POLLUTION AND WASTE-TO-ENERGY: MYTH OR REALITY?

Thursday, 07 April 2022,
10:00 – 11:45 CET

ESWET

About ESWET

- **ESWET** is the association representing the **European Suppliers of Waste-to-Energy Technology**.

- Our main task is to **foster the development** and **dissemination** of Waste-to-Energy Technologies.

- We seek to **raise awareness of the positive implications of the technology** both for the environment and the recovery of energy and materials.

- ESWET has **31 members** which are all suppliers of the main components of Waste-to-Energy plants and are active building and maintaining Waste-to-Energy plants in Europe and throughout the world.

Members

ESWET

- AC BOILERS S.p.A. formerly Ansaldo Caldaie
- ANDRITZ
- B&W BABCOCK & WILCOX RENEWABLE
- CARMEUSE
- CLYDE BERGEMANN
- CNIM
- DOOSAN Lentjes
- GE
- GENERAL KINEMATICS
- Hitachi Zosen INOVA
- Howden
- IEM ConveyingSystems
- Keppel Seghers Solutions for a Cleaner Future
- Lab
- Lhoist
- LISEGA
- loibl CONVEYING TECHNOLOGIES
- LUEHR FILTER Air Pollution Control Technology
- MAGALDI Dependable Technologies
- MARTIN
- meldgaard
- MITSUBISHI POWER
- NOOTER ERIKSEN NE
- SAGE EXPERT
- SICK Sensor Intelligence.
- JFE Engineering Group Standardkessel Baumgarte
- STC POWER
- Steinmüller Babcock Environment NIPPON STEEL ENGINEERING GROUP
- steinmüller engineering The Engineers Company
- Sumitomo SHI FW
- VINCI ENVIRONNEMENT

Thursday, 07 April 2022
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ESWET

POLLUTION AND WASTE-TO-ENERGY: MYTH OR REALITY?

A conversation with

- **Anita Matic, EUROPEAN COMMISSION**
- **Leen de Bruycker, CEWEP**
- **Giovanni Lonati, POLYTECHNIC UNIVERSITY OF MILAN**
- **Rüdiger Margraf, ESWET**
- **Aurélie Moll, ESWET**

Moderated by

- **Aurélien Ballagny, ESWET**

Thursday, 07 April 2022
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POLLUTION AND WASTE-TO-ENERGY: MYTH OR REALITY?

- Anita Matic, Policy Officer, EUROPEAN COMMISSION
  - Waste incineration and the IED: pollution prevention and monitoring requirements
- Leen de Bruycker, Technical Officer, CEWEP
  - Presentation on CEWEP's report on dioxins and WtE plants
- Giovanni Lonati, Associate Professor, POLYTECHNIC UNIVERSITY OF MILAN
  - Comparison between road traffic and WtE pollution in Northern Italy
- Rüdiger Margraf, Managing Director at LUEHR, ESWET Technical Commmitte
  - Presentation on the depollution technologies for WtE
- Aurélie Moll, Strategic Industry Manager at SICK, ESWET Technical Committee
  - Presentation on measurement technology and data evaluation from WtE
- Panel Discussion and Q&A

Waste incineration and the IED: pollution prevention and monitoring requirements

April 2022

DG ENV Unit C4

Industrial Emissions & Safety

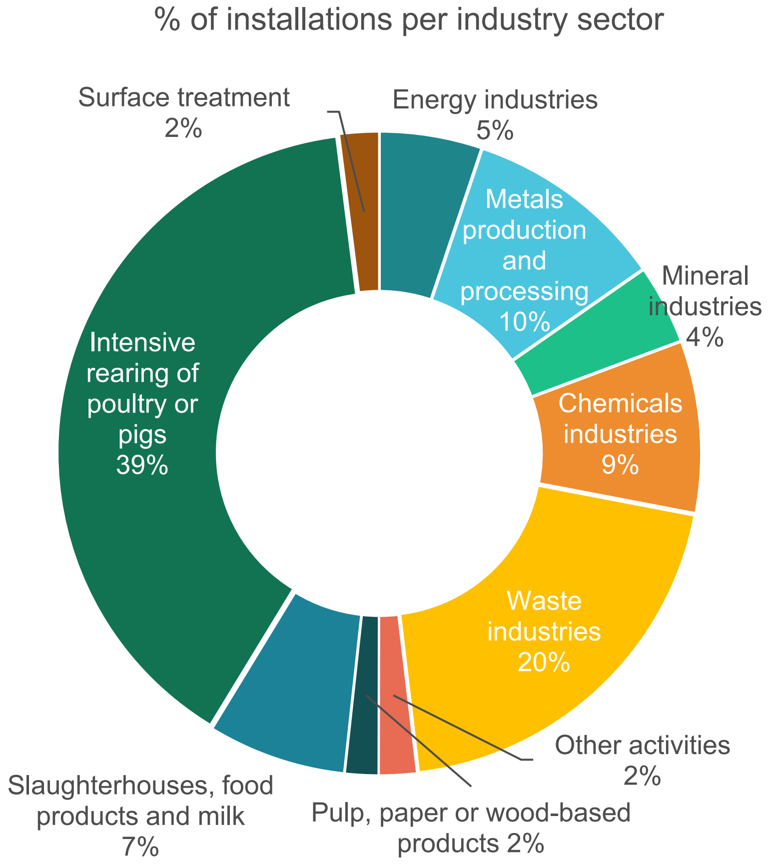
Content

1. IED/E-PRTR
2. Waste incineration and the IED/BAT conclusions
3. IED & E-PRTR revision

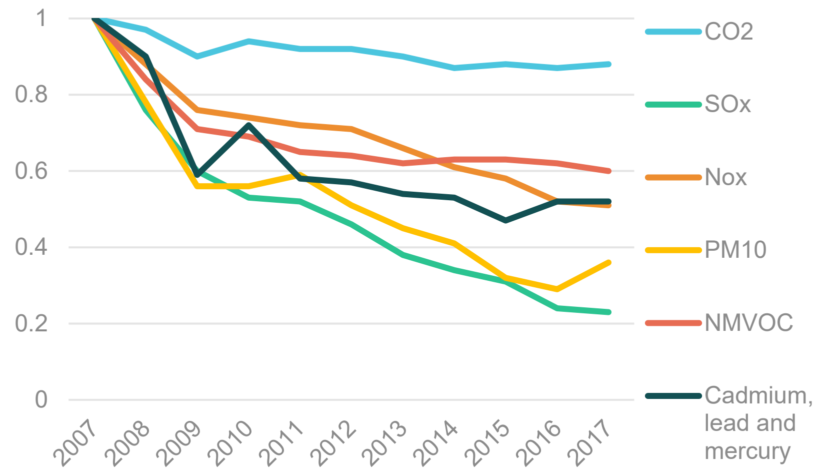
European Commission

Industrial Emissions (IED)

IED regulates around **52 000 of the largest industrial installations**



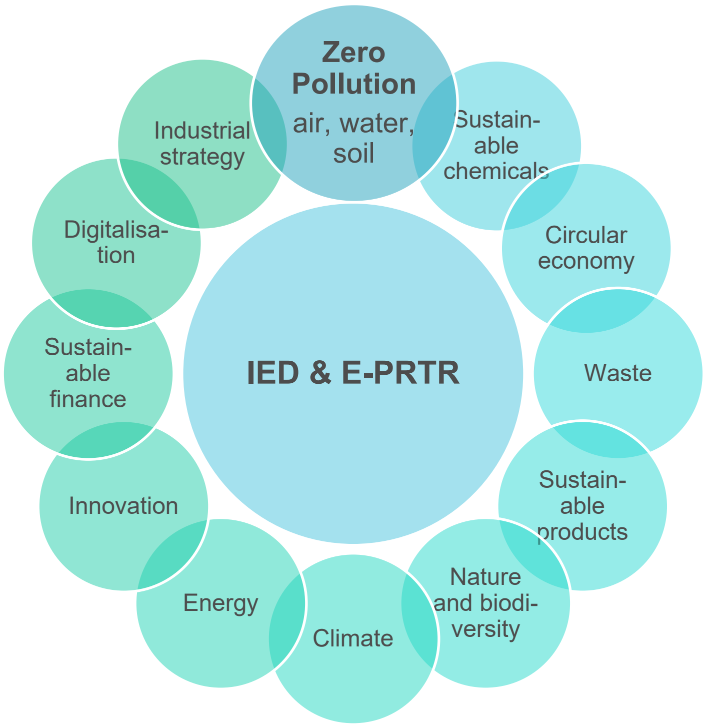
Supports a **high level of protection** of human health and the environment as a whole



*Release of **air pollutants** by industry (based on E-PRTR: Europe-wide register providing environmental data)*

Of the EU's overall pollutant emissions (by mass), IED installations account for around: 20% of emissions to air, 20% of emissions to water and 40% of GHG emissions.

Strong **links with other EGD policies**



European Commission

Industrial Emissions (E-PRTR Regulation)

- Establishes a **database with data on the annual mass emissions** of pollutants, covering mostly IED installations
- E-PRTR Regulation (EC) 166/2006, transposes the Kyiv Protocol
- Aims to **inform and involve the public** in environmental decision-making

" The E-PRTR is a crucial tool for the public and key stakeholders to access emission data and to find out about pollution in their area

- Covers 33 countries: EU27 + Iceland, Liechtenstein, Norway, Serbia, Switzerland and UK
- Annual reporting - data available as of 2007 (first published in 2009)

https://industry.eea.europa.eu/

Waste incineration (WI) and the IED

Chapter IV and Annex VI

- **ELVs safety net:** daily and half hourly averages
- Monitoring requirements
- Process conditions
- Compliance assessment rules
- If a derogation granted, IED ELVs remain applicable

Chapter II

- Legally binding status of BAT conclusions under IED
- Permits must be updated within 4 years after publication by **December 2023 !**
- **Emission limit values (ELVs) in permits must not exceed BAT associated emission levels (BAT-AELs)**
- Derogation only in specific and justified cases: (Art 15(4)) of the IED

European Commission

WI BAT conclusions

What is new?

- BAT-AELs (BAT-associated emission limit values) for air and water emissions
- BAT-AEELs (BAT-associated energy efficiency levels)
- Levels for new and existing plants
- Recovery of materials from bottom ashes

Monitoring

- ***More demanding monitoring requirements*** including for toxic and persistent organic pollutants such as polychlorinated dioxins and furans and dioxin -like PCBs .
- ***Improved sampling procedures*** for the monitoring of emission of polychlorinated dioxins and furans and for dioxin-like PCBs that cover other than normal operating conditions such as start-up, shut down and malfunction.
- For continuously monitored pollutants, BAT-AELs set as daily levels only.
- Monitoring of: brominated dioxins and furans; chlorinated dioxins and furans; dioxin-like PCBs and benzo[a]pyrene.

European Commission

IED/E-PRTR revision process

" The Commission will review EU measures to address pollution from large industrial installations. It will look at the sectoral scope of the legislation and at how to make it fully consistent with climate, energy and circular economy policies." ***#EUGreenDeal***

- **Q1 2020** – IED Inception Impact Assessment, *155 responses*
- **Q2 2020**
- **Q3 2020** – E-PRTR Inception Impact Assessment, *37 responses*
- **Q4 2020** – IED/E-PRTR 1st Stakeholder Workshop
- **Q1 2021** – IED/E-PRTR Open Public Consultation, *335 responses*
- **Q2 2021** – IED/E-PRTR Targeted Stakeholder Surveys and Focus Groups
- **Q3 2021** – IED/E-PRTR 2nd Stakeholder Workshop
- **Q1 2022** – **Adoption/publication** of the IED/E-PRTR proposals by the Commission

General overview of proposals

To transform IED and Industrial Emissions Portal into forward-looking legislation to accompany the industrial transformation

1. More effective

- Increase the ambition in permits
- More accessible information on permits and performance
- New revised Portal

2. Support innovation

- Flexible permitting for frontrunners
- Create INCITE to ensure latest technologies are employed
- Transformation plans

3. Resources & chemicals

- IED operators' EMS to improve resource efficiency, apply circular economy practices and use safer chemicals
- Report resource use

4. Support decarbonisation

- Curb non-ETS emissions
- Energy efficiency requirements
- IED review

5. Scope: widening to critical activities + simplified permits for livestock farms

Thank you

More info?

IED / Industrial Emissions Portal proposals:
Green Deal: Modernising EU industrial emissions rules (europa.eu)
IED revision: https://ec.europa.eu/environment/industry/stationary/ied/evaluation.htm
E-PRTR revision: https://ec.europa.eu/environment/industry/stationary/e-prtr/evaluation.htm
CIRCABC: https://circabc.europa.eu/ui/group/06f33a94-9829-4eee-b187-21bb783a0fbf/library/36379180-c0a6-4b66-9019-64a5a0229116?p=1&n=10&sort=modified_DESC

#IEDIA #EPRTRIA

European Commission


Brista WtE plant, Sweden

Dioxins and Waste-to-Energy plants

By CEWEP, the Confederation of European Waste-to-Energy Plants

Leen De Bruycker

ESWET webinar – Pollution and Waste-to-Energy: Myth or Reality? - 7th April 2022

CEWEP Report

Dioxins and Waste-to-Energy Plants – State of the Art

European-wide overview of long-term analysis of dioxins in WtE plant surroundings

Dioxins are labelled Persistent Organic Pollutants (POPs) due to bioaccumulation and impact on health and environment

Historically the sector has been associated with dioxin emissions. In light of the more recent attention on the topic, CEWEP prepared the report[1] to:

- Showcase the sector's efforts to reduce its environmental impacts based on practical examples
- **Provide an in-depth assessment of the WtE sector's current monitoring practices of dioxins and furans based on extensive data collection from CEWEP members**

[1] CEWEP Report available at www.cewep.eu/dioxins-wte-state-of-the-art/

CEWEP Report

Dioxins and Waste-to-Energy Plants – State of the Art

European-wide overview of long-term analysis of dioxins in WtE plant surroundings

Main conclusions:

1. European WtE sector one of the **most strictly regulated industries** in terms of pollution prevention and control.
   - → Today, WtE dioxin emissions account for **less than 0.2% of the total industrial dioxin emissions**
   - → Stringent limits for monitoring of dioxins during **different operating stages**
2. Regardless of specific measuring equipment a well managed EU WtE plant **emits extremely low concentrations of dioxins and furans** thanks to its sophisticated combustion control and pollution abatement system.
3. **No correlation between dioxins measured in the environment and emissions at the stack, regardless of periodic or continuous sampling.**

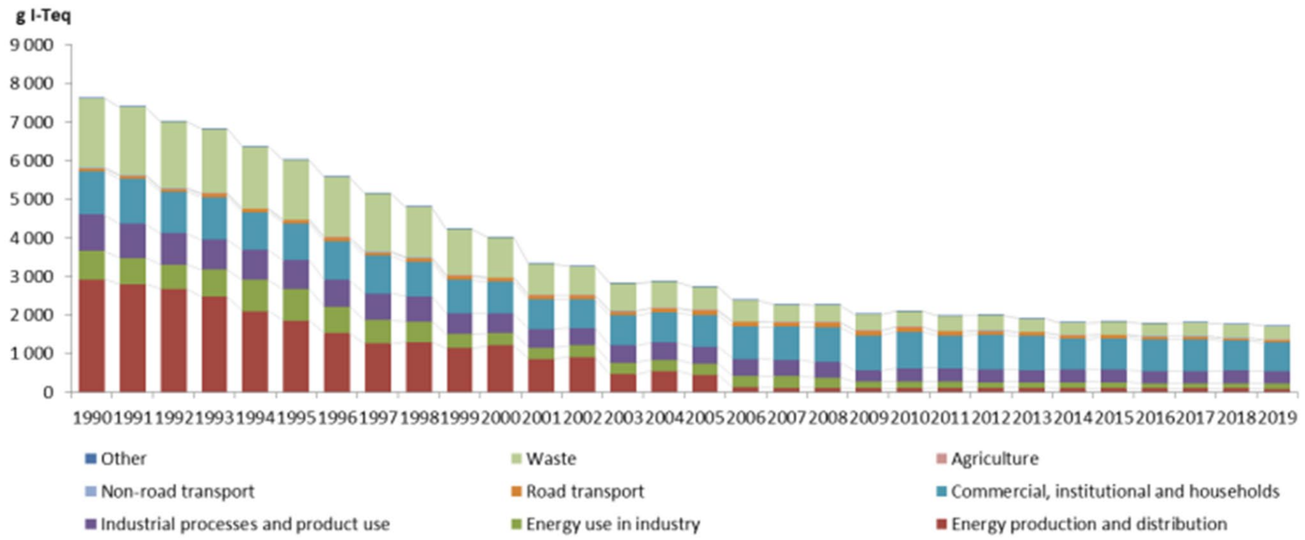
Dioxins and Waste-to-Energy Plants – State of the Art

European-wide overview of long-term analysis of dioxins in WtE plant surroundings

1. European WtE sector one of the most strictly regulated industries in terms of pollution prevention and control.
   → Today, WtE dioxin emissions account for **less than 0.2% of the total industrial dioxin emissions[1]**
   → Stringent limits for monitoring of dioxins during **different operating stages**

1989: Specific stringent legislation for WtE plants to prevent and control pollution.

2019: Publication of <u>Waste Incineration BAT Conclusions </u>with even more ambitious emission limits for dioxins and furans



Source: EEA, 2021

Note: I-Teq, international toxic equivalent.

