

# Construction Retrofit in the Context of the LEZ Berlin

7<sup>th</sup> VERT FORUM

Filter and  
deNOx-technologies

Efficient for both, diesel and  
gasoline direct injection vehicles



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**Berlin**

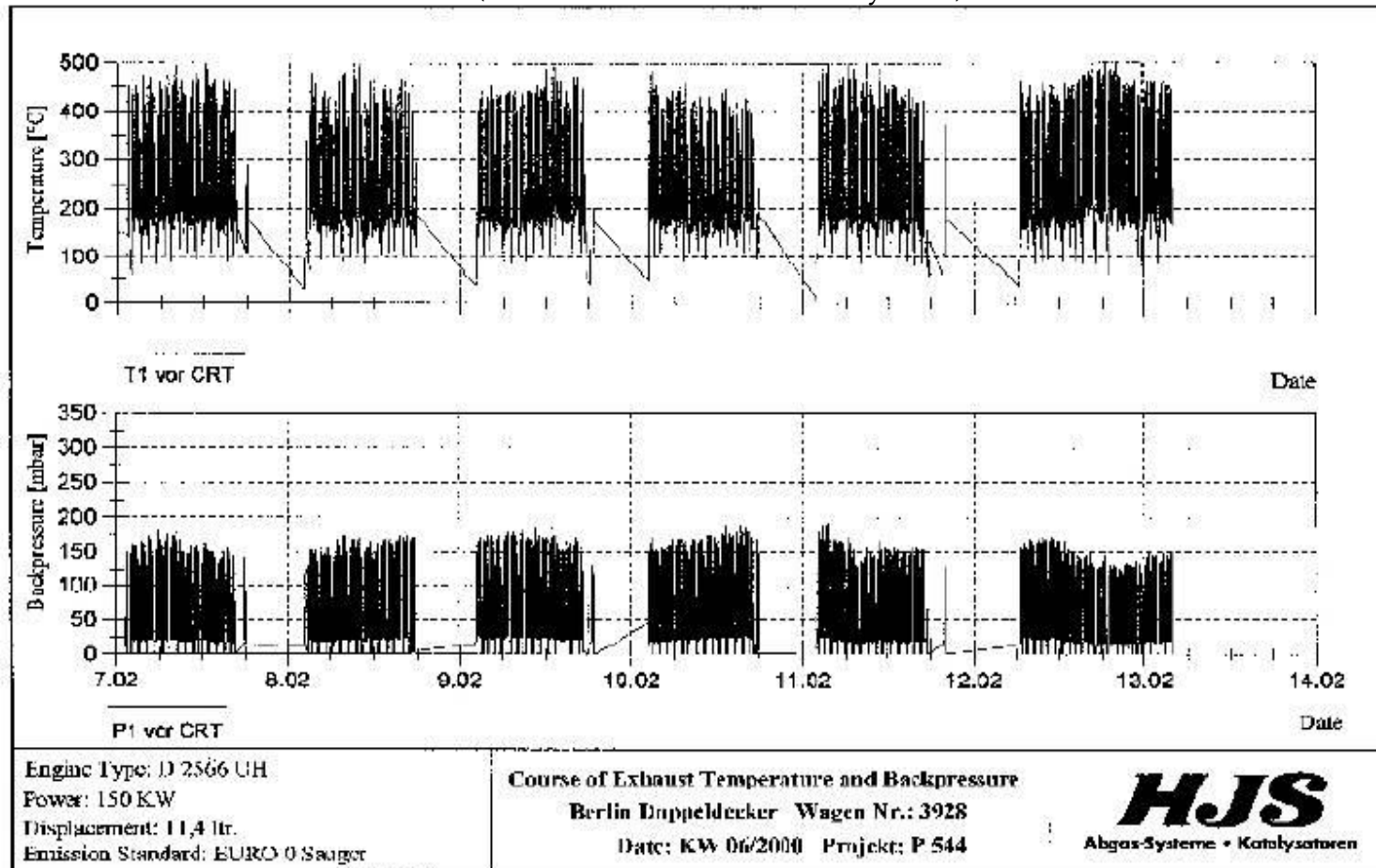
## What to expect from this presentation?

- Contribution to reduction of superfine soot particle emission in low emission zone
- New engines of construction machines are regarding exhaust emission characteristics worse than 10 years old engines of HD on-road vehicles
- Inquiries of citizens regarding measures also at construction machines (equal treatment)
- The target is to determine what is possible and where is the borderline

## The backpressure and temperature with CRT

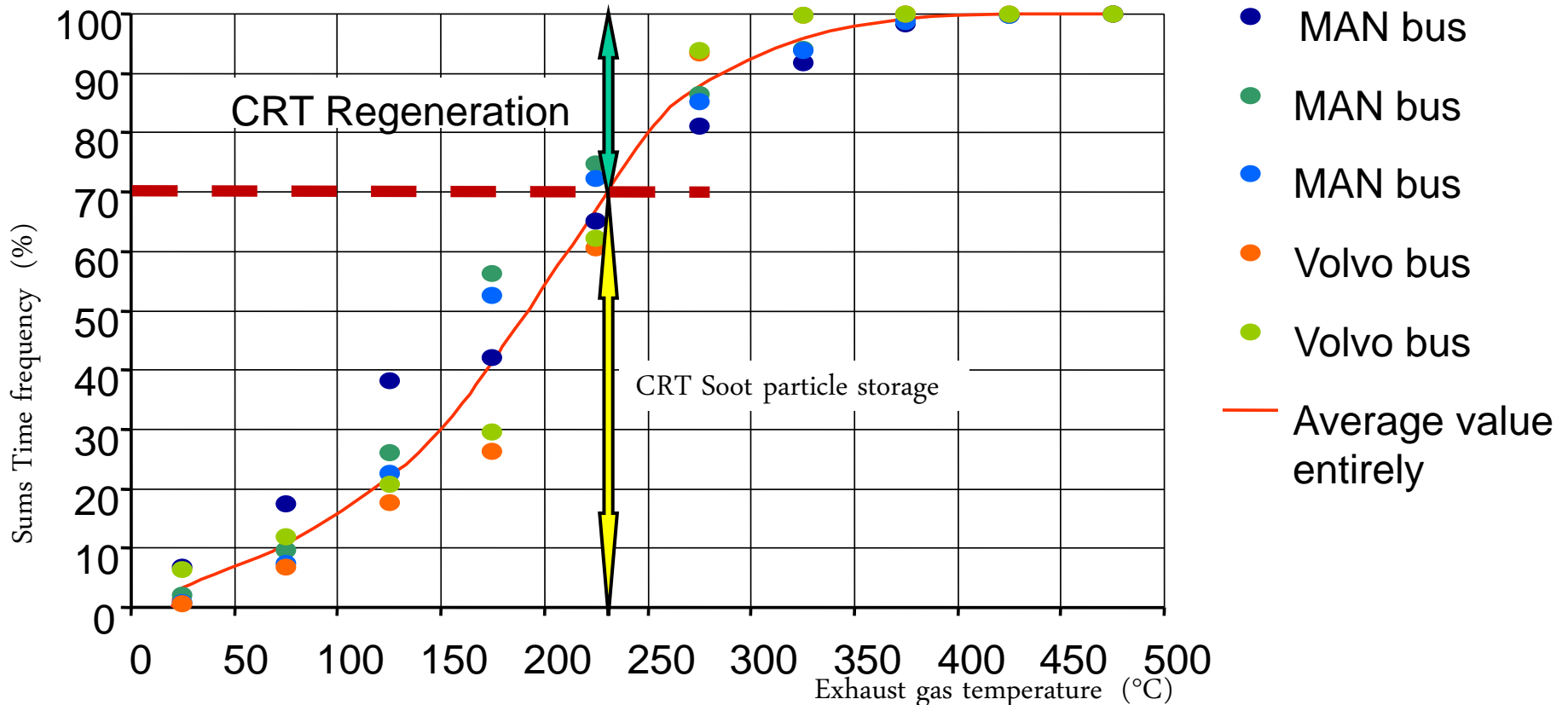
Temperature and exhaust-gas back-pressure ahead of CRT

