



Significance of and challenges for flue gas treatment systems in waste incineration with the reference to the emission levels under the first draft of BAT-Document

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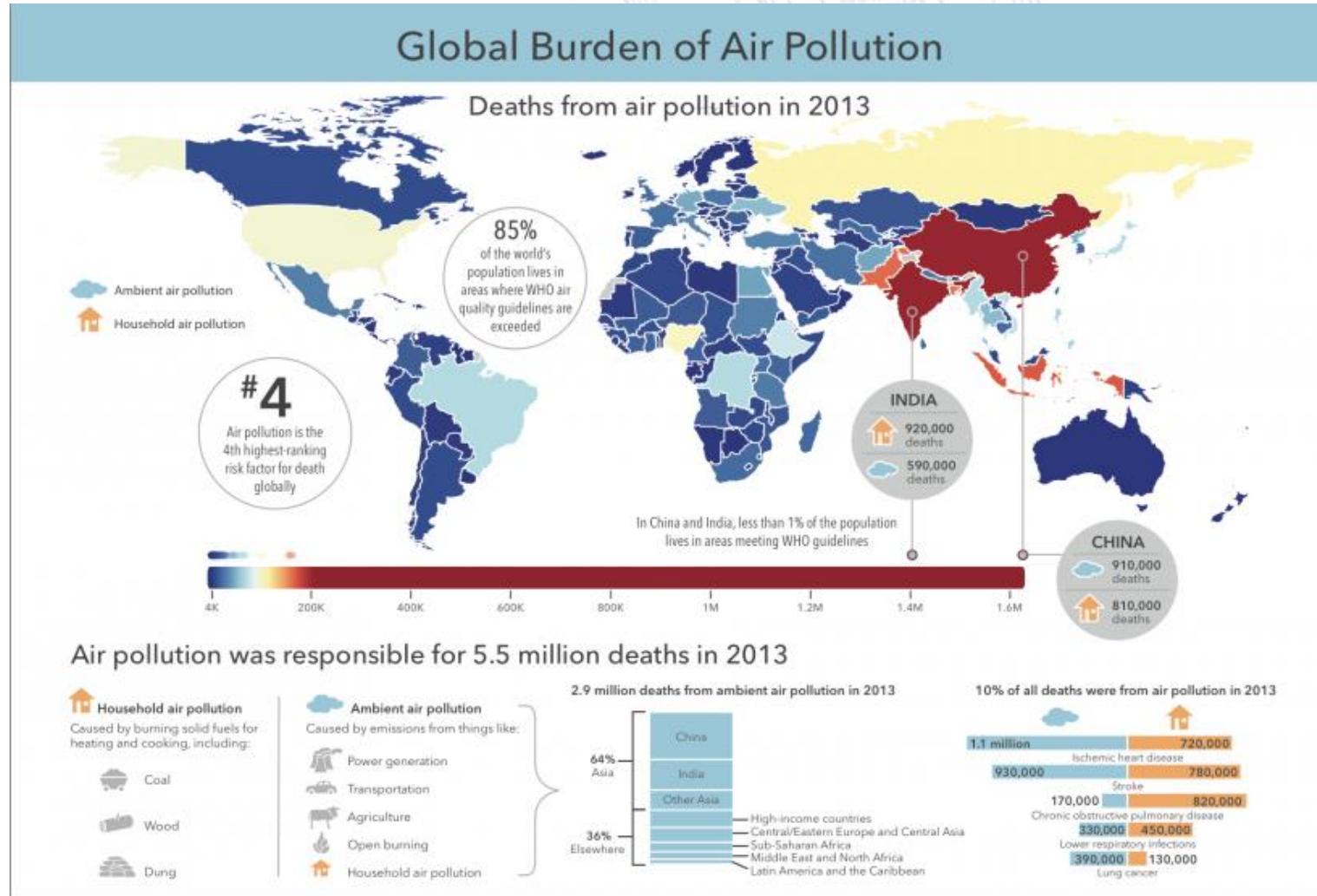


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Introduction

Motivation and background

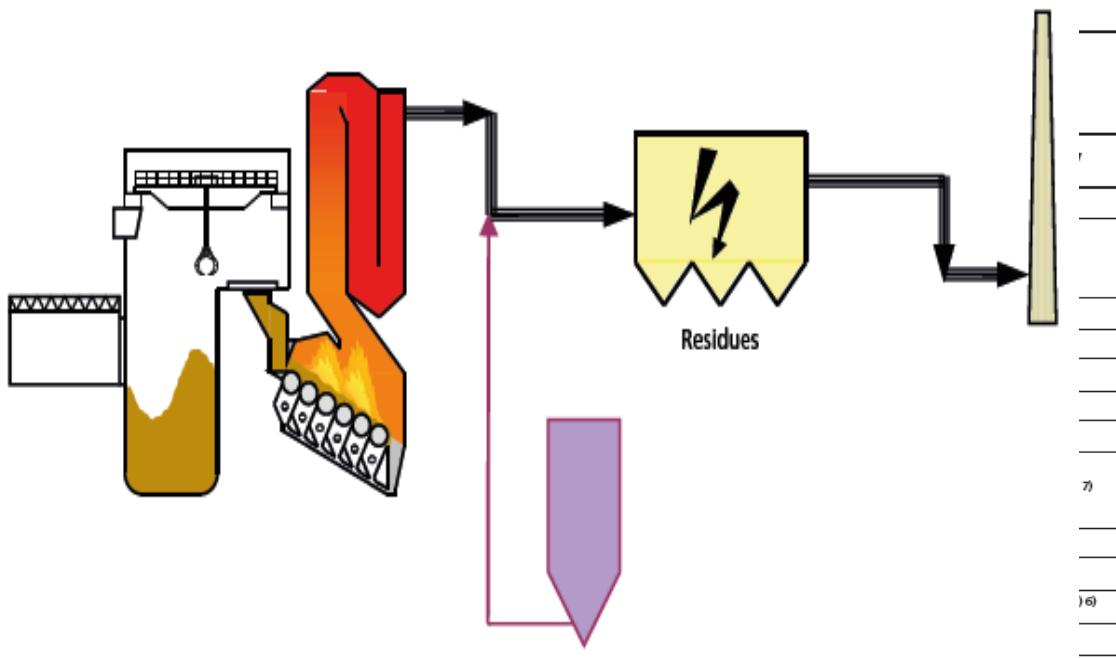
Significance of flue gas treatment



Source: WHO Global Burden of Disease Study 2013

Development of flue gas treatment systems according the legal requirements using the example of Germany

