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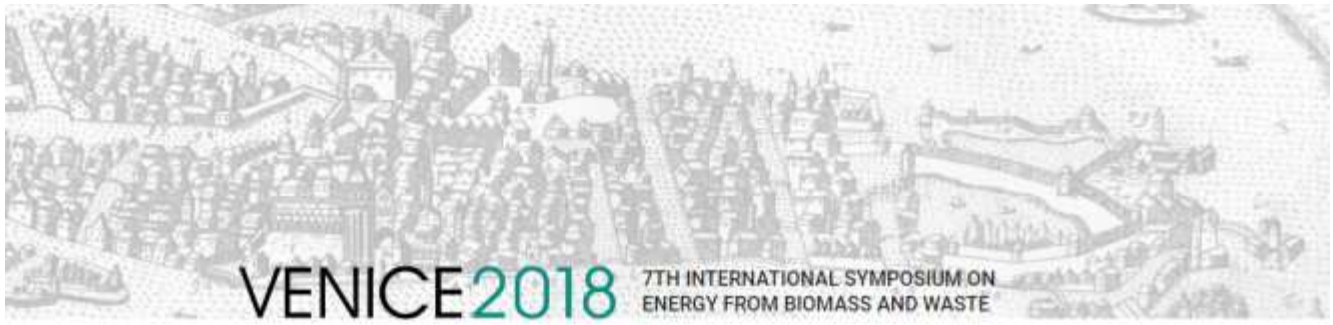
POLITECNICO DI MILANO



POLITECNICO
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Brianza Energia Ambiente

Session E7
Control of contaminants in waste management and health protection

The actual contribution of WTE plants emissions to air quality: a case study from Northern Italy

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Overview

- Background & motivation
- Study goals
- Materials and methods
- Results
- Conclusions

Background & motivation

- Waste to Energy (WTE) facilities are subject to **stricter and stricter regulatory emission limits** and forced to adopt **state-of-the-art technology** for flue gas treatment
- Nevertheless, they frequently face **strong protests** from local communities where they are situated and the location of new plants is critical because of the considerable **concern in the public opinion** about possible **adverse health effects** associated with waste incineration
- Health risk assessment studies for new plants, usually based on both maximum plant throughput and stack concentrations (i.e. precautionary estimating upper bound impact on air quality), indicate **acceptable incremental risk**.

Background & motivation

- Nevertheless, **risk perception** in most of the public opinion is biased by a number of factors, because proper environmental education (i.e.: levels of risk awareness and knowledge) is still scarce. *(Ren et al., 2015)*
- **Risk communication** and public involvement are ways to reduce overpriced risk perception *(Petts, 1992)*.
- Finally, studies **comparing the impact on local air quality due to emissions from WTE plants and other common sources** (e.g.: road traffic, domestic heating through biomass burning) are rare and limited to emission inventory data comparison, thus neglecting the features of flue gas release into the atmosphere.

Study goals

This work focuses on the following three issues:

- **assess** the **actual impact of a WTE plant** on local air quality based on its real emission data,
- **assess** the impact on plant's emissions and ensuing impact on air quality **impact of the latest plant retrofit in 2016**,
- **compare** the impact on local air quality of the **WTE plant**'s stack emissions with the impact of **ground-level road traffic** emissions from the main roads crossing the municipality where WTE plant is located

Case study for this work is WTE plant run by BEA SpA in Desio (Northern Italy – Lombardia Region)

Plant history

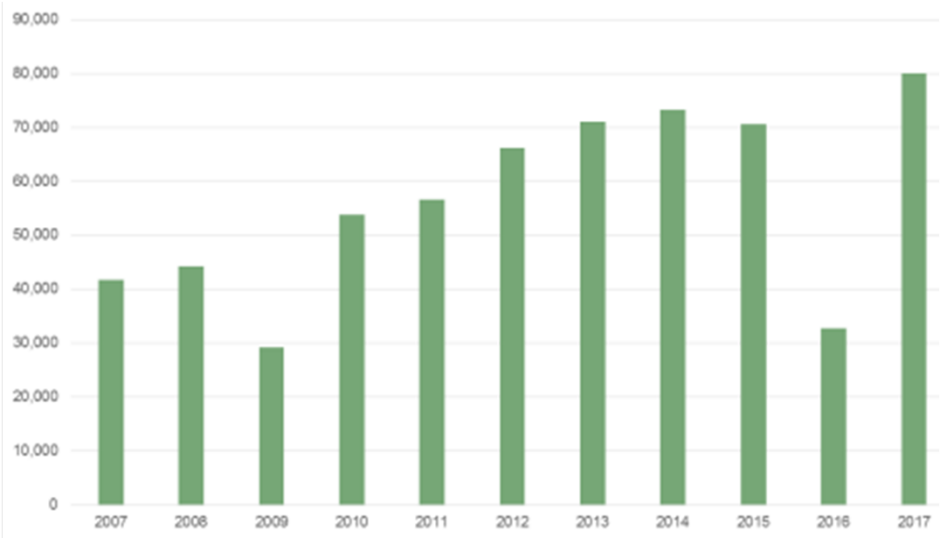
1976 – Plant start-up

1989 – Energy recovery start-up

1997 – District heating start-up

2016 – Plant revamping

Waste throughput (tons/year)