(Berlin double-decker, February 2000)



## Cumulative probability of bus exhaust-gas temperatures

(CRT filter regenerates above curve, but accumulates particles below curve)



## CRT costs

	<b>Material cost</b>	<b>Wage cost</b>
CRT retrofitting	5,500 to 7,000 EUR	150 EUR
CRT regeneration		200 EUR

CRT failure	0.5% p.a.
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# 1400 Busses for municipal public transport

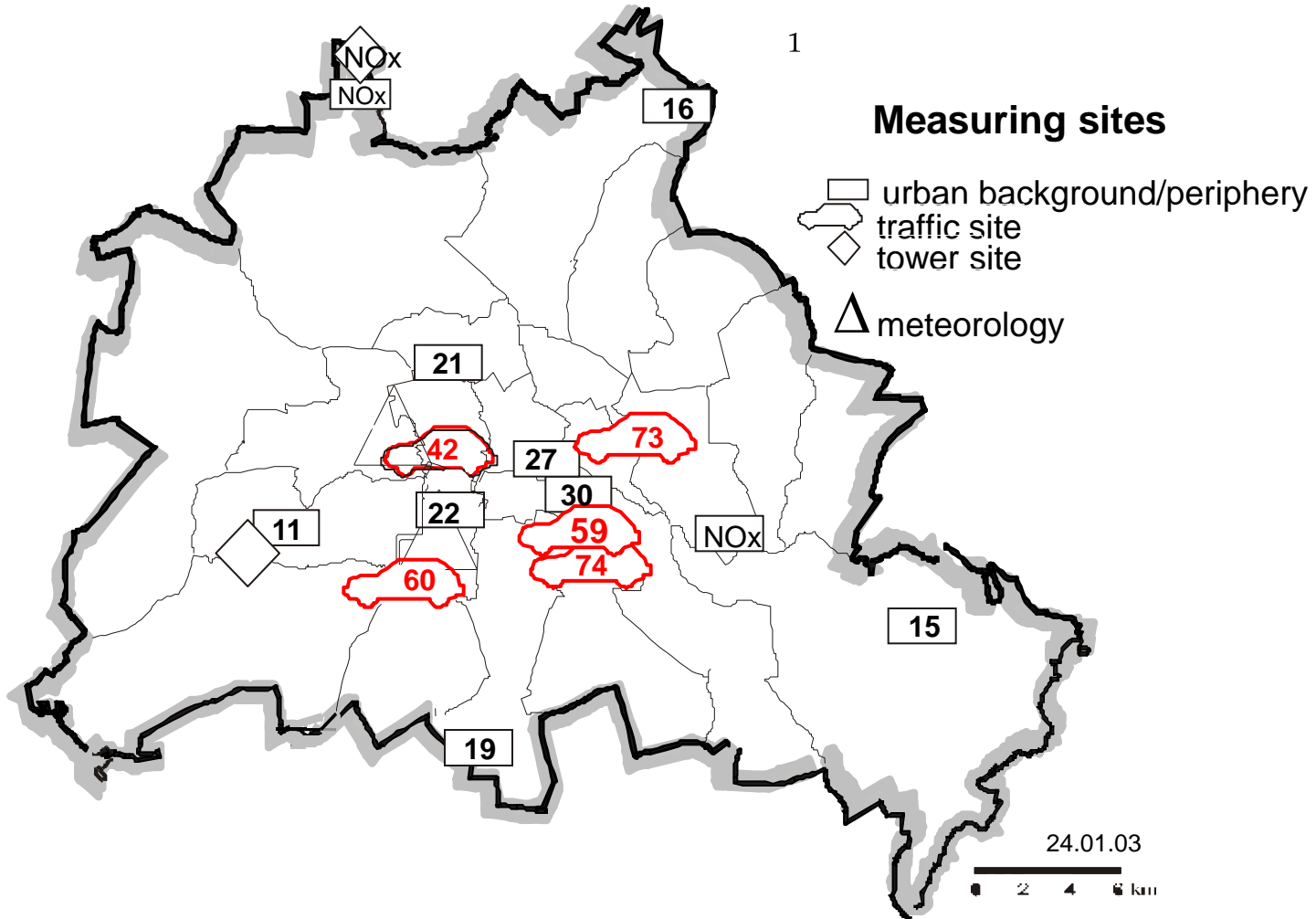
2004 72% with particulate filter

100% in only 8 years with particulate filter

	Referenz 2004	2005	2006	2007	2008	2009
EURO 0	28%	22%	10%			
EURO 0 with CRT- Particulate filter	11%	7%	7%	4%		
EURO 1 with CRT- Particulate filter	12%	12%	12%	12%	3%	
EURO 2 with CRT- Particulate filter	35%	35%	35%	35%	35%	26%
EURO 3 with CRT- Particulate filter	12%	21,9%	22%	22%	22%	22%
EURO 4 with CRT- Particulate filter	0,1%	0,1%	12%	12%	12%	12%
EURO 5 with Particulate filter / EEV	2%	2%	2%	15%	28%	40%

# Air quality monitoring network

 Number of days above  $50 \mu\text{g}/\text{m}^3$  PM10 in 2005



# Berlin LEZ emission criteria






## Area:

about 88 km<sup>2</sup>  
(Berlin total area: 892 km<sup>2</sup>)

## Inhabitants:





about 1 Million  
(Berlin total: 3,4 Mio)

## Stage 1: since 1.1.2008

-  Diesel vehicles: at least Euro 2 or Euro 1 & retrofit
-  Gasoline vehicles: at least Euro 1
-  7% of vehicle fleet affected