Pollutant	Unit	TA Luft 1974 version		TA 1986
		General requirements	Geir requir	
O ₂ -reference percentage	Vol.-% dry		11	
Dust	mg/m ³	100		1
Total Organic Carbon (TOC)	mg/m ³	-		1
Hydrogen chloride (HCl)	mg/m ³	100		1
Hydrogen fluoride (HF)	mg/m ³	5		1
Carbon monoxide (CO)	mg/m ³	1,000		1
Sulphur dioxide (SO ₂)	mg/m ³	-		1
Nitrogen oxide (NO _x)	mg/m ³	-		5
Ammonia (NH ₃)	mg/m ³	-		
<i>Heavy metals</i>				
Mercury (Hg)	mg/m ³	-		
Dioxins and furans	ng/m ³	-		
Class I	mg/m ³	20***		0
Class II	mg/m ³	50***	1	0.5
Class III	mg/m ³	75***	5	0.05



The concentration data is based on standard temperature and pressure, dry state, for each oxygen reference value; DAV indicates daily average value; HHAV indicates half hourly average value; YAV indicates yearly average value; Heavy metals class I: Σ Cd/Tl; Heavy metals class II: Σ Sb, As, Pb, Cr, Co, Ni, Cu, Mn, V, Sn; Heavy metals class III: Σ As, benzo[ghi]perylene, Cd, Co(aq), Cr(IV)

* not applicable to use of coal, untreated wood only; ** combustion capacity > 6t/h or new facilities; *** related to the former classification

¹⁾excluding Sn; ²⁾applicable to Tl (single substance); ³⁾applicable to Pb, Co, Ni, Se, Te; ⁴⁾applicable to Sb, Cr, CN, F, Cu, Mn, V, Sn; ⁵⁾not applicable to use of existing plants with RTI < 50 MW; ⁶⁾to be valid as of 2019; ⁷⁾not applicable for existing plants; ⁸⁾applicable to Mercury if the emission value is always < 20 % of the requested emission value

RTI: Rated Thermal Input



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Development of flue gas treatment systems according to the legal requirements using the example of Germany

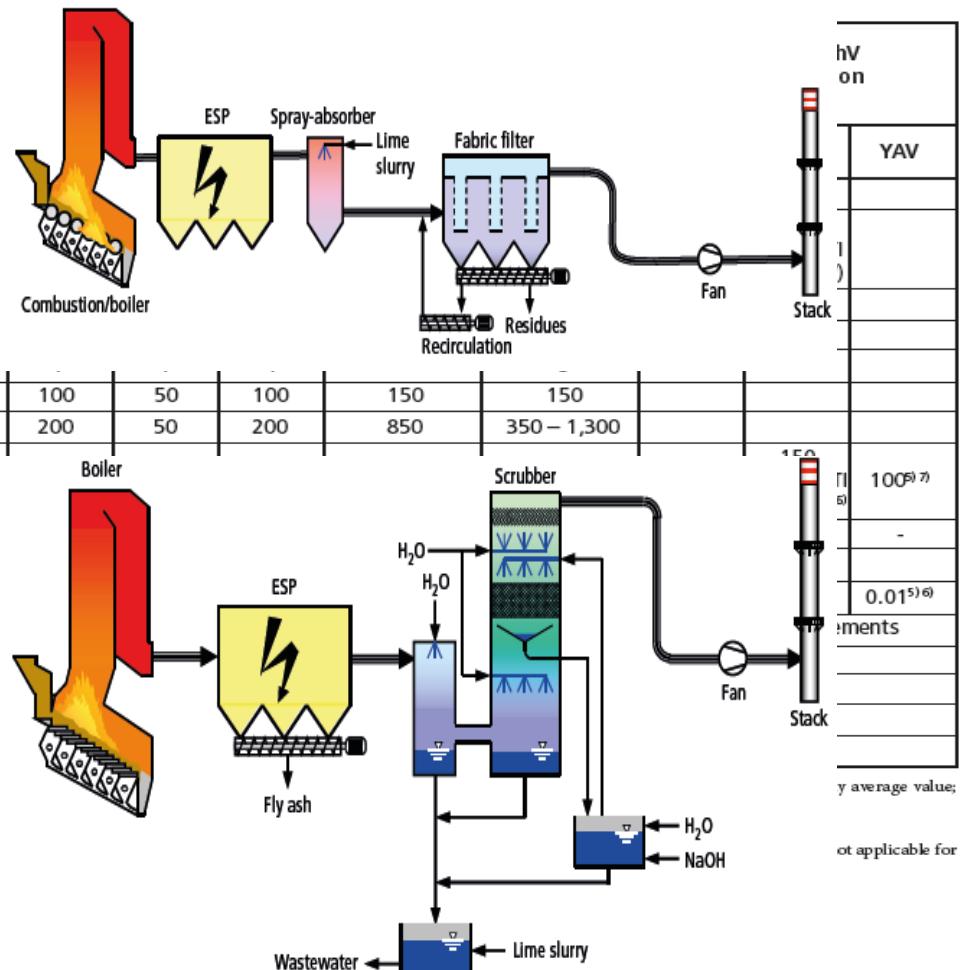
Pollutant	Unit	TA Luft 1974 version	TA Luft 1986 version	17. BI 2003
		General requirements	General requirements	DAV
O ₂ -reference percentage	Vol.-% dry		11	
Dust	mg/m ³	100	30	10
Total Organic Carbon (TOC)	mg/m ³	-	20	10
Hydrogen chloride (HCl)	mg/m ³	100	50	10
Hydrogen fluoride (HF)	mg/m ³	5	2	1
Carbon monoxide (CO)	mg/m ³	1,000	100	50
Sulphur dioxide (SO ₂)	mg/m ³	-	100	50
Nitrogen oxide (NO _x)	mg/m ³	-	500	200
Ammonia (NH ₃)	mg/m ³	-	-	-
<i>Heavy metals</i>				
Mercury (Hg)	mg/m ³	-	-	0.03
Dioxins and furans	ng/m ³	-	-	Single me
Class I	mg/m ³	20***	0.2	0.05
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Class III	mg/m ³	75***	5	0.5

The concentration data is based on standard temperature and pressure, dry state, for each oxygen reference percentage. Heavy metals class I: Σ Cd/Tl; Heavy metals class II: Σ Sb, As, Pb, Cr, Co, Ni, Cu, Mn, V, Sn; Heavy metals class III: Σ Hg, Σ Sn, Σ Pb, Σ As, Σ Sb, Σ Cr, Σ Co, Σ Ni, Σ Cu, Σ Mn, Σ V, Σ Sn.