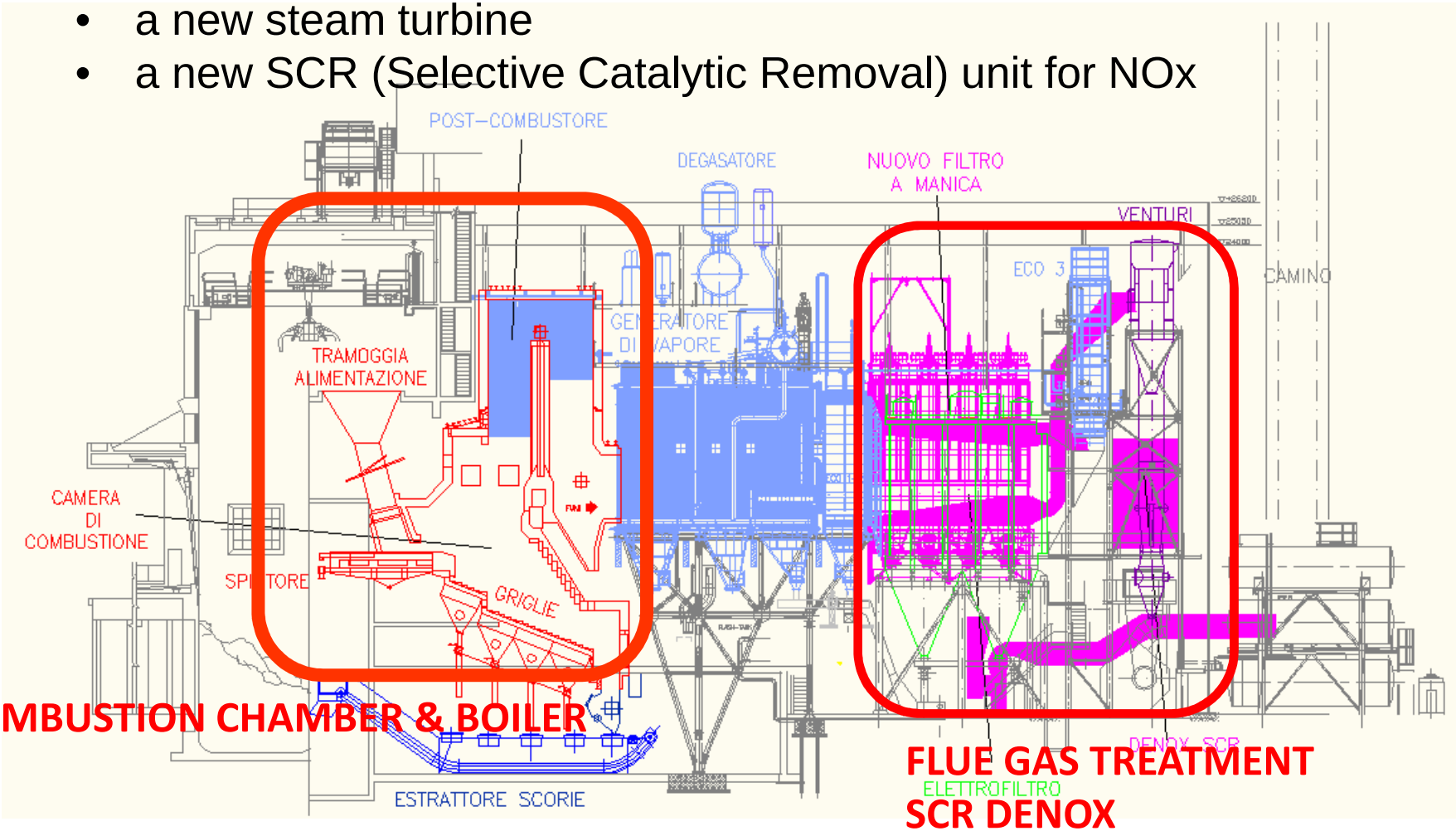


HCl 2.78 mg/Nm3	CO 12.20 mg/Nm3	NOx 70.31 mg/Nm3	NH3 0.18 mg/Nm3
COT 0.04 mg/Nm3	SO2 1.37 mg/Nm3	Polveri 0.00 mg/Nm3	PCDDs/PCDFs 0,002 ngTEQ/Nm^3

Plant revamping 2016

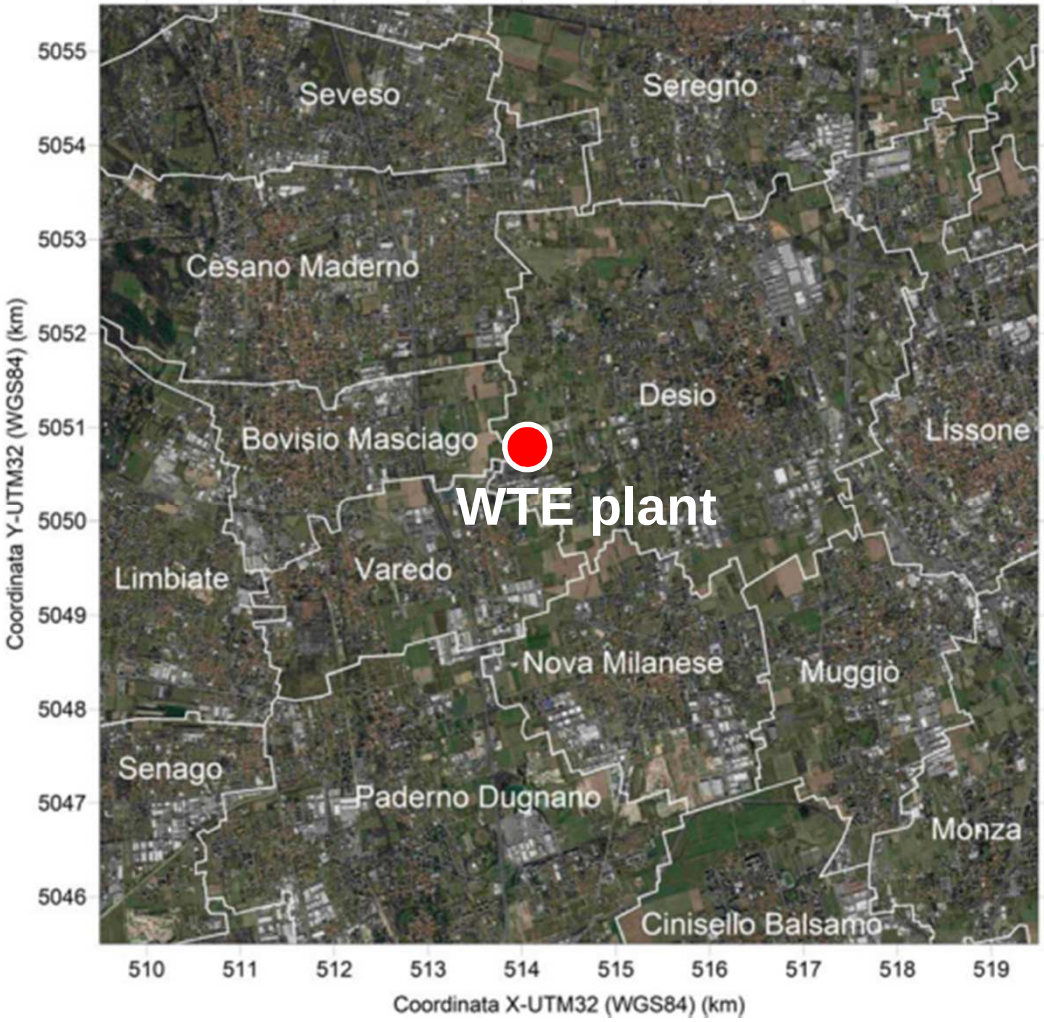
Plant retrofit in 2016 involved:

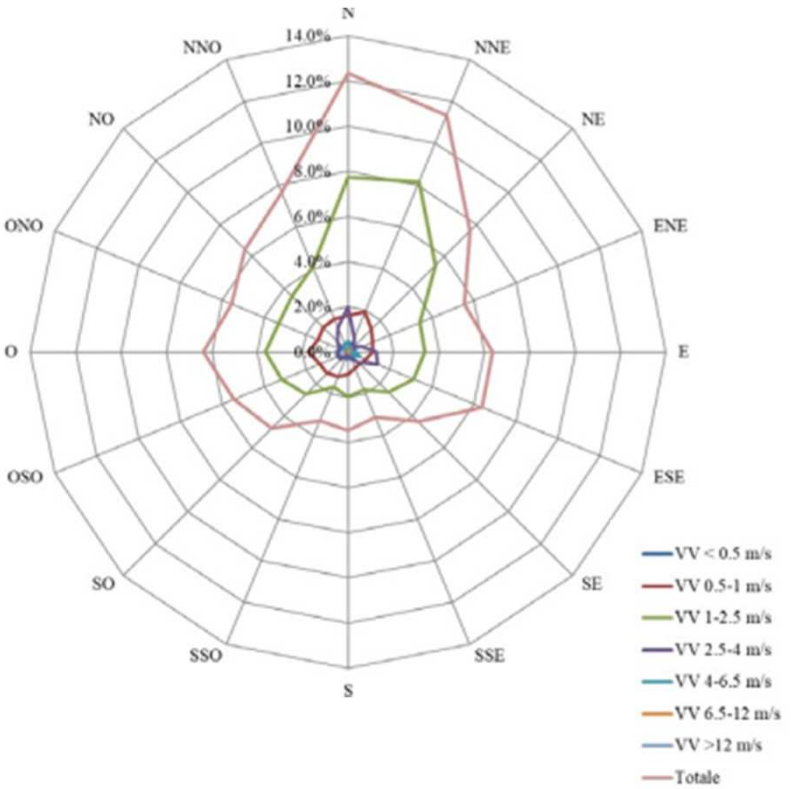
- a 40% increase in the incineration capacity,
- a new steam turbine
- a new SCR (Selective Catalytic Removal) unit for NOx



Materials & methods
Study area

- Desio municipality and surroundings





Meteorological data supplied by the Regional Environmental Protection Agency for year 2016

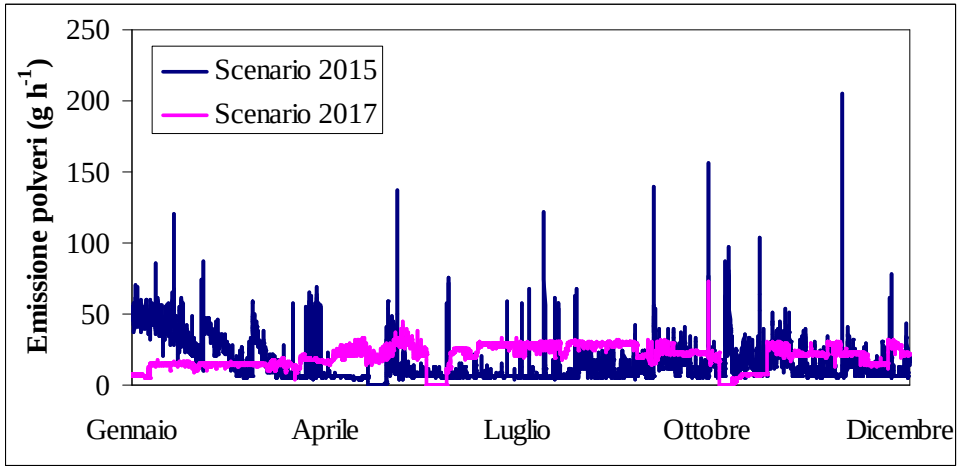
Materials & methods
WTE emission data

- Two Scenarios simulated
  - Scenario 2015 (before plant revamping)
  - Scenario 2017 (after plant revamping)
- Hourly data for flue gas temperature and speed, PM10 and NOx from CEM system (SME) of the plant
- Cd and PCDD/F concentrations from discontinuous sampling
  - Max value out of 3 annual data for Cd
  - Monthly averaged concentration for continuous sampling for PCDD/F

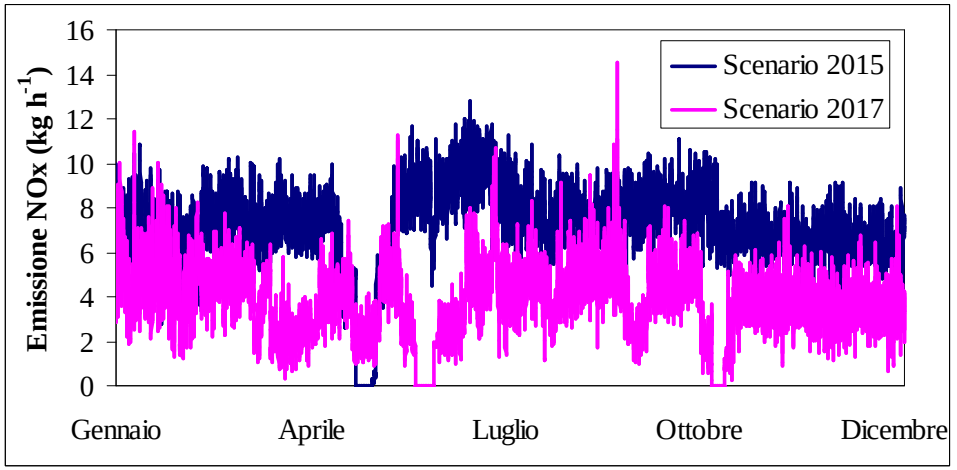
Parameter	PM10 (g h^{-1})		NOx (kg h^{-1})		Cd (mg h^{-1})		PCDD/F (ng_{TEQ} h^{-1})	
	2015	2017	2015	2017	2015	2017	2015	2017
Average	15.5	20.9	7.38	4.00	11.4	22.2	69.1	39.9
Median	10.8	21.6	7.38	4.00	11.6	23.3	64.8	40.7
Minimum	0.4	1.4	0.07	0.22	0.6	4.5	3.2	1.8
Maximum	205.6	72.7	12.82	14.54	15.4	29.4	202.7	110.2
Maximum Authorized	1100		22		5500		11000	