## Stage 2: since 1.1.2010

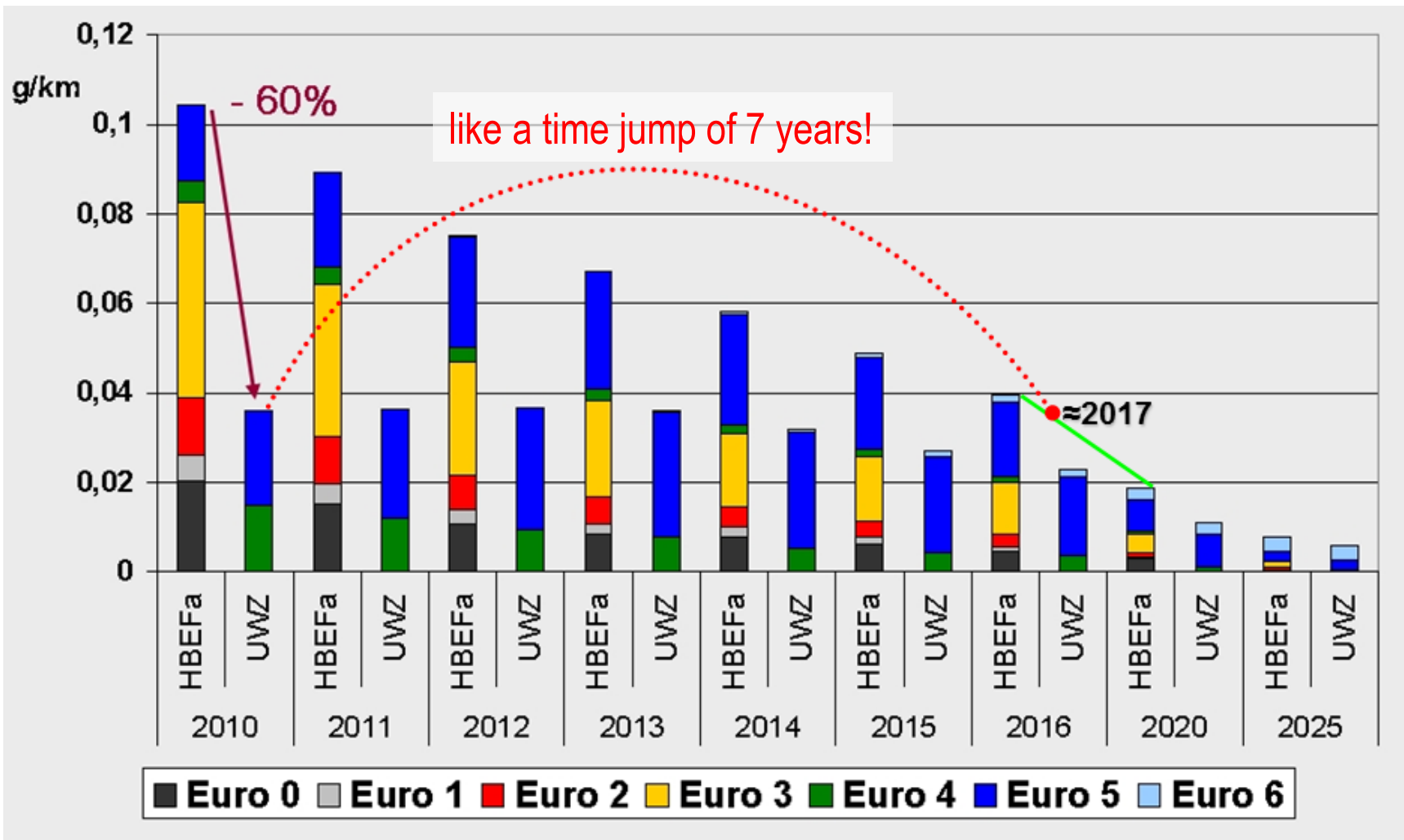
-  Diesel: particle emission Euro 4:
-  cars: Euro 3 + particle filter or better
-  goods vehicles: also retrofit of Euro 1-3 towards Euro 4<sub>Particle</sub>
-  10% of the vehicle fleet affected



 more than 40 LEZ planned/in force in Germany, another 30 LEZ in the EU, but with different emission criteria



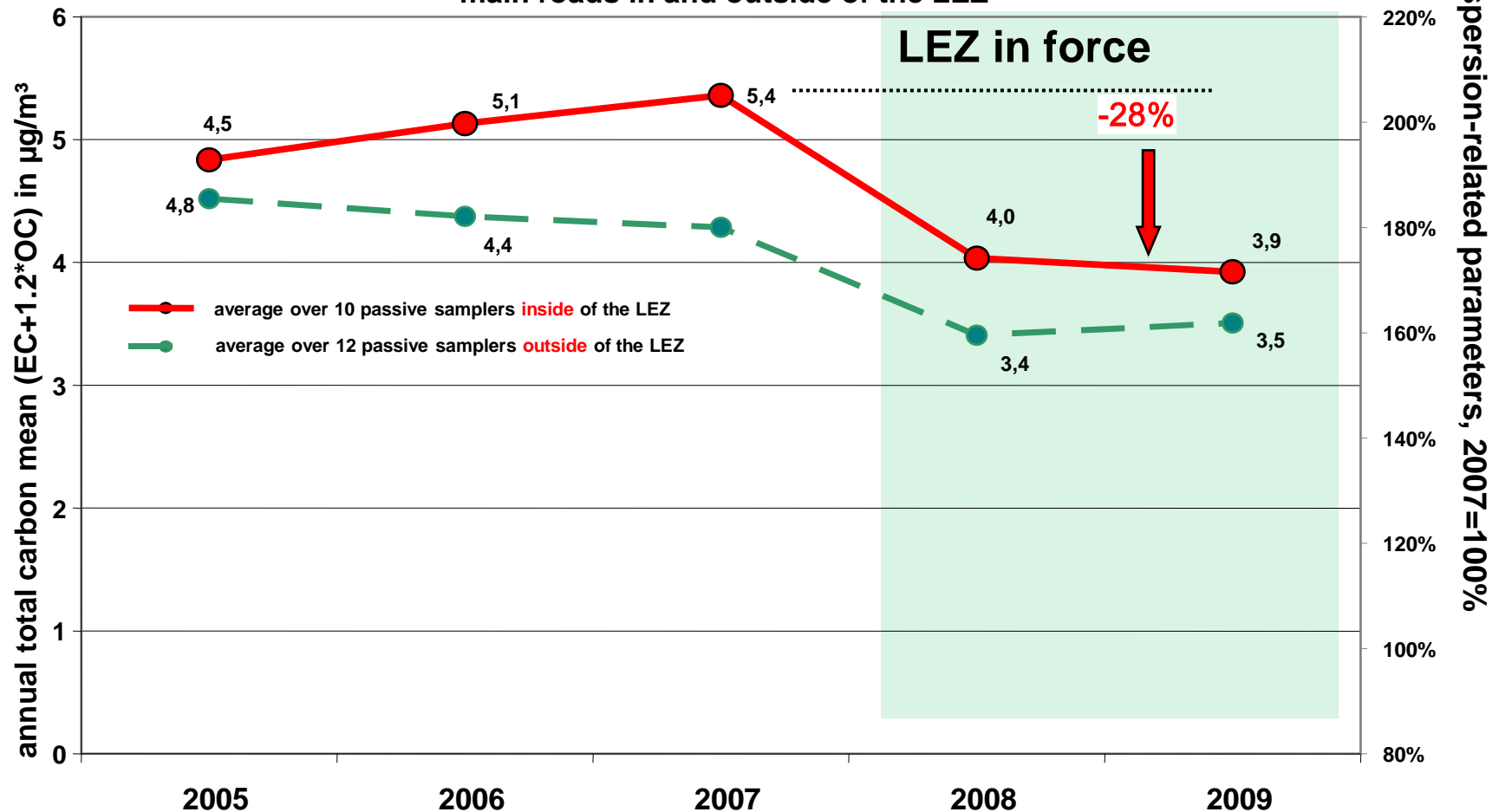
## Reduction which has been achieved in road traffic



