Significance of and challenges for flue gas treatment systems in waste incineration

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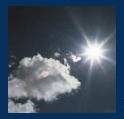
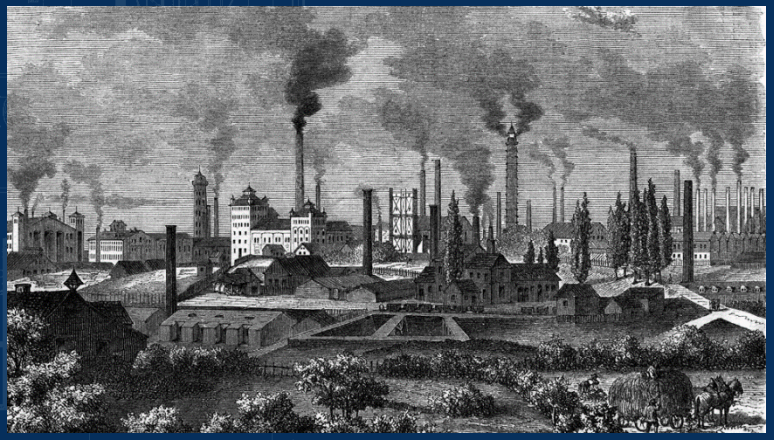
THM TECHNISCHE HOCHSCHULE MITTELHESSEN | CAMPUS GIESSEN | LSE Life Science Engineering



Source: *Coalbrookdale at night from Philipp Jakob Loutherbourg der Jüngere 1801*

Source: wordpress



Source: ARD-Wissen-Natur; 14. July 2016

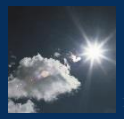
Source: ARD-Wissen-Natur; 4. March 2014

Significance of flue gas treatment

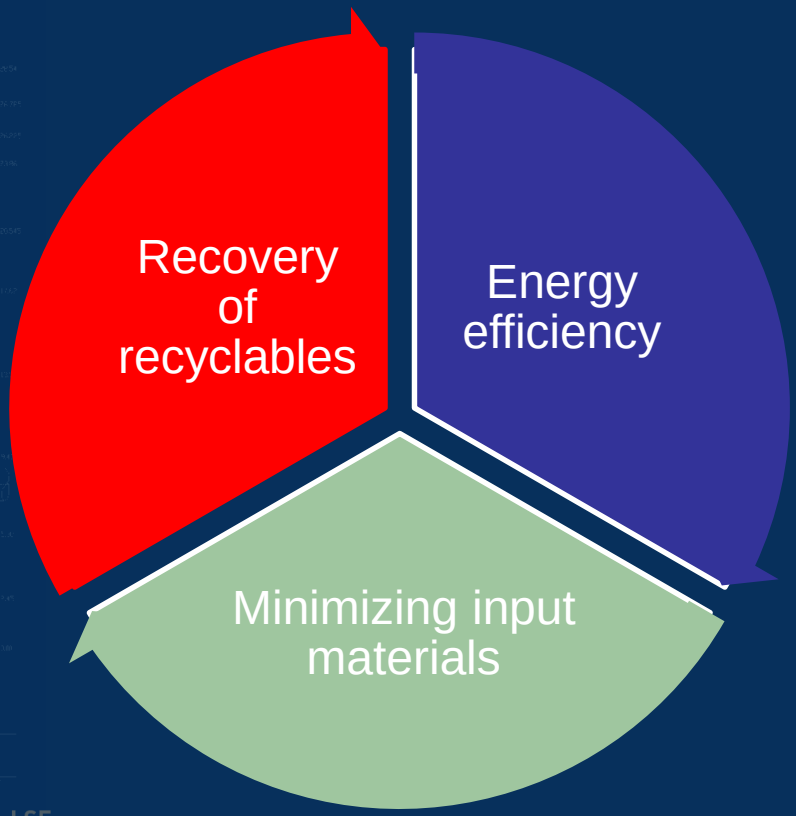
Source: © picture-alliance/AP

Source: Handelsblatt 25. Oct. 2015

Motivation and Background



The motivation of today's developments lies in addition to an efficient pollutant gas separation in topics such as