Great historical decline

Other sources more prominent

[1] European Pollutant Release and Transfer Register, https://industry.eea.europa.eu/
[2] Best Available Techniques (BAT) Conclusions for waste incineration: Commission implementing decision (EU) 2019/2010 of 12 November 2019

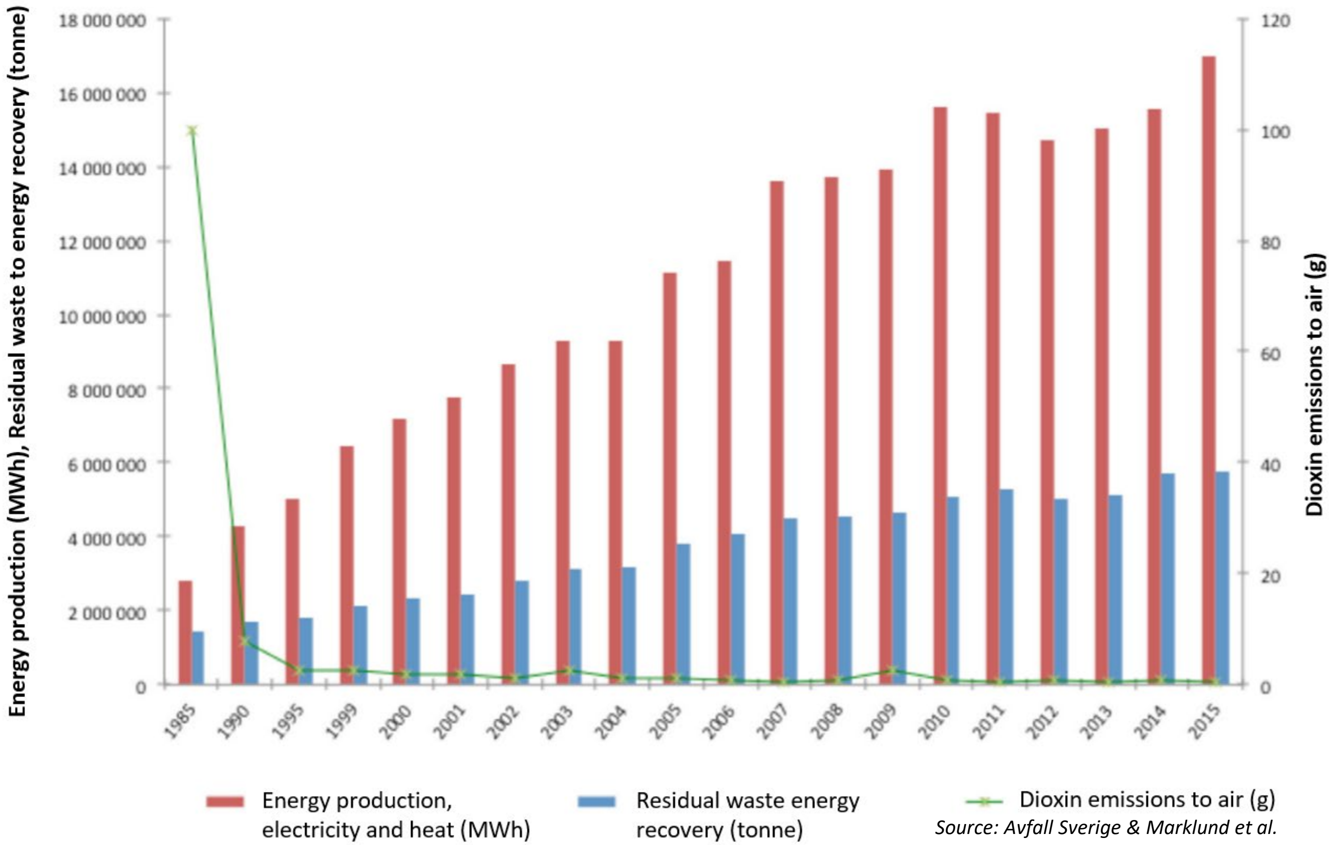
Great historical decline & Other sources more prominent

Swedish nationwide study[1]

More than 100 g/y in 1985

Less than 1 g/y in 2015

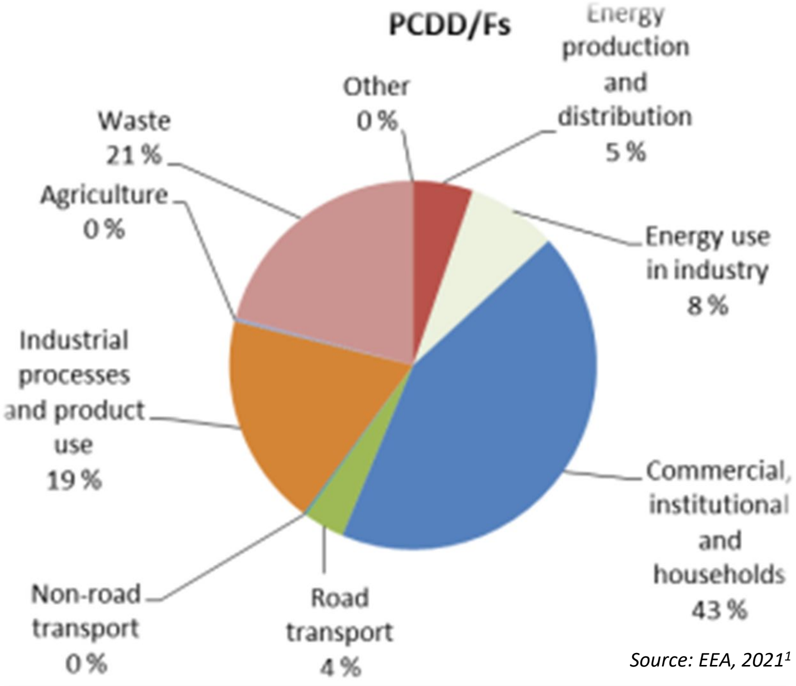
- Capacity more than doubled
- Great increase in energy production



Source: Avfall Sverige & Marklund et al.

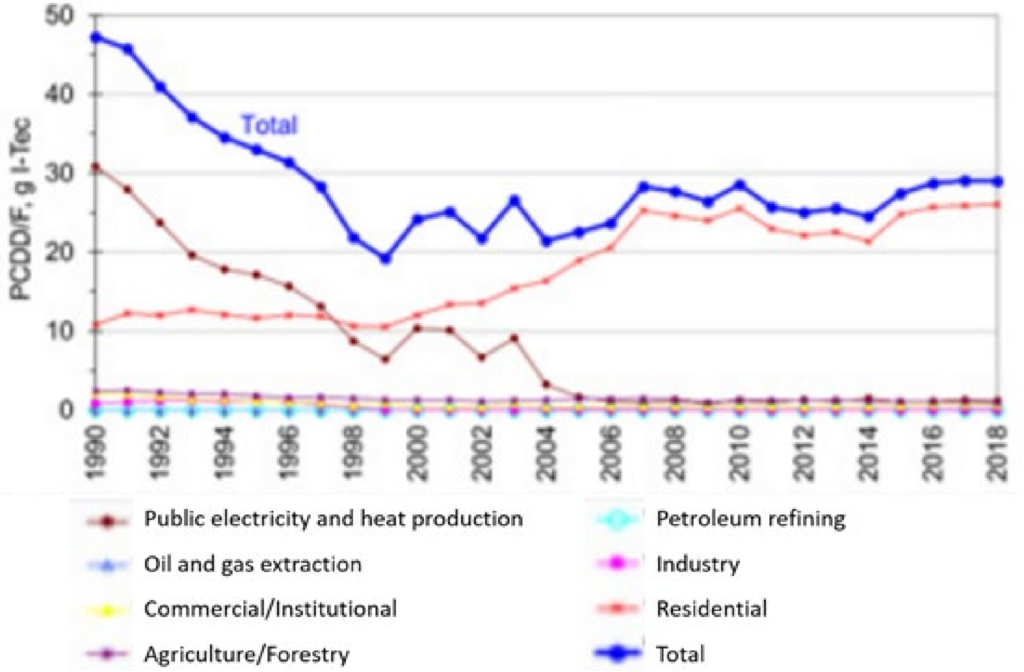
[1] Marklund et al., Dioxins and waste incineration (2017). Avfall Sverige & SteMar Konsult

Great historical decline & Other sources more prominent



Note: WtE included in 'Energy production and distribution'

Danish nationwide study[2]



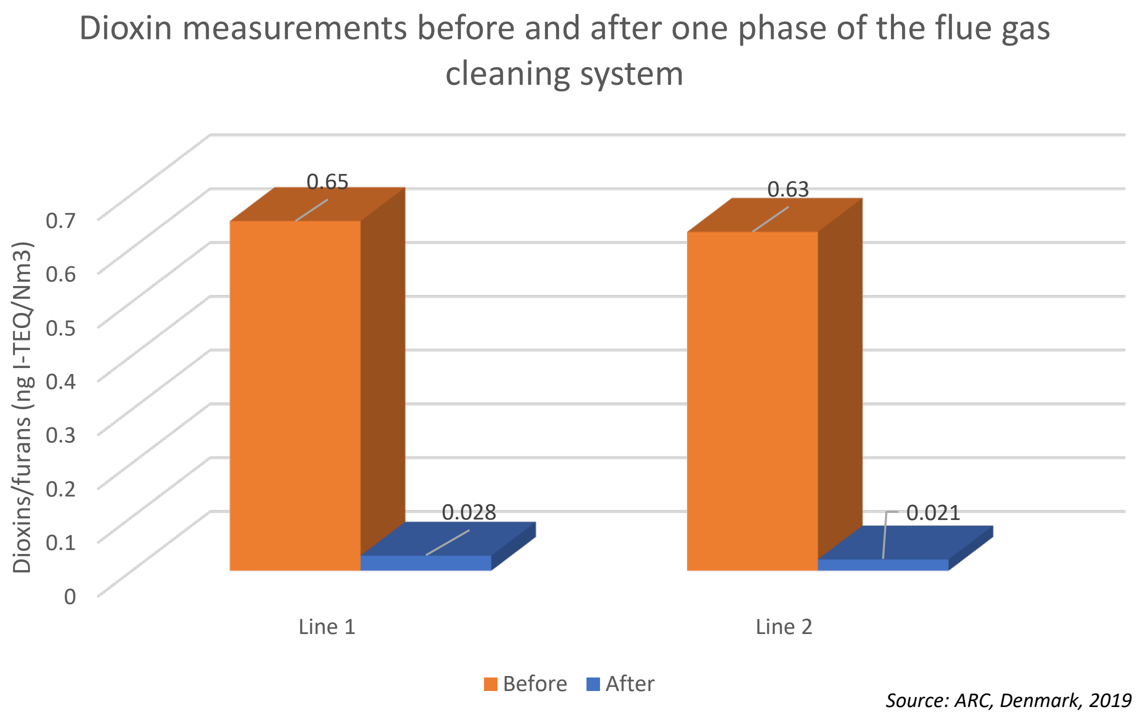
[1] European Environment Agency (EEA), 2021 EU emission inventory report 1990-2019 under UNECE Convention on Long-range Transboundary Air Pollution (Air Convention). EEA
[2] Nielsen M., Danish emission inventories for stationary combustion plants. Inventories until 2018. (2021). Danish Centre for Environment and Energy

Dioxins and Waste-to-Energy Plants – State of the Art

European-wide overview of long-term analysis of dioxins in WtE plant surroundings

2. Regardless of specific measuring equipment a well managed EU WtE plant **emits extremely low concentrations of dioxins and furans** thanks to its sophisticated combustion control and pollution abatement system.

→ Highly controlled and complex flue gas cleaning systems in place



Source: ARC, Denmark, 2019

Dioxins and Waste-to-Energy Plants – State of the Art

European-wide overview of long-term analysis of dioxins in WtE plant surroundings

2. Regardless of specific measuring equipment a well managed EU WtE plant **emits extremely low concentrations of dioxins and furans.**

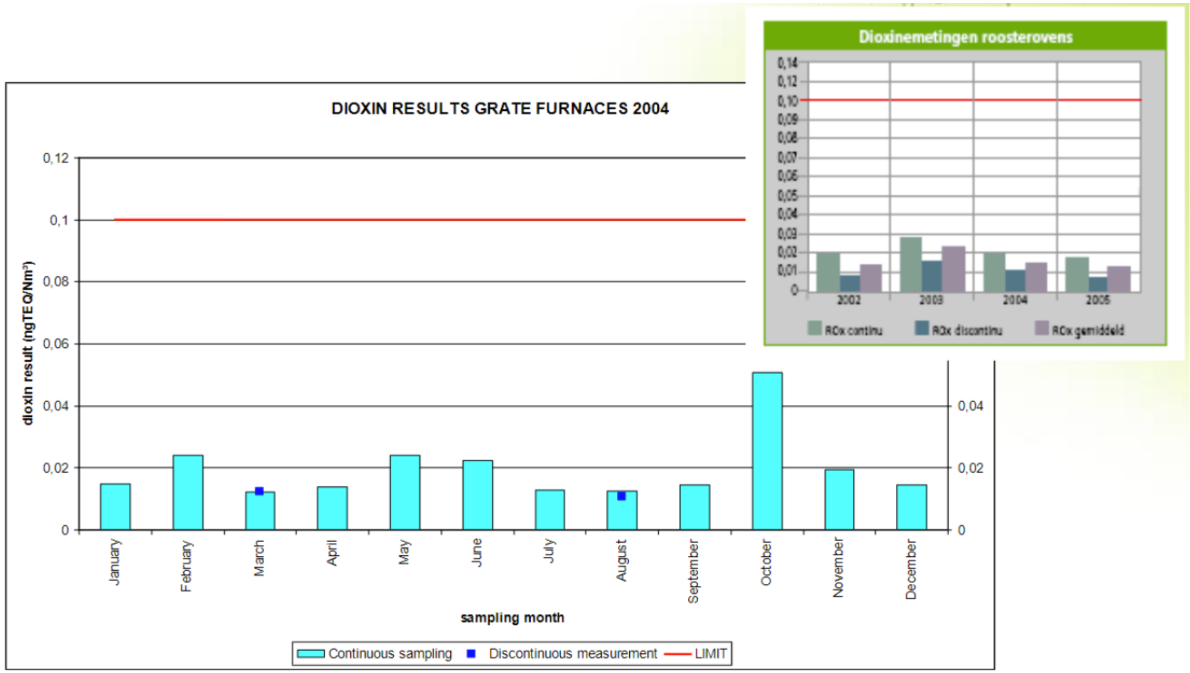
Data assessments, comparisons and long-term experience of operators have shown **similar emission patterns between periodic measurements and continuous sampling** .

Continuous sampling can also happen to include abnormal operations

Outside normal conditions emissions of dioxins are not significantly higher!

	average of periodic samplings	average of continuous samplings
ng ITEQ /Nm³	0,011	0,019

Source: SVDU FNADE, 2014 [1]



Source: Indaver, Belgium

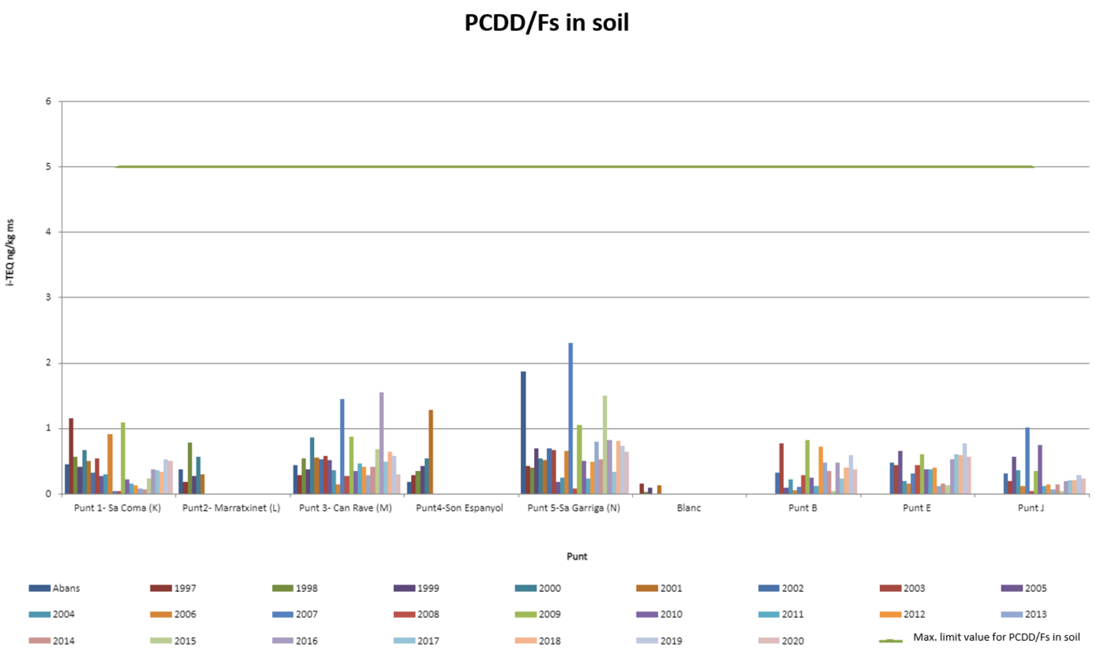
[1] SVDU & FNADE. (2014). SVDU-FNADE study: comparison between periodic and continuous sampling measurements for PCDD/F.

Dioxins and Waste-to-Energy Plants – State of the Art

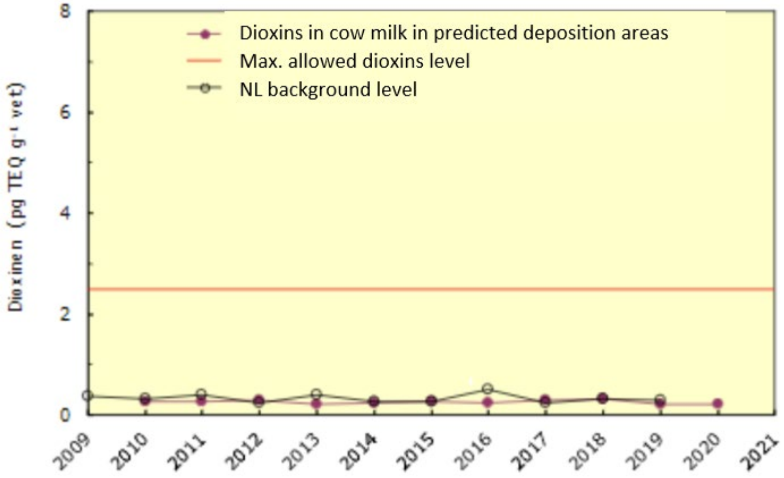
European-wide overview of long-term analysis of dioxins in WtE plant surroundings

3. No correlation between dioxins measured in the environment and emissions at the stack, regardless of periodic or continuous sampling.

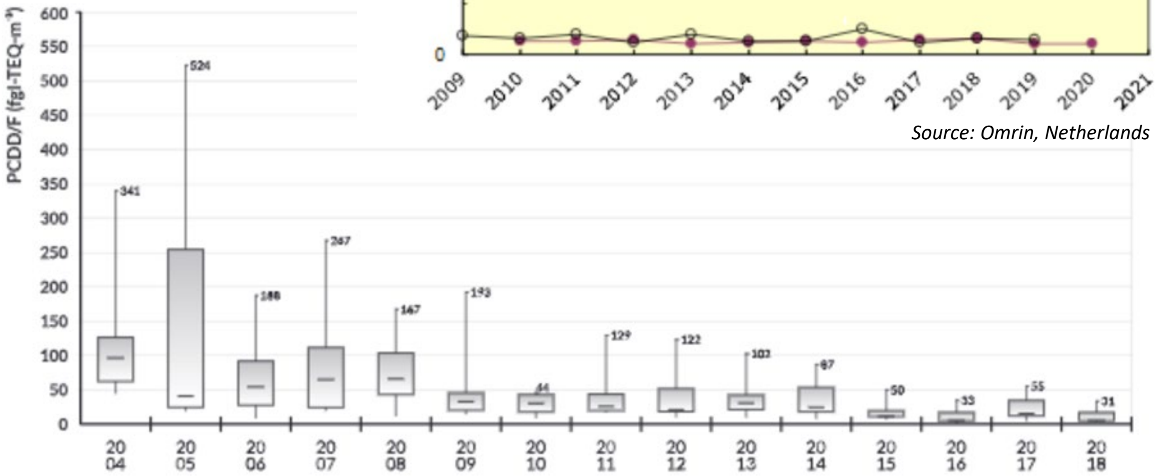
→ Assessments and comparisons **between emissions at the stack of WtE plants and concentrations measured in the surroundings** have shown that there is **no correlation with the plant's emissions**.