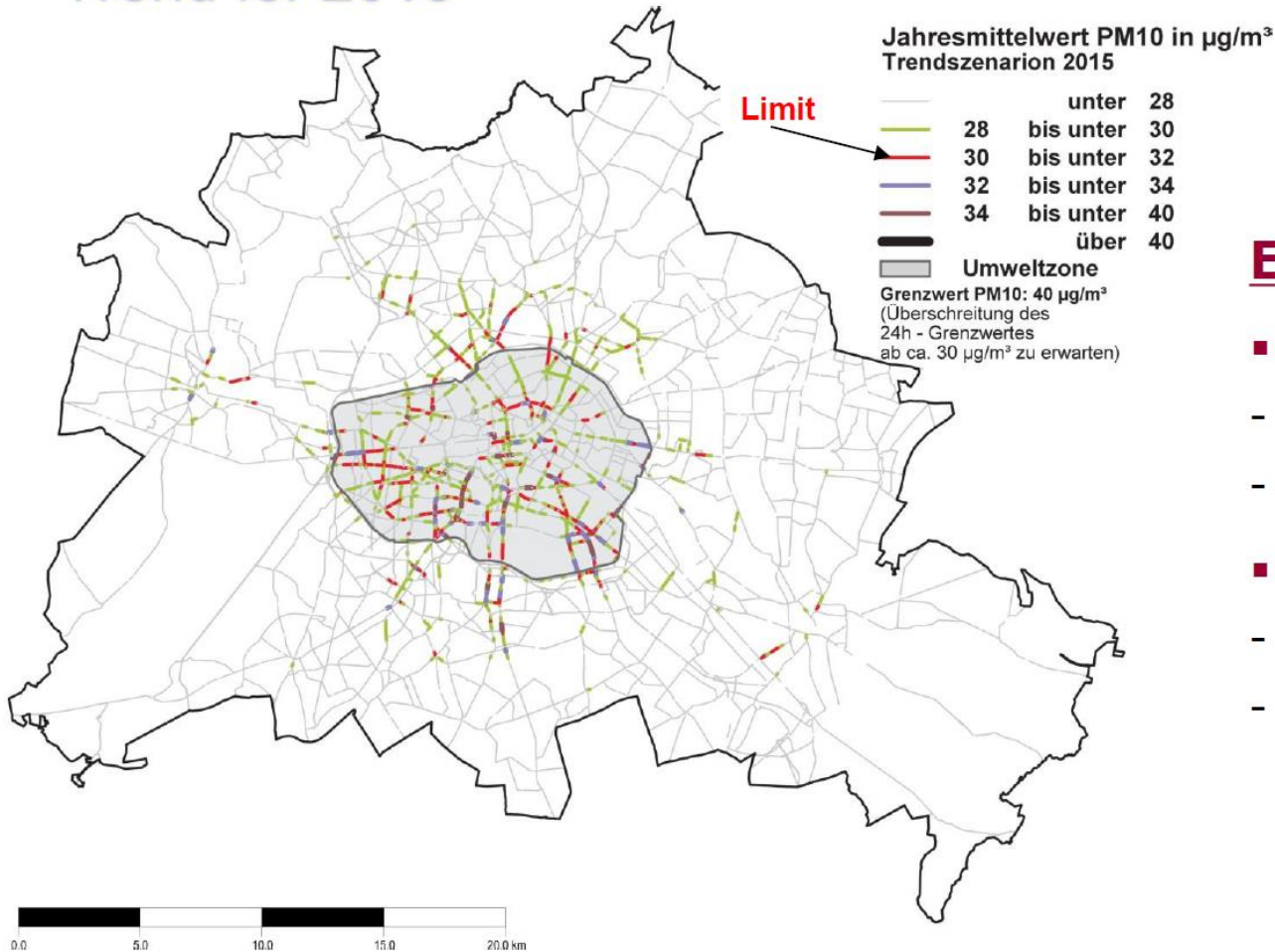
# Berlin LEZ – real impact analysis

☞ total carbon concentration

traffic-adjusted trend of the local traffic increment of total carbon concentrations in main roads in and outside of the LEZ



# PM10 immission by traffic: Trend for 2015



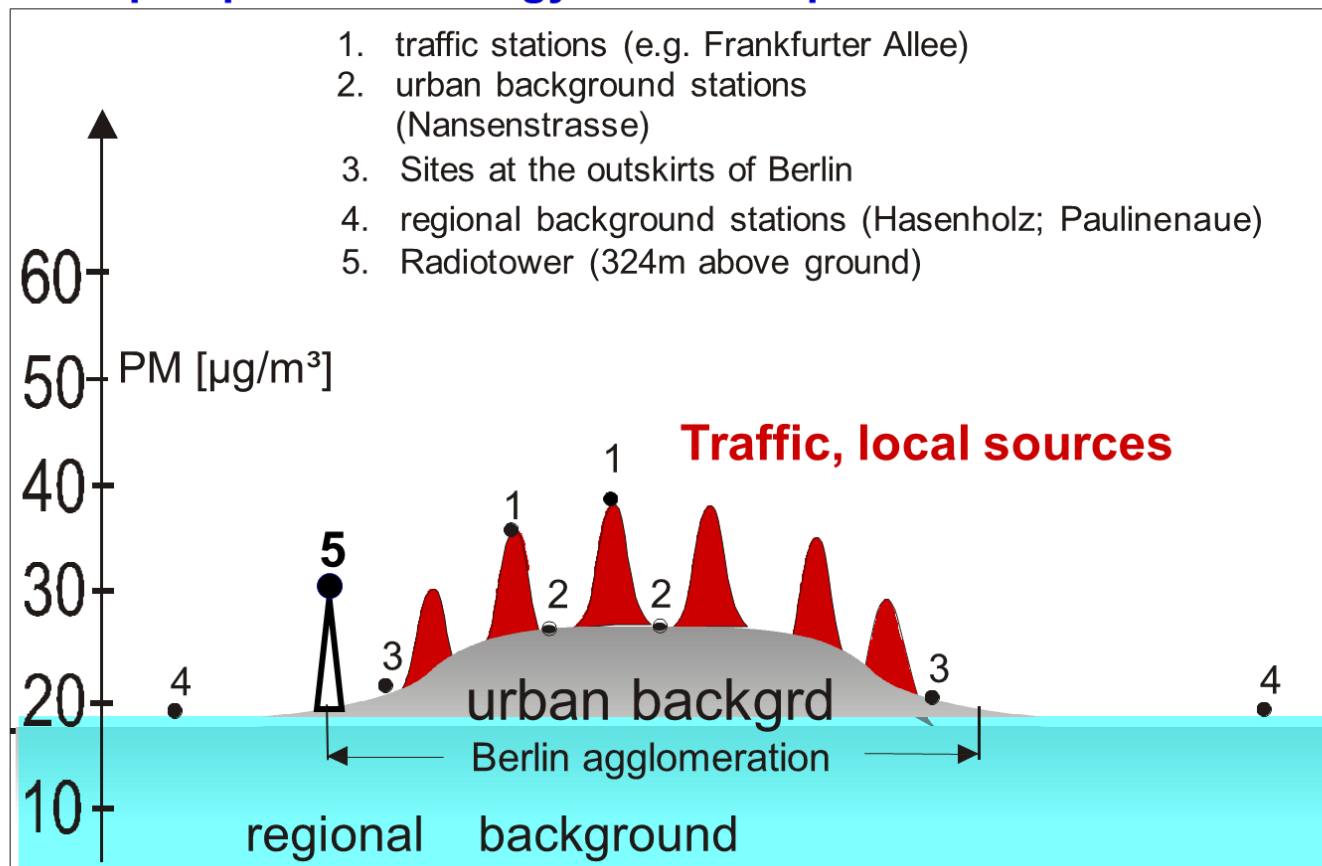
## Exceedance:

- **above  $30 \mu\text{g}/\text{m}^3$ :**
  - 52,1 km
  - 43.600 individuals
- **above  $32 \mu\text{g}/\text{m}^3$ :**
  - nearly 16 km
  - above 14.000 individuals

## source analysis

👉 where does it come from & how much ?

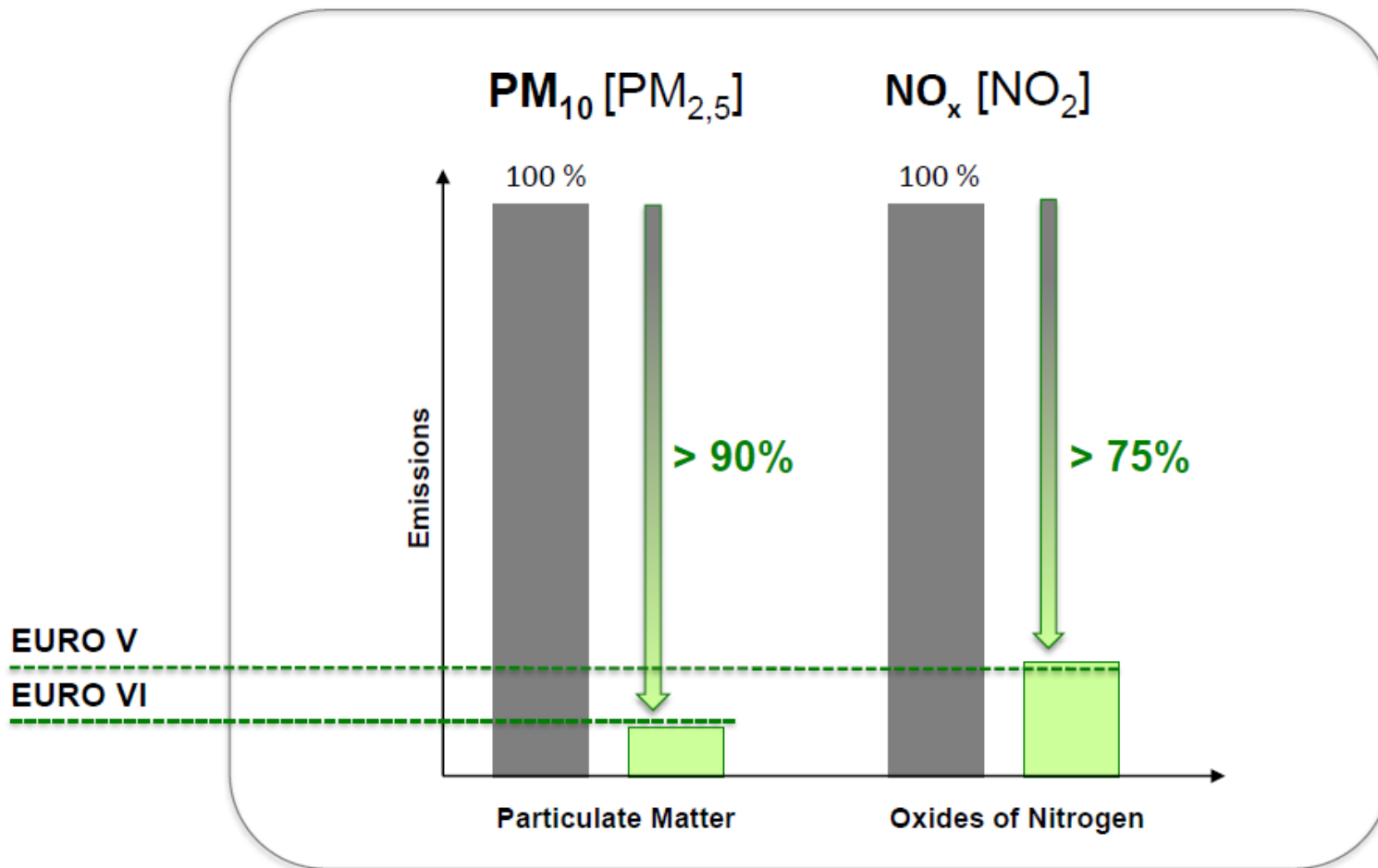
### Example: phenomenology of the PM-pollution around Berlin



## Additional transport measures

- SCRT retrofit for public buses
- particulate filter for construction machines
- and as an option for the future,
  - SCRT retrofit for goods vehicles
  - Lez with a new light-blue sticker