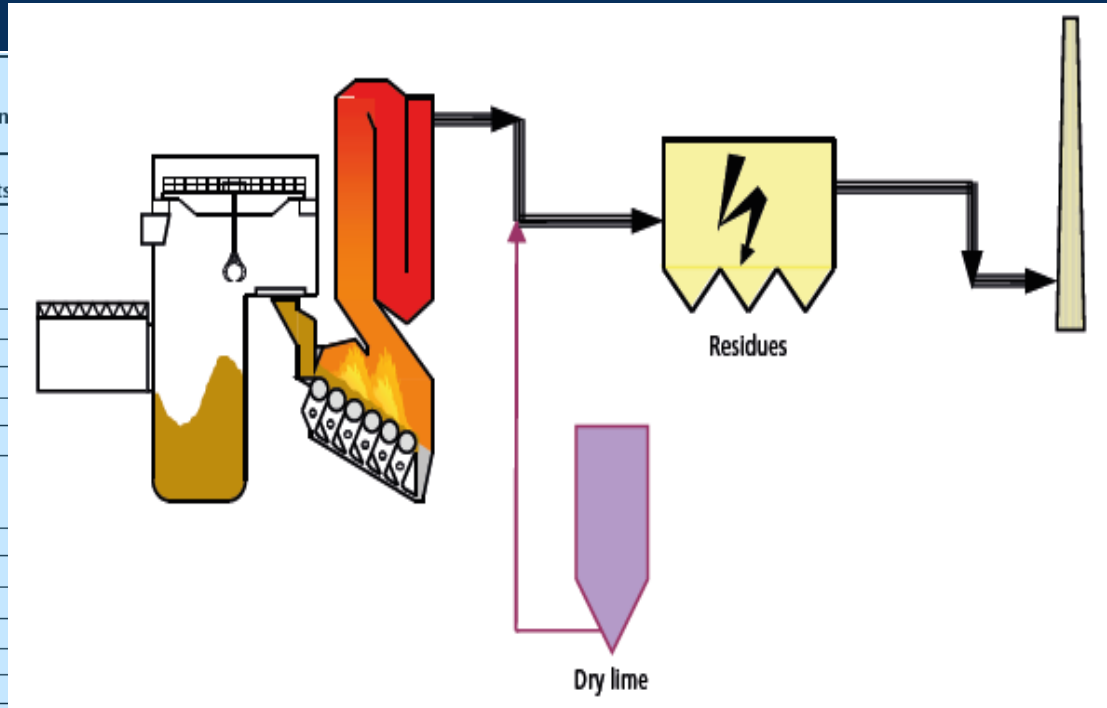


Overview

Flue gas treatment yesterday and Today

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

Pollutant	Unit	TA Luft 1974 version
		General requirements
O_2-reference percentage	Vol.-% dry	
Dust	mg/m³	100
Total Organic Carbon (TOC)	mg/m³	-
Hydrogen chloride (HCl)	mg/m³	100
Hydrogen fluoride (HF)	mg/m³	5
Carbon monoxide (CO)	mg/m³	1,000
Sulphur dioxide (SO_2)	mg/m³	-
Nitrogen oxide (NO_2)	mg/m³	-
Ammonia (NH_3)	mg/m³	-
Heavy metals		
Mercury (Hg)	mg/m³	-
Dioxins and furans	ng/m³	-
Class I	mg/m³	20***
Class II	mg/m³	50***
Class III	mg/m³	75***



1	0.5	0.5[7]		0.5	0.5[7]	0.5	
5	0.05	-	-	0.05*	1[4]	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, benzopyrene, 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

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

Pollutant	Unit	TA Luft 1974 version	TA Luft 1986 version
		General requirements	General requirements
O_2-reference percentage	Vol.-% dry	11	
Dust	mg/m³	100	30
Total Organic Carbon (TOC)	mg/m³	-	20
Hydrogen chloride (HCl)	mg/m³	100	50
Hydrogen fluoride (HF)	mg/m³	5	2
Carbon monoxide (CO)	mg/m³	1,000	100
Sulphur dioxide (SO_2)	mg/m³	-	100
Nitrogen oxide (NO_2)	mg/m³	-	500
Ammonia (NH_3)	mg/m³	-	-
Heavy metals			
Mercury (Hg)	mg/m³	-	-
Dioxins and furans	ng/m³	-	-
Class I	mg/m³	20***	0.2
Class II	mg/m³	50***	1
Class III	mg/m³	75***	5