Materials & methods
WTE emission data

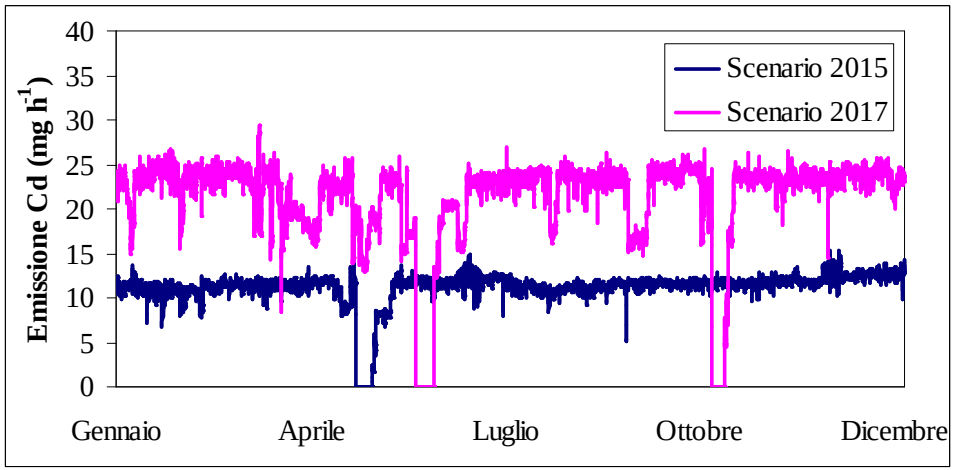
- Actual mass flow rate



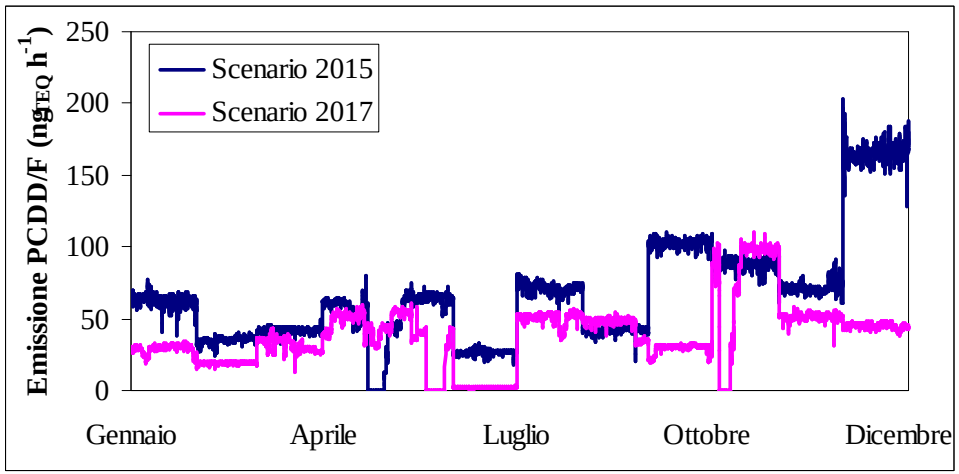
Authorized flow rate: 1100 g h^{-1}



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



Authorized flow rate: 5500 mg h^{-1}

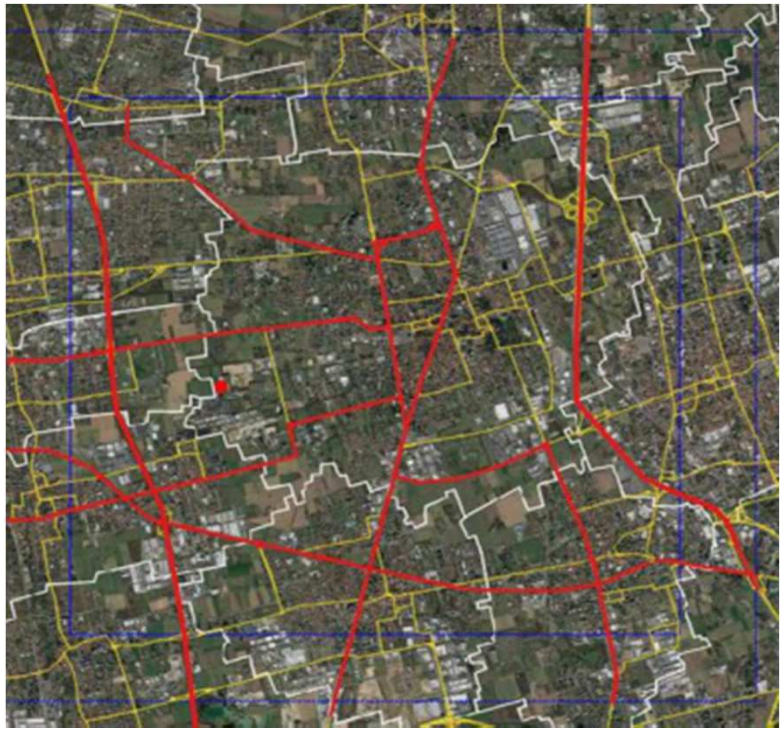


Authorized flow rate: 11000 ng_{TEQ} h^{-1}

Materials & methods
Road traffic emission data

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

	u.o.m.	Cars	Vans (< 3.5 t)	Trucks (> 3.5 t)
PM10	mg km^{-1}	39.9	77.4	217.9
NO_2	mg km^{-1}	152.8	347.9	598.3
Cd	mg km^{-1}	0.0007	0.0009	0.0024
PCDD/F	pg_{TEQ} km^{-1}	21.3	39.6	49.4



Main roads considered (red arches)

- Comparison between the traffic emissions (this study) vs. total traffic emissions for Desio Municipality (emission inventory data, 2014)

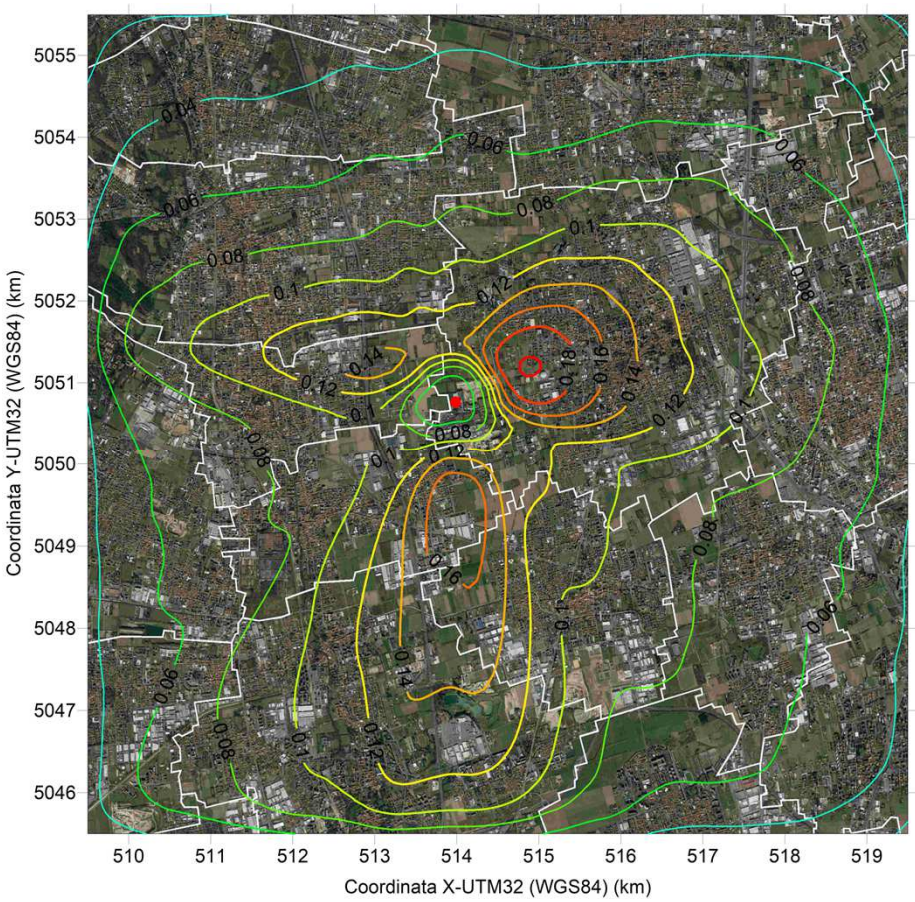
30% underestimation in our study

because «urban traffic» is neglected

Study results

- Atmospheric dispersion modelling through CALPUFF model
- WTE plant scenario comparison
  - Long-term concentrations (annual average for NO_2, PM10, Cd, PCDD/F)
  - Short-term concentrations (1-h average for NO_2, 24-h average for PM10)
- WTE plant (scenario 2017) vs. road traffic comparison
  - Long-term concentrations (annual average for NO_2, PM10, Cd, PCDD/F)
  - Short-term concentrations (1-h average for NO_2, 24-h average for PM10)