Source: Tirme, Mallorca



Source: Omrin, Netherlands



Source: Lipor, Portugal

Dioxins and Waste-to-Energy Plants – State of the Art

European-wide overview of long-term analysis of dioxins in WtE plant surroundings

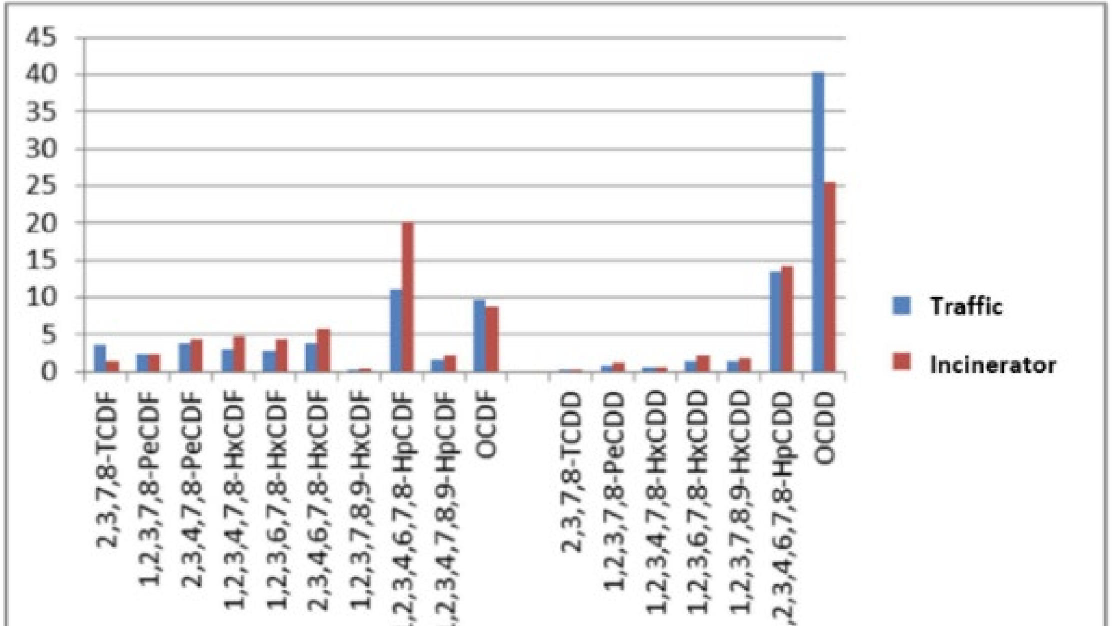
3. No correlation between dioxins measured in the environment and emissions at the stack, regardless of periodic or continuous sampling.

→ Identification of the emission source: a challenging task!

→ **Not possible to guarantee the source solely based on the levels in biomarkers**

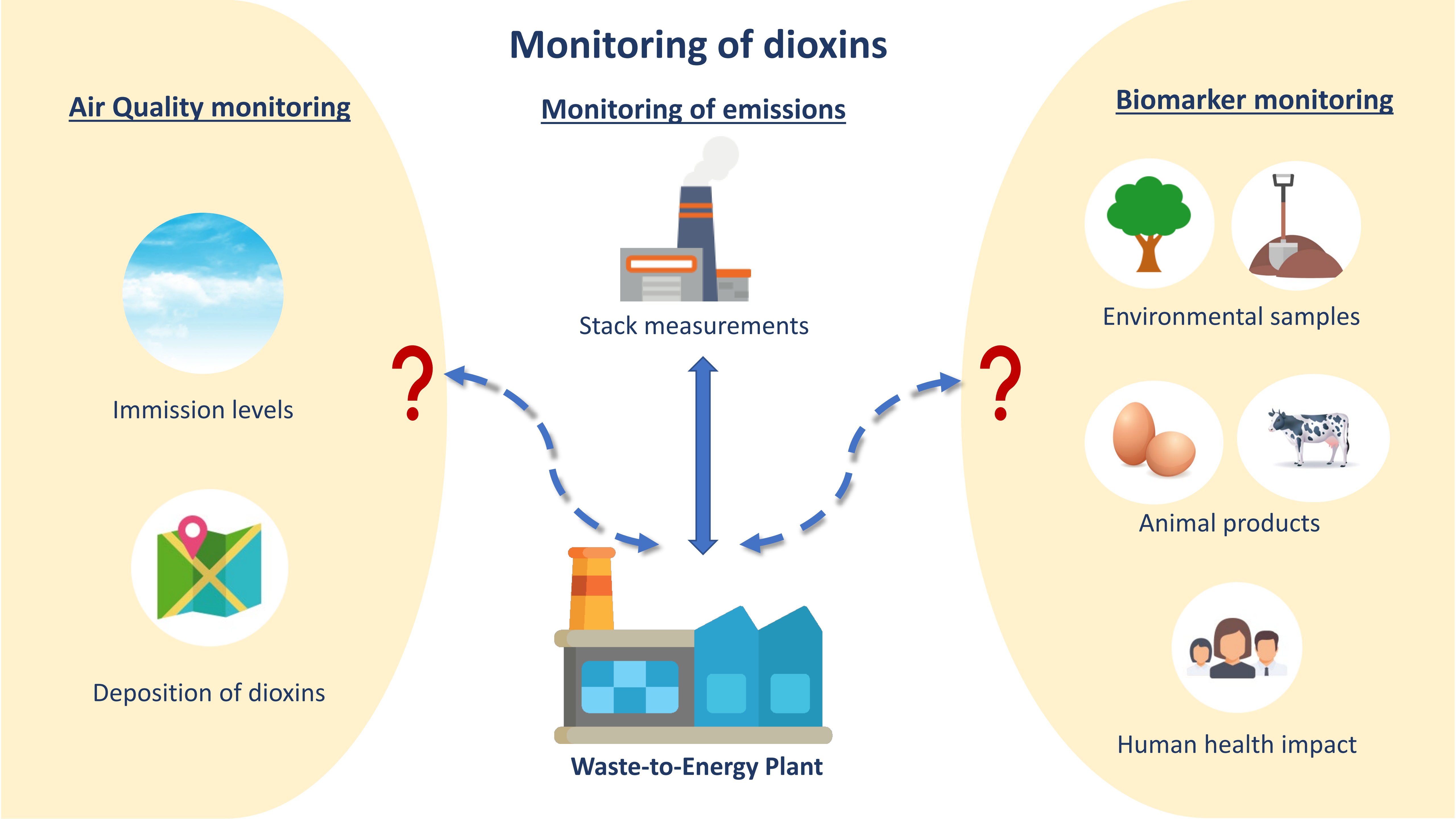
- No conclusive congener pattern available for municipal waste incineration
- All combustion processes show similar patterns[1]

→ **Measurements and patterns should be compared with a framework of measurements from all potential sources in the surroundings, including stack measurements**



Source: Tersa, Barcelona

[1] Buekens, A., Cornelis, E., Huang, H., & Dewettinck, T. (2000). Fingerprints of dioxin from thermal industrial processes


Monitoring of dioxins
Air Quality monitoring
Monitoring of emissions
Biomarker monitoring
Stack measurements
Environmental samples
Immission levels
?
?
Animal products
Deposition of dioxins
Human health impact
Waste-to-Energy Plant


Brista WtE plant, Sweden

Thank you for your attention!

CEWEP, the Confederation of European Waste-to-Energy Plants

Leen De Bruycker – leen.de.bruycker@cewep.eu

Comparison between road traffic and WtE pollution in Northern Italy

Prof. Giovanni Lonati
Civil & Environmental Engineering dept.

Summary

- Reasons for public concerns on WtE plants
- Our case studies:
  - Goals
  - Methods
  - Results
- Overall conclusions

Public concerns

Though human health risk assessment show **acceptable incremental risk,** incineration and Waste to Energy (WTE) facilities frequently face **strong protests** from local communities:

- **concern** about possible **adverse health effects** associated with atmospheric emissions
- **mistrust** in plant operators and control authorities
- **biased risk perception**, lacking proper environmental education (i.e.: levels of risk awareness and knowledge)
- scarce **awareness on risk** associated with everyday life sources (e.g.: road traffic, domestic heating through biomass burning).
- **political position** driven preconception

Our case studies

Development of 2 case studies in Northern Italy

- Common goal:
  - ✓ **assess** the **actual impact of a WtE plant** on local air quality
- Common methods:
  - ✓ atmospheric dispersion modelling through **CALPUFF model**
  - ✓ model simulations based on **real emission data** from **CEM systems**
- Specific goals:
  - ✓ **Case #1 (Desio plant): compare the impact of the WtE plant**'s stack emissions and local **road traffic** emissions

    Lonati et al., 2019. The actual impact of waste-to-energy plant emissions on air quality: a case study from Northern Italy. Detritus, 6, 77-84.
  - ✓ **Case #2 (Schio plant): compare the contribution of the WtE plant**'s stack emissions with **ambient air concentrations**

    Lonati et al., 2022. Air Quality Impact Assessment of a Waste-to-Energy Plant: Modelling Results vs. Monitored Data. Atmosphere, 13(4), 516

Case study #1

BACKGROUND

Public concerns

Our case studies

CASE STUDY #1
Desio plant

Methods

Results

Conclusions

CASE STUDY #2
Schio plant

Methods

Results

Conclusions

OVERALL
CONCLUSIONS

Desio WtE plant (Lombardia Region) run by BEA SpA

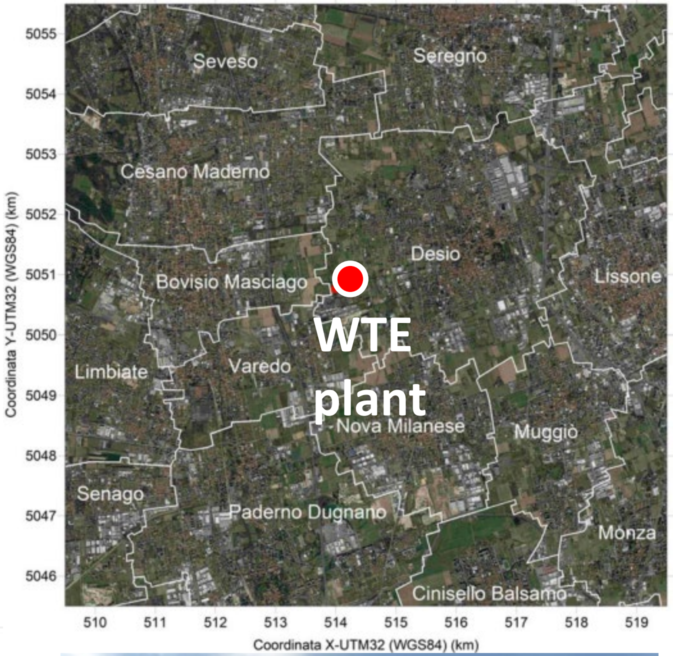
1976 – Plant start-up

1989 – Energy recovery start-up

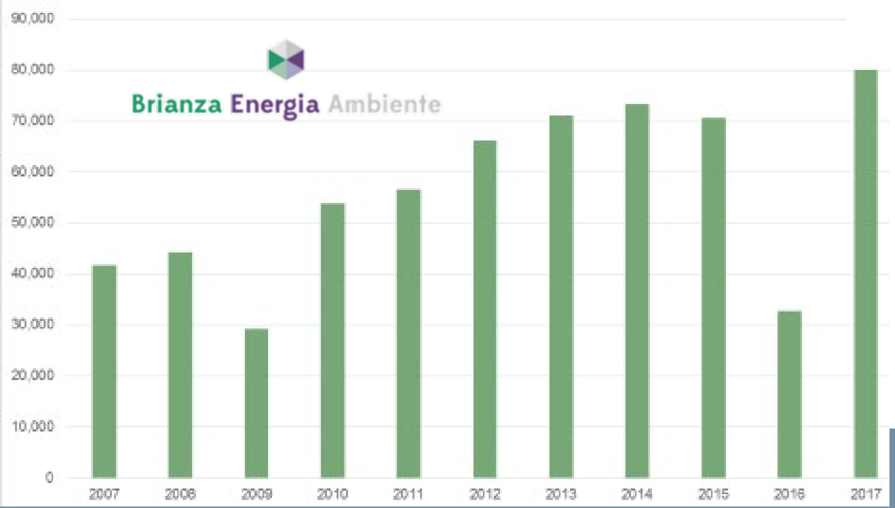
1997 – District heating start-up

2016 – Plant revamping:

- 40% increase incineration capacity
- new steam turbine
- new SCR unit for Nox control

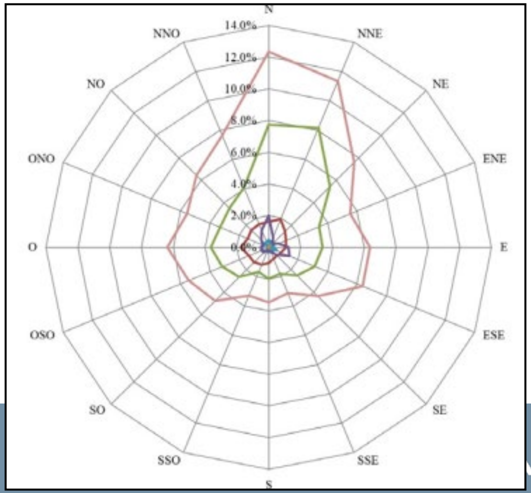


Waste throughput (tons/year)



Case study #1 - Methods

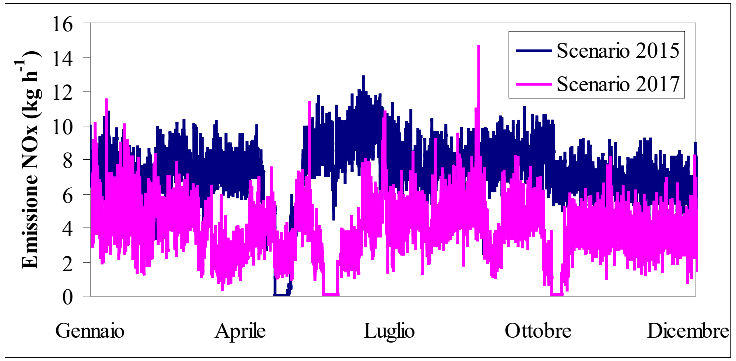
- **Hourly emission data from CEM system:**
  - flue gas temperature and speed, PM10 and NOx
- **PCDD/F concentrations from discontinuous monitoring:**
  - Monthly averaged concentration from continuous sampling for PCDD/F (dioxins)
- **Two Scenarios simulated**
  - Scenario A (before plant revamping)
  - Scenario B (after plant revamping)
- Model simulations for **year 2016** based on meteo data from Regional EPA



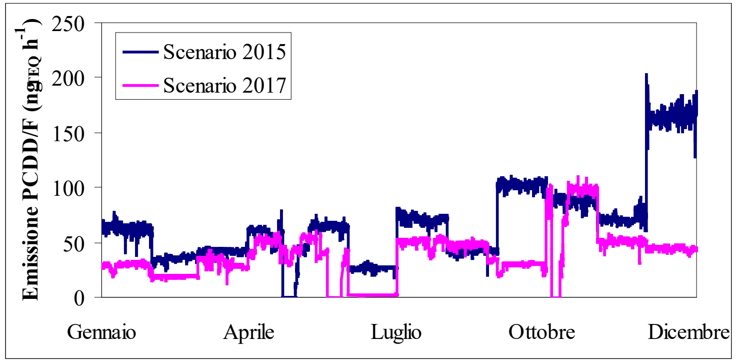
Case study #1 - WtE Plant's real emissions

- Emissions were/are well below maximum authorized limits
- Improved performance for NOx & PCDD/F (*thanks to SCR*)
- Worse performance for PM10 (*due to larger waste throughput*)

Parameter	PM10 ($g\ h^{-1}$)		NOx ($kg\ h^{-1}$)		PCDD/F ($ng_{TEQ}\ h^{-1}$)	
	Sc. A	*Sc. B*	*Sc. A*	*Sc. B*	*Sc. A*	*Sc. B*
Average	**15.5**	**20.9**	**7.38**	**4.00**	**69.1**	**39.9**
Median	10.8	21.6	7.38	4.00	64.8	40.7
Minimum	0.4	1.4	0.07	0.22	3.2	1.8
Maximum	205.6	72.7	12.82	14.54	202.7	110.2
Maximum Authorized	1100		22		11000	

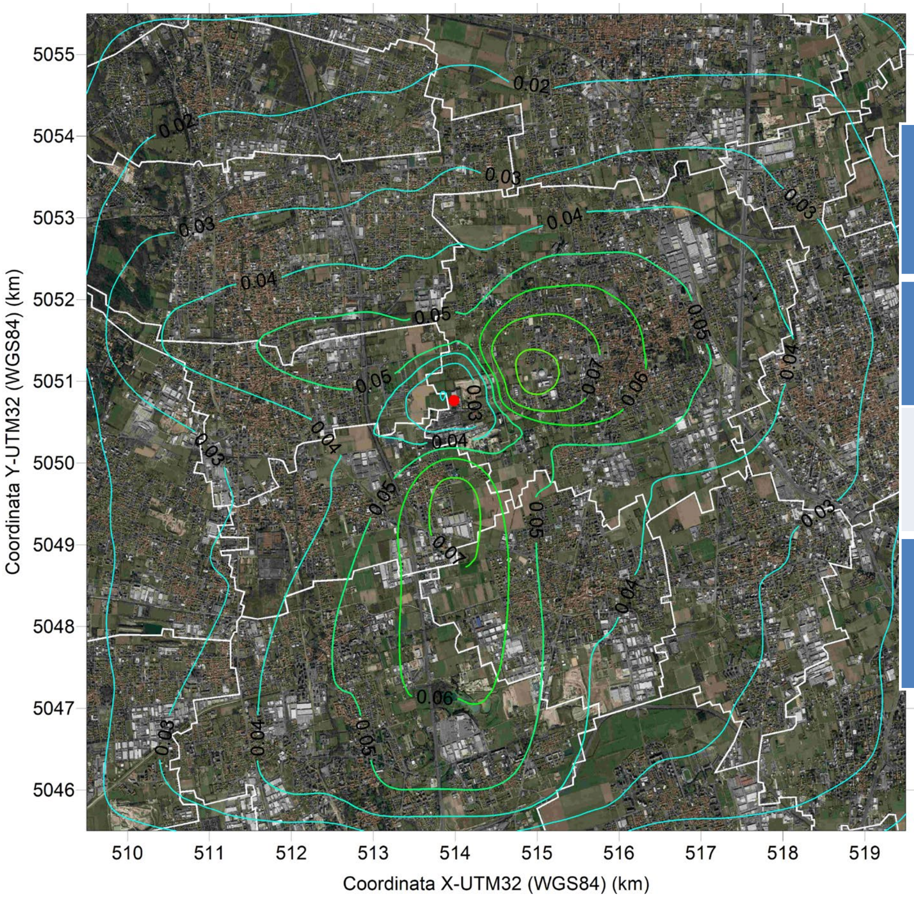


Authorized flow rate: 22 kg h^{-1}



Authorized flow rate: 11000 $ng_{TEQ}\ h^{-1}$

- **NO_2 annual average concentration (plant contribution)**



Scenario B (after revamping)
Max: 0.08 µg/m³
Desio urban area: 0.05-0.07 µg/m³

	PM10 (µg m^{-3})	NO_2 (µg m^{-3})	PCDD/F (fg_{TEQ} m^{-3})
Max. value	$4.4 \cdot 10^{-4}$	0.08	$8.1 \cdot 10^{-4}$
Urban area	$2\text{-}3.5 \cdot 10^{-4}$	0.05-0.07	$5\text{-}7 \cdot 10^{-4}$
AQ limit	40	40	150 (*)

(*) German guideline value

2016 NO_2 annual average concentration (Desio: 46.4 µg m^{-3})

Local road traffic impact on air quality

Methods

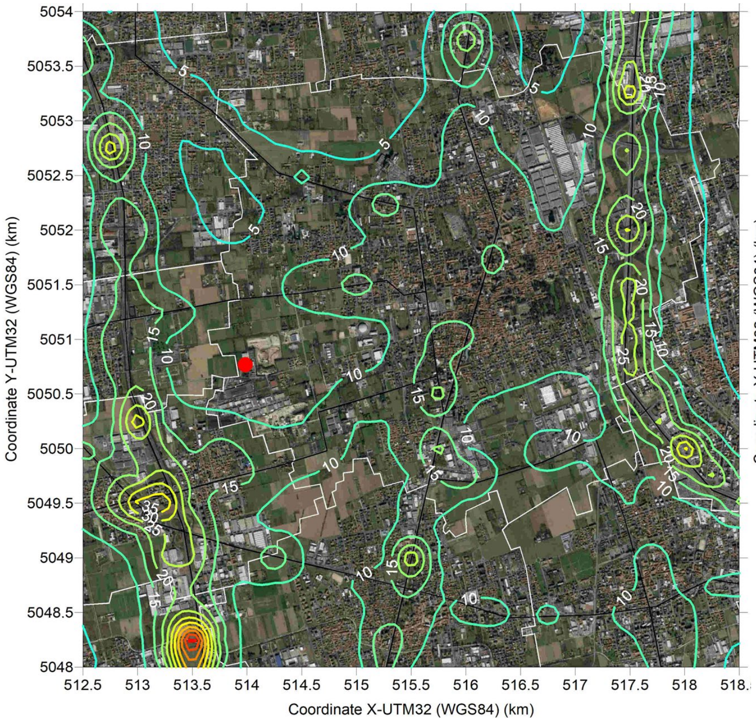
- Assessment restricted to main roads (i.e.: national and highly-trafficked local roads): **about 70% of total traffic emission**
- Dedicated study for hourly traffic flow of 3 vehicles' classes
- Emission assessment based on literature emission factors