The concentration data is based on standard temperature and pressure, dry state, for each o
Heavy metals class I: Σ Cd/Tl; Heavy metals class II: Σ Sb, As, Pb, Cr, Co, Ni, Cu, Mn, V, Sn; H
* not applicable to use of coal, untreated wood only; ** combustion capacity > 6t/h or new faci
1) excluding Sn; 2) applicable to Tl (single substance); 3) applicable to Pb, Co, Ni, Se, Te; 4) applica
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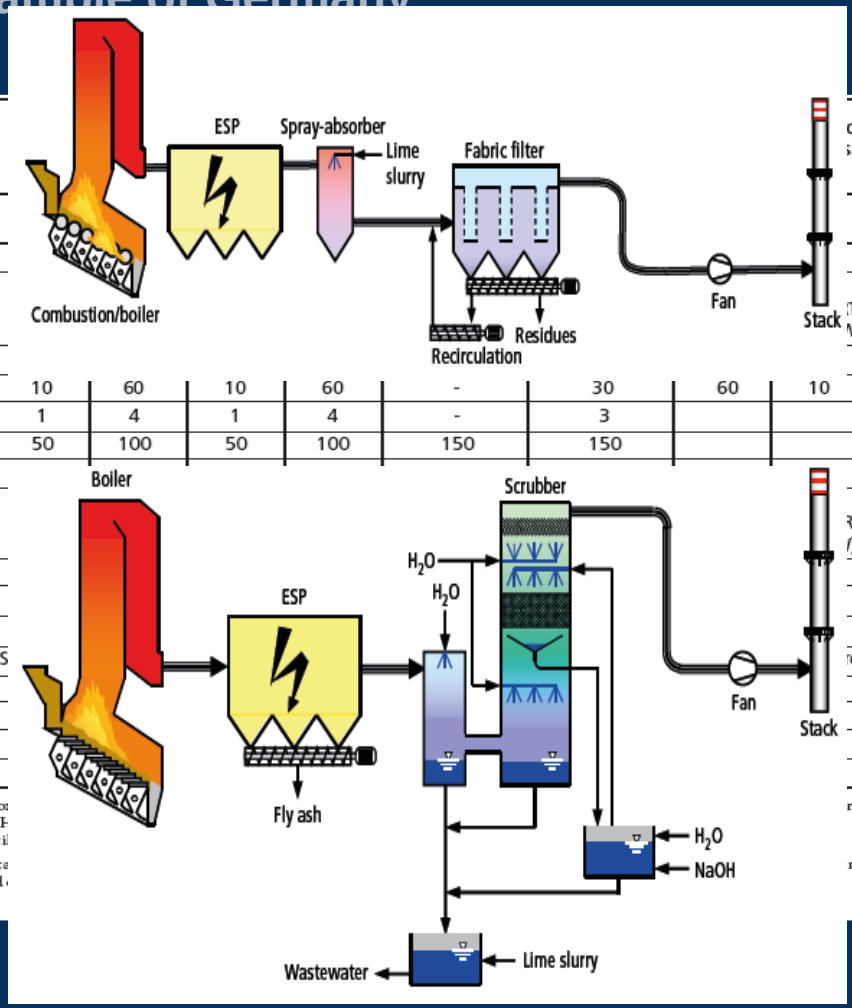
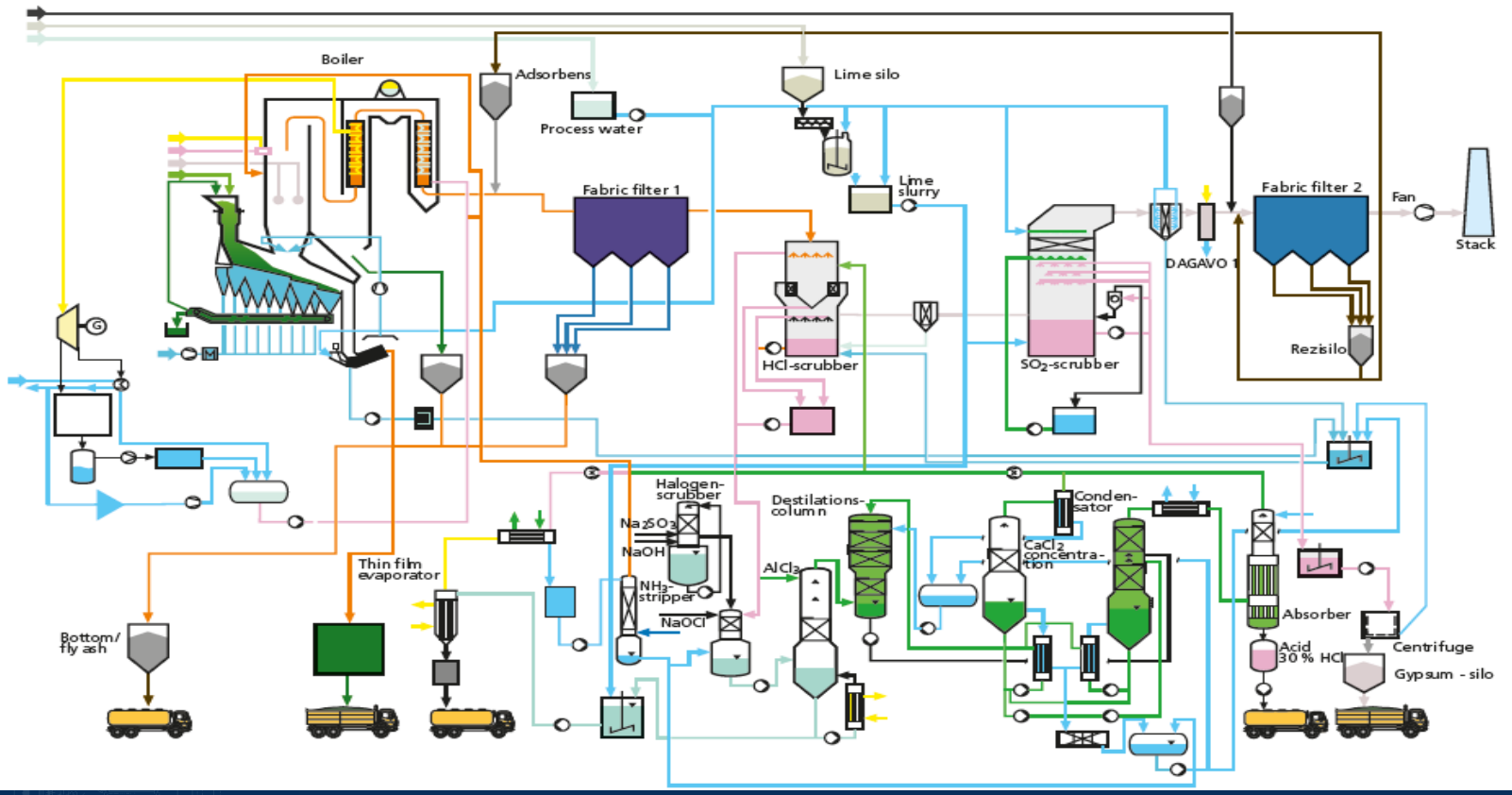
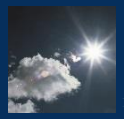
RTI: Rated Thermal Input



Entwicklung der Emissionsanforderungen am Beispiel Deutschland

Pollutant	Unit	TA Luft 1974 version	TA Luft 1986 version	17. BImSchV 2003 version	EU Guideline 2000/76	13. BImSchV 2004 version 50 MW < RTI < 100 MW	TA Luft 2002 version RTI < 50 MW	17. BImSchV 2013 version





Significance of flue gas treatment

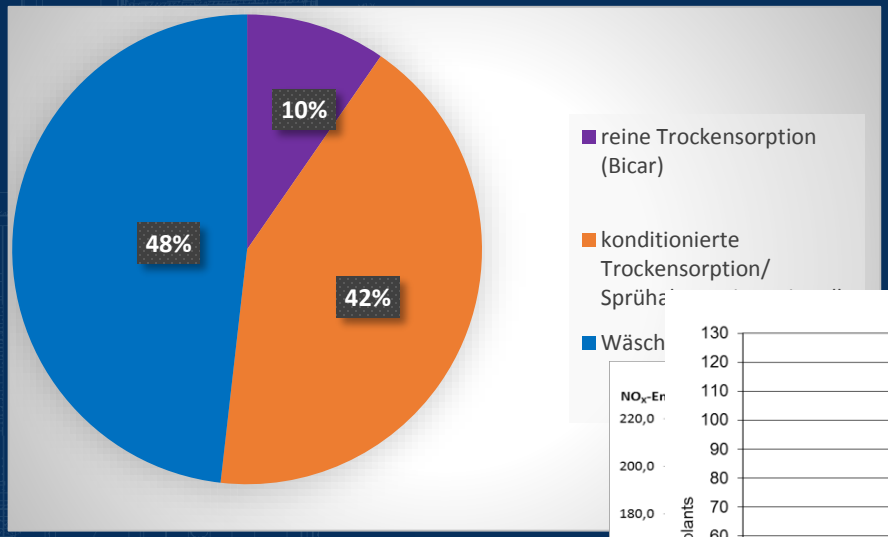
What was the experience with such complex plants?