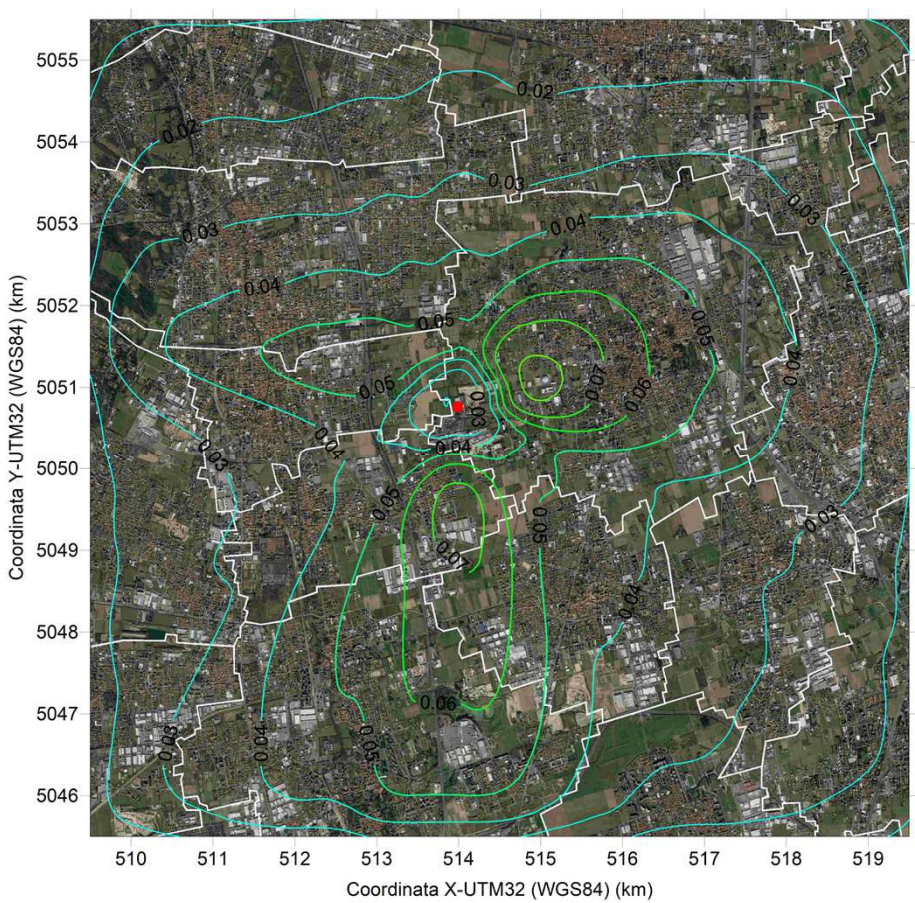
Results: WTE Plant scenarios
NO_2 annual average concentration



Scenario 2015

Max: 0.20 µg/m³

Desio urban area: 0.12-0.18 µg/m³



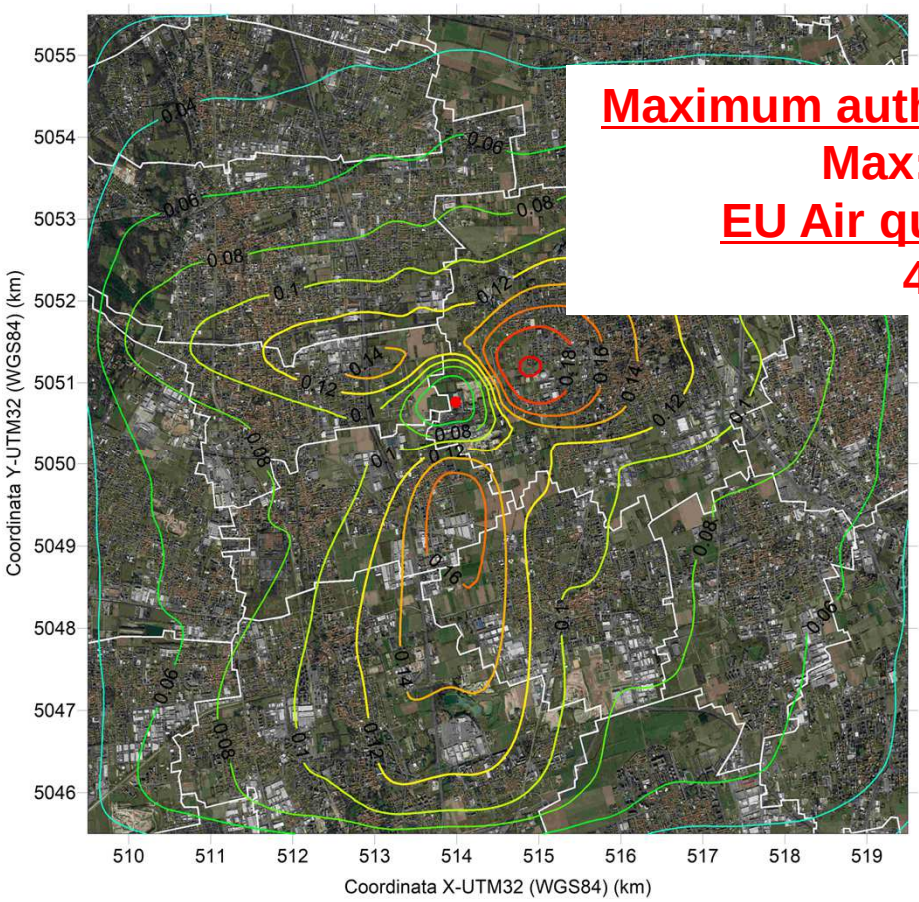
Scenario 2017

Max: 0.08 µg/m³

Desio urban area: 0.05-0.07 µg/m³

Results: WTE Plant scenarios
NO_2 annual average concentration

Maximum authorized emission rate
Max: 0.46 µg/m³
EU Air quality limit (NO_2)
40 µg/m³