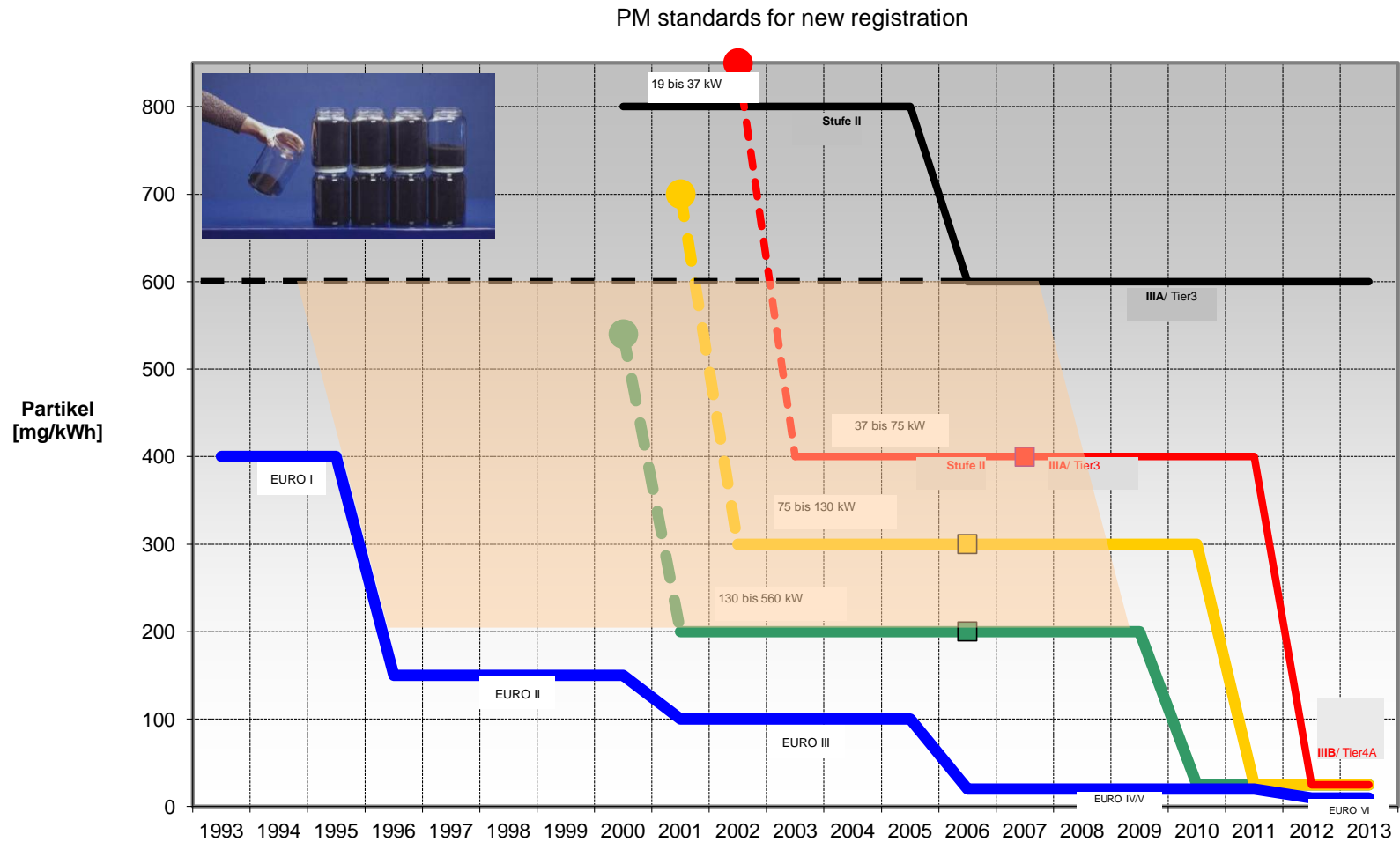
# Retrofit – Efficiency SCR + DPF® Systems



# Retrofit is more cost-effective

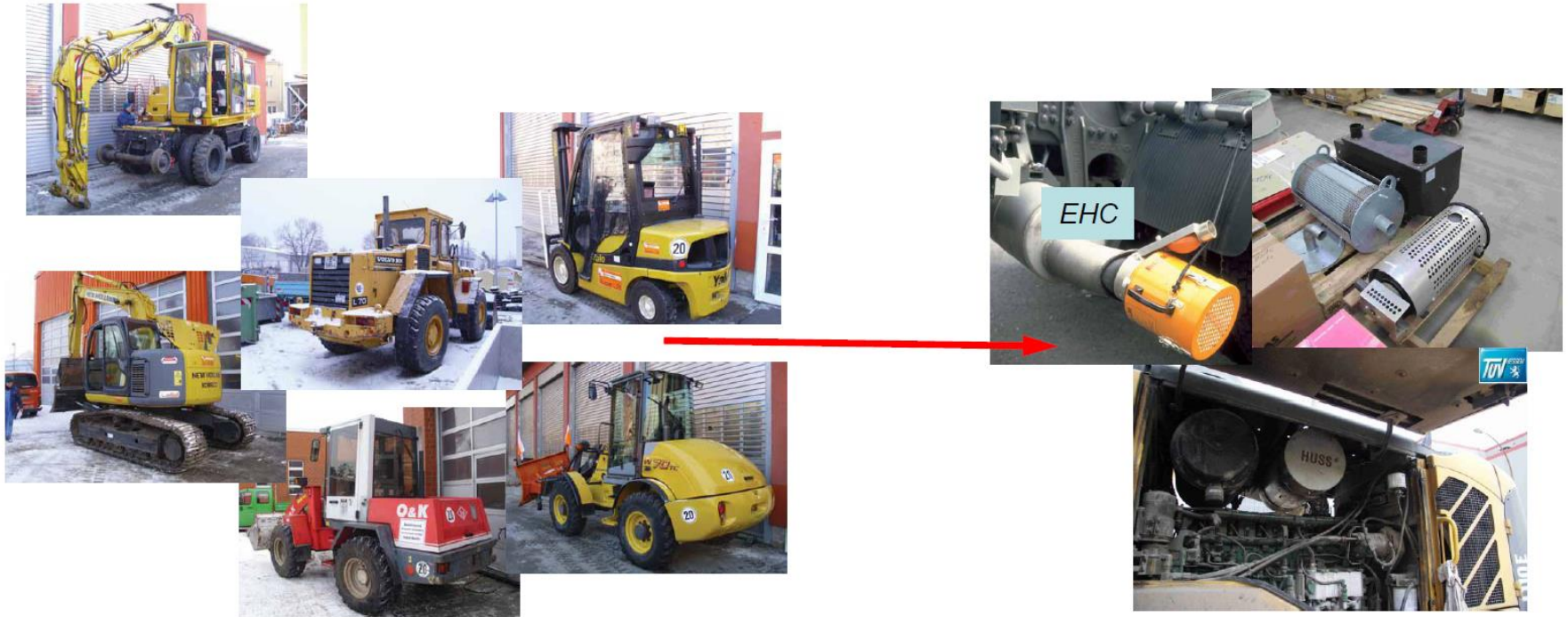


# PM standards for NRMM in comparison to HD vehicles





## DPF trial on Berlin's construction machines



### Target-setting:

- Technology trial with 40 construction machines
- Effect of the filter systems on total costs
- Filter durability over 2 years operation
- Which circumstances can limit the reliability of operation?
- Recommendation for further retrofit application