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

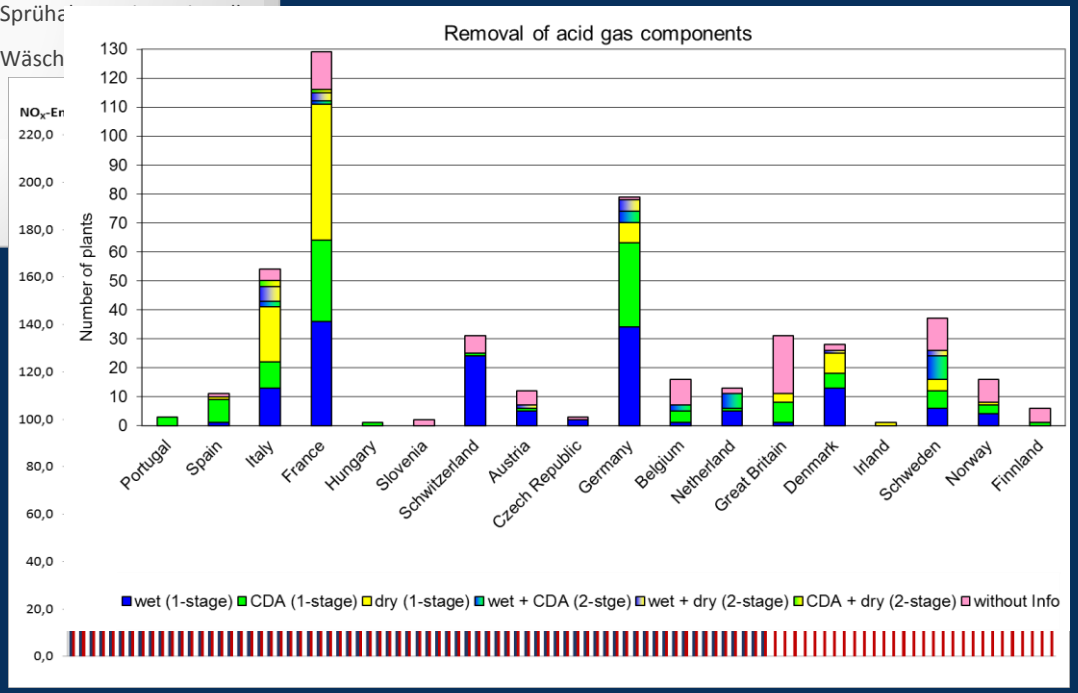
→ while these insights were gained, waste incineration underwent a metamorphosis from mere waste disposal to energy recovery from waste