Scenario 2015
Max: 0.20 µg/m³
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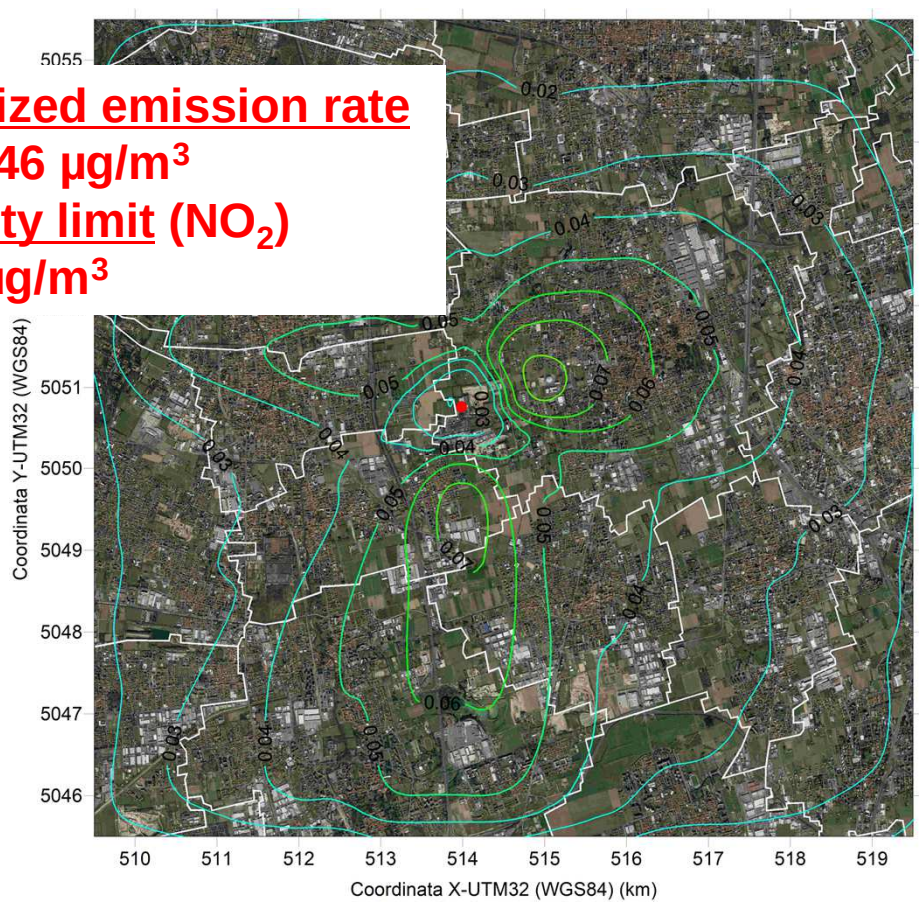


Scenario 2017
Max: 0.08 µg/m³
Desio urban area: 0.05-0.07 µg/m³

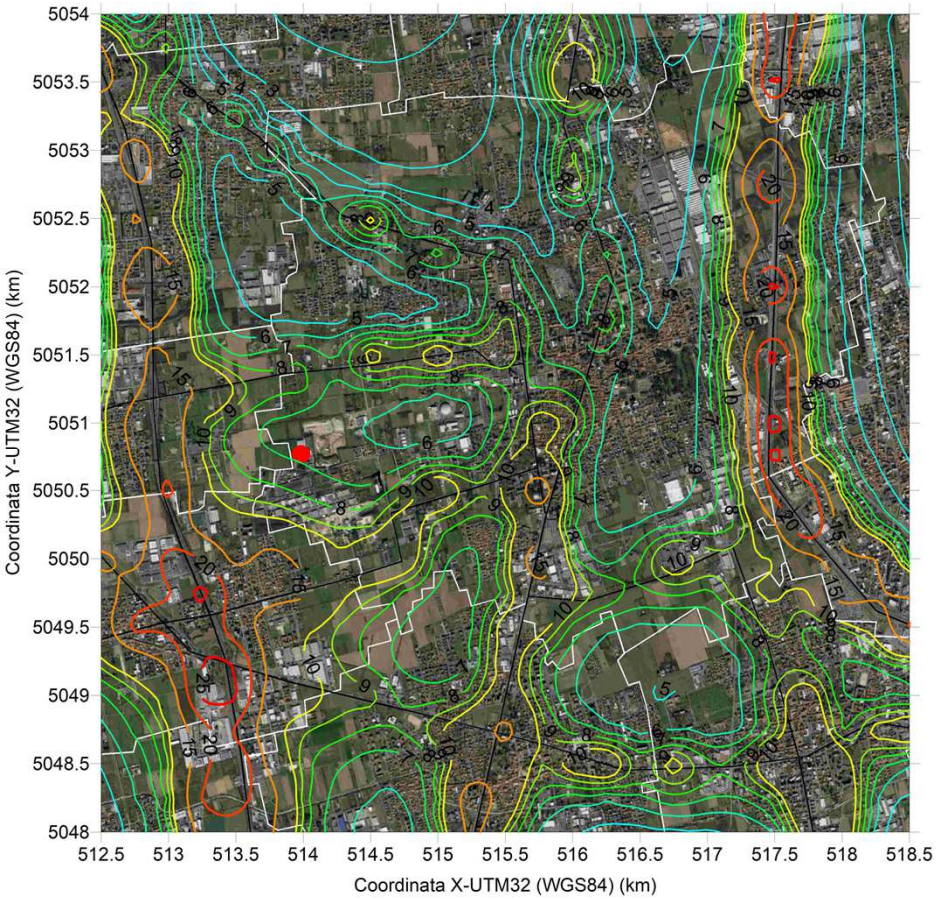
Results: WTE Plant scenarios
Annual average concentrations

		PM10 ($\mu g\ m^{-3}$)	NO_2 ($\mu g\ m^{-3}$)	Cd ($ng\ m^{-3}$)	PCDD/F ($fg_{TEQ}\ m^{-3}$)
Scenario 2015	Maximum value	$5.2 \cdot 10^{-4}$	0.20	$3.3 \cdot 10^{-4}$	$2.3 \cdot 10^{-3}$
	Urban area range	$3\text{-}4.5 \cdot 10^{-4}$	0.12-0.18	$2\text{-}3 \cdot 10^{-4}$	$1.2\text{-}1.8 \cdot 10^{-3}$
Scenario 2017	Maximum value	$4.4 \cdot 10^{-4}$	0.08	$4.8 \cdot 10^{-4}$	$8.1 \cdot 10^{-4}$
	Urban area range	$2\text{-}3.5 \cdot 10^{-4}$	0.05-0.07	$3\text{-}4 \cdot 10^{-4}$	$5\text{-}7 \cdot 10^{-4}$
Air quality limit (annual average)		40	40	1	150 (*)

