

"Abatement of PM and NO₂ pollution in Berlin: The low emission zone and other measures" Can Copenhagen learn anything from Germany/Berlin?



Martin Lutz

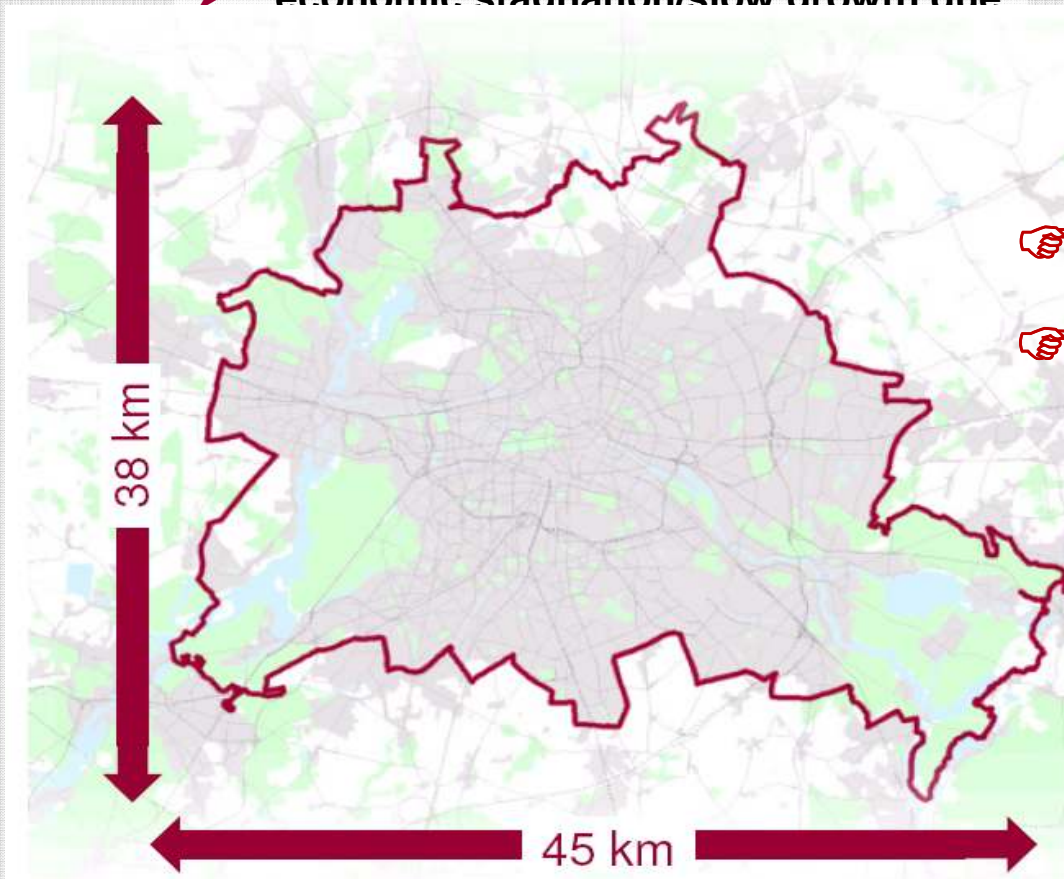
Berlin Senate Department for Urban
Development and Environment
Directorate IX, Environment Policy

- ⊗ why a **low emission zone** (LEZ) ?
- ⊗ **effect** on traffic flows & **vehicle** fleet
- ⊗ real **impact** on **emission** & **air pollution**
- ⊗ problems, **pros & cons**
- ⊗ scope for **additional local action**
- ⊗ **résumé**

Berlin

☞ a few facts

- low commuter numbers & car density
- economic stagnation/slow growth due



area: 889 km ²
inhabitants: 3,4 million
48% car-free households
car ownership: 317 cars/1.000 inhab.
passenger cars: 1,1 million
bicycles: 1,8 million
147 bus lines - 1662 km
22 tram lines - 189 km
9 metro lines - 144 km
32 MRT lines* - 458 km