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

Existing plants for acid gas removal

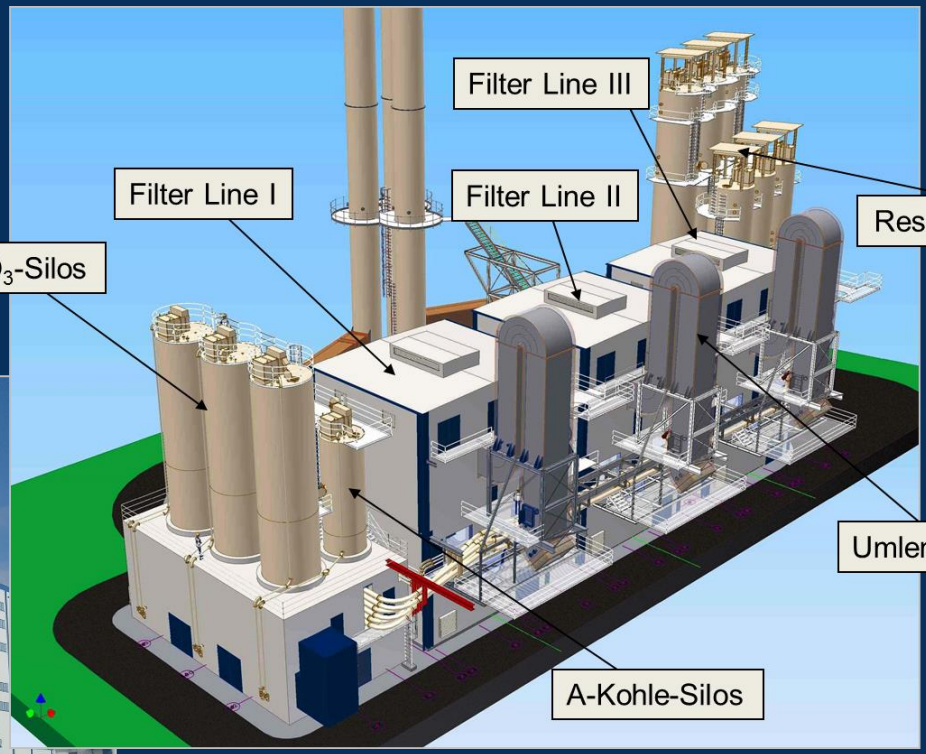


Source: ITAD, Düsseldorf



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

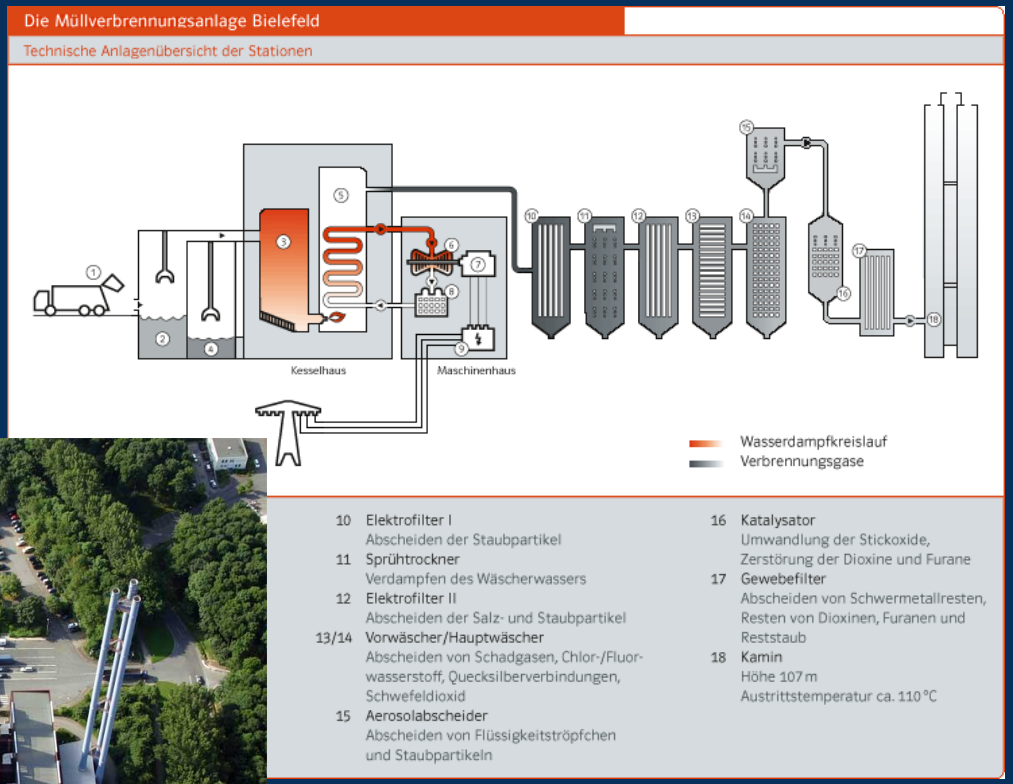
simple system
SNCR – single-stage dry sorption $NaHCO_3$



Source: Lühr-Filter, Stadthagen

complex system

ESP – Spray dryer – ESP – 2-stage scrubber – Aerosol separator – SCR – Fabric-Ffilter



Source: Interargem, Bielefeld

Challenges

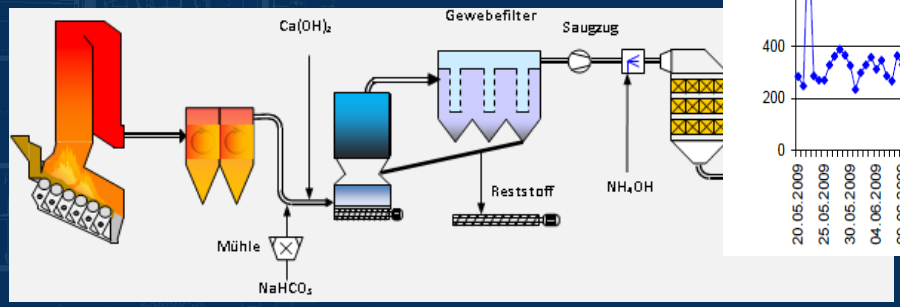
for flue gas treatment systems

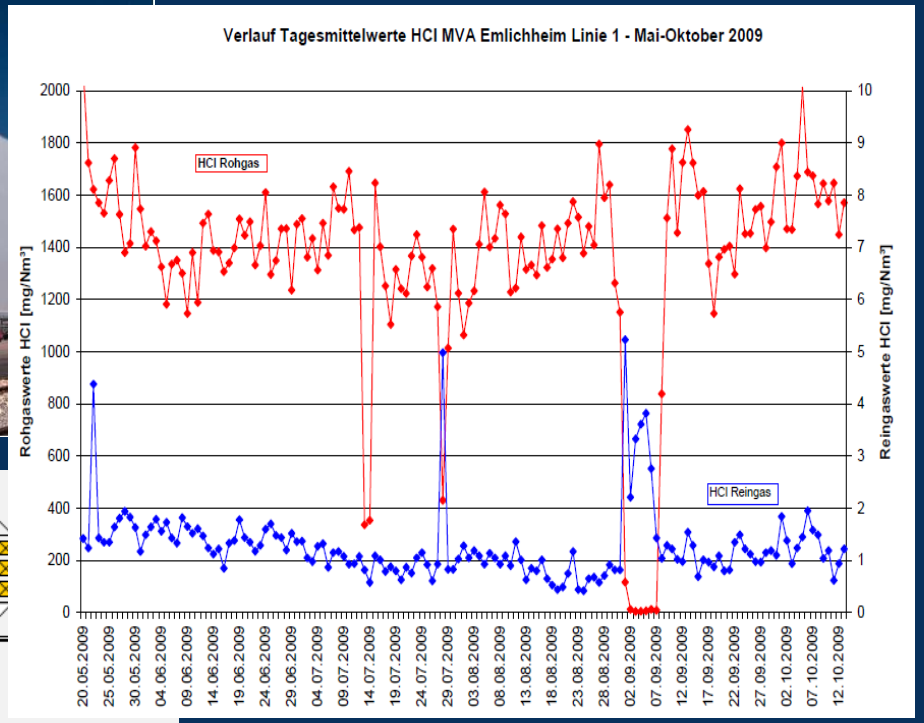
BREF waste incineration – emission figures

Parameter	Unit	17. BImSchV[1]			Existing plants	New plants	Monitoring frequency
		DAV	HAV	JAV	DAV	DAV	
dust	mg/m³ STP, dry	5	20	-	<2-5		continuously
HCl	mg/m³ STP, dry	10	60	-	<2-8	<2-6	continuously
HF	mg/m³ STP, dry	1	4	-	<1	< 1	continuously (1)
NO_x (SCR)	mg/m³ STP, dry	150	400	100	50-150 (2)	50-120	continuously
SO_x als SO_2	mg/m³ STP, dry	50	200	-	5-40	5-30	continuously
Hg	mg/m³ STP, dry	0,03	0,05	0,01	<0,005-0,02		continuously (3)
					0,001-0,01		Long term monitoring
NH_3	mg/m³ STP, dry	10	15	-	2-10 (4)	2-10	continuously
N_2O	mg/m³ STP, dry				Wird nicht angegeben		yearly (7) (8)
CO	mg/m³ STP, dry	50	100	-	10-50		continuously
Cd + Tl	mg/m³ STP, dry		0,05		0,005-0,02		every 6 month
∑Sb+As+Pb+Cr+Co+ Cu+Mn+Ni+V+(Sn)	mg/m³ STP, dry		0,5		0,01-0,3		
∑As+Benzo(a)pyren+ Cd+Co+Cr	mg/m³ STP, dry		0,05		-		yearly
PCDD/F (*)	ng I-TEQ /m³ STP dry		-		< 0,01-0,06	< 0,01-0,04	every 6 month
					< 0,01-0,08	< 0,01-0,06	monthly (5)
PCDD/F + Dioxin-like PCBs (*)	ng WHO-TEQ /m³ STP dry		0,1		< 0,01-0,08	< 0,01-0,06	every 6 month(6)
					< 0,01-0,1	< 0,01-0,08	monthly (5) (6)
TVOC / $C_{ges.}$	mg/m³ STP, dry	10	20	-	< 3-10		continuously