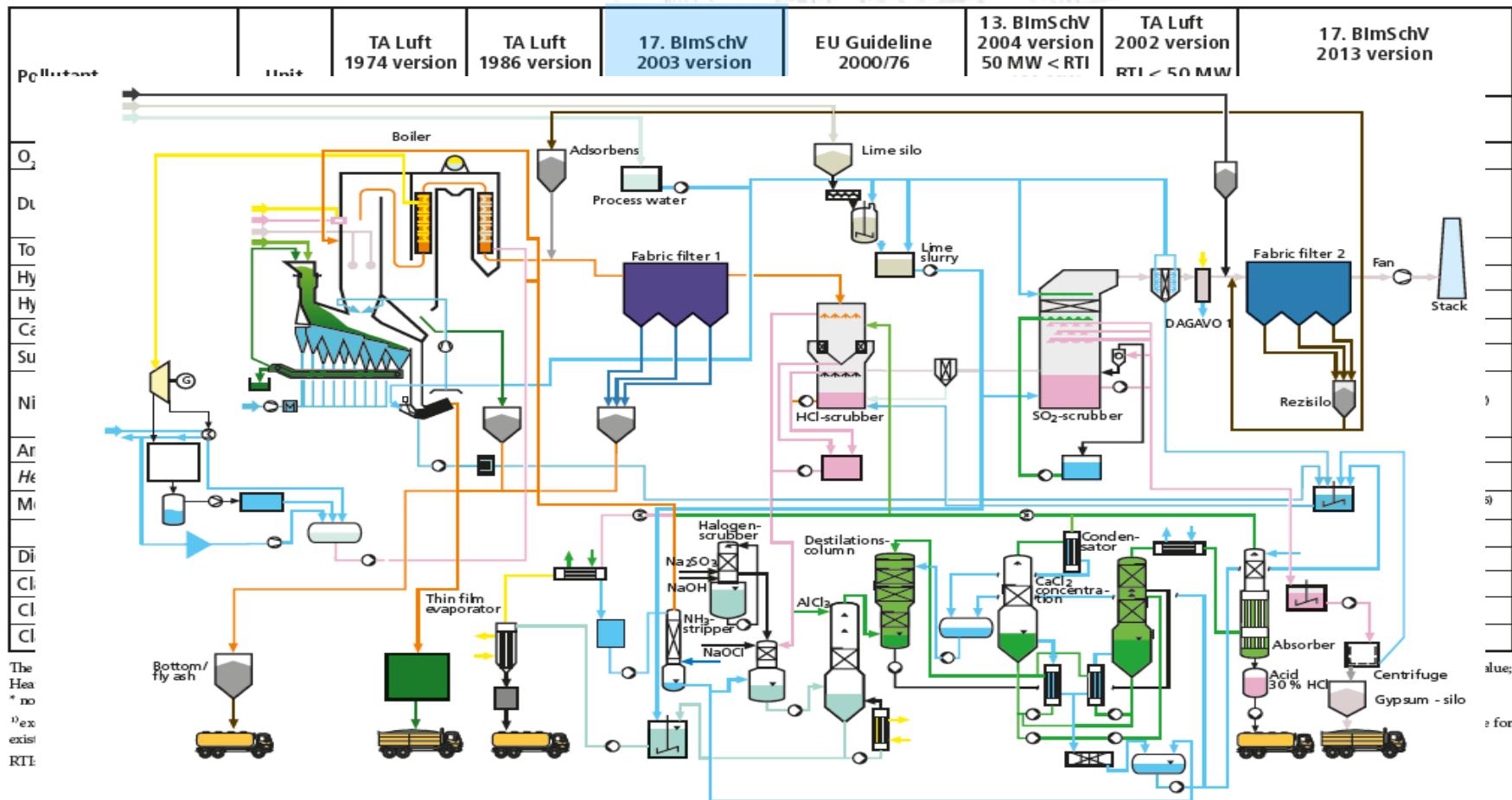
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RTI: Rated Thermal Input



Development of flue gas treatment systems according the legal requirements using the example of Germany



Significance of flue gas treatment

What was the experience with such complex plants?

- there was no market for the by-products
- the energy expenditure and plant construction was very high

→ while these insights were gained, waste incineration underwent a metamorphosis from mere waste disposal to energy recovery from waste

From then on, energy efficiency was in the focus and became an important design criterion both for new and modified plants

Comparison of the emission requirements of the Draft 1 for the revision of the BAT instructions for the waste incineration

Process parameter	Unit	BAT-AELS (2006)	IED (+CI)	17. BlmSchV	Draft BAT-AELS Value for new plant	Draft BAT-AELS Value for existing plant	Averaging period
Dust	[mg/m³n]	1-5	10 (± 3)	5	2-5		Daily avg.
TOC	[mg/m³n]	1-10	10 (± 3)	10	3-10		Daily avg.
HCl	[mg/m³n]	1-8	10 (± 4)	10	2-6	2-8	Daily avg.
HF	[mg/m³n]	1	1 ($\pm 0,4$)	1	<1	<1	Daily avg.
SO ₂	[mg/m³n]	1-40	50 (± 10)	50	10-30	10-40	Daily avg.
NO _x - SCR	[mg/m³n]	40-100	200 (± 40)	150	50-120	50-150	Daily avg.
NO _x - SNCR	[mg/m³n]	120-180		200 (for the existing plants till 2019)	50-120	50-180	Daily avg.
NH ₃ (SNCR)	[mg/m³n]	1-10		10	3-10	3-10 (15)	Daily avg.
Hg	[$\mu\text{g}/\text{m}^3\text{n}$]	0,001-0,02	50	30	5-20	5-25	Daily avg.
Hg (indicative value)	[$\mu\text{g}/\text{m}^3\text{n}$]		Over the sampling period	50	15-35	15-40	Hourly avg.
CO	[mg/m³n]	5-30	50 (± 5)	50	10-50		Daily avg.
PCDD/F	[ng I-TEQ/ m^3n]	0,01-0,1	0,1		<0,01-0,04	<0,01-0,06	Monthly resp. over the sampling period
PCDD/F + dioxin-like PCBs	[ng WHO-TEQ/ m^3n]			0,1	<0,01-0,06	<0,01-0,08	
Cd + Tl	[mg/m³n]	0,005-0,05	0,05	0,05	0,01-0,02		Over the sampling period
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	[mg/m³n]	0,005-0,5	0,5	0,5	0,05-0,3		Over the sampling period

Challenges for flue gas treatment systems in the future

Challenges for flue gas cleaning will continue to be high pollutant removal efficiency and very high efficiency in the use of energy and consumables (minimum consumption of resources)

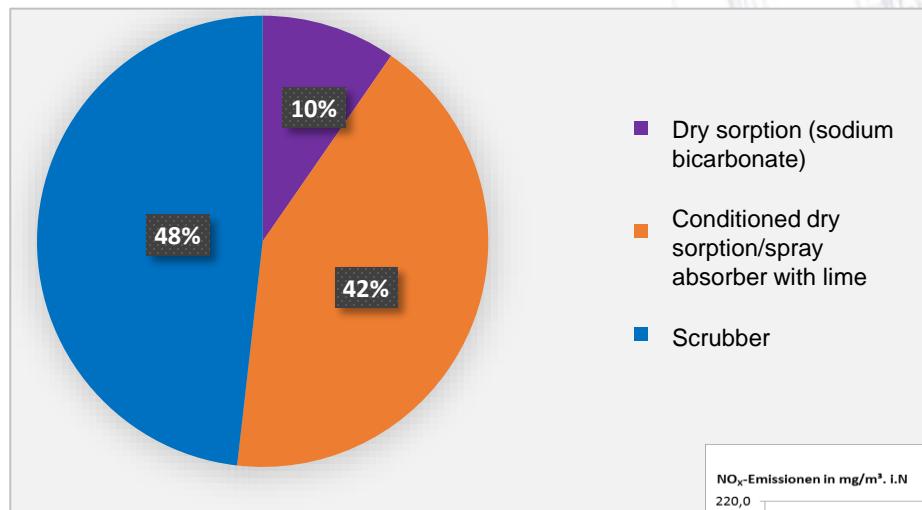
The present-day flue gas cleaning systems are unique in design and their specific configuration often reflects the development of the emission limits over time.