(*) German guidelines: *Laenderausschuss fur Immissiosschutz*

~2.5x factor

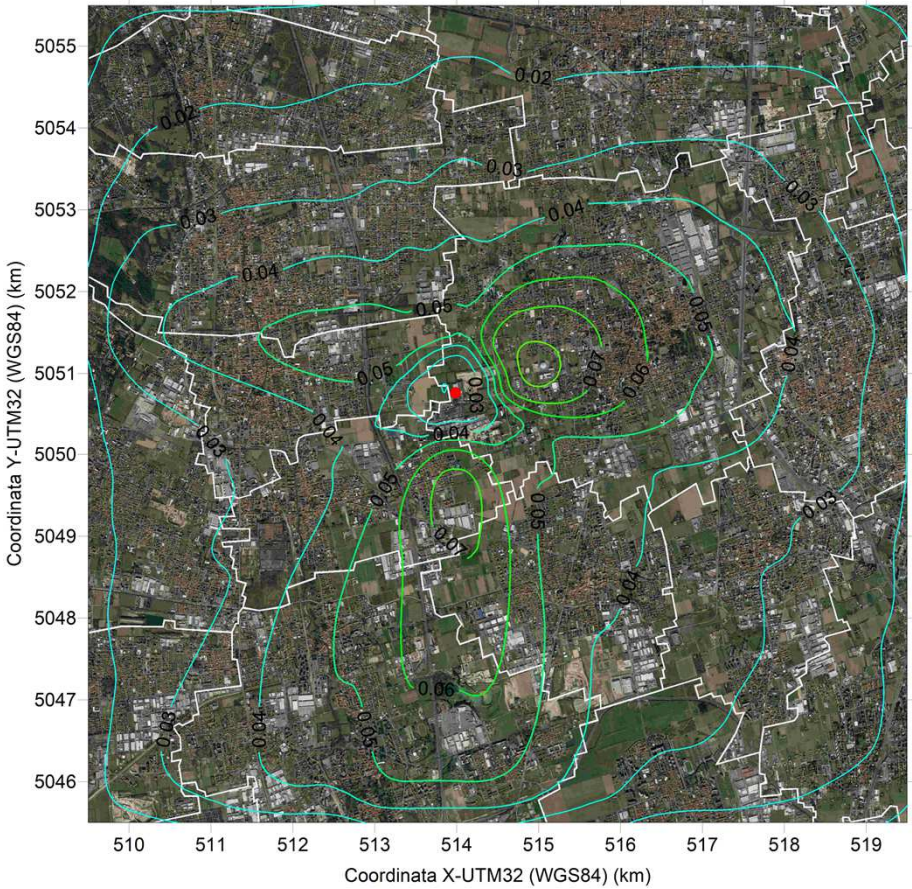
Results: Road traffic vs. WTE Plant
NO_2 annual average concentration



Road traffic

Max: 15-20 µg/m³

Desio urban area: 6-10 µg/m³

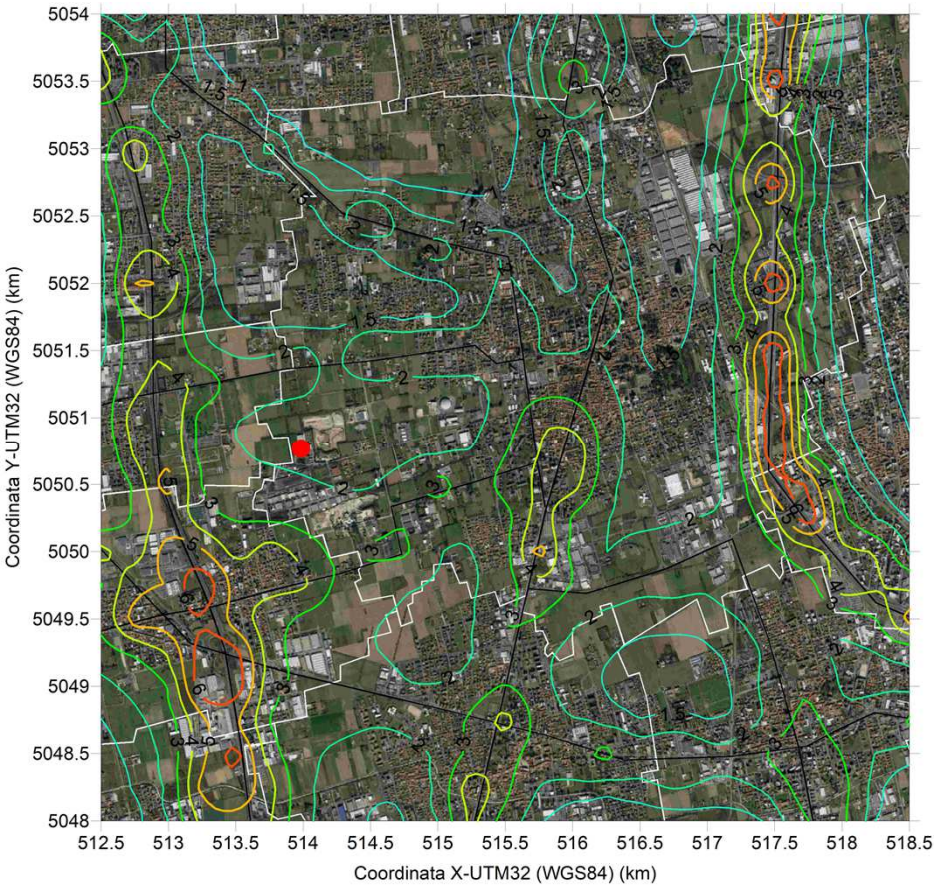


WTE plant - Scenario 2017

Max: 0.08 µg/m³

Desio urban area: 0.05-0.07 µg/m³

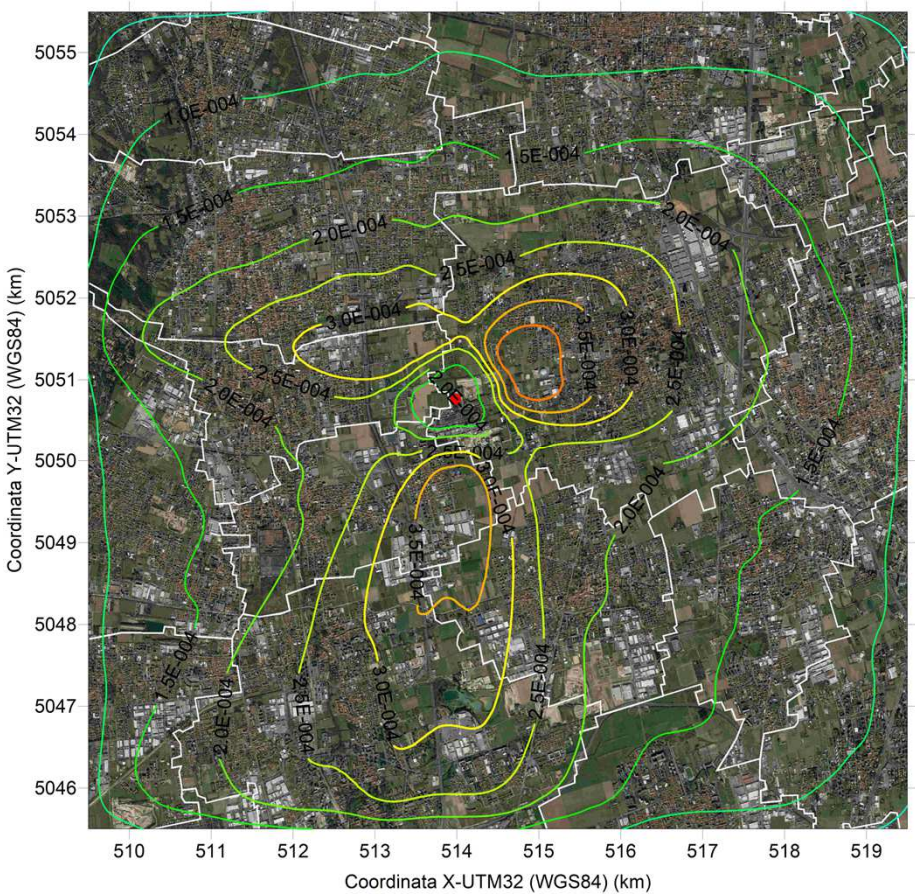
Results: Road traffic vs. WTE Plant
PM10 annual average concentration