### Adaption of existing filter technologies

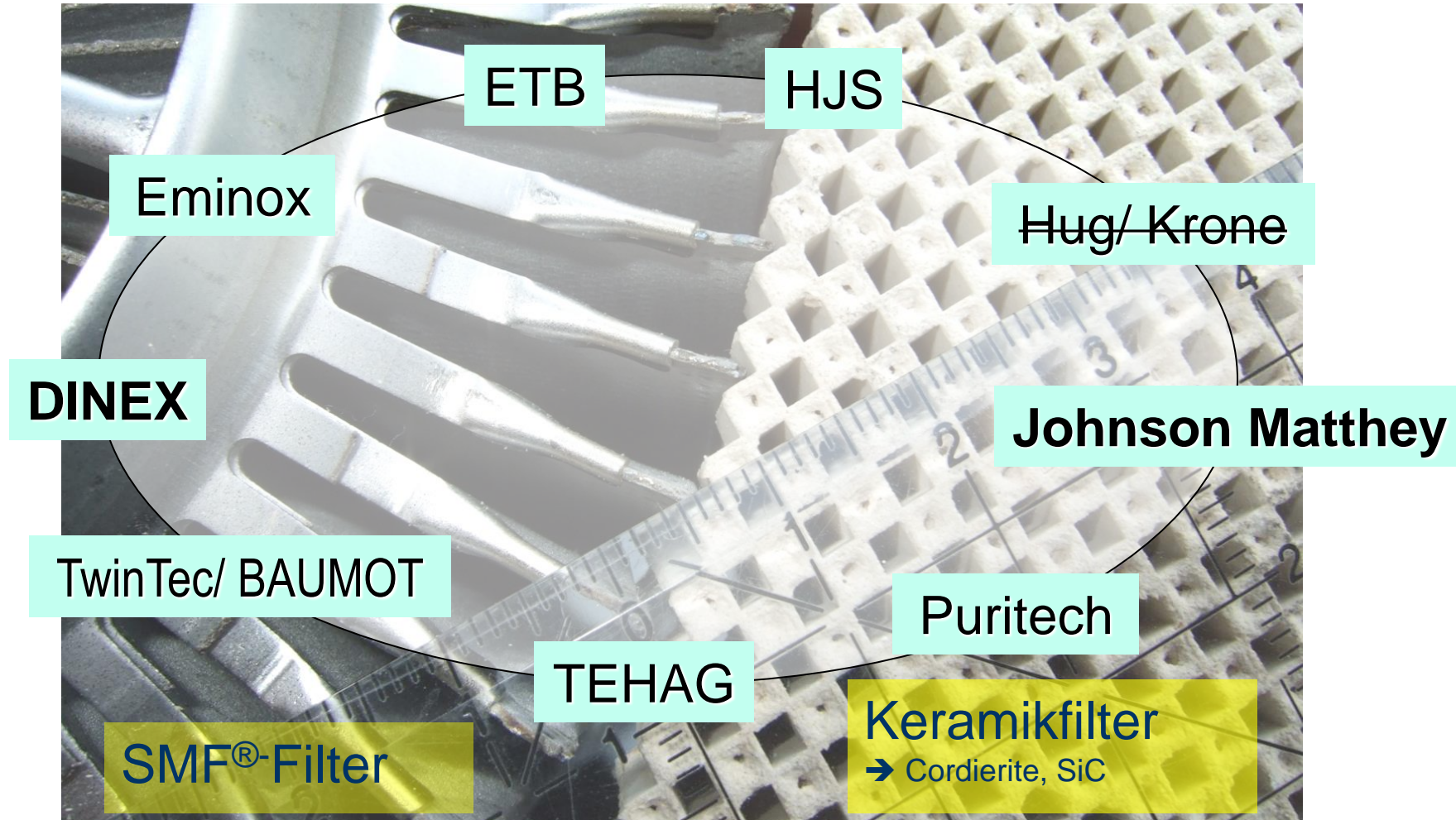
## Project realization

- **Catalogue preparation of construction machines for Berlin's retrofit trial.**
- **Assessment of available construction machines for their DPF ability**
- **Allocation of construction machines for DPF application among the filter manufacturers according to first-come principle**
- **Free of charge installation of DPFs into the construction machines.**
- **Measurements in fresh conditions (new DPF), after one year and two years operation.**
- **Agreement for cost sharing among filter manufacturers and operating companies after successful end of trial.**

# Measurement program

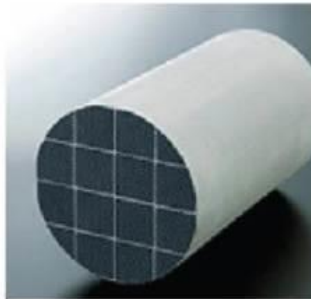
- 4 exhaust gas emission measurements carried out by TÜV Hessen:
  - ↪ in original condition (w/o DPF): 45 construction machines
  - ↪ with new installed DPF → acceptance control
  - ↪ after one year operation
  - ↪ after two years operation (end of project)
- further parameters to be measured:
  - ↪ Opacity in front of and behind filter as a degree for precipitation (standard AU technology). Other measurement principles will be applied in future as well.
  - ↪ Exhaust gas backpressure
  - ↪ Engine speed
  - ↪ Exhaust gas temperature
- **additionally:** Data-Logger of some manufacturers during the entire project time:
  - ↪ Exhaust gas backpressure
  - ↪ Operation hours
  - ↪ Exhaust gas temperature ?

## Participating DPF manufacturers

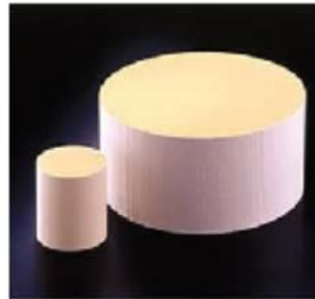


## DPF-Filtermedien

Clean<sup>+</sup>axx  
■ Rußfilterreinigung ■ Industriereinigung ■ Handel



Silicon Carbide Internals



Cordierite Internals



Sintered Metal Internals





## Regeneration principles installed, based on filter manufacturers' choice

- with additive (FBC)
- with additive + temporarily add-on electrical heating by alternator
- passive → catalytically coated filter (CRT principle)
- passive with catalytically coated filter + temporarily electrical regeneration “over night”
- external regeneration in oven

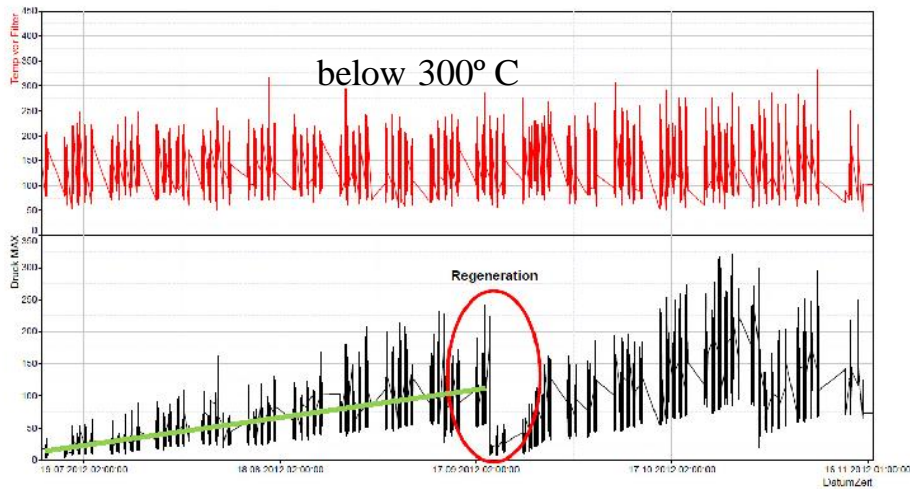
## Two passive, catalytically coated filters (CRT principle)