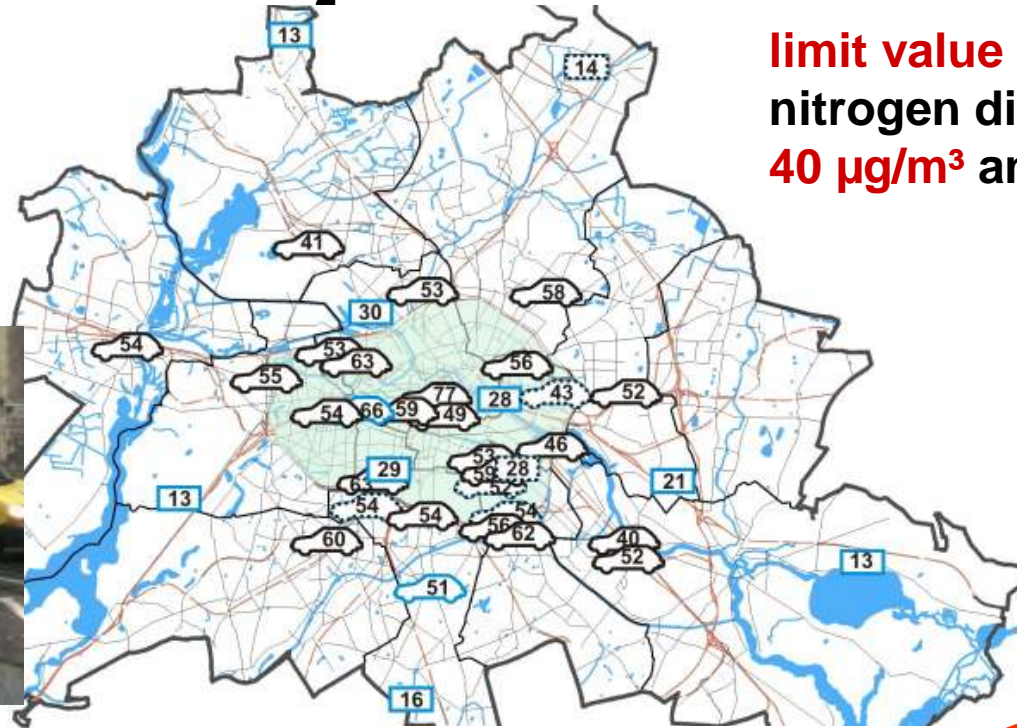
* S-, RB-; RE- lines

Berlin

👉 struggling with NO₂ compliance

Annual NO₂ – levels 2011

limit value for
nitrogen dioxide (NO₂)
40 µg/m³ annual mean

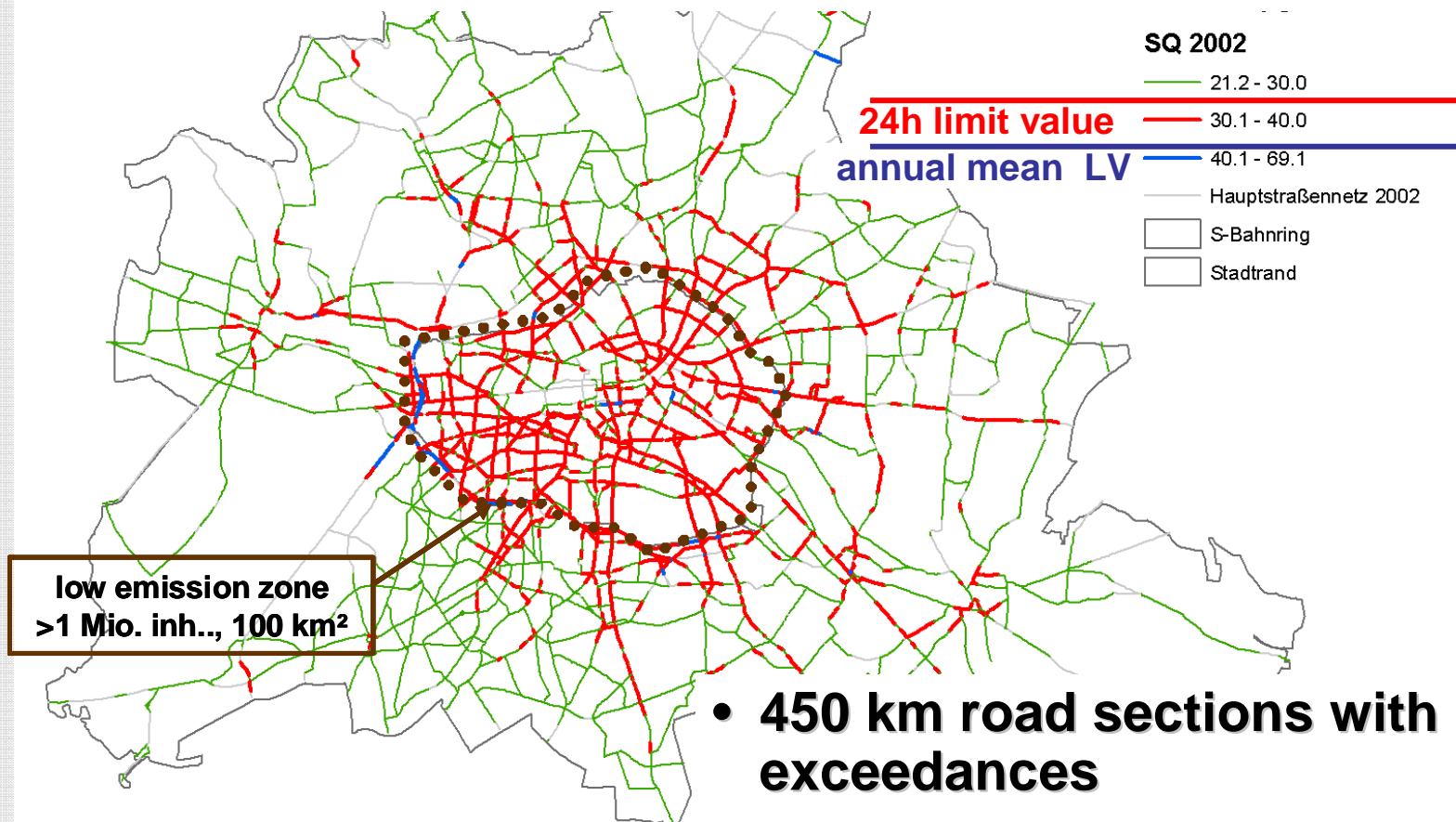


- Low emission zone
- Automatic monitoring site in residential areas and at the cities' periphery
- Automatic monitoring site in busy roads at the kerbside
- monitoring site with miniaturised monitoring devices for traffic related pollutants in busy roads

need for action

☞ particulate matter concentrations (PM10)