Process overview

of the executed flue gas treatment plants
Impact on the possible emission reduction

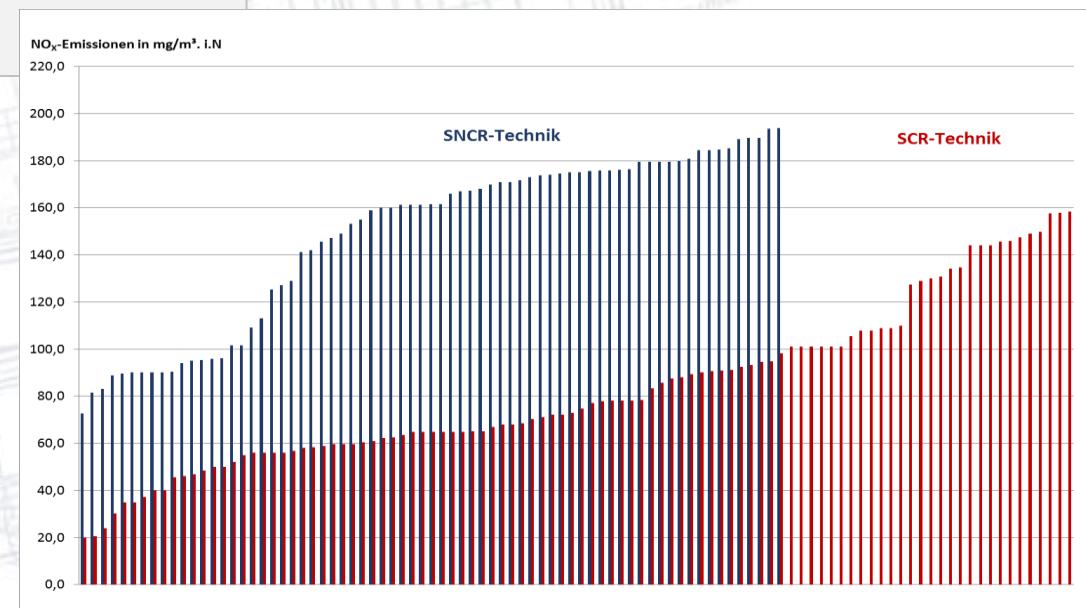


Separation of acid gases based on German wte plants



Source: ITAD, Düsseldorf

Separation of NOx based on German wte plants



Source: M. Treder: ITAD Emissionsbericht 2016, vorläufig, unveröffentlicht, Düsseldorf 10.09.2017