* the equivalence factors are used either according to I-TEQ or WHO-TEQ, 17. BImSchV (page 21) according to WHO-TEF 2005

Example of existing plant – MVA EVI-Europark





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

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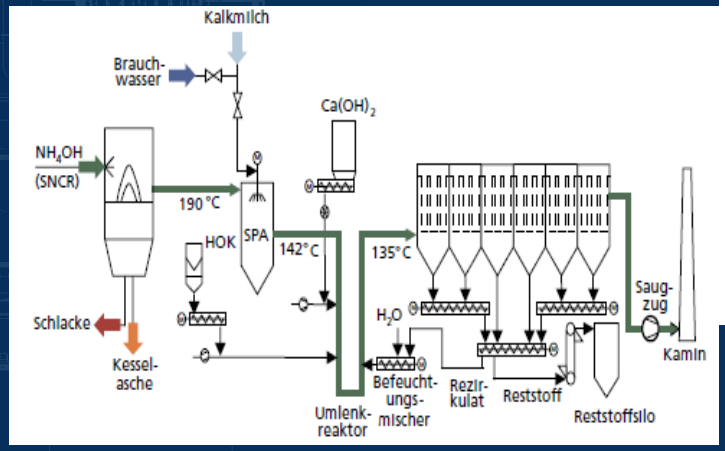
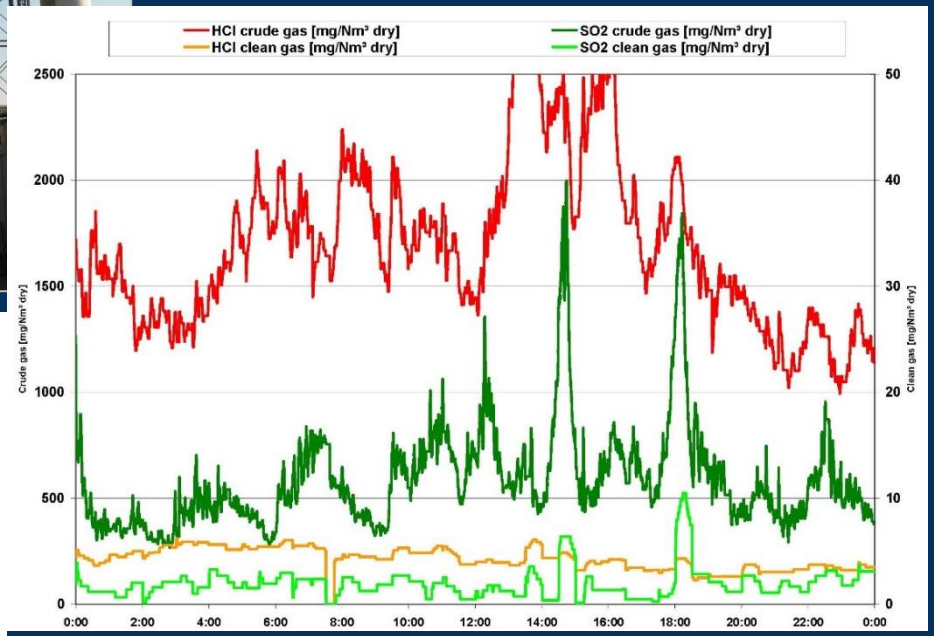
Example of existing plant – MHKW Rothensee





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

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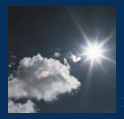


Challenges for flue gas treatment systems in the future

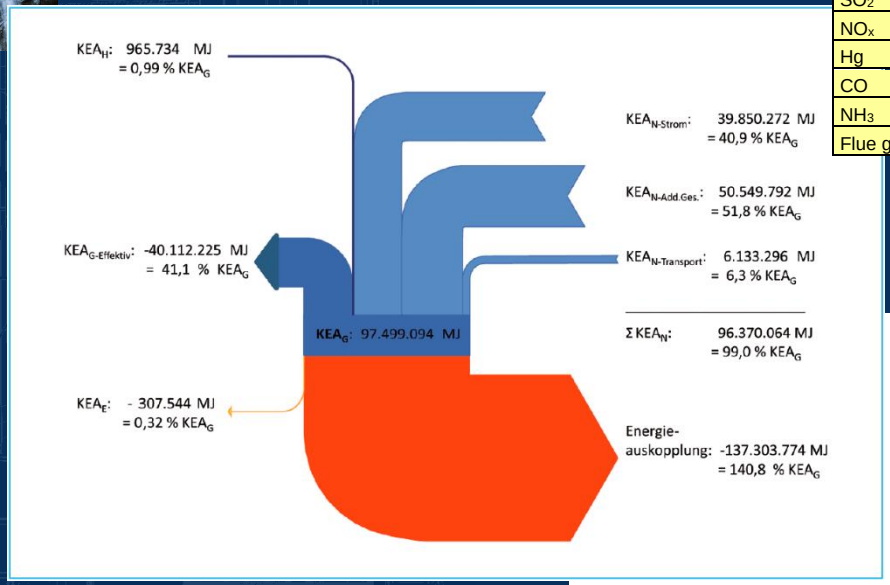
Challenges for flue gas cleaning will continue to be high pollutant removal efficiency and very high efficiency in the use of energy and consumables (minimum consumption of resources)