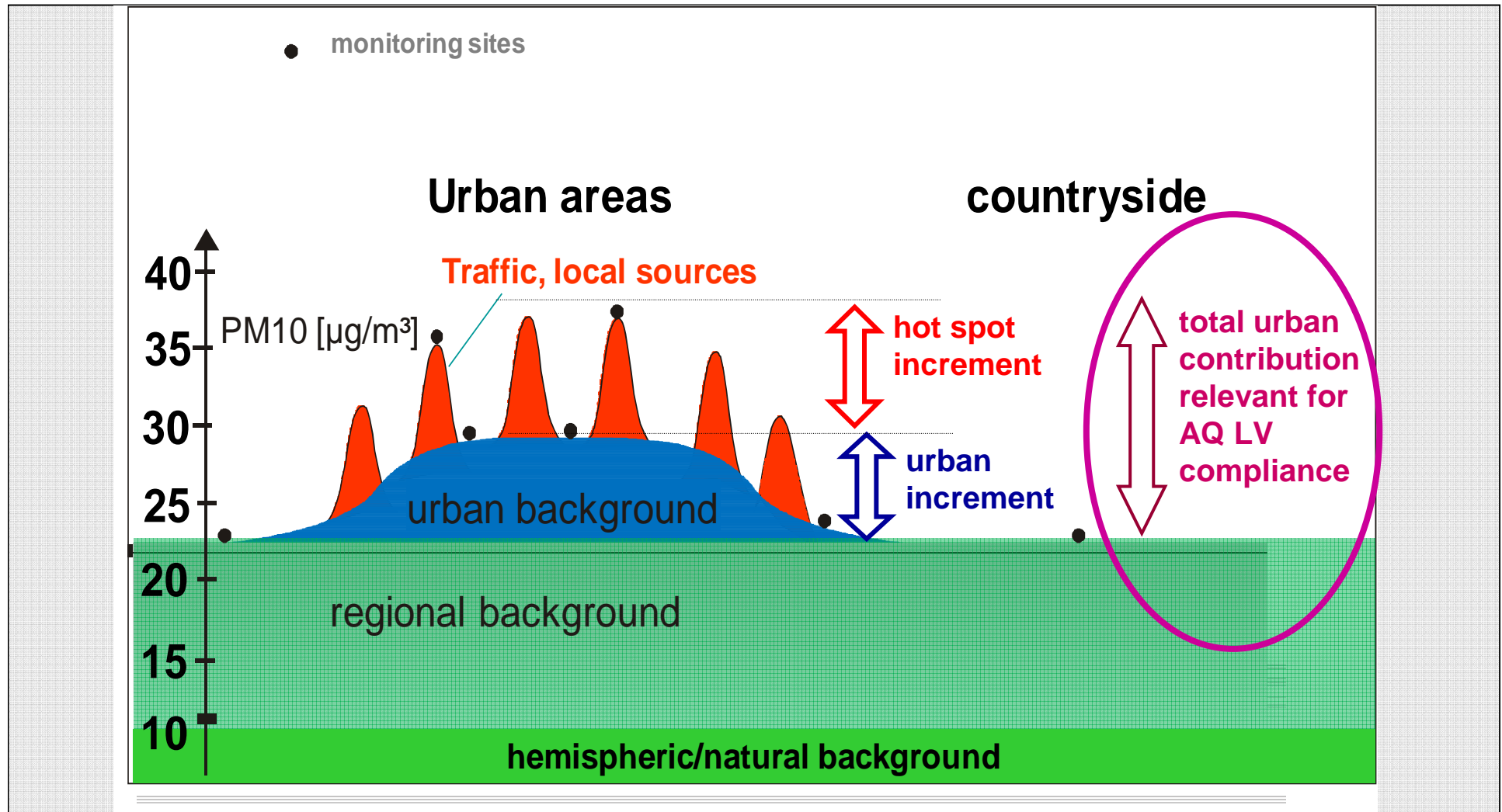
modelled particle levels in base year 2002