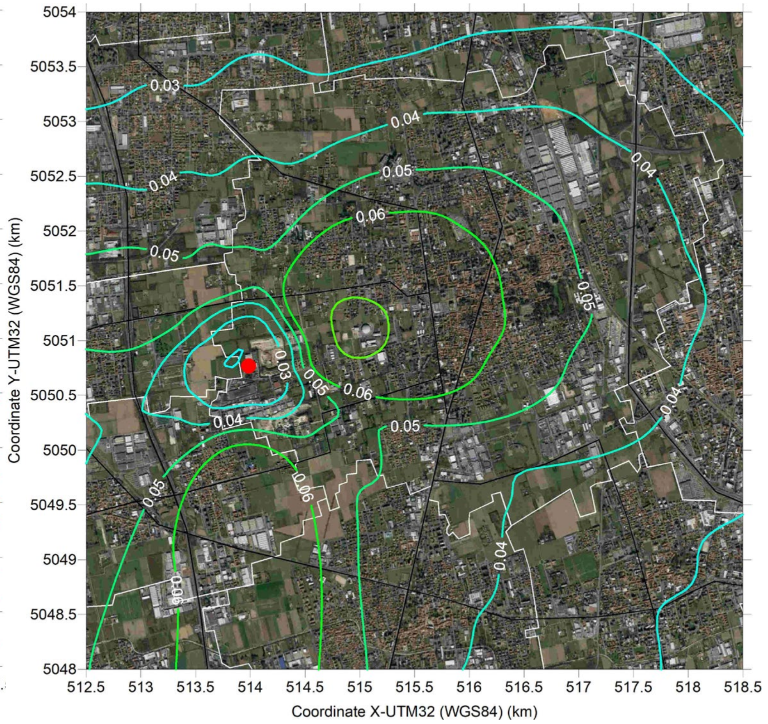
	Cars	LDV	HDV
PM10 (mg km^{-1})	39.9	77.4	217.9
NO_2 (mg km^{-1})	152.8	347.9	598.3
PCDD/F (pg_{TEQ} km^{-1})	21.3	39.6	49.4


Main roads considered (red arches)

Local road traffic vs. WtE plant

Contribution to NO_2 & PM10 annual average concentration





Road traffic

Max: 15-20 µg/m³
Desio urban area: 6-10 µg/m³

Max: 5-6 µg/m³
Desio urban area: 2-3 µg/m³

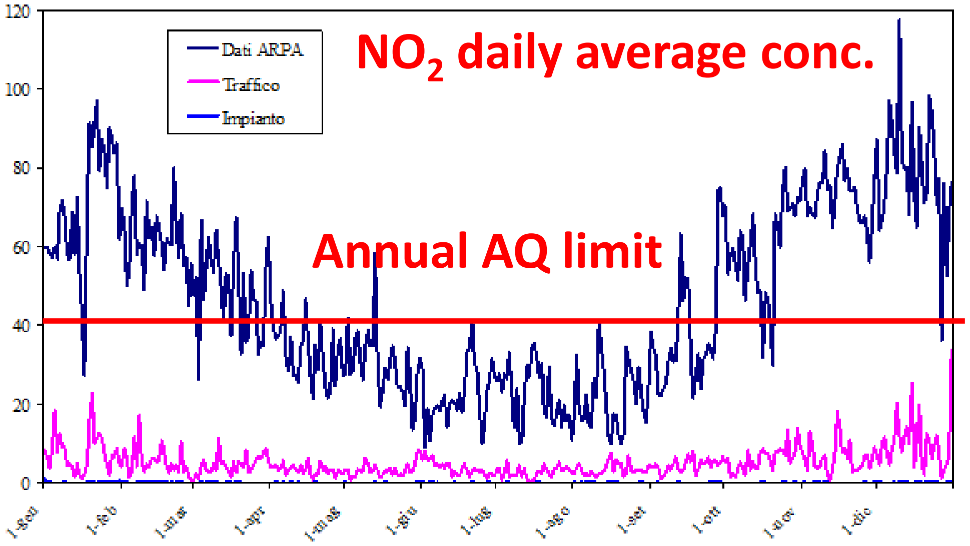
WTE plant - Scenario B

Max: 0.08 µg/m³
Desio urban area: 0.05-0.07 µg/m³

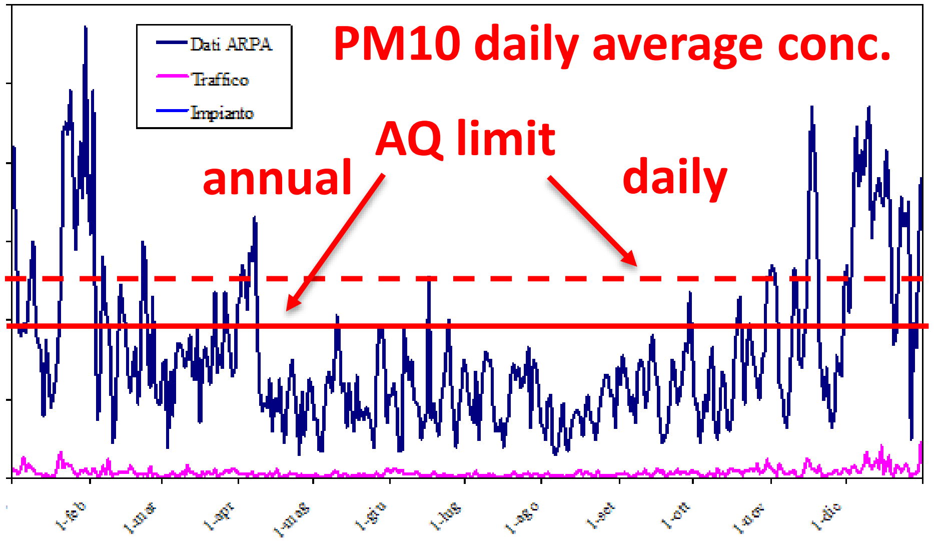
Max: $4.4 \cdot 10^{-4}$ µg/m³
Desio urban area: $2.0\text{-}3.5 \cdot 10^{-4}$ µg/m³

Local road traffic vs. WtE plant

Road traffic and WtE plant contribution vs. air quality data



Desio urban area, calendar year 2016



Case study #1 - Conclusions

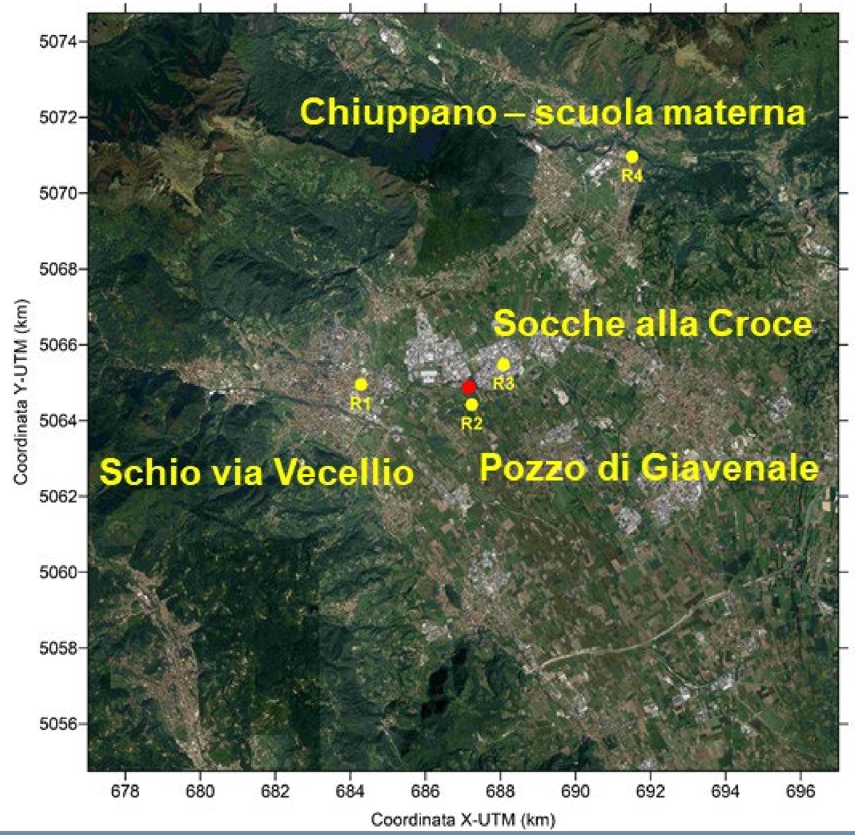
- ***Confirmation*** of WtE plant impact on air quality in Desio urban area
- ***Relevant downsizing*** of WtE plant actual impact on local air quality (at least 5x factor for NOx, up to 250x factor for PCDD/F)
- ***Positive effect*** of flue gas treatment revamping with strong reduction (60%) of air quality impact for NOx and PCDD/F thanks to SCR in spite of the increased incineration capacity

  Max NO_2 annual avg. from 0.003 µg/m^3/kt$_{waste}$ down to 0.001 µg/m^3/kt$_{waste}$
- ***Extremely modest contribution*** of WtE plant emission to ambient concentration levels, both as annual average and as short-term values
- ***Air quality impact of road traffic emission definitely greater than WtE*** (orders of magnitude), not only for criteria pollutants (PM10 and NOx) but also for organic and inorganic trace pollutants

Case study #2

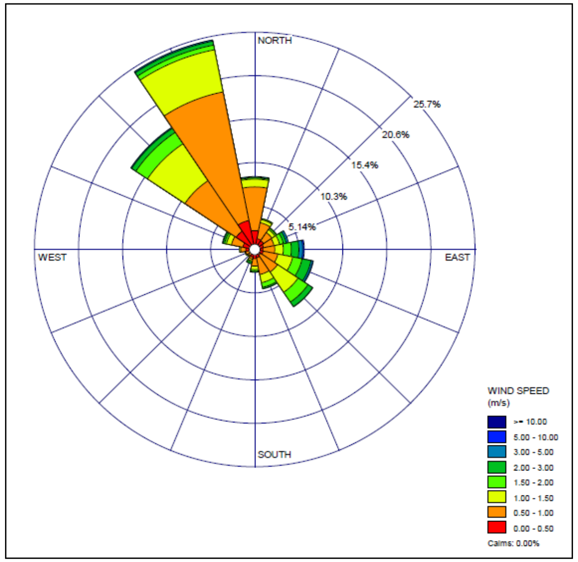
Schio WtE plant (Veneto Region) run by AVA Srl

- 3 separate combustion lines, all equipped with moving grate technology
- overall daily waste throughput of about 230 tons day^{-1}



Case study #2 - Methods

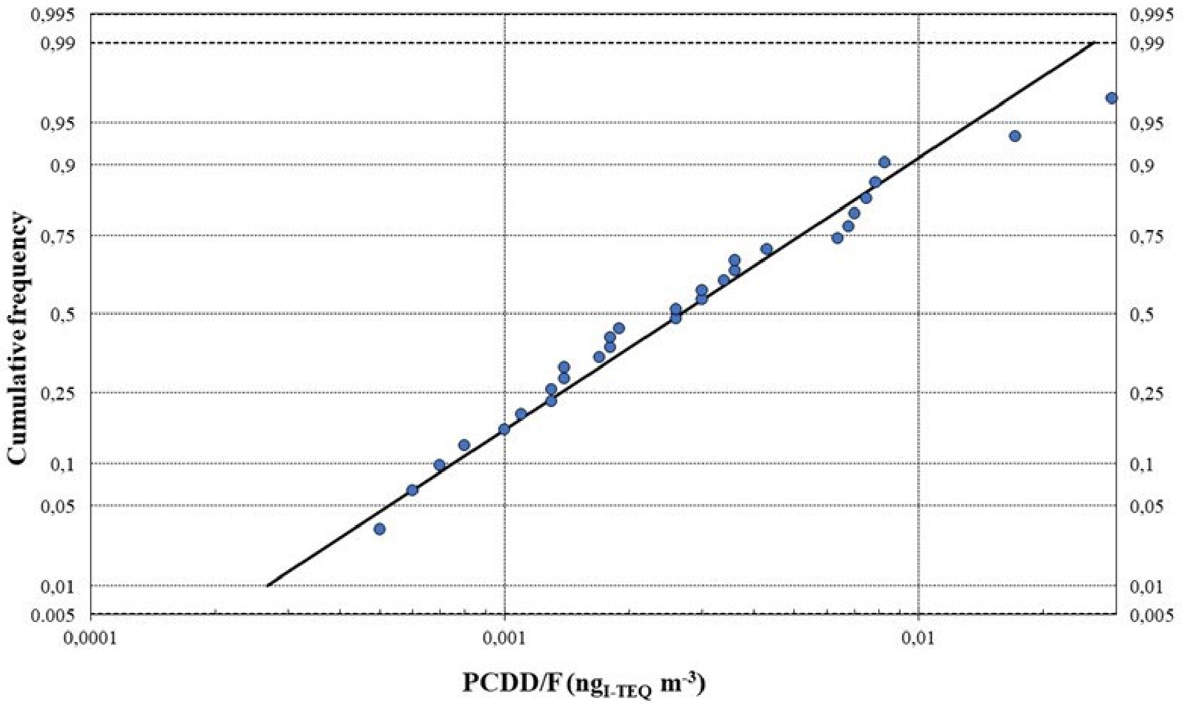
- **Hourly emission data from CEM system:**
  - flue gas temperature and speed, PM10 and NOx
- **PCDD/F and toxic elements concentrations from discontinuous monitoring**
  - Statistical analyses of routinary monitoring data
- Model simulations for **year 05-2018/04-2019** based on meteo data from Regional EPA



Case study #2 - WtE Plant's real emissions

- BACKGROUND
  - Public concerns
  - Our case studies
- CASE STUDY #1 Desio plant
  - Methods
  - Results
  - Conclusions
- CASE STUDY #2 Schio plant
  - Methods
  - Results
  - Conclusions
- OVERALL CONCLUSIONS

Statistical analyses of routinary monitoring data



Distributions of PCDD/F concentration data in WtE flue gas (values referred to 0 °C, 101.3 kPa, dry gas, 11% O_2)

Emission limit: 0,1 ng_{I-TEQ} m^{-3} @ ref. conditions

Case study #2 - Methods

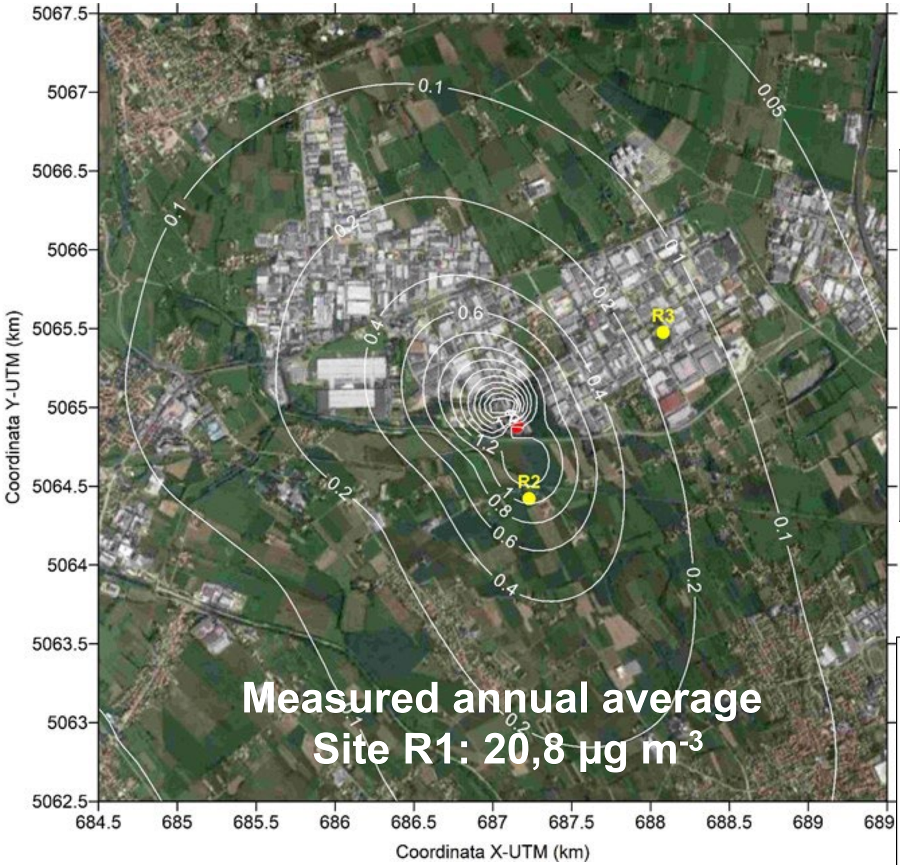
Monitoring data

- **Institutional air quality data**
  (Schio - via Vecellio monitoring station)
  - **continuous monitoring: NO_2, PM10**
  - **periodic sampling: BaP, As, Cd, Ni, Pb**

- **Data from dedicated monitoring campaigns**
  - Site R2, R3, R4: September 2018, Feb-Mar 2019 (AVA)
  - Site R1: June 2018 (ARPAV)
    - **As, Cd, Ni, Pb, BaP, PCDD/F, Hg**

Case study #2 - WtE impact on air quality

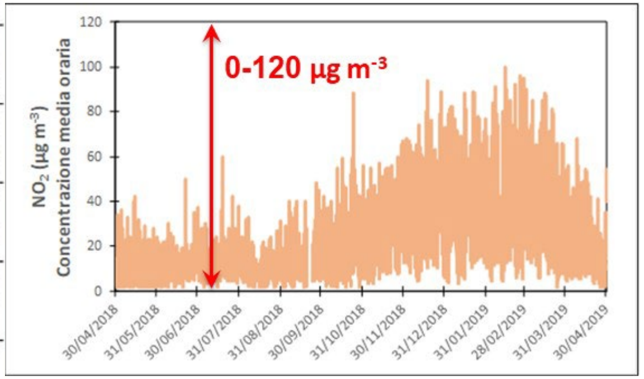
NO_2 annual average contour lines ($\mu g\ m^{-3}$)



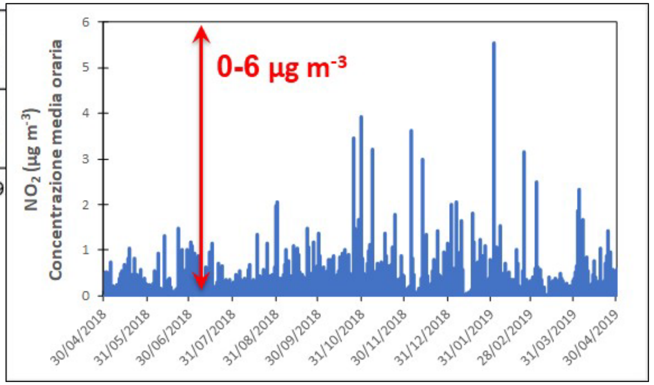
Model results
Max: 2,7 $\mu g\ m^{-3}$
R1: 0,08 $\mu g\ m^{-3}$ **R2**: 1,1 $\mu g\ m^{-3}$
R3: 0,15 $\mu g\ m^{-3}$ **R4**: 0,01 $\mu g\ m^{-3}$