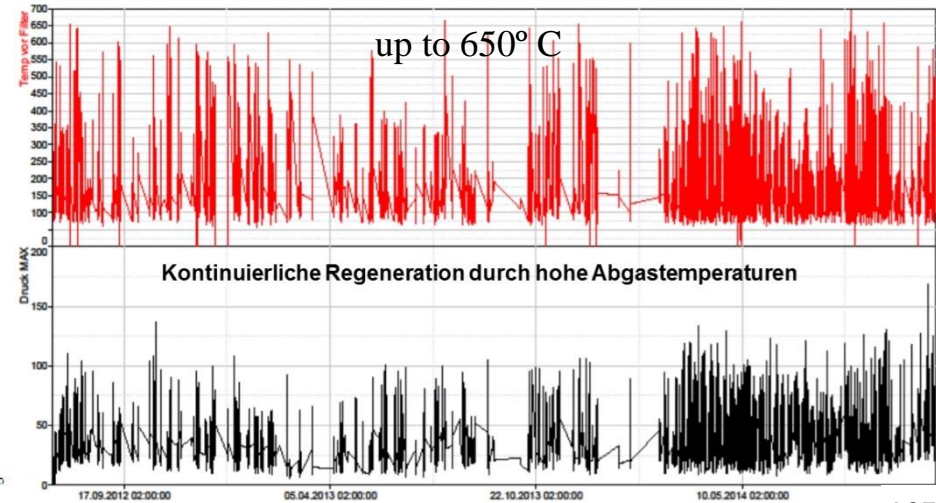


## HJS with additive + temporarily add-on electrical heating by alternator

Fz-Hersteller / Fz-Typ	Motortyp / Leistung	Hubraum	Schadstoff-klasse	Filterfläche	Laufleistung am:	DPF-Typ
Yale / GDP30VX	Yanmar (4TNE92-NM-H) / 31,2 KW	2,659 ltr.	Stufe III A	2,7 m² SMF	am 13.11.2014:601 Bt	SMF-AR

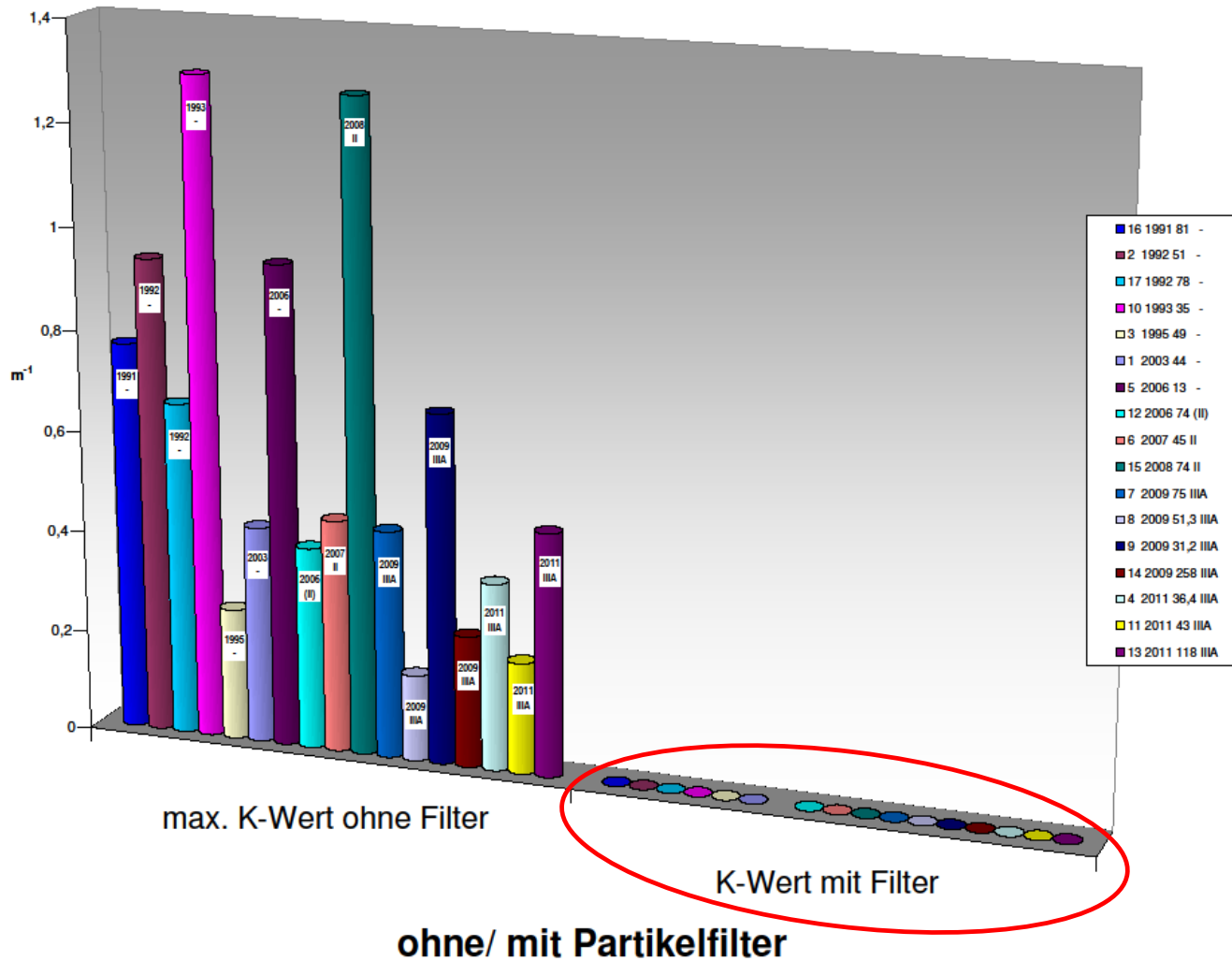


Fz-Hersteller / Fz-Typ	Motortyp / Leistung	Hubraum	Schadstoff-klasse	Filterfläche	Laufleistung am:	DPF-Typ
Terex TL 65	Deutz (D2011LD4) / 31,2 KW	3,109 ltr.	Stufe III A	1,8 m² SMF	n. bekannt	SMF-AR



937 h

# Opazität nach Baujahr



## Final results

- Not every vehicle can be refitted, because there may be no space for the refit, or the conversion is not cost-effective
- Malfunction only occurred when the DPF was assembled inadequately or the regeneration technology had not been adjusted.
- After the installation of the DPF the soot values had dropped near the detection limit in all tests.
- Use low-ash oil and the cleaning intervals will be at 1,000-2,500h. A professional cleaning including transport costs ca. 400 €
- IN ORDER TO REFIT SUCCESSFULLY YOU NEED A COMPETENT AND RELIABLE PARTNER, (DPF-Producer + a company that assembles filters) who sometimes says “NO” to cheap, passive regenerative filters

Every machine could then emit as few particles as these retrofitted vehicles



**Thank you!**



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