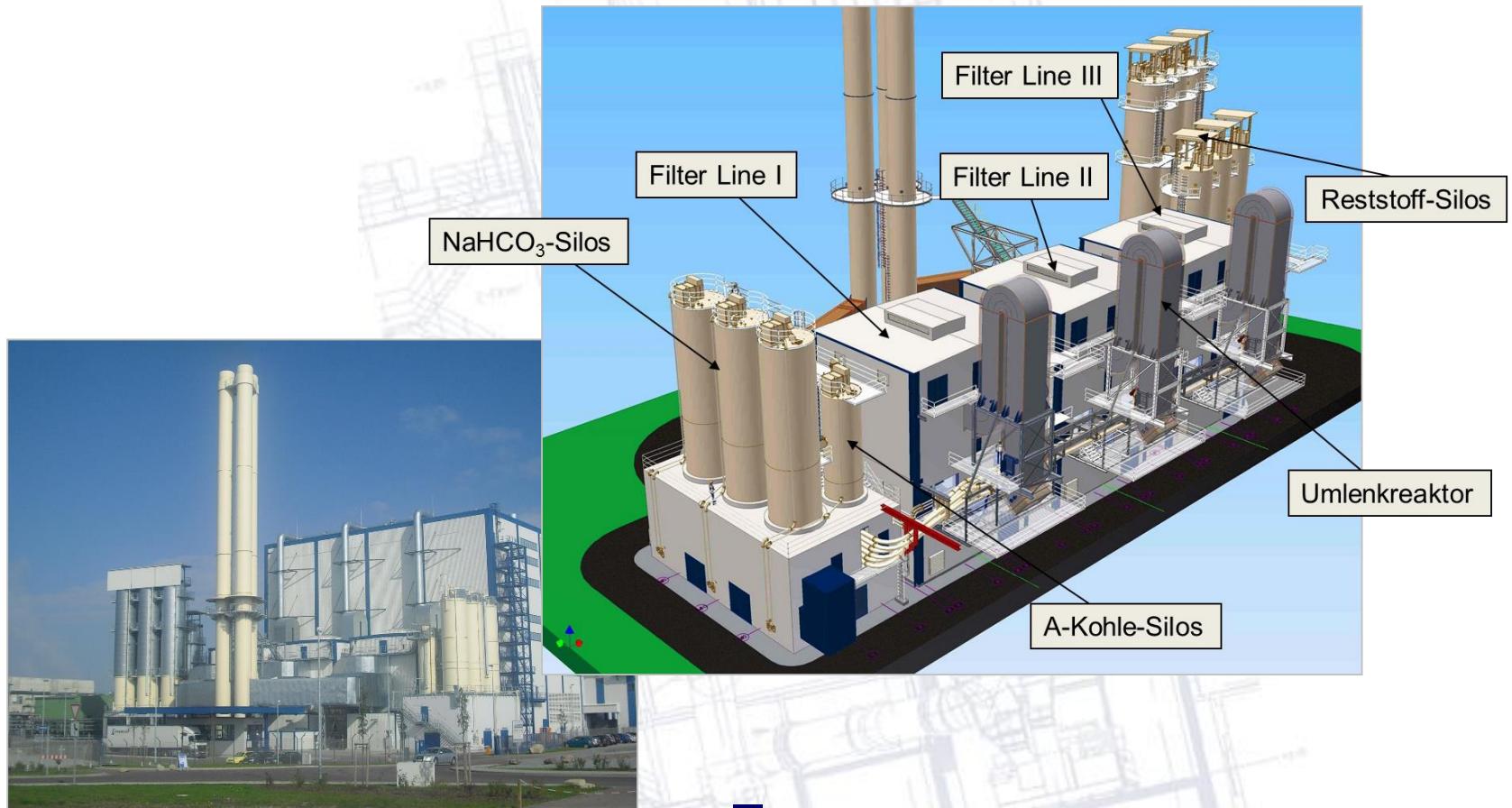


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Simple plant construction

SNCR – one-stage dry sorption with NaHCO_3



Source: Lühr-Filter, Stadthagen

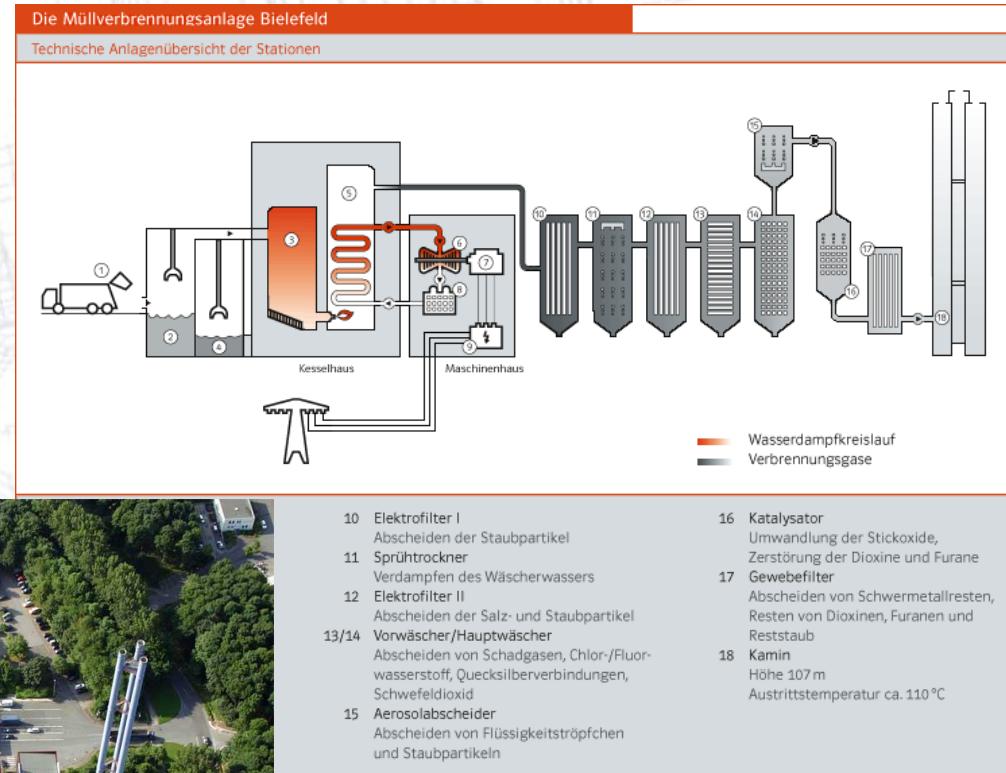


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Complex plant construction

ESP – Spray-dryer – ESP – 2-stage Scrubber – Aerosol-separator – SCR – Fabric filter



Source: Interargem, Bielefeld



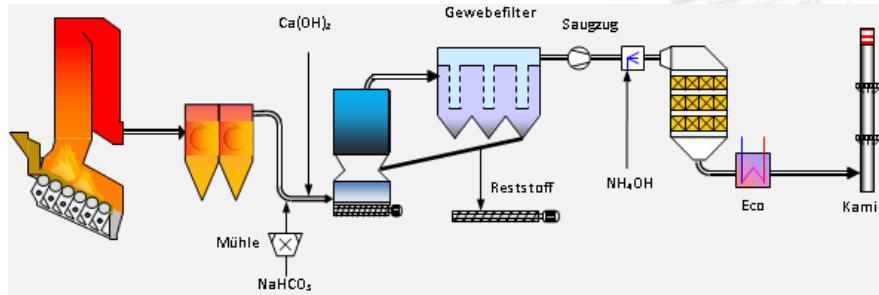
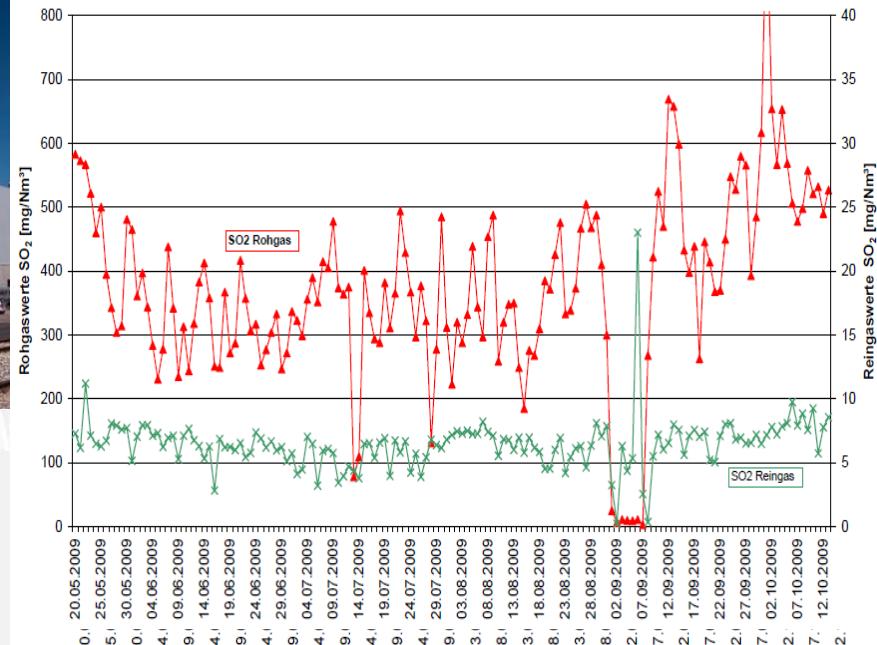
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Waste incineration plant EVI-Europark (Germany)