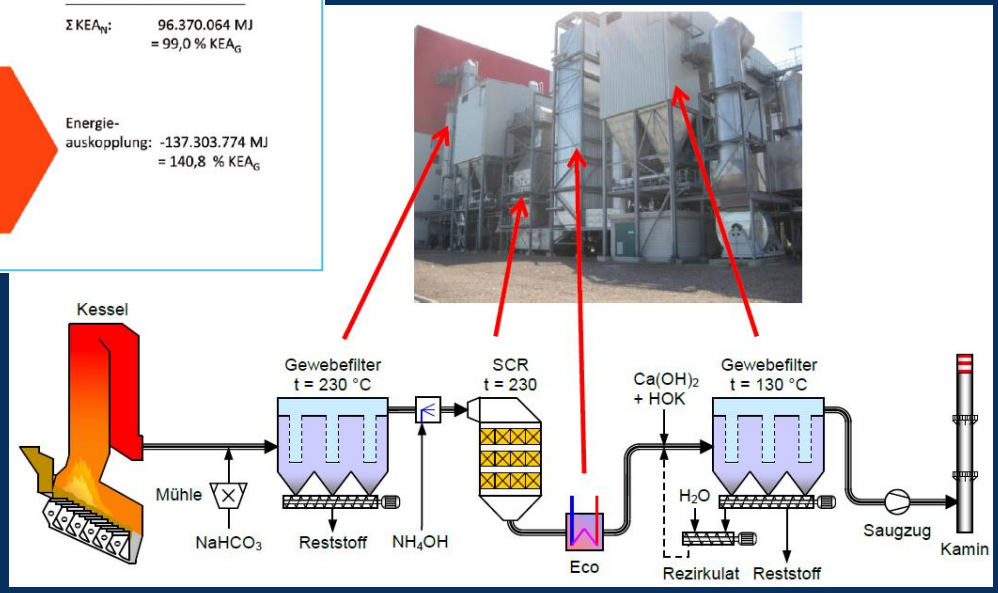
The present-day flue gas cleaning systems are unique in design and their specific configuration often reflects the development of the emission limits over time.

Sankey-Diagram CED-complete

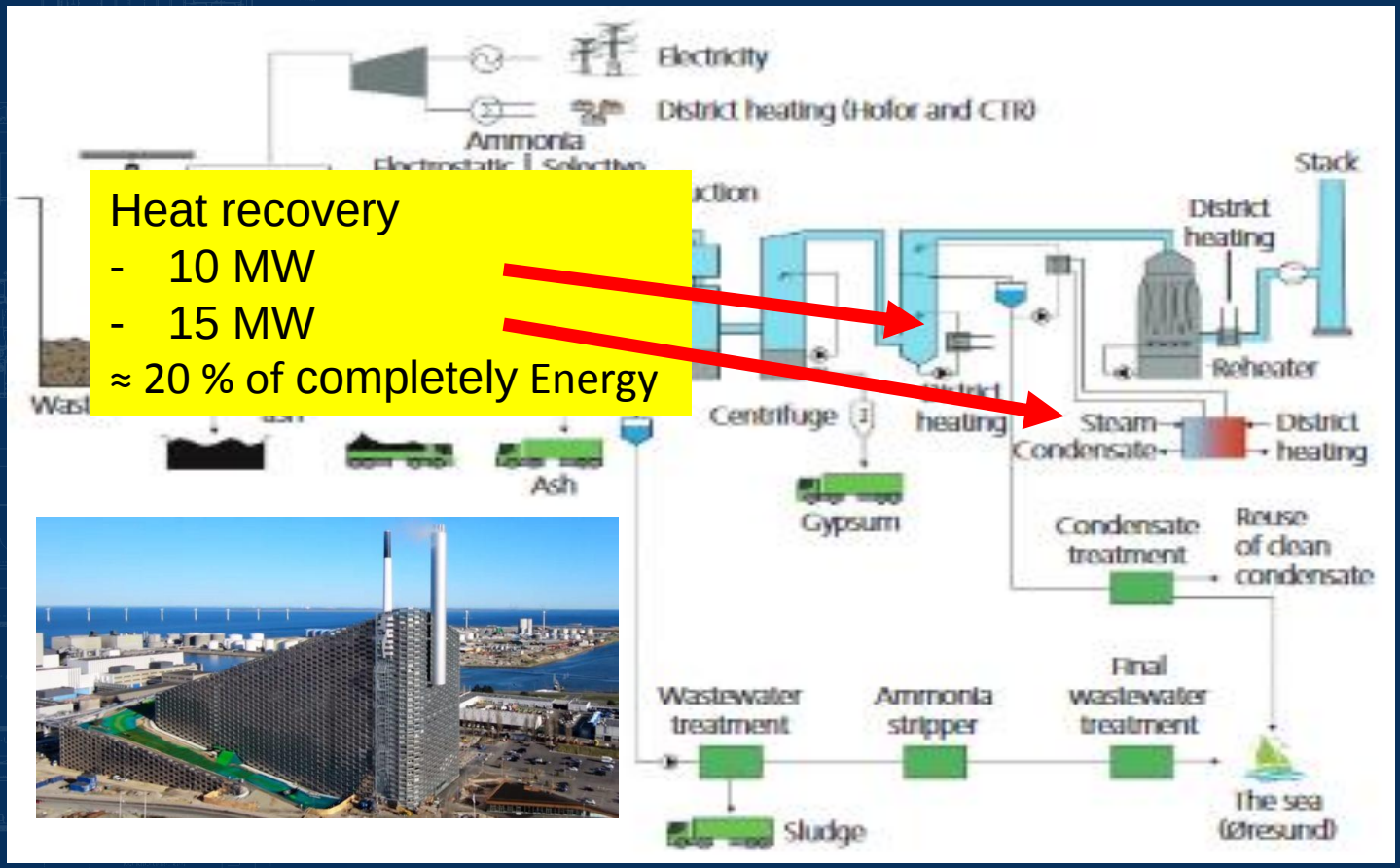
(CED_U for HCl-raw gas 1.300 mg/m³; SO_2-raw gas 500 mg/m³); 8000 Oh