Road traffic

Max: 5-6 µg/m³

Desio urban area: 2-3 µg/m³



WTE plant - Scenario 2017

Max: $4.4 \cdot 10^{-4}$ µg/m³

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

Results: Road traffic vs. WTE Plant
Summary tables

- Concentration range for Desio urban area

	PM10 ($\mu g\ m^{-3}$)	NO_2 ($\mu g\ m^{-3}$)	Cd ($ng\ m^{-3}$)	PCDD/F ($fg_{TEQ}\ m^{-3}$)
WTE plant	0.0002-0.00035	0.05-0.07	0.0003-0.0004	0.0005-0.0007
Road traffic	2-3	6-10	0.02-0.03	0.5-1

AQ limits for annual average
PM10: 40 µg/m³
NO_2: 40 µg/m³

	PM10: p90.4-24h ($\mu g\ m^{-3}$)	NO_2: p99.8-1h ($\mu g\ m^{-3}$)
WTE plant	$0\text{-}8\text{-}1.2 \cdot 10^{-3}$	2.5-4
Road traffic	3-6	100-150

AQ limits for 24-h and 1-h avg.
PM10: 50 µg/m³ (24-h)
NO_2: 200 µg/m³ (1-h)

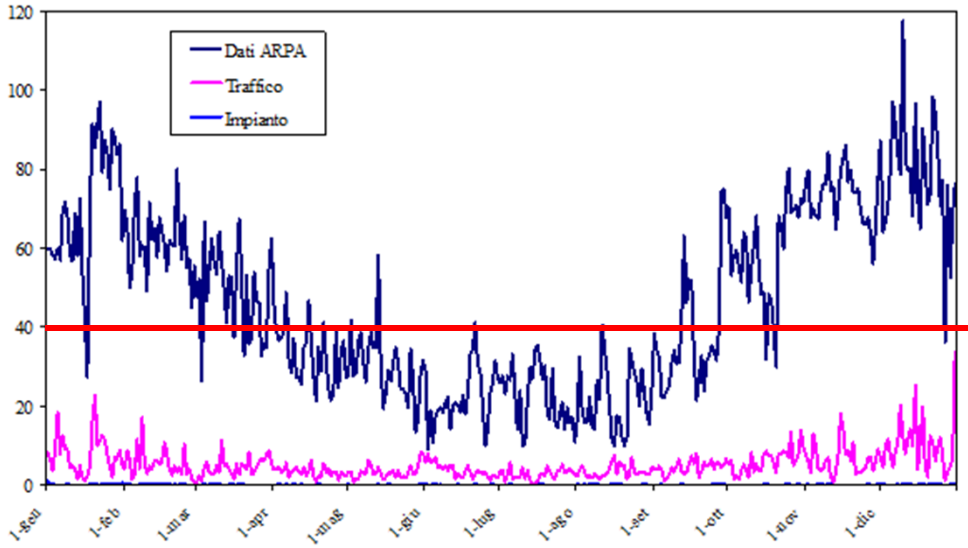
- Concentrations at maximum fallout point

	PM10 ($\mu g\ m^{-3}$)	NO_2 ($\mu g\ m^{-3}$)	Cd ($ng\ m^{-3}$)	PCDD/F ($fg_{TEQ}\ m^{-3}$)	PM10 p90.4-24h ($\mu g\ m^{-3}$)	NO_2 p99.8-1h ($\mu g\ m^{-3}$)
WTE plant	$4.4 \cdot 10^{-4}$	0.08	$4.8 \cdot 10^{-4}$	$8.1 \cdot 10^{-4}$	$1.50 \cdot 10^{-3}$	5.5
Road traffic	2	6	0.02	1	3	100

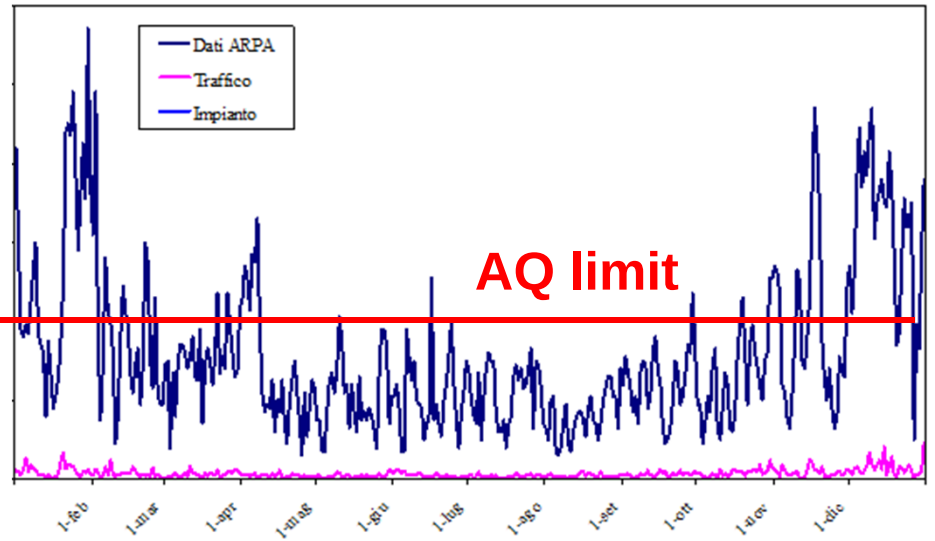
Results: Road traffic vs. WTE Plant
Air quality impact

- Comparison of road traffic and WTE plant contribution with air quality data (Desio urban area, calendar year 2016)

NO_2 daily average conc.



PM10 daily average conc.



Conclusions

- ***Confirmation*** of WTE plant impact on air quality in Desio urban area
- ***Relevant resizing*** of WTE plant actual impact on local air quality (at least 5x factor for NOx, up to 250x factor for Cd and 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 $\mu g/m^3/kt_{waste}$ down to 0.001 $\mu g/m^3/kt_{waste}$
- ***Extremely modest contribution*** of WTE plant emissioni 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

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Thanks for your attention