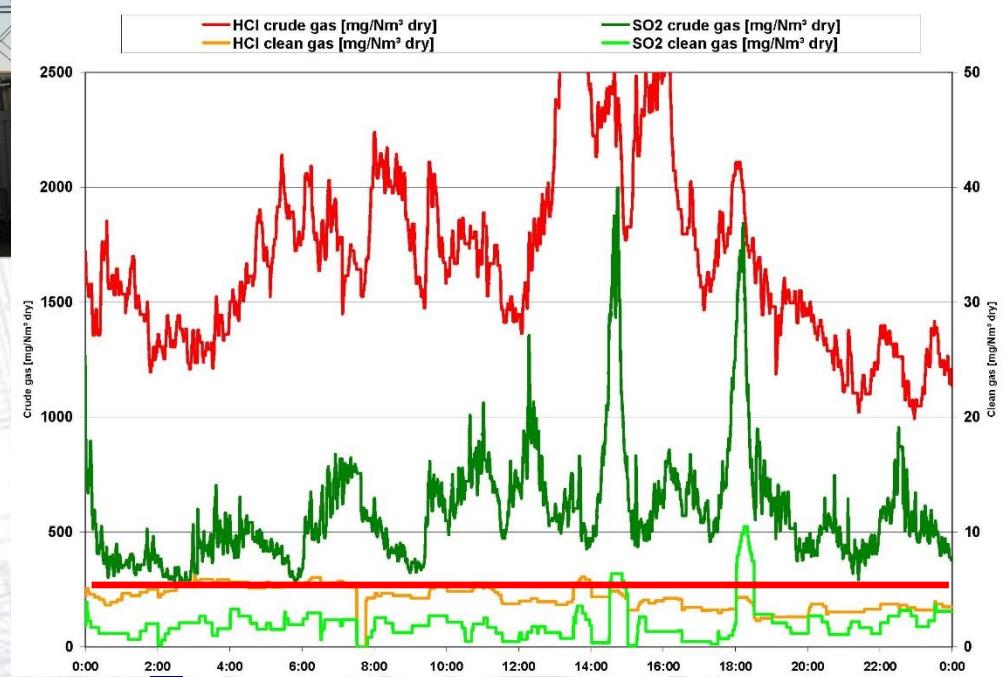
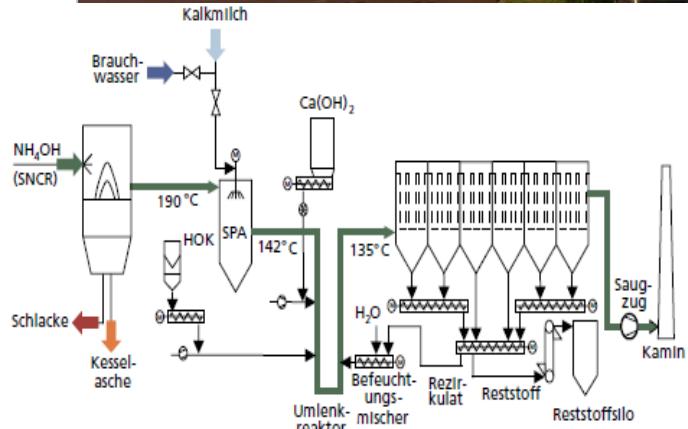


Verlauf Tagesmittelwerte SO₂ - MVA Emlichheim Linie 1 - Mai-Oktober 2009



Source: Dr. Buhlmann; Trockene Rauchgasreinigung der MVA-EVI-Europark;
5. Tagung- Trockene Abgasreinigung für Feuerungsanlagen und
andere thermische oder chemische Prozesse Essen, 12. - 13. November 2009

Waste incineration plant Rothensee (Germany)



Source: R. Margraf; Dry, Semi-dry or Wet – Which System Fits Best Depending on the Overall Conditions?, IRRC, Vienna 2017

Challenges for flue gas treatment systems in the future

Increasing energy efficiency will continue to be another challenge for flue gas treatment processes!

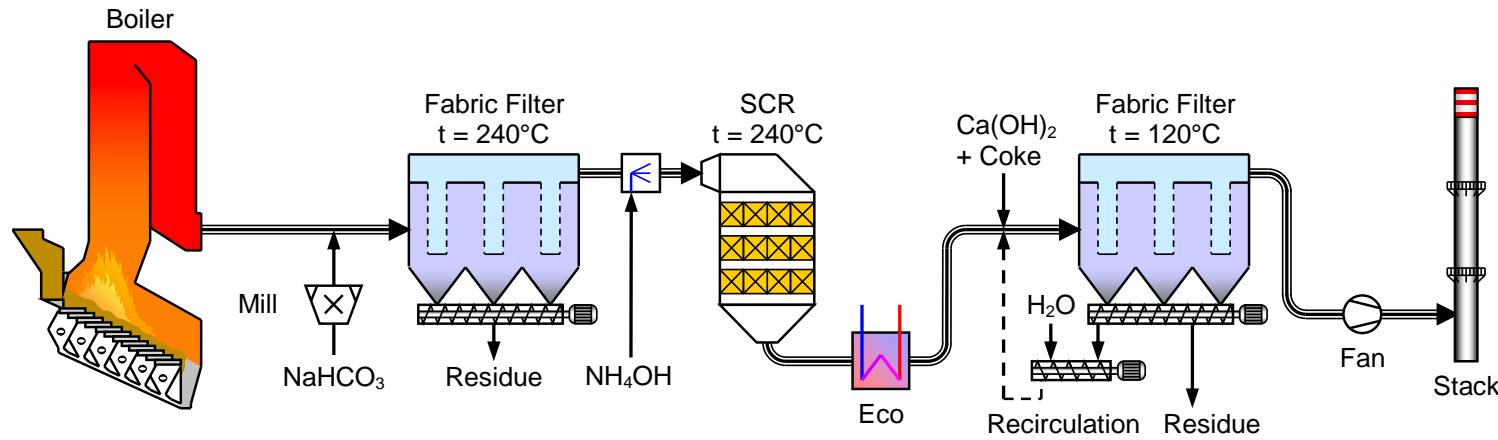
A very comprehensive and detailed study on the net emissions balance as a function of energy expenditure shows that the energy expenditure for a multi-stage flue gas treatment system with minimum emissions is not necessarily higher than that of single-stage systems!



Modern-day and future know-how regarding the design of efficient plants will not necessarily imply the development of new processes, but rather place a focus on the intelligent combination and configuration of proven process stages

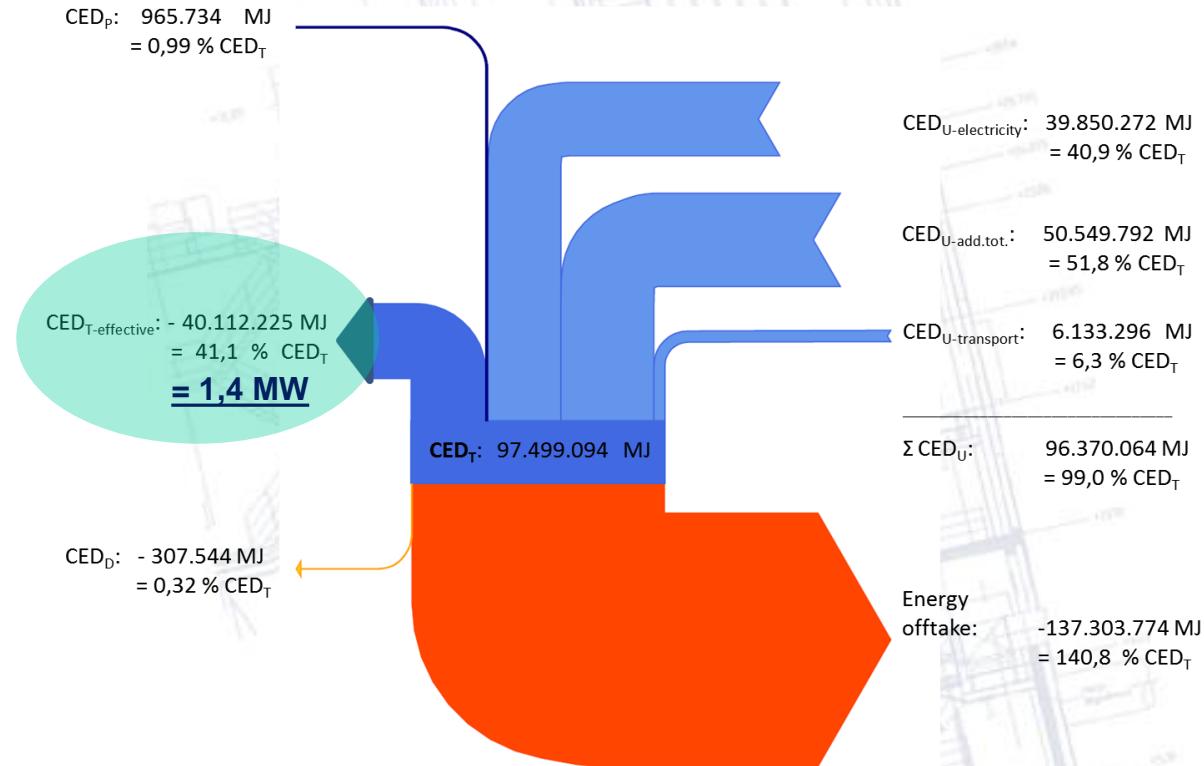
Challenges for flue gas treatment systems in the future

