280°C)



Air Pollution Control - SYSAV



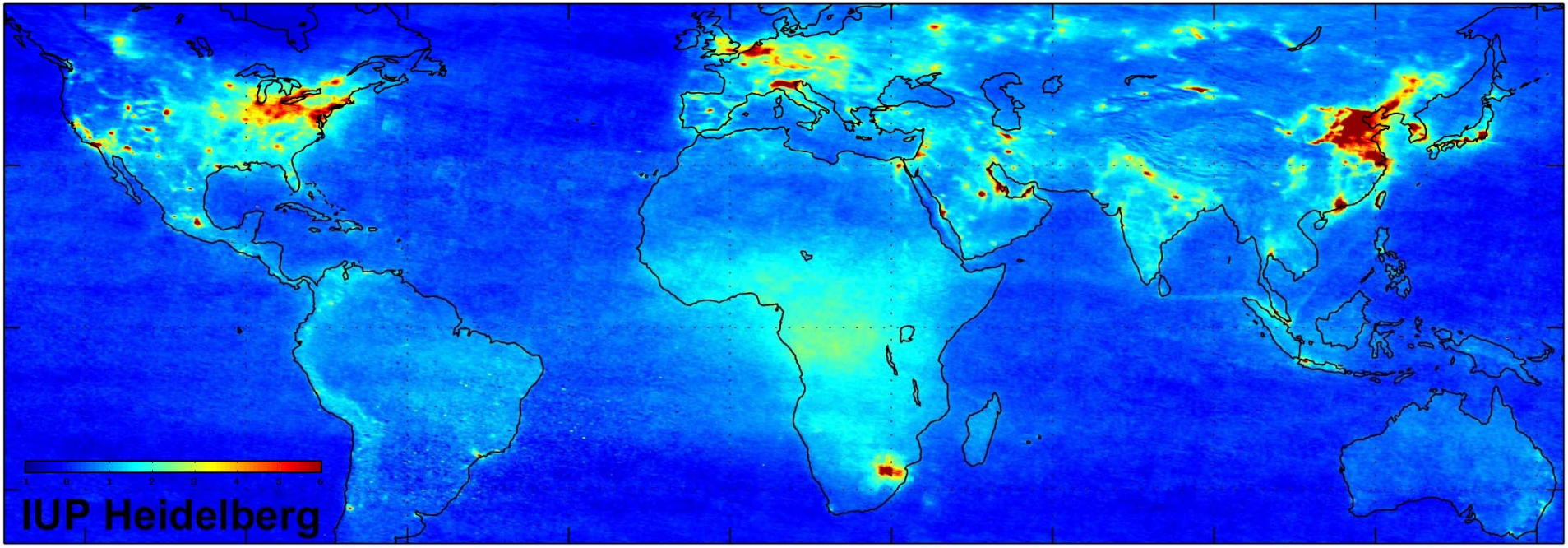
- ***Height 70-80 ft***
- ***Width 45 ft***

Cost

	SCR 90 ppmdv@7% O_2	SCR 50 ppmdv@7% O_2	SNCR 90 ppmdv@7% O_2
Total Capital Cost (mill USD)	**8-9.5**	**8-9.5**	**1.8**
Annual Cost (mill USD)			
- Capital cost, 5% 20 years	0.65-0.75	0.65-0.75	0.14
- Extra maintenance	0.07	0.07	
- Consumables - NH_3	0.04	0.05	0.06
- Consumables – additional electricity for ID-fan	0.06	0.06	
- Lost electricity revenue from steam use to reheating	0.20	0.20	
Total Annual Cost (mill USD)	**1-1.12**	**1-1.13**	**0.20**
Cost pr. ton of waste (USD/t)	**5.6-6.2**	**5.7-6.30**	**1.13**

Cost of electricity = 70 USD/MWh. Cost of NH_3 (100%) = 400 USD/tonne

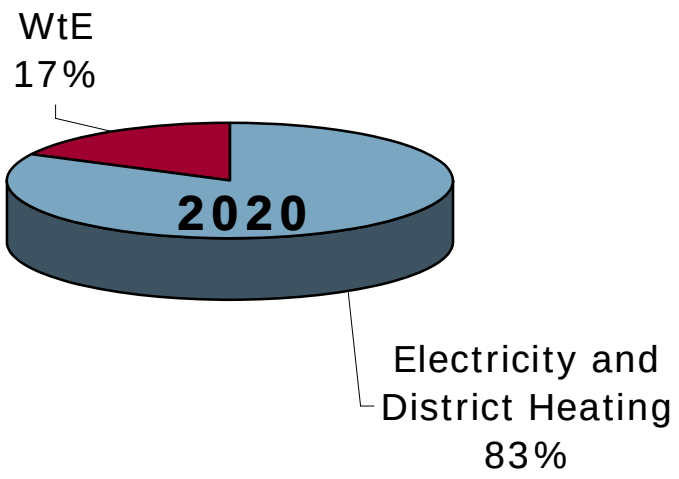
Global NOx Pollution



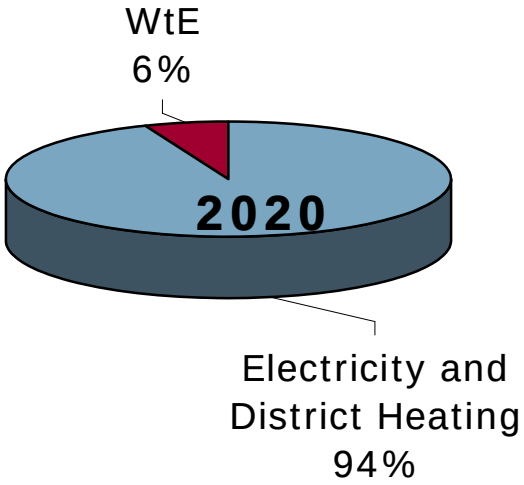
Institut für Umweltphysik

Power Production, Denmark

SNCR 135 ppm/200 mg/Nm^3



SCR 50 ppm/70 mg/Nm^3



Source: Danish EPA

Lessons Learned

- SNCR has a limit around 70-100 ppm (100-150 mg/Nm3) – otherwise high NH3 slip
- High dust SCR is risky - be aware of SO2 content
- Good operational experience with tail-end SCR
- Optimise energy consumption – use drum steam and control the SO2 correspondingly
- The choice is depending on emission limits!

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