Hourly data at site R1

Observations

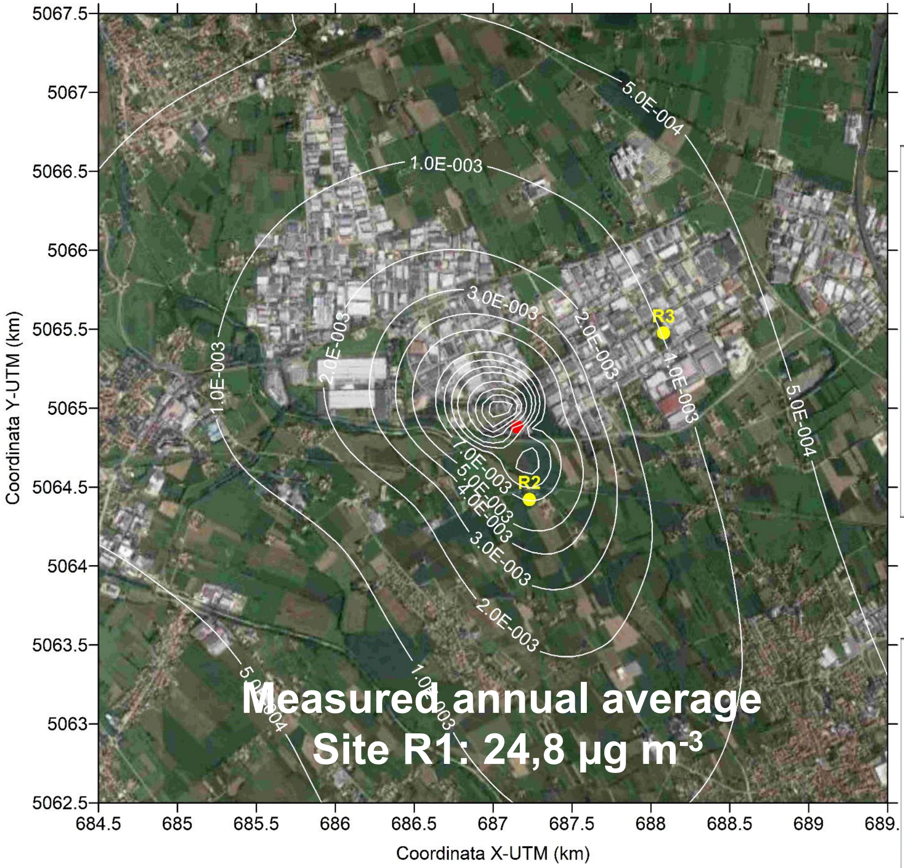


Model results



Case study #2 - WtE impact on air quality

PM10 annual average contour lines ($\mu g\ m^{-3}$)



Model results

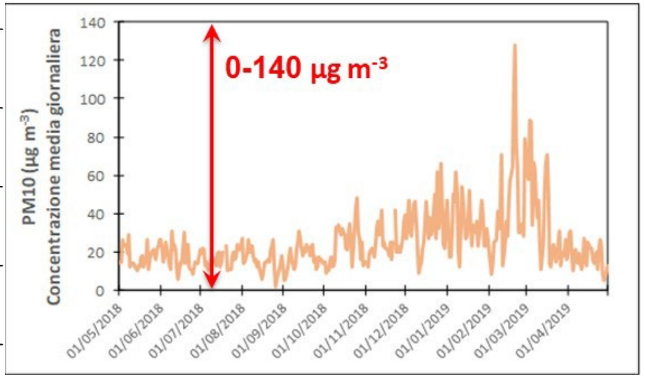
Max: $2{,}0\cdot10^{-2}$ $\mu g\ m^{-3}$

R1: $0{,}05\cdot10^{-2}$ $\mu g\ m^{-3}$ **R2**: $0{,}8\cdot10^{-2}$ $\mu g\ m^{-3}$

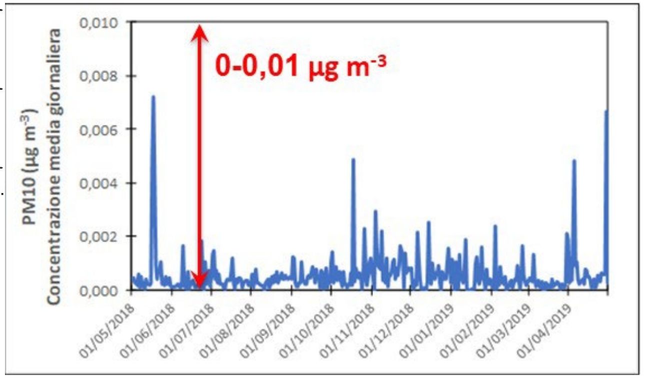
R3: $0{,}1\cdot10^{-2}$ $\mu g\ m^{-3}$ **R4**: $0{,}1\cdot10^{-2}$ $\mu g\ m^{-3}$

Daily data at site R1

Observations

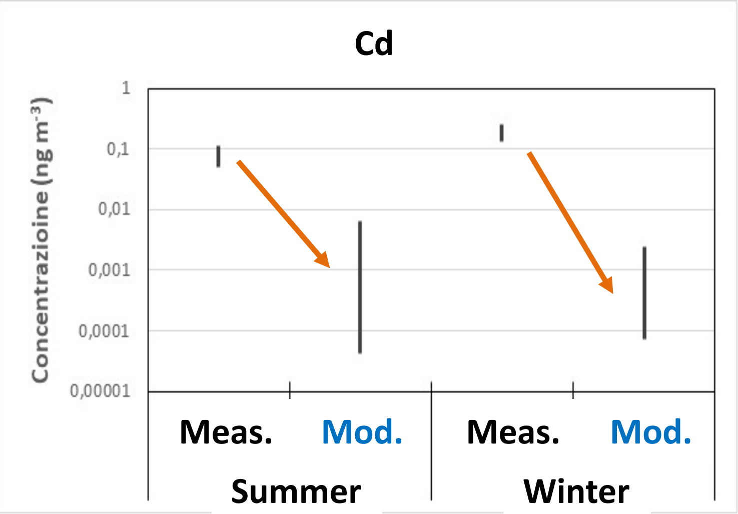


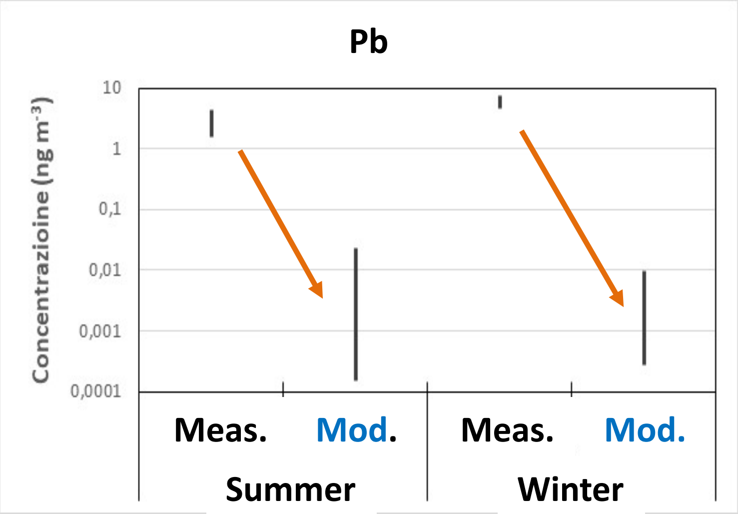
Model results

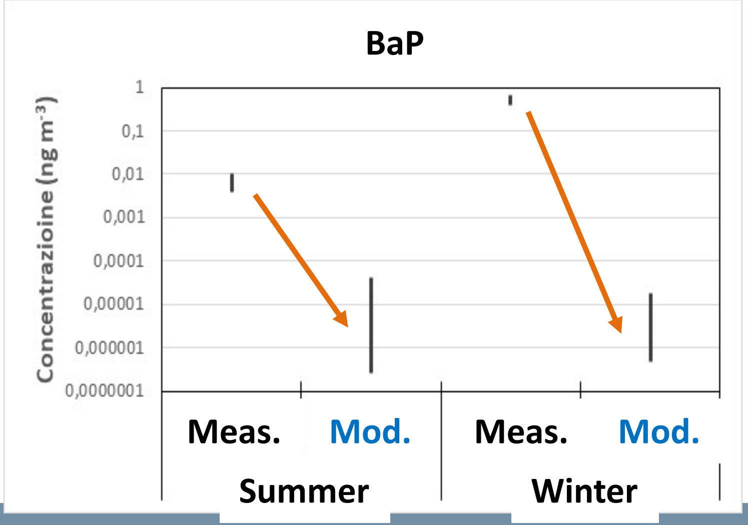


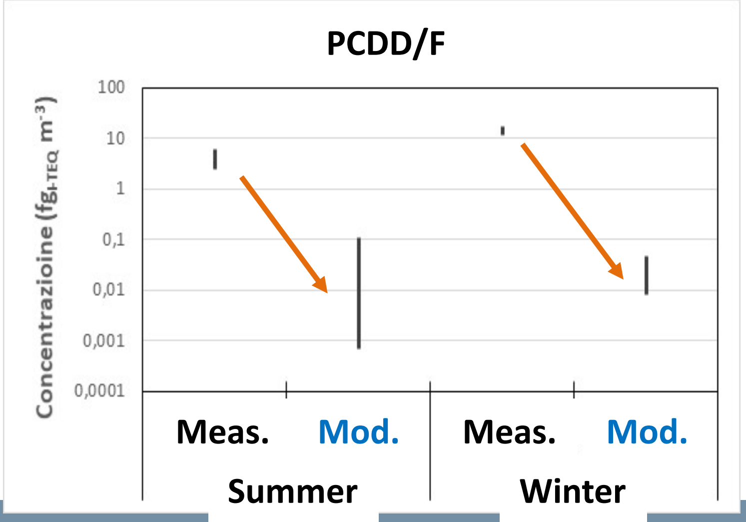
Case study #2 - WtE impact on air quality

Organic and inorganic trace pollutants









Case study #2 - Conclusions

- Completely ***marginal role*** of the WtE plant's emissions at the network monitoring site, for both NO_2 and PM10 as well as for the regulated toxic pollutants.
- Observed concentration levels due to the contribution of all the sources distributed over the area, with ***residential biomass burning***, ***road transport*** and some ***industrial process activities*** arising as the most significant contributors
- For ***toxic pollutants*** estimated contributions due to WtE plant's emissions at least two ***orders of magnitude lower*** than ambient levels at the closest site and much lower at the farther sites
- ***Provocatory question***: "Do (periodic) ambient monitoring campaigns provide suitable information on the real impact of WtE plant's emission in areas with complex and diversified source activities?"

Overall conclusions

- WtE plant emissions have an impact on air quality ….

…. as *other sources, too*

- In our studies the contribution of WtE plant's emission to ambient level was extremely small (both in absolute and relative terms) and sometimes totally negligible ….

…. as *other sources are strongly active*

- Regulation, emission control technologies, monitoring & modelling, transparent communication are mandatory ….

…. to rise the acceptance of plants

Thanks for your attention

Presentation on the depollution technologies for WtE

Dipl.-Ing. Rüdiger Margraf,
Member of the ESWET Technical Committee and Managing Director LUEHR FILTER GmbH

Index

- Classification of pollution & separation technologies
- Execution examples FGT for WtE
- Summary

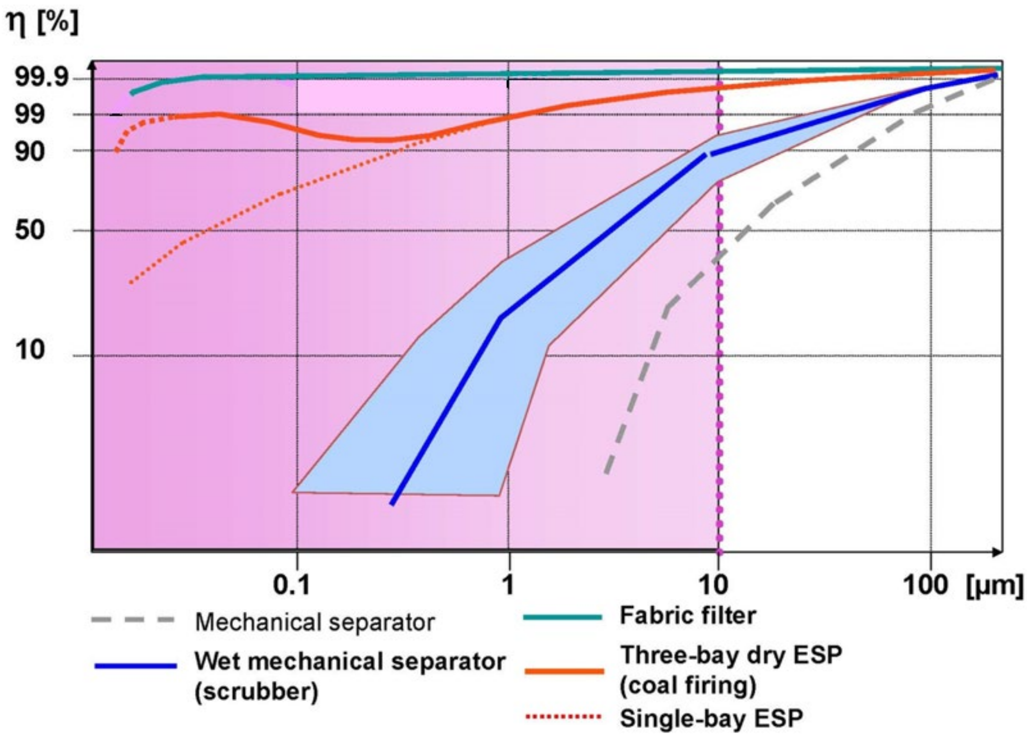
1) Classification of pollution & separation technologies

WI-BREF 2019

Parameter		BATAELS (2006) (typical values)	ELV IED(+Cl)	New BAT-AEL for new plant	New BAT-AEL for existing plants	Unit	Sampling period
Dust		1 – 5	10 (± 3)	< 2 – 5		mg/Nm³	daily
TOC		1 – 10	10 (± 3)	< 3 – 10		mg/Nm³	daily
HCl		1 - 8	10 (± 4)	< 2 - 6	< 2 – 8	mg/Nm³	daily
HF		1	1 (± 0,4)	< 1	< 1	mg/Nm³	daily
SO_2		1 – 40	50 (± 10)	5 - 30	5 – 40	mg/Nm³	daily
NO_x	SCR	40 – 100	200 (± 40)	50 - 120	50 – 150	mg/Nm³	daily
	SNCR	120 – 180			50 – 180		
NH_3	(SNCR)	1 – 10		2 - 10	2 – 10 (15)	mg/Nm³	daily
Hg		0.001 – 0.02	50 over sampling period	< 5 - 20	< 5 – 20	µg/Nm³	daily
Hg (indicative)				< 15 – 35	< 15 – 40		indicative half hourly
CO		5 – 30	50 (± 5)	10 – 50		mg/Nm³	daily
PCCD/F		0,01 – 0,1	0,1	< 0,01 – 0,04	< 0,01 – 0,06	ng/Nm³	long term sampling
PCCD/F + dlPCB				< 0,01 – 0,06	< 0,01 – 0,08	ng/Nm³	
Cd + Tl		0,005 – 0,05	0,05	0,005 – 0,02		mg/Nm³	over sampling period
Sb+As+Pb+Cr+Cp+Cu+Mn +Ni+V		0,005 – 0,5	0,5	0,01 – 0,3		mg/Nm³	over sampling period

- Pollutants in solid form : Particles, heavy metals in solid form
- Acid components : HF, HCl, HF
- Further gaseous pollutants : Hg, PCDD/PCDF, heavy metals (gaseous)
- Further pollutants : NO_x (NH_3)

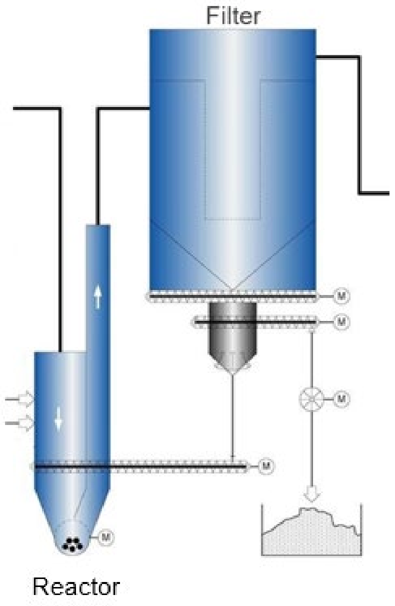
Particulate matter

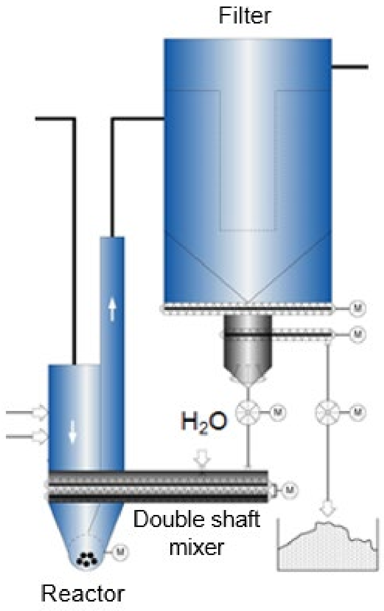


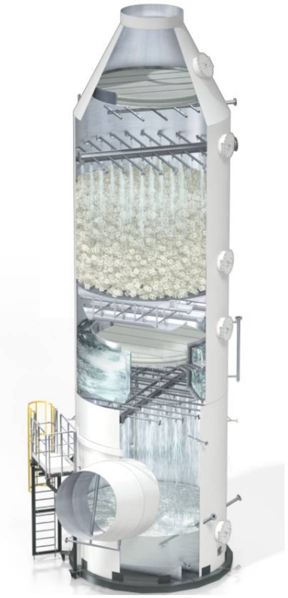
Fabric filter

- Particles, particulate heavy metals
- In combination with different additives also acid pollutants, gaseous heavy metals incl. Hg, PCDD/PCDF

Sorption procedures





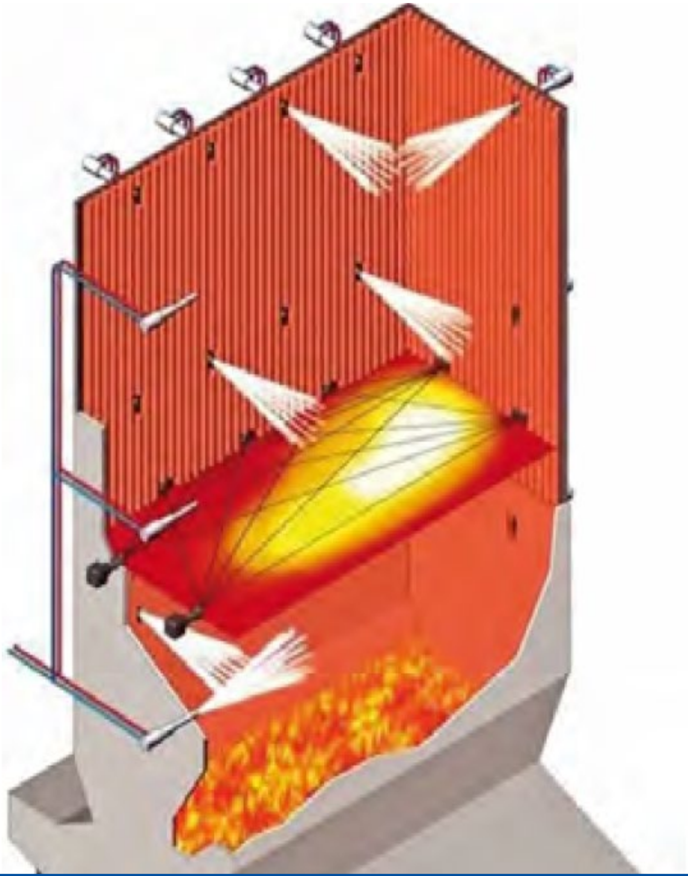


Dry sorption with $NaHCO_3$ and AC
- Acid pollutants
- Heavy metals incl. Hg
- Dioxins / Furans