		Downstream Sodiumbicarbonat FF Stage	Downstream SCR DeNOx	Stack	Permitted emission values
Dust	mg/m³	< 1	< 1	< 1	10
C_{ges}	mg/m³			< 0,5	10
HCl	mg/m³	< 115	< 115	< 1	5
SO_2	mg/m³	< 30	< 30	< 5	25
NO_x	mg/m³	350	< 70	< 70	70
Hg	mg/m³			< 0,005	0,02
CO	mg/m³			< 10	50
NH_3	mg/m³			< 2	5
Flue gas temp.	°C	230	230	135	





Waste to energy plant „Amager Bakke“ in Copenhagen, Denmark



Source: Hulgaard, T.; Søndergaard, I.: Integrating waste-to-energy in Copenhagen, Denmark. Civil Engineering, Volume 171, Issue CE5, Pages 3-10

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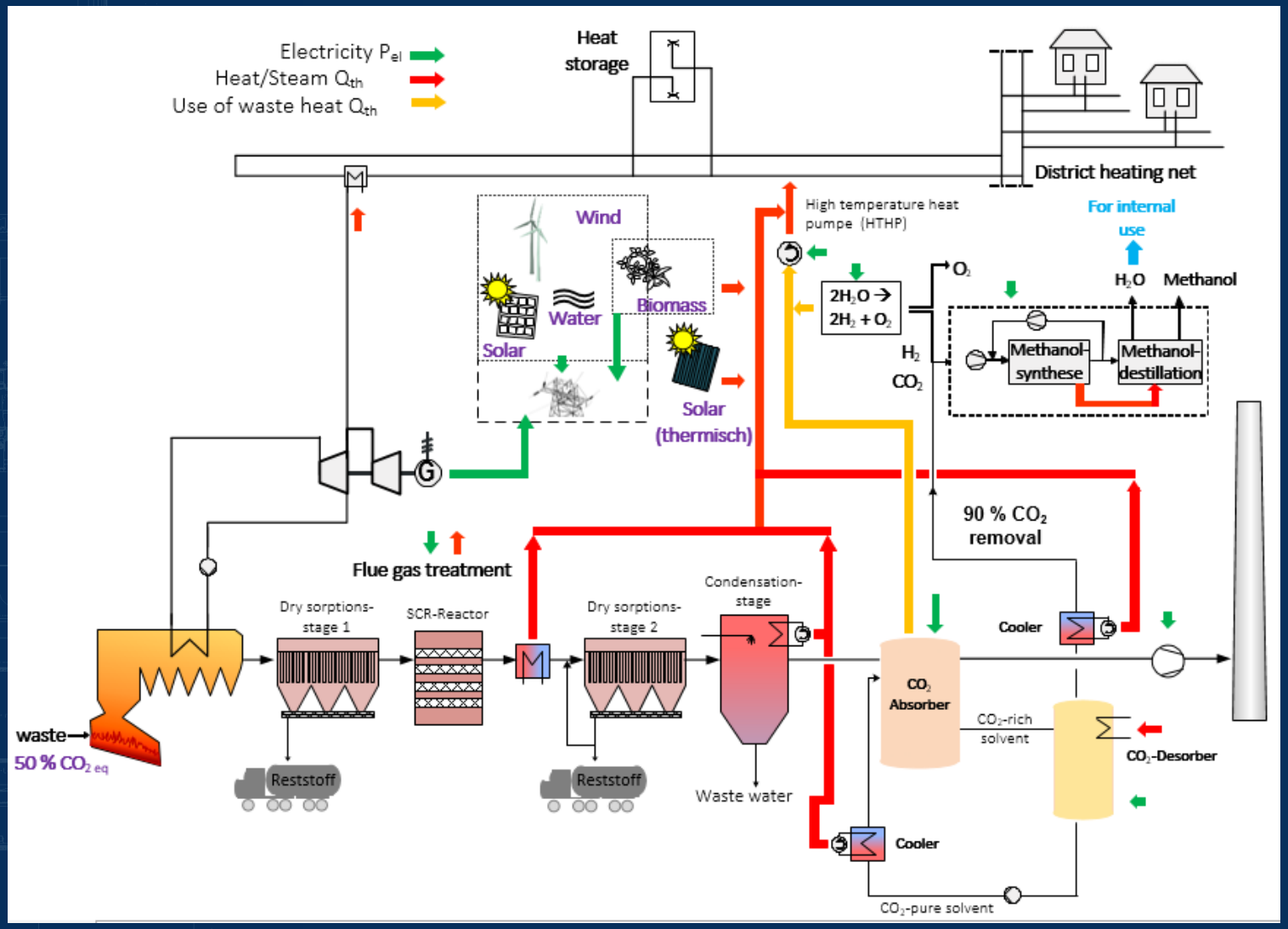
Optimized flue gas treatment system in adaptation to the future energy market

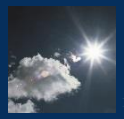


Conclusion

Conclusion

- The current level of emissions from flue gas purification systems downstream of waste incineration systems partly borders on the confidence levels of the existing measurement technology, so that there is fundamental optimization potential here too, but this does not represent the ultimate challenges.

- In addition to efficient pollutant gas separation, the future challenges lie in topics such as
  - Energy efficiency,
  - Minimization of the input materials up to
  - for recovering valuable substances from flue gas cleaning (e.g. CO_2).



Conclusion

- In addition, the location plays an important role, especially for new systems, so that synergies can be used, which must be taken into account when planning the predicted mega-cities.

- It will not be a question of developing completely new systems or processes, but rather the intelligent combination of existing processes and the use of synergies.

Thank you for your attention!