One example of this is the Delfzijl waste incineration facility in the Netherlands.



Challenges for flue gas treatment systems in the future

In order to compare different systems the cumulative energy demand was used



Conditions:

- HCl-inlet 1300 mg/m³
- SO₂-inlet 500 mg/m³
- Reference period 8000 h

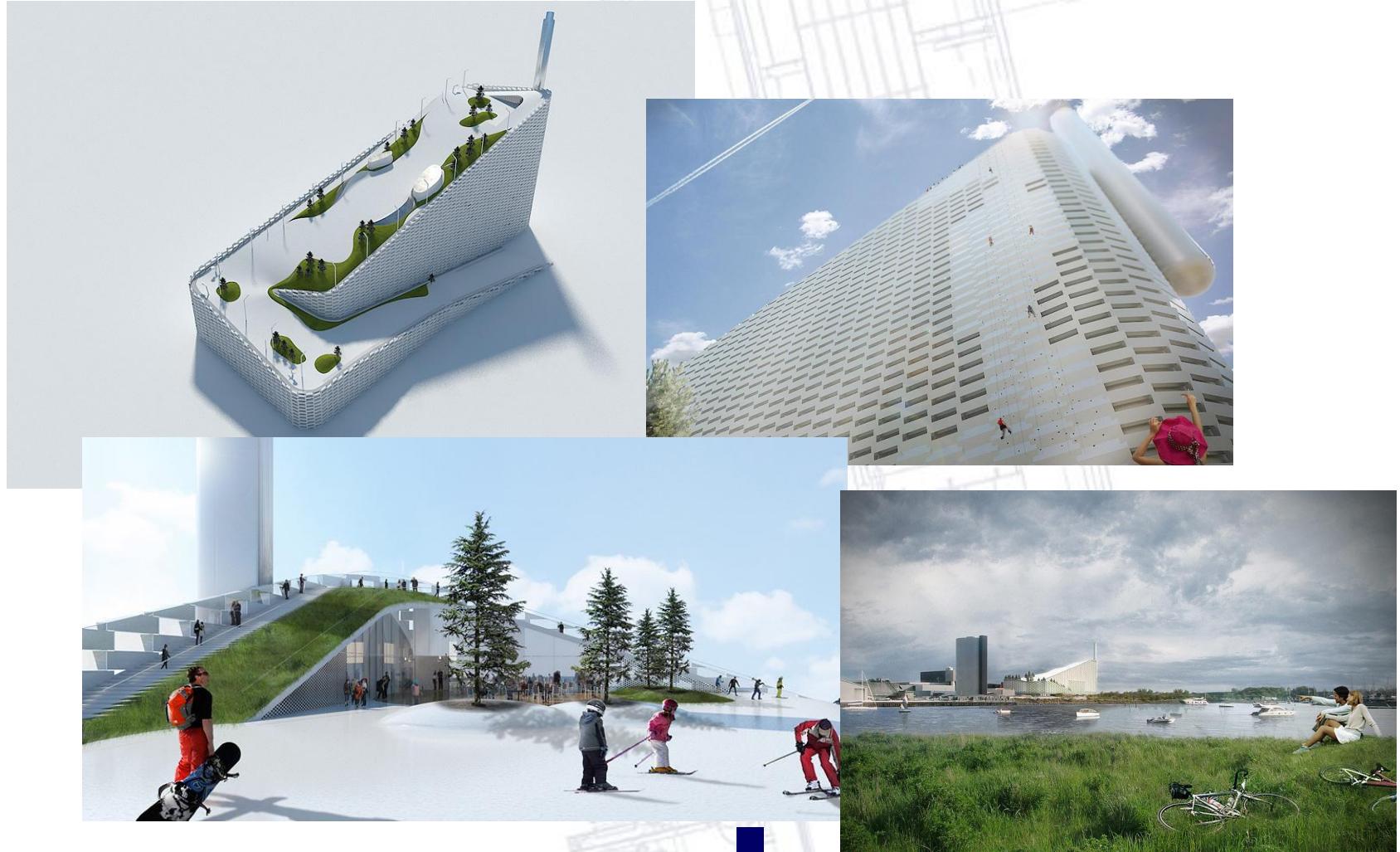
Challenges for flue gas treatment systems in the future

My appeal is ...



.. as regards the future selection of sites for new plants, this implies that plants should be built at sites where a suitable infrastructure including energy sinks exist!