Cond. dry sorption with $Ca(OH)_2$ and AC
- Acid pollutants
- Heavy metals incl. Hg
- Dioxins / Furans

Wet scrubber with NaOH or $CaCO_3$
- Acid pollutants
- Heavy metals incl. Hg
- NH_3

NO_x reduction

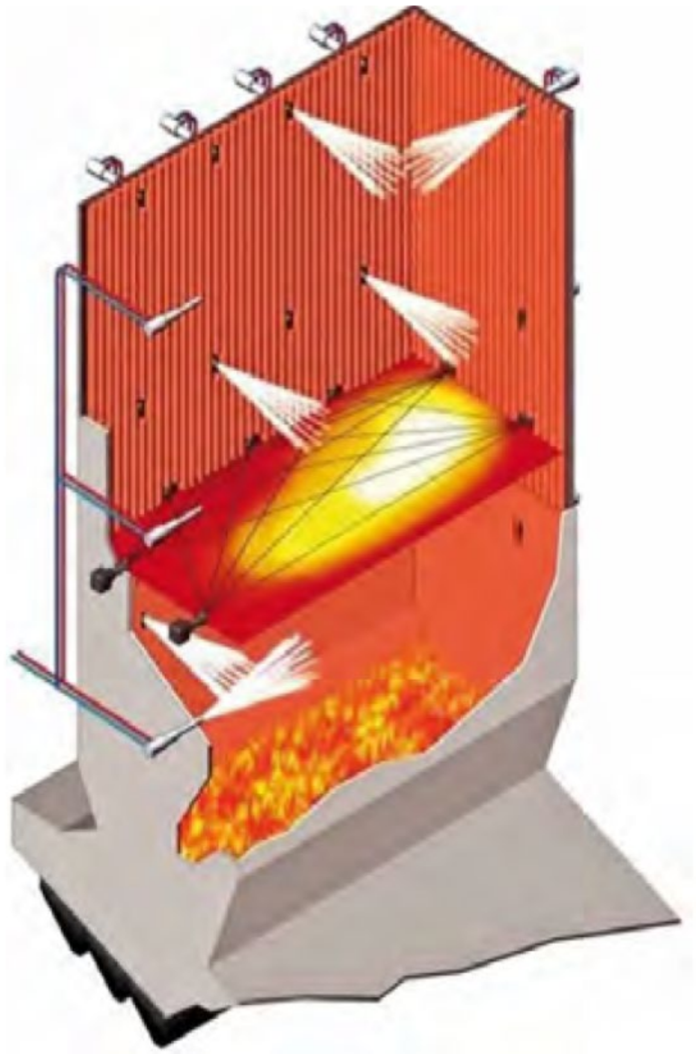


Selective **N**on **C**atalytic **R**eduction

Selective **C**atalytic **R**eduction

2) Execution examples FGT for WtE

SNCR & conditioned dry sorption



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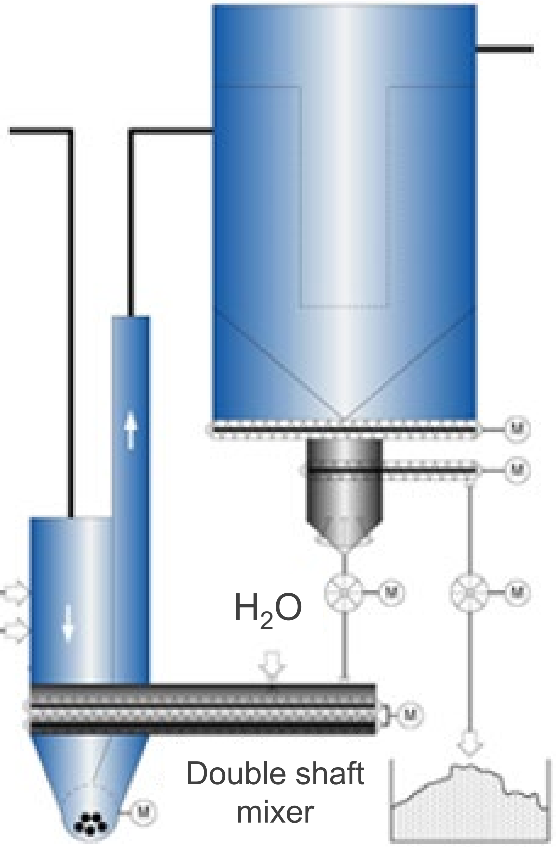
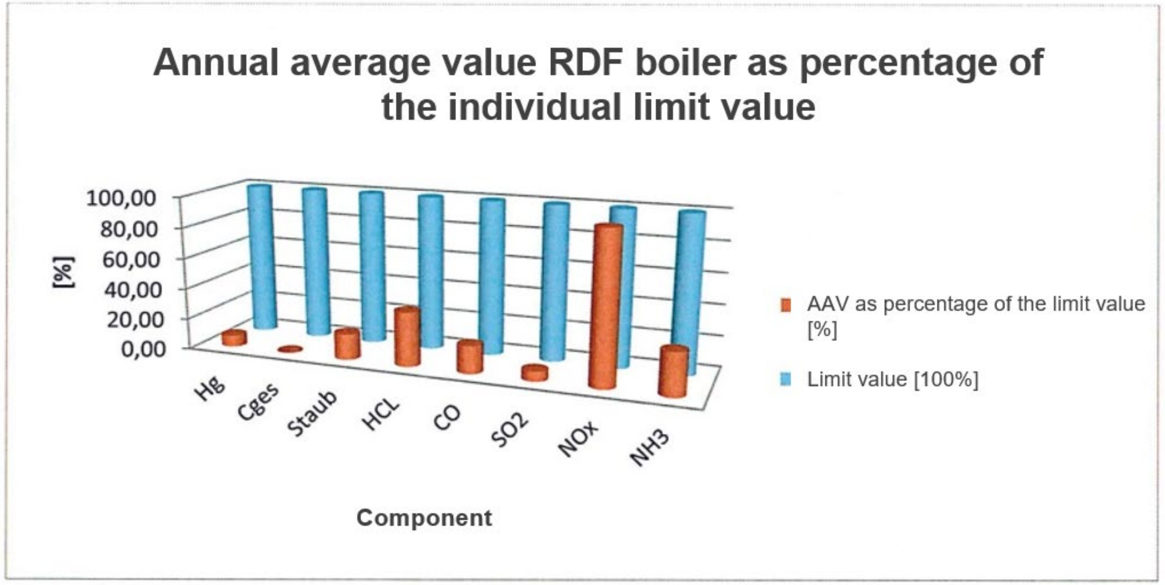
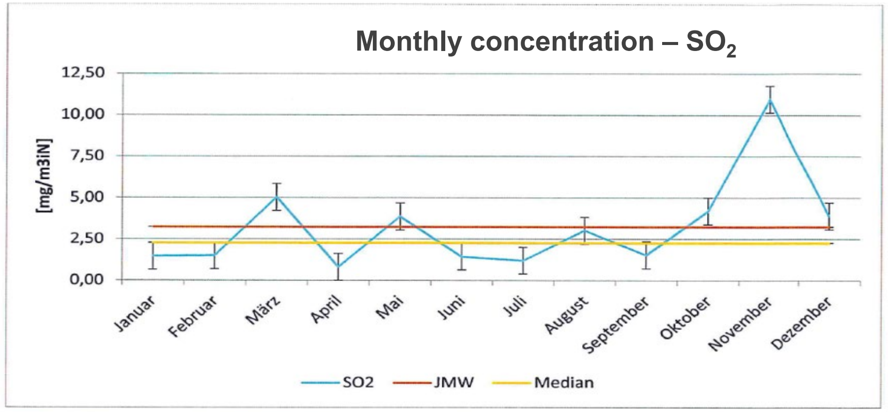


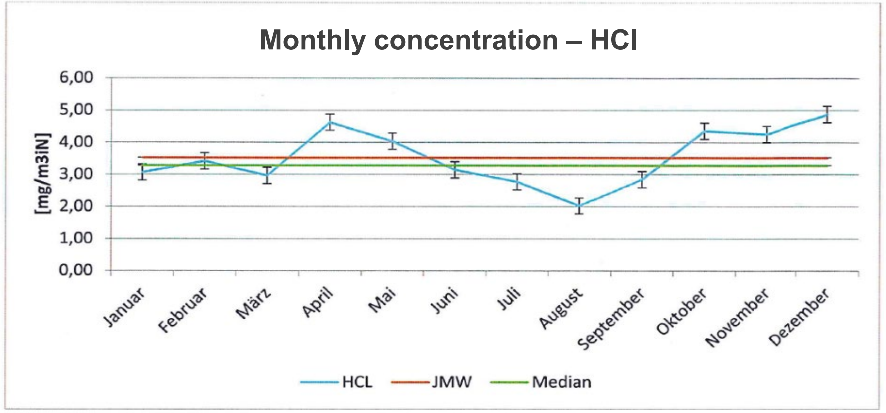
WtE Spremberg / Germany Emissions 2017

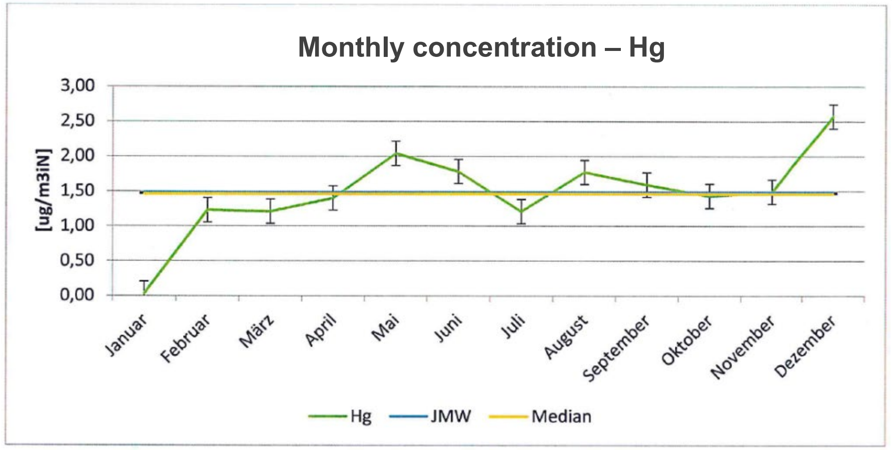
	Hg	C_{ges}	Dust	HCl	CO	SO_2	NO_x	NH_3	TNBZ
	mg/m³	mg/m³	mg/m³	mg/m³	mg/m³	mg/m³	mg/m³	mg/m³	°C
AAV RDF boiler	0,00149	0,06	0,84	3,51	8,95	3,25	192,70	2,77	1.009,55
Limit value	0,02	10,00	5,00	10,00	50,00	50,00	200,00	10,00	850,00
Median	0,38	194,92	0,02	3,82	0,19	1,25	6,60	1,88	1.018,28

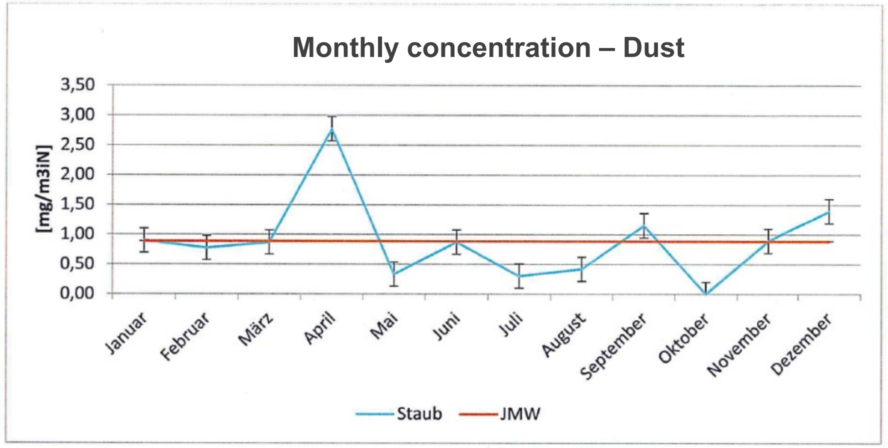


Monthly and yearly average values



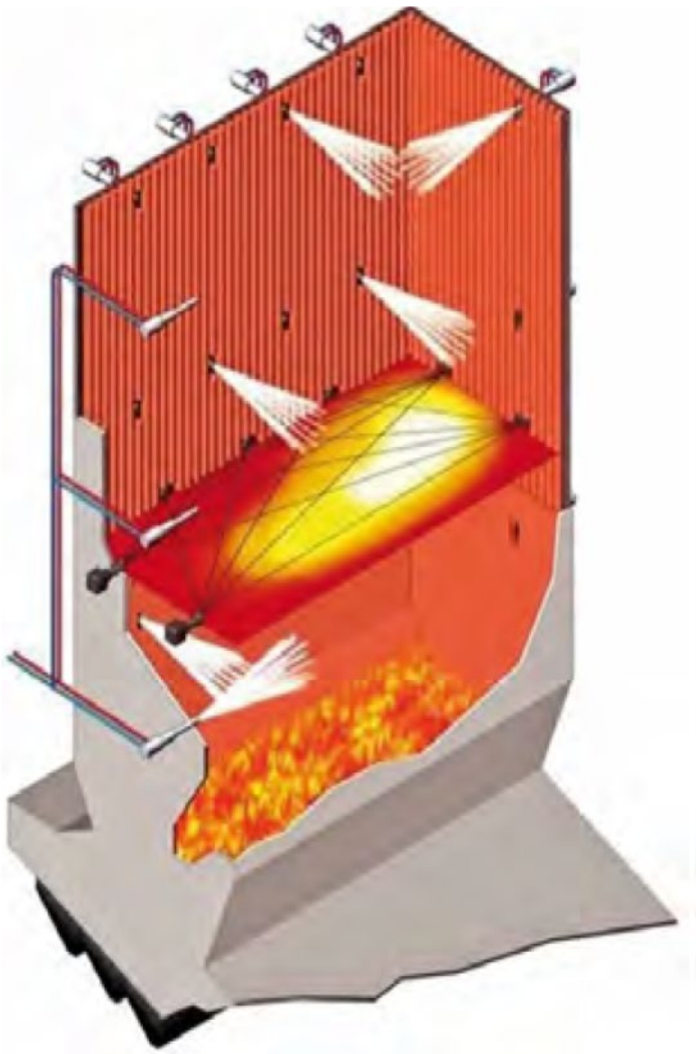






Measuring component	Unit	Measured value	Emission limit
PCCD/F/PCB TEQ (WHO 2005) excl. BG	$ng_{I\text{-}TEQ}/m^3$	< 0.005	0.1

SNCR & dry sorption



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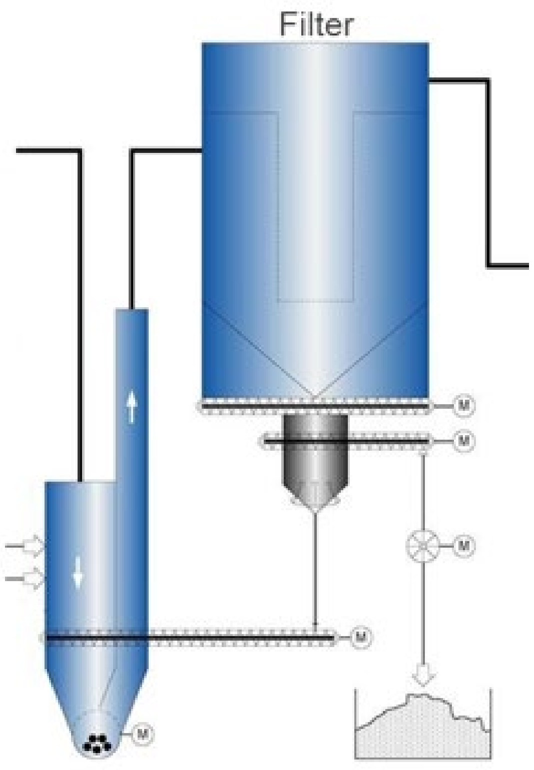


WtE Bernburg / Germany emission Report 2017

Die Energie Anlage Bernburg GmbH betreibt am Standort Bernburg eine Thermische Abfallbehandlungsanlage zur thermischen Verwertung und Beseitigung von aufbereiteten Abfällen (Ersatzbrennstoffen EBS) und nicht aufbereiteten Abfällen. Die Anlage ist speziell für die umweltverträgliche thermische Verwertung und Beseitigung von aufbereiteten und nicht aufbereiteten ungefährlichen Abfällen ausgelegt (Herkunftsbereich hauptsächlich Siedlungs- und Gewerbeabfälle). Die jährliche Betriebszeit der TAB EAB beträgt 8.760 h/a (365 Tagen pro Jahr über 24 Stunden pro Tag im Schichtbetrieb).

Betreiber:	Energie Anlage Bernburg GmbH (EAB) Köthensche Straße 3a 06406 Bernburg	
Standort:	Werksgelände - EAB Köthensche Straße 3a 06406 Bernburg	
Anlage:	Verbrennungsanlage der Nr. 8.1.1.3 des Anhang 1 der 4. BImSchV	
Ansprechpartner:	Herr Jacobi, Techn. Leiter Herr Licht, Immissionsschutzbeauftragter	Tel.: 03471 / 6898-100 Tel.: 03471 / 6898-220
Betrachtungszeitraum:	01.01.2017 - 31.12.2017	

Verbrennungsbedingungen	Parameter
Verbrennungstemperatur (Mindesttemperatur)	850°C
Mindestverweilzeit bei Mindesttemperatur	2 Sekunden
Bezugssauerstoffgehalt	11 Vol.%

Tabelle1: Einzuhaltende Verbrennungsbedingungen

	Grenzwerte nach 17. BImSchV		Jahresmittelwerte der kontinuierlichen Messung in mg/m³		
Emittierte Stoffe	**Tagesmittelwert in mg/m³**	**Halbstundenmittelwert in mg/m³**	**Linie 1**	**Linie 2**	**Linie 3**
Staub	5	20	1,04	0,11	0,38
Hg	0,03	0,05	0,00029	0,00036	0,00026
HCl	10	60	9,25	9,15	9,64
CO	50	100	13,22	9,15	10,07
NOx	200	400	186,43	190,26	190,84
NH3	10	15	0,11	0,01	0,17
Cges	10	20	0,69	0,49	0,45
SO2	50	200	12,25	11,32	8,22
HF	1	4	0,60	0,52	0,20

Tabelle2: Einzuhaltende Emissionsgrenzwerte und Ergebnisse der kontinuierlichen Messungen

In der **Tabelle2** sind die Emissionen aufgeführt, die wie in der Genehmigung gefordert, kontinuierlich überwacht und gemessen werden. Diese Messwerte und eventuelle Grenzwertüberschreitungen werden per Emissionsfernüberwachung an die zuständige Überwachungsbehörde übermittelt. Wie aus Tabelle1 ersichtlich, liegen die über das Berichtjahr ermittelten Emissionswerte unterhalb der Grenzwerte. Auch hier wurden die gesetzlichen Anforderungen eingehalten.