Wte plant Copenhagen - Amager



Wte plant issy-les muolineaux, Paris



© Jacques Mossot



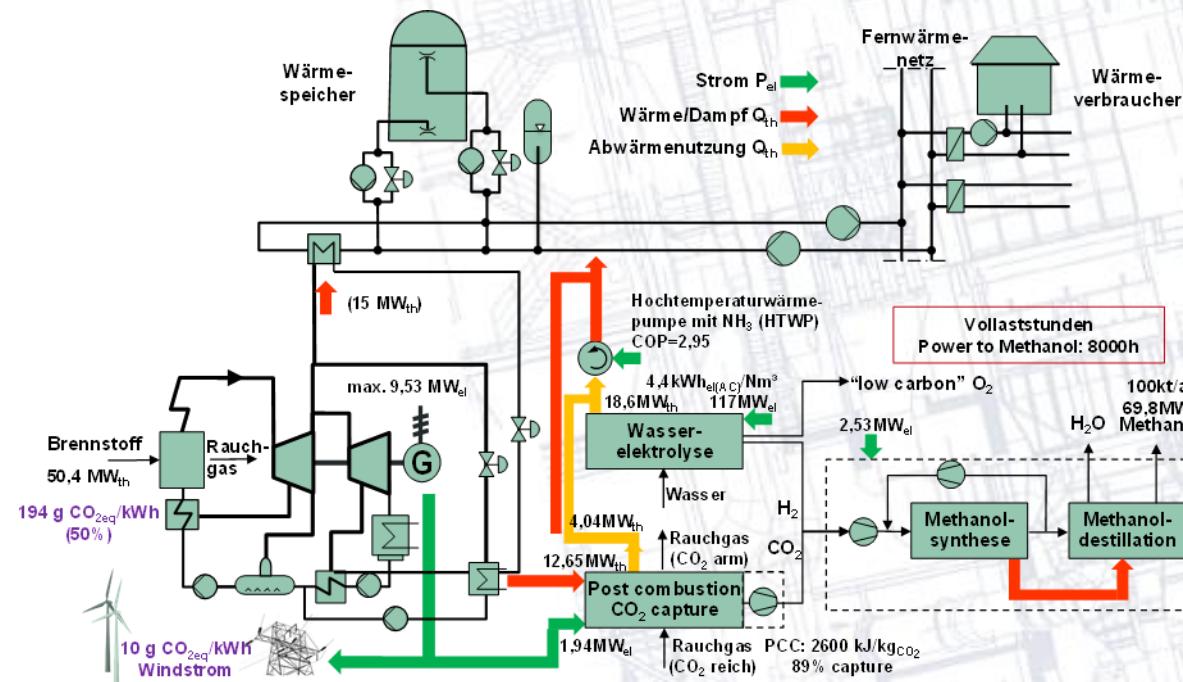
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Challenges for flue gas treatment systems in the future

Apart from energy efficiency, recent discussions indicate the imminent renaissance of recovery of valuable by-products from the flue gas – this time, however, not in the form of producing materials such as gypsum or hydrochloric acid, but in the form of feeding the combustion product CO_2 back into the carbon cycle, for instance in the form of methanol!



Challenges for flue gas treatment systems in the future

Synthesis of methanol from CO₂ may be a sensible option for some waste incineration plant sites lacking other options for utilization of the energy due to the nature of the nearby infrastructure.

Another approach for using the CO₂ present in the flue gas was pursued in the energy-from-waste plant in Twence, the Netherlands, where sodium bicarbonate is successfully produced from CO₂ and soda.



Further changes and influence on the flue gas treatment process

Heat utilization – measuring scope

Further requirements from the Draft 1 for the revision of the BAT instructions for the waste incineration

f.	High steam conditions	<p>The higher the steam conditions (temperature and pressure), the higher the electricity conversion efficiency allowed by the steam cycle.</p> <p>Working at increased steam conditions (e.g. above 45 bar, 400 °C) requires the use of special steel alloy or refractory cladding to protect the boiler sections that are exposed to the highest temperatures.</p>	<p>Applicable to new plants and to major retrofits of existing plants, where the plant is mainly oriented towards the generation of electricity.</p> <p>The applicability may be limited by:</p> <ul style="list-style-type: none"> • the stickiness of the fly ashes; • the corrosiveness of the flue gas.
g.	Cogeneration	<p>Cogeneration of heat and electricity where the heat (mainly from the steam system) is used for heating and water/steam to be used in industrial processes/activities or in a public network to a district heating system.</p>	<p>Applicable within the constraints associated with the local heat and power demand.</p>
h.	Flue-gas condenser	<p>A heat exchanger where the water vapour contained in the flue-gas condenses, transferring the latent heat to water at a sufficiently low temperature (e.g. return flow of a district heating network).</p> <p>The flue-gas condenser also provides co-benefits by reducing emissions to air (e.g. of dust and acid gases).</p> <p>The use of heat pumps can increase the amount of energy recovered from flue-gas condensation</p>	<p>Applicability may be limited by the demand for low-temperature heat, e.g. by the availability of a district heating network with a sufficiently low return temperature</p>

Due to the requirement of an effluent-free operation, in Germany it is not feasible!

Further requirements from the Draft 1 for the revision of the BAT instructions for the waste incineration

Substance/ Parameter	Process	Standard(s) (*)	Minimum monitoring frequency	Monitoring associated with
NO _x	Incineration	Generic EN standards	Continuous	BAT 29
NH ₃	When SNCR and/or SCR is used	Generic EN standards	Continuous	BAT 29
N ₂ O	• Incineration in fluidised bed furnaces • When SNCR is operated with urea	EN 21258	Once every year	BAT 29
CO	Incineration	Generic EN standards	Continuous	BAT 29
SO ₂	Incineration	Generic EN standards	Continuous	BAT 28
HCl	Incineration	Generic EN standards	Continuous	BAT 28
HF	Incineration	Generic EN	Continuous	BAT 28

N ₂ O	<ul style="list-style-type: none"> • Incineration in fluidised bed furnaces • When SNCR is operated with urea 	EN 21258	Once every year	BAT 29
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TVOC	Incineration	Generic EN standards	Continuous	BAT 30
PCDD/F	Incineration	No EN standard available for long-term sampling, EN 1948-2, EN 1948-3	Once every month (*)	BAT 30
Dioxin-like PCBs	Incineration	No EN standard available for long-term sampling, EN 1948-2, EN 1948-4	Once every month (*)	BAT 30
Benzo[a]pyrene	Incineration	No EN standard available	Once every year	BAT 30

(*) Generic EN standards for continuous measurements are EN 15267-1, EN 15267-2, EN 15267-3, and EN 14181. EN standards for periodic measurements are given in the table or in the footnotes.

(*) The continuous measurement of HF may be replaced by periodic measurements with a minimum frequency of once every six months if the HCl emission levels are proven to be sufficiently stable. No EN standard is available for the periodic measurement of HF.

(*) For incineration plants with a capacity of < 100 000 tonnes/year incinerating exclusively non-hazardous waste, and for plants incinerating wastes with intrinsically low and constant mercury content (e.g. sewage sludge, mono-streams of waste of controlled composition), the continuous monitoring of emissions can be replaced by long-term sampling or periodic monitoring with a minimum frequency of once every six months. In the latter case the relevant standard is EN 13211.

(*) The monitoring frequency of once every month refers to monitoring carried out by long-term sampling. For incineration plants incinerating exclusively non-hazardous waste and for incineration plants where PCDD/F emission levels are proven to be sufficiently stable, the monthly long-term sampling of PCDD/F emissions can be replaced by periodic measurements with a minimum monitoring frequency of once every six months. In this case

Summary



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Challenges for flue gas treatment systems in the future

As already mentioned above in the context of energy efficiency, it is not important to develop entirely new systems or processes, but rather to combine available processes in an intelligent manner and exploit synergies!

HerzLICHe Grüße aus dem Herzen der Natur!



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Thank you for your attention