Durchführung einer amtlichen Einzelmessungen gem. § 13 der 17. BImSchV in der Zeit vom 26.09.-29.09.2017

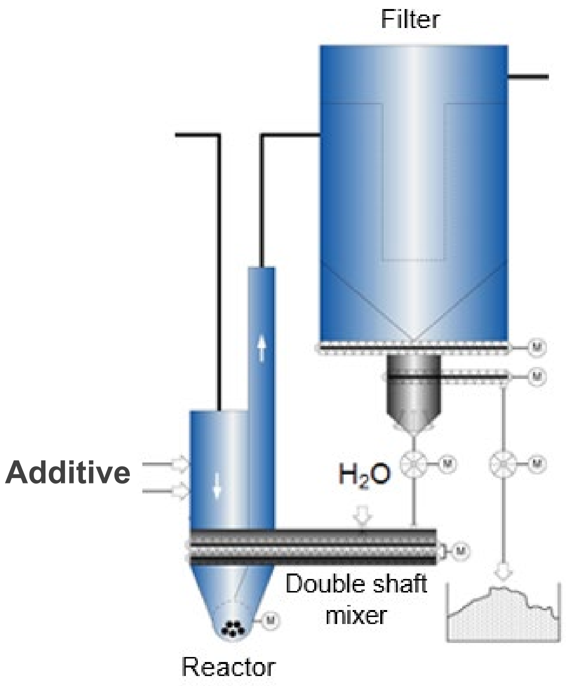
Abgasparameter	Grenzwerte gem. §4 und § 5 17.BImSchV	Messwerte Linie1 als Maximalwert über die Probenahmezeit	Messwerte Linie2 als Maximalwert über die Probenahmezeit	Messwerte Linie3 als Maximalwert über die Probenahmezeit
Dioxine und Furane (PCDD/PCDF)	0,1 ng TE/m³	0,0000 ng TE/m³	0,0000 ng TE/m³	0,0000 ng TE/m³
Cadmium, Thalium und deren Verbindungen	0,05 mg/m³	0,0000 mg/m³	0,0020 mg/m³	0,0000 mg/m³
Schwermetalle Sb; As; Pb; Cr; Co; Cu; Mn; Ni; V; Sn	0,5 mg/m³	0,0200 mg/m³	0,0400 mg/m³	0,0100 mg/m³
Benzo(a)pyren, As,- Cd,- Co und Cr	0,05 mg/m³	0,0020 mg/m³	0,0050 mg/m³	0,0020 mg/m³

Die Messergebnisse beziehen sich auf den trockenen Normzustand des Abgases und einem Volumengehalt an Sauerstoff im Abgas von 11 von Hundert (Bezugssauerstoffgehalt) als Maximalwert zuzüglich Messunsicherheit.
Die Emissionsmessungen wurden durch TÜV Nord Umweltschutz GmbH, einer nach § 29b BImSchG bekanntgegeben Messstelle, durchgeführt.

Tabelle3: Einzuhaltende Emissionsgrenzwerte und Ergebnisse der diskontinuierlichen Messungen

In der **Tabelle3** sind die Emissionen aufgelistet, die entsprechend der 17.BImSchV diskontinuierlich überwacht werden, die gemessenen Emissionswerte unterschreiten ebenfalls die Grenzwerte.

Conditioned dry sorption & SCR & dry sorption



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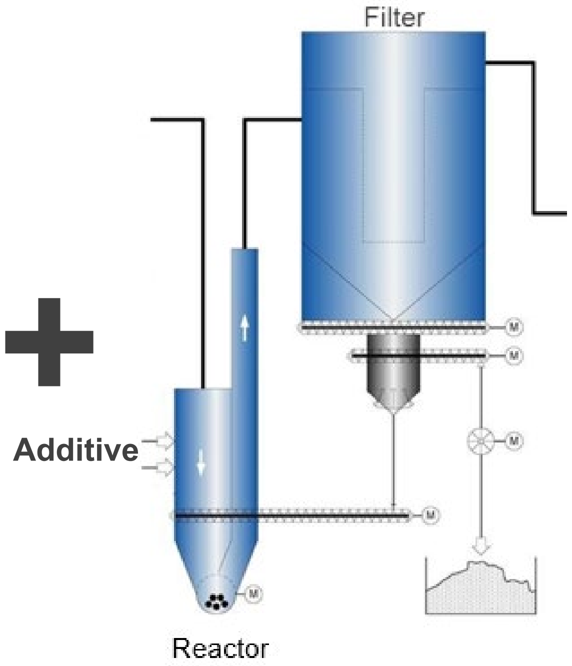


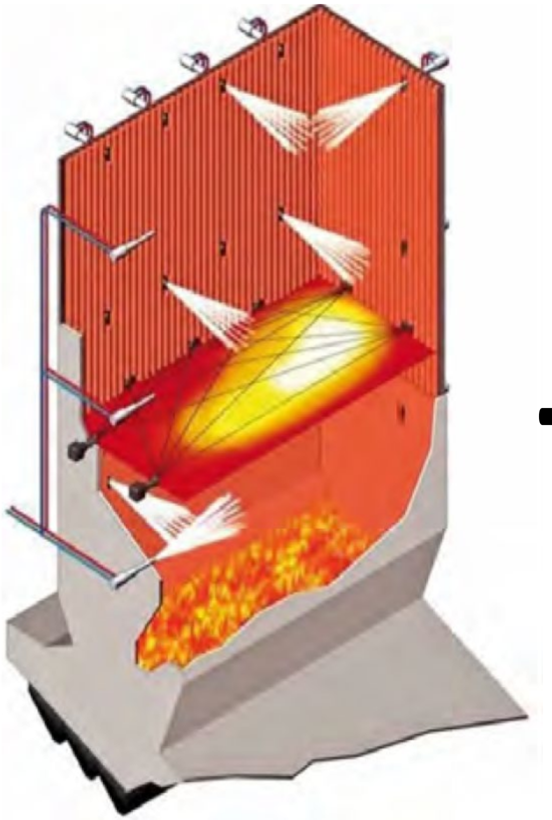
Emission values of WtE plant ENERTEC Hameln, line 4

Continuous measurements		
Pollutant	**Unit**	**YAV**
Dust	mg/Nm^3	0.15
SO_2	mg/Nm^3	1.47
HCl	mg/Nm^3	0.06
NO_2	mg/Nm^3	90.6
HF	mg/Nm^3	0.28
NH_3	mg/Nm^3	0.36
Hg	µg/Nm^3	0.19

Individual measurements		
Pollutants	**Unit**	**YAV**
Sum Cd+Tl	mg/Nm^3	< 0.0001
Sum Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn	mg/Nm^3	0.0018
Sum As, Cd, Co, Cr, Benzo(a)pyrene	mg/Nm^3	< 0.001
PCCD/PCDF	ng/Nm^3	< 0.0001

Extract of emission report 2018
Enertec Hameln Line 4

SNCR & conditioned dry sorption & wet scrubber



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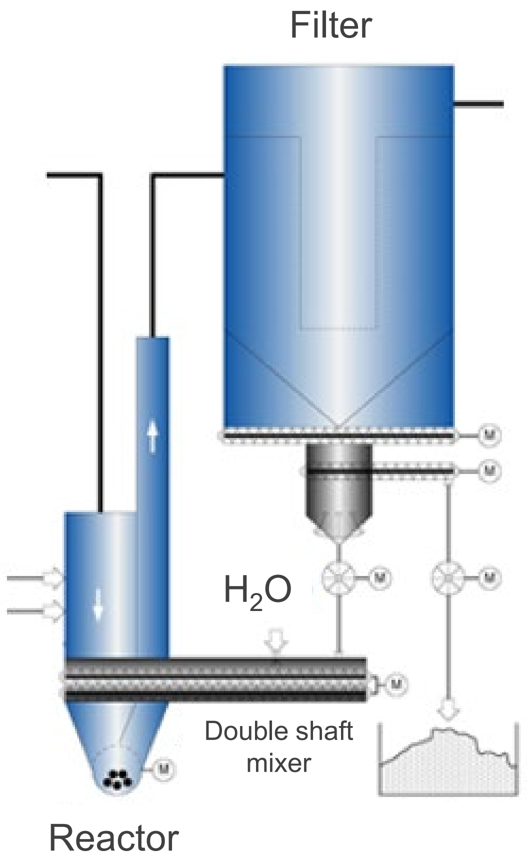

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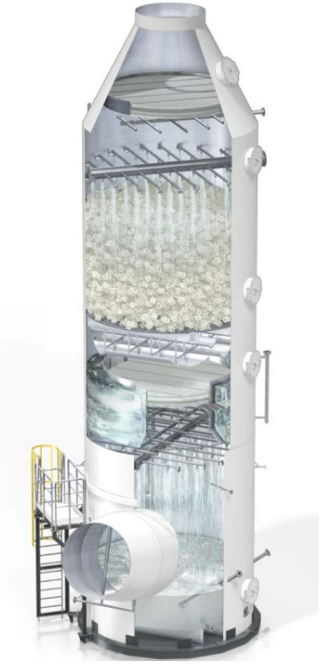

Emission values exemplary shown at WtE plant Oulun Energia

PÄÄSTÖMITTAUKSET

	HETKELLIS-ARVOT		REDUSOIDUT ARVOT	
NH3	2.00 mg/Nm³	12HNE10CQ001	1.95 mg/Nm³	12HNE10CQ901
O2	8.70 %	12HNE10CQ002		
CO2	7.03 %	12HNE10CQ003	6.86 %	12HNE10CQ903
HCL	0.17 mg/Nm³	12HNE10CQ004	0.17 mg/Nm³	12HNE10CQ904
S02	0.09 mg/Nm³	12HNE10CQ005	0.08 mg/Nm³	12HNE10CQ905
H20	16.90 %	12HNE10CQ006		
CO	16.54 mg/Nm³	12HNE10CQ007	14.75 mg/Nm³	12HNE10CQ907
NO	86.02 mg/Nm³	12HNE10CQ008	84.01 mg/Nm³	12HNE10CQ908
HF	0.00 mg/Nm³	12HNE10CQ010	0.00 mg/Nm³	12HNE10CQ910
NOx	131.72 mg/Nm³	12HNE10CQ011	138.73 mg/Nm³	12HNE10CQ911
TOC	0.31 mg/Nm³	12HNE10CQ012	0.30 mg/Nm³	12HNE10CQ912
PARTIKKELIT	0.29 mg/Nm³	12HNE10CQ009	0.28 mg/Nm³	12HNE10CQ909
VIRTAUS MÄRKÄ	129409.1 Nm³/h	12HNE10CF001		
KORJAUS	1.0			
VIRTAUS KUIVA	107538.2 Nm³/h	12HNC10CF901		
VIRTAUS	156754.7 m³/h	12HNC10CF901		

3) Summary

Summary

- There are several different technologies available to remove the pollutants, which are listed as BAT in the WI-BREF.
- All combinations of technologies in operation reliably fulfil today‘s and future requirements for emission limits including a sufficient safety margin.
- The selection of technology is made depending on the application not least in regard to fuel composition and energy efficiency.
- The continuous emission monitoring systems (CEMS) allow to monitor the efficiency of the FGT systems.

Thank you for your attention!

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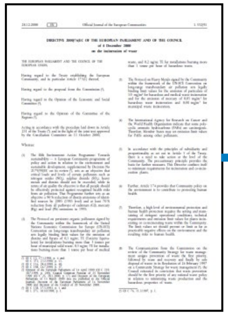
Measurement technologies and data evaluation from WtE

Aurélie Moll
Member of the ESWET Technical Committee and Strategic Industry Manager CCUS at SICK

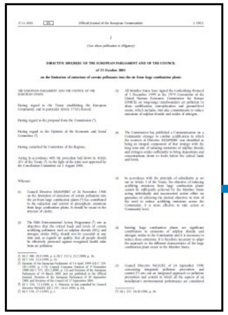
Continuous Emission Regulations in Europe

FROM WID & LCPD TO BREF

2000-76 EC **WID**
Waste Incineration Directive



2001-80 EC **LCPD**
Large Combustion Plants Directive



2010-75 EU **IED**
Industrial Emissions Directive


17.12.2010 EN Official Journal of the European Union L 334/17

DIRECTIVES

DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 24 November 2010
on industrial emissions (integrated pollution prevention and control)
(Recast)
(Text with EEA relevance)

WID BREF (2019)

LCP BREF (2017)

BREF: **B**est available techniques **REF**erence Document

Related standards:

EN 14181 **Quality assurance of automated measuring systems**

EN 15267 **Certification of automated measuring systems**

Continuous Emission Regulations in Europe: WI BREF

EMISSION LIMITS FOR WASTE TO ENERGY PLANTS

Parameter	Units	Current ELVs	WI BREF 2019 BATAELs		Averaging period
		IED	Existing plant	New plant	
Dust	mg/Nm^3	10	<2-5		Daily average
Cd+Tl	mg/Nm^3	0.05	0.005-0.02		Average over the sampling period
Sb+AS+Pb+Cr+Co+Cu+Mn+Ni+V	mg/Nm^3	0.5	0.01-0.3		Average over the sampling period
HF	mg/Nm^3	1	<1		Daily average or average over the sampling period
HCl	mg/Nm^3	10	<2-8	<2-6	Daily average
SO2	mg/Nm^3	50	5-40	5-30	Daily average
NOx	mg/Nm^3	200	50-150 *	50-120 *	Daily average
			50-180 **		Daily average
CO	mg/Nm^3	50	10-50		Daily average
NH3	mg/Nm^3		2-10	2-10	Daily average
TVOC	mg/Nm^3	10	<3-10		Daily average
PCDD/F	ng I-TEQ/Nm^3	0.1	<0.01-0.06	<0.01-0.04	Average over the sampling period
			<0.01-0.08	<0.01-0.06	Long-term sampling period
PCDD/F + dioxin like PCBs	ng WHO-TEQ/Nm^3		<0.01-0.08	<0.01-0.06	Average over the sampling period
			<0,01-0,1	<0,01-0,08	Long-term sampling period
Hg	µg/Nm^3	50	<5-20	<5-20	Daily average or average over the sampling period
			1-10	1-10	Long-term sampling period

I-TEQ: International toxic equivalent according to the North Atlantic Treaty Organization (NATO) schemes

WHO-TEQ: Toxic equivalent according to the World Health Organization (WHO) schemes

IED: Industry Emission Directive

WI BREF: Waste Incineration Best Available Technologies – Reference Document

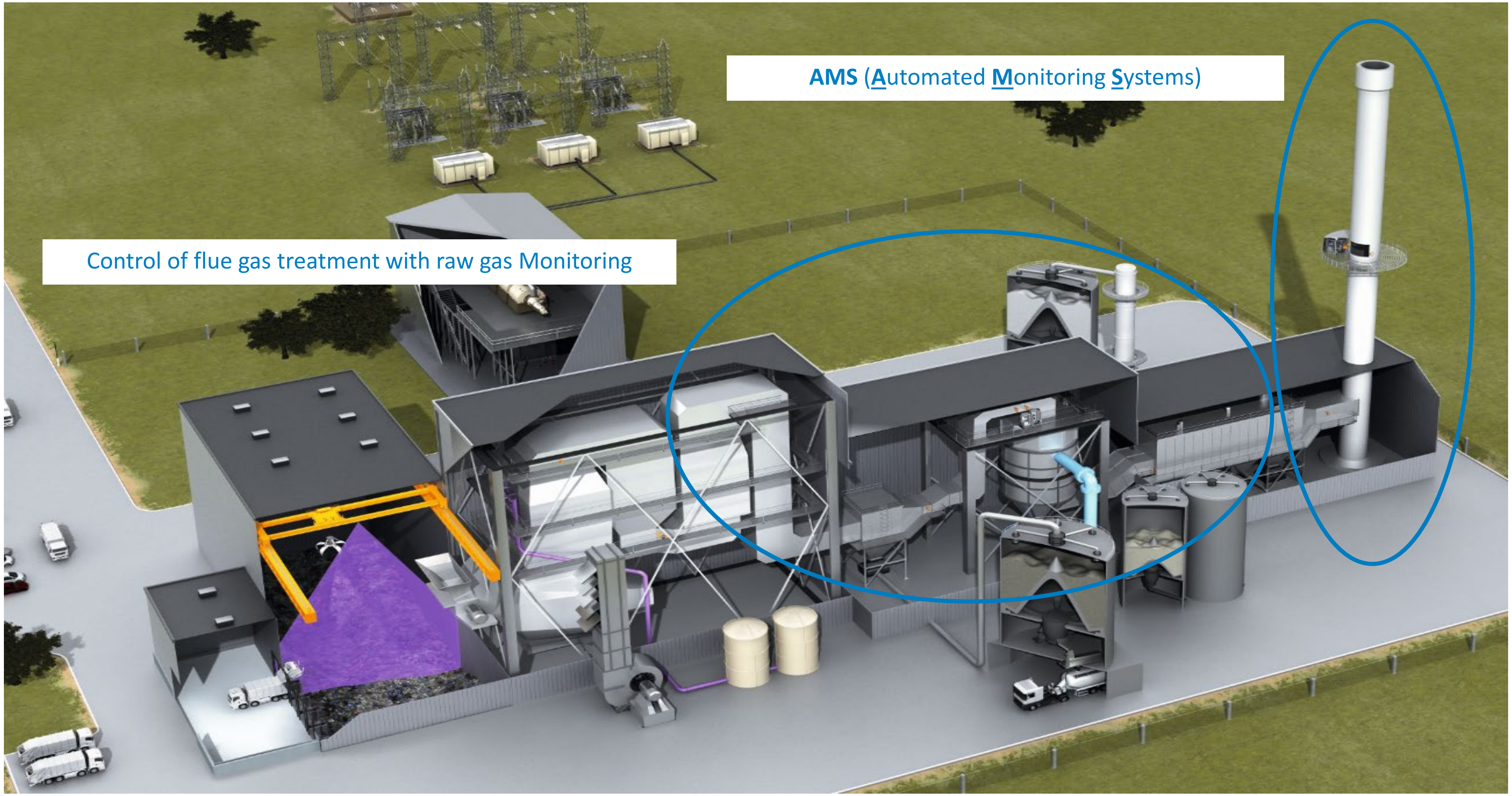
BAT AEL: Best Available Technologies – Associated Emission Levels

* the lower end of the BAT-AEL range can be achieved when using SCR

** where SCR is not applicable

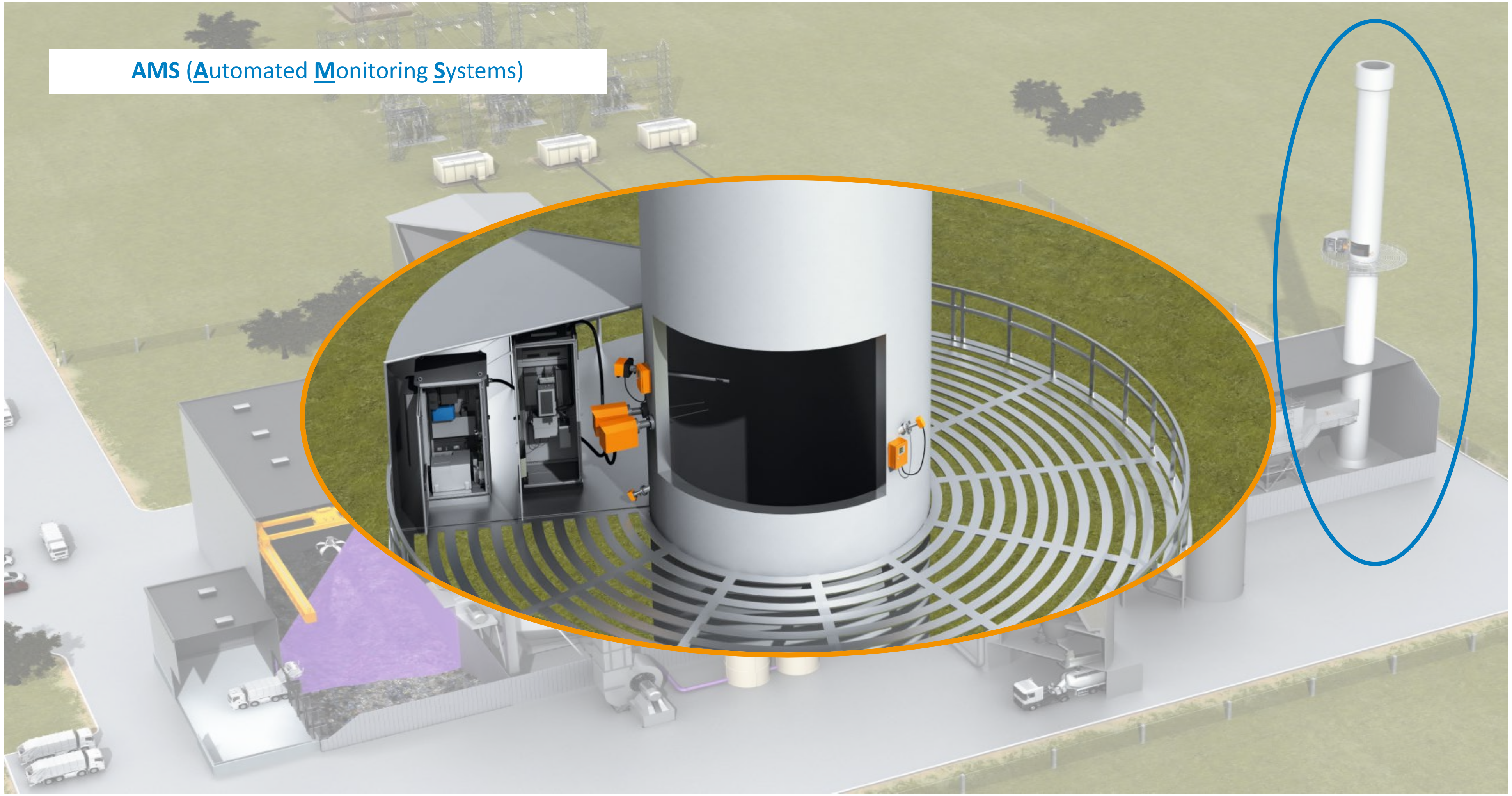
Measurement technologies and data evaluation from WtE

Continuous monitoring systems



Measurement technologies and data evaluation from WtE

Continuous Emission Monitoring : AMS



Measurement technologies and data evaluation from WtE

Continuous Emission Monitoring: AMS

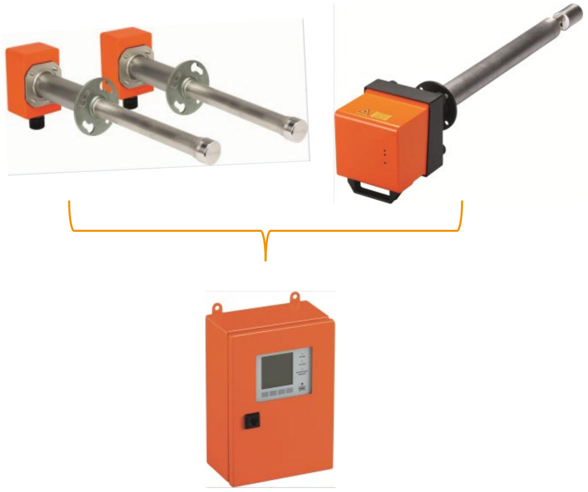
Continuous Emission Monitoring of all required components according to **the european regulations**

Multi-component Analyzer

SO_2, CO, NH_3, HCl, HF, TOC, NOx, CO_2, H_2O, O_2

Total Mercury Analyzer

Mercury

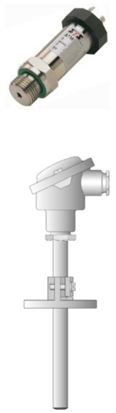


Flowmeter

Flow

Dust Analyzer

Dust



Pressure Temperature

Reference values

Data Acquisition and Handling System

Data evaluation and storage

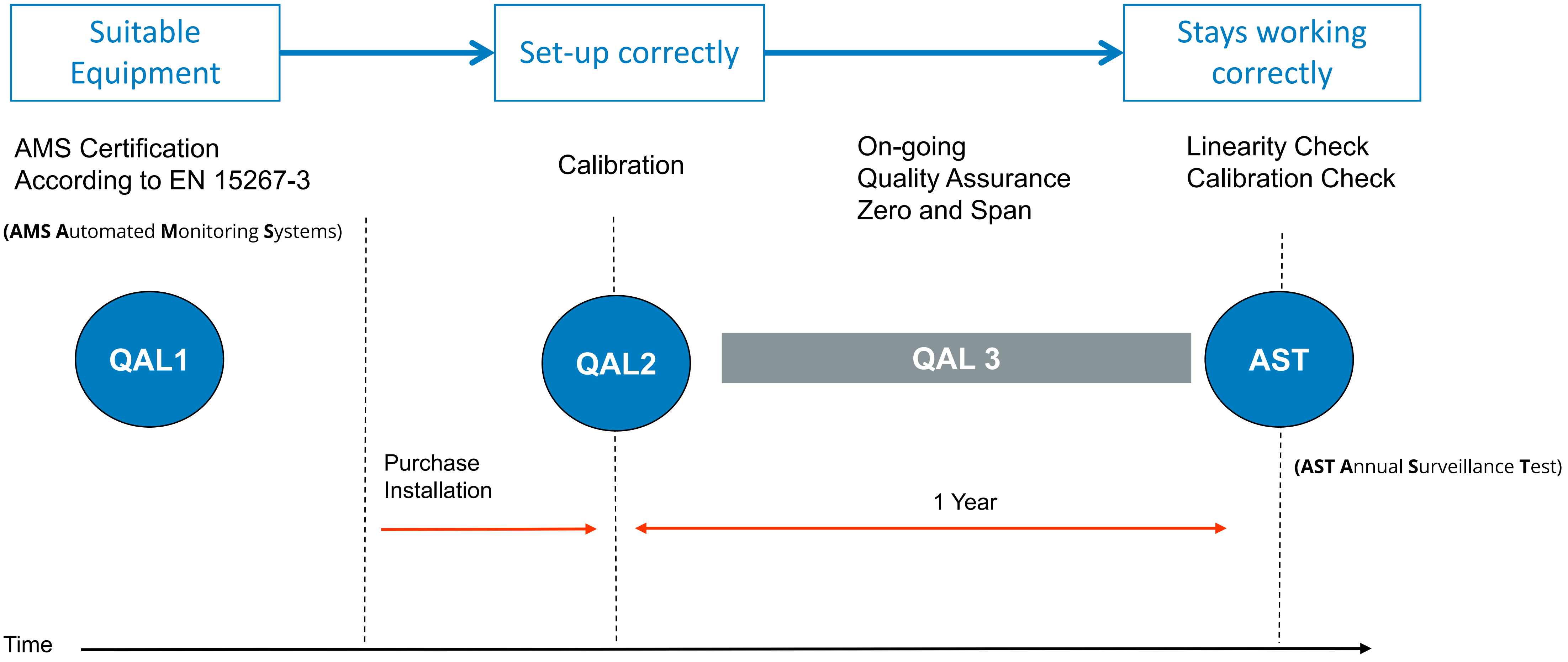
Continuous control of ELVs compliance

Reporting to the Authorities

Regulations for Continuous Emission Monitoring

Quality steps according to the European Regulations

Overview on the QAL "EN14181" systematic

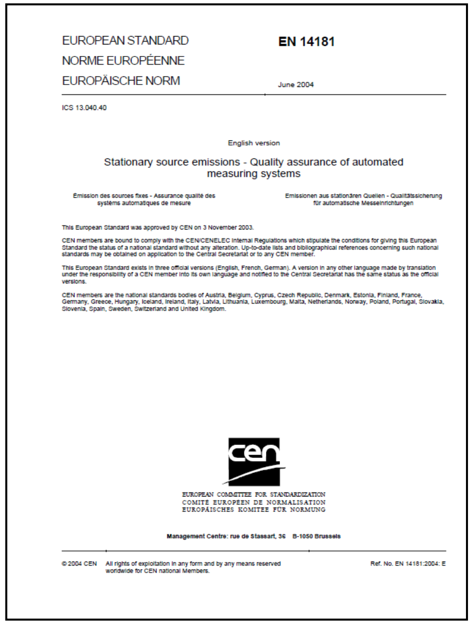


Regulations for Continuous Emission Monitoring

Legal linkages

EU Directives

QAL3



EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 14181

June 2004

ICS 13.040.40

English version

Stationary source emissions - Quality assurance of automated measuring systems

Émission des sources fixes - Assurance qualité des systèms automatiques de mesure

Emissionen aus stationären Quellen - Qualitätssicherung für automatische Messeinrichtungen

This European Standard was approved by CEN on 3 November 2003.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

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Ref. No. EN 14181:2004: E

Type Approval

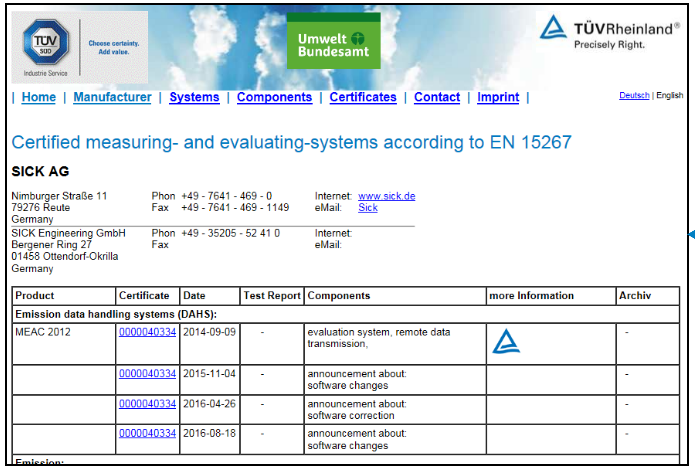
QAL1

QAL2
&
AST

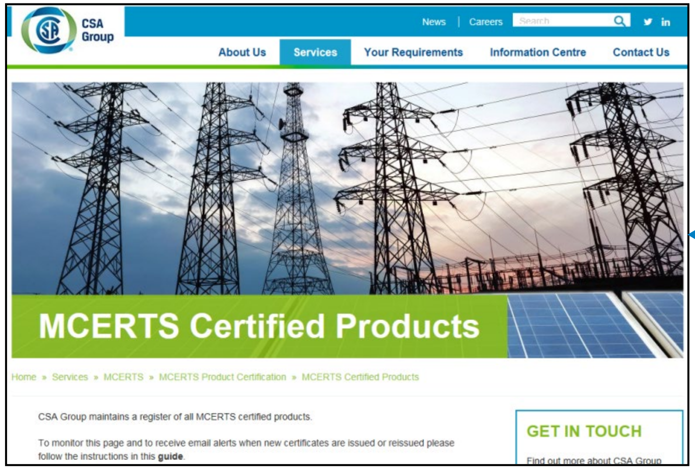
Accredited Labs

Regulations for Continuous Emission Monitoring

EN 15267-3 Certification of AMS, Performance criteria and test procedures

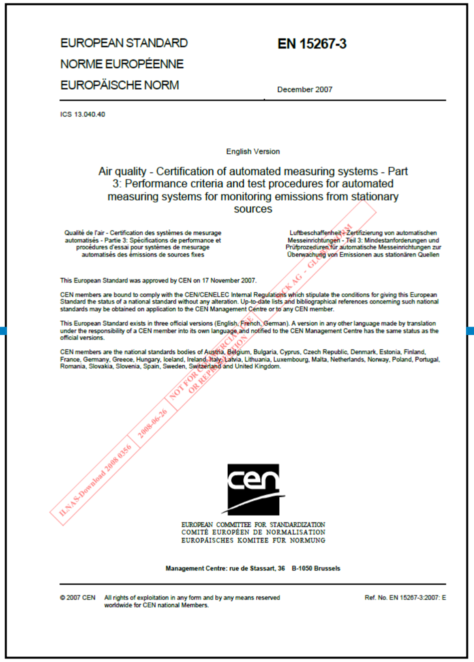


http://www.qal1.de/en/index.htm



http://www.csagroupuk.org/services/mcerts/263/

Certification of AMS



QAL1

EN 15267-3 certified

Regulations for Continuous Emission Monitoring

EN 15267-3 Certification of AMS, Performance criteria and test procedures

EN 15267-3 Performance criteria, which must be fulfilled for all analyzers

- Response time
- Repeatability standard deviation at zero and span points
- Lack of fit (linearity) under laboratory and field conditions
- Zero and span drift under laboratory and field conditions
- Influence of ambient temperature
- Influence of sample gas pressure
- Influence of sample gas flow for extractive AMS (Automated Measuring System)
- Influence of voltage variations
- Influence of vibration

Regulations for Continuous Emission Monitoring

EN ISO/IEC 17025 – Accreditation of Labs

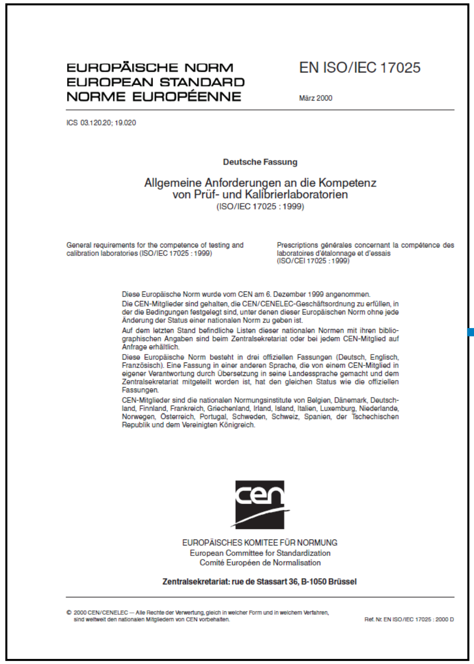
General requirements for the competence of testing and calibration laboratories

TÜV NORD

LNE LABORATOIRE NATIONAL D'ESSAIS

NPL National Physical Laboratory

1999/2005/2017



EUROPÄISCHE NORM
EUROPEAN STANDARD
NORME EUROPÉENNE

EN ISO/IEC 17025

März 2000

ICS 03.120.20; 19.020

Deutsche Fassung

Allgemeine Anforderungen an die Kompetenz von Prüf- und Kalibrierlaboratorien (ISO/IEC 17025 : 1999)

General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025 : 1999)

Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais (ISO/CEI 17025 : 1999)

Diese Europäische Norm wurde vom CEN am 6. Dezember 1999 angenommen.

Die CEN-Mitglieder sind gehalten, die CEN/CENELEC-Geschäftsordnung zu erfüllen, in der die Bedingungen festgelegt sind, unter denen dieser Europäischen Norm ohne jede Änderung der Status einer nationalen Norm zu geben ist.

Auf dem letzten Stand befindliche Listen dieser nationalen Normen mit ihren bibliographischen Angaben sind beim Zentralsekretariat oder bei jedem CEN-Mitglied auf Anfrage erhältlich.

Diese Europäische Norm besteht in drei offiziellen Fassungen (Deutsch, Englisch, Französisch). Eine Fassung in einer anderen Sprache, die von einem CEN-Mitglied in eigener Verantwortung durch Übersetzung in seine Landessprache gemacht und dem Zentralsekretariat mitgeteilt worden ist, hat den gleichen Status wie die offiziellen Fassungen.

CEN-Mitglieder sind die nationalen Normungsinstitute von Belgien, Dänemark, Deutschland, Finnland, Frankreich, Griechenland, Irland, Island, Italien, Luxemburg, Niederlande, Norwegen, Österreich, Portugal, Schweden, Schweiz, Spanien, der Tschechischen Republik und dem Vereinigten Königreich.

cen

EUROPÄISCHES KOMITEE FÜR NORMUNG
European Committee for Standardization
Comité Européen de Normalisation

Zentralsekretariat: rue de Stassart 36, B-1050 Brüssel

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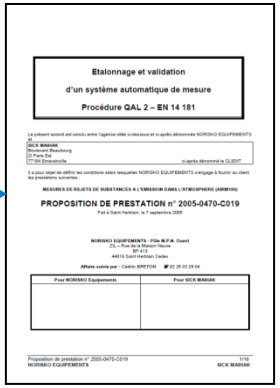
Ref. Nr. EN ISO/IEC 17025 : 2000 D

QAL2 & AST



Etalonnage et validation
d'un système automatique de mesure
Procédure QAL 2 – EN 14 181

Le présent accord est conclu entre l'agence citée ci-dessous et ci-après dénommée NORISKO EQUIPEMENTS et

SICK MAIHAK
Boulevard Beaubourg
ZI Paris Est
77184 Emerainville
ci-après dénommé le CLIENT

Il a pour objet de définir les conditions selon lesquelles NORISKO EQUIPEMENTS s'engage à fournir au client les prestations suivantes :

MESURES DE REJETS DE SUBSTANCES A L'EMISSION DANS L'ATMOSPHERE (AIRM100)

PROPOSITION DE PRESTATION n° 2005-0470-C019

Fait à Saint Herblain, le 7 septembre 2005

NORISKO EQUIPEMENTS - Pôle M.P.N. Ouest
ZIL – Rue de la Maison Neuve
BP 413
44819 Saint Herblain Cedex

Affaire suivie par : Cédric BRETON 02 29 03 29 04

Pour NORISKO Equipements	Pour SICK MAIHAK

Proposition de prestation n° 2005-0470-C019 1/16
NORISKO EQUIPEMENTS SICK MAIHAK

BS EN14181 Calibration

STOP DO NOT ADJUST WITHOUT PRIOR APPROVAL

Type	Carried Out	Next Due

Measurement technologies and data evaluation from WtE

Summary

Long-term stable low emissions at WTE ensured by

- **Continuous monitoring and reporting** of emissions
  - with certified AMS (Automated Monitoring Systems)
  - Regulatory Reporting and continuous data acquisition of emissions values
- European Regulations and WI BREF with legally binding BAT conclusions
- **Quality insurance of AMS** according to European standards
  - Compliant hardware setup and factory calibration
  - Reliable on-site calibration
  - Ongoing quality check during operation
- **Accredited laboratories** for certification of AMS and ongoing quality checks

Thank you for your attention!

Aurélie Moll
Strategic Industry Manager
Carbon Capture Utilization & Storage
aurelie.moll@sick.de

Panel Discussion and Q&A

- **Anita Matic**
  Policy Officer, DG Environment, EUROPEAN COMMISSION
- **Leen de Bruycker,**
  Technical Officer, CEWEP
- **Giovanni Lonati,**
  Associate Professor, POLYTECHNIC UNIVERSITY OF MILAN
- **Rüdiger Margraf**
  Managing Director at LUEHR, ESWET TC COMMMITTEE
- **Aurélie Moll,**
  Strategic Industry Manager CCUS at SICK, ESWET TC COMMITTEE

THANK YOU FOR YOUR PARTICIPATION!

For any further information, please write to:

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www.eswet.eu

ESWET
EUROPEAN SUPPLIERS OF WASTE-TO-ENERGY TECHNOLOGY