- 450 km road sections with exceedances
- 190.000 affected residents

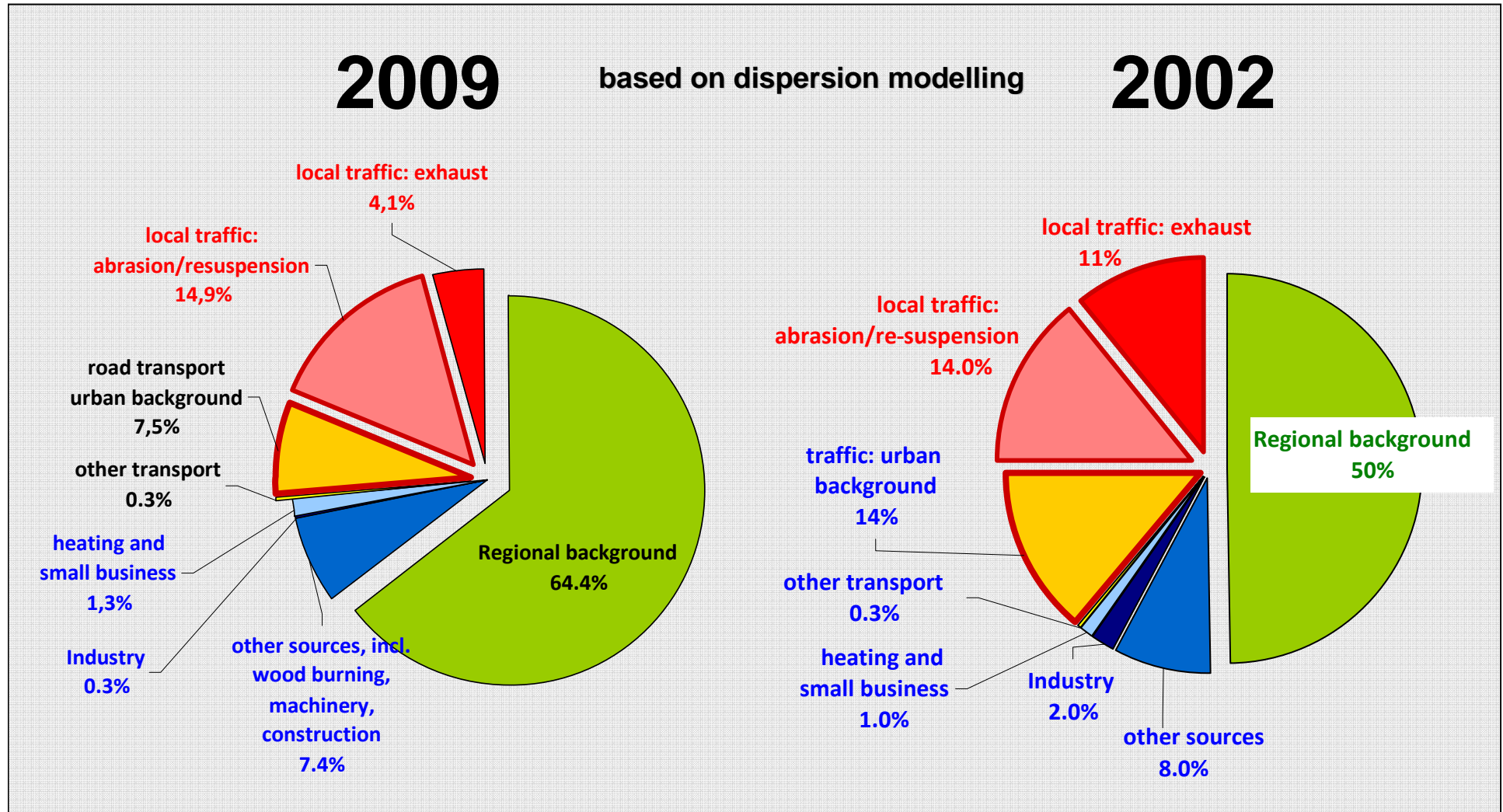
Source analysis

👉 schematic of PM distribution



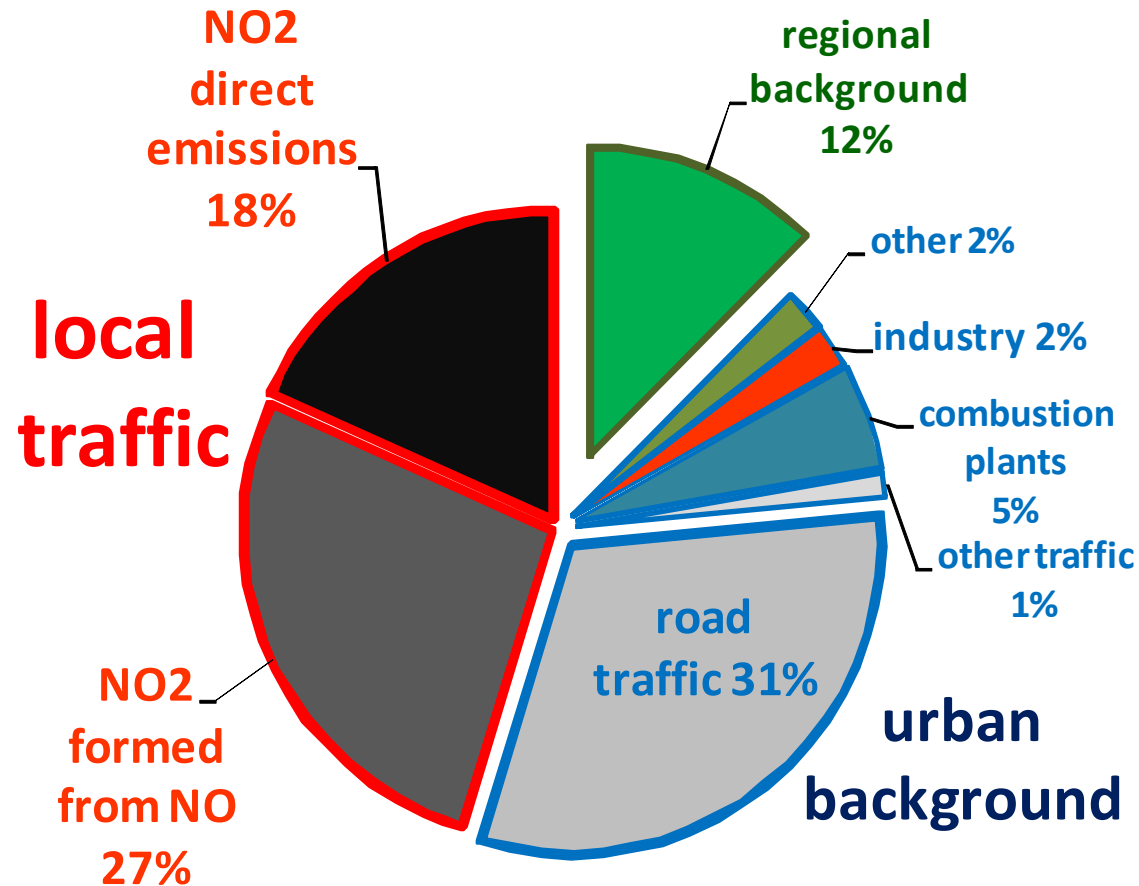
Source analysis Berlin

👉 sectoral origin of kerbside particle levels (PM10)



Source analysis Berlin

👉 origin of kerbside NO₂



Based on dispersion modelling

need for **transport measures** in 2002

👉 **reasons for Low Emission Zone**

- **road traffic predominant** urban polluter in Berlin
- **large-scale non-attainment** of PM10 & NO2 in central main roads
- **local scale traffic restrictions** merely **shift** problem in other roads
- **previous measures insufficient**
 - 👉 modernisation of municipal & other captive fleets
 - 👉 funding scheme for CNG-vehicles
 - 👉 shift to clean transport modes by traffic planning




Core measure: cleaning up the vehicle fleet

- 👉 **LEZ: selective traffic ban** for most **polluting** vehicles
 - ↪ **large-scale:** not only in single roads but covering the whole (potential) non-attainment area
 - ↪ **durable:** not only on days in excess of 24h-limit value
 - ↪ **transition period** (> 2 ½ years) prior to the start
 - 👉 ensures **proportionality**
 - 👉 **no general exemptions** for residents and commercial traffic
 - 👉 **some individual** temporal exemptions possible

Berlin's Low Emission Zone

👉 vehicle **emission criteria**



„Zeichen 270.1“
Umwelt
ZONE
frei

Innerer S-Bahnring
(„Hundekopf“)

Reinickendorf, Pankow, Gesundbrunnen, Mitte, Ostkreuz, Lichtenberg, Westkreuz, Südkreuz, Spandau, Charlottenburg, Wilmersdorf, Stiglitz, Zehlendorf, Tempelhof, Neukölln, Treptow-Köpenick, Marzahn-Hellersdorf

Area:
about 88 km²
(Berlin total area: 892 km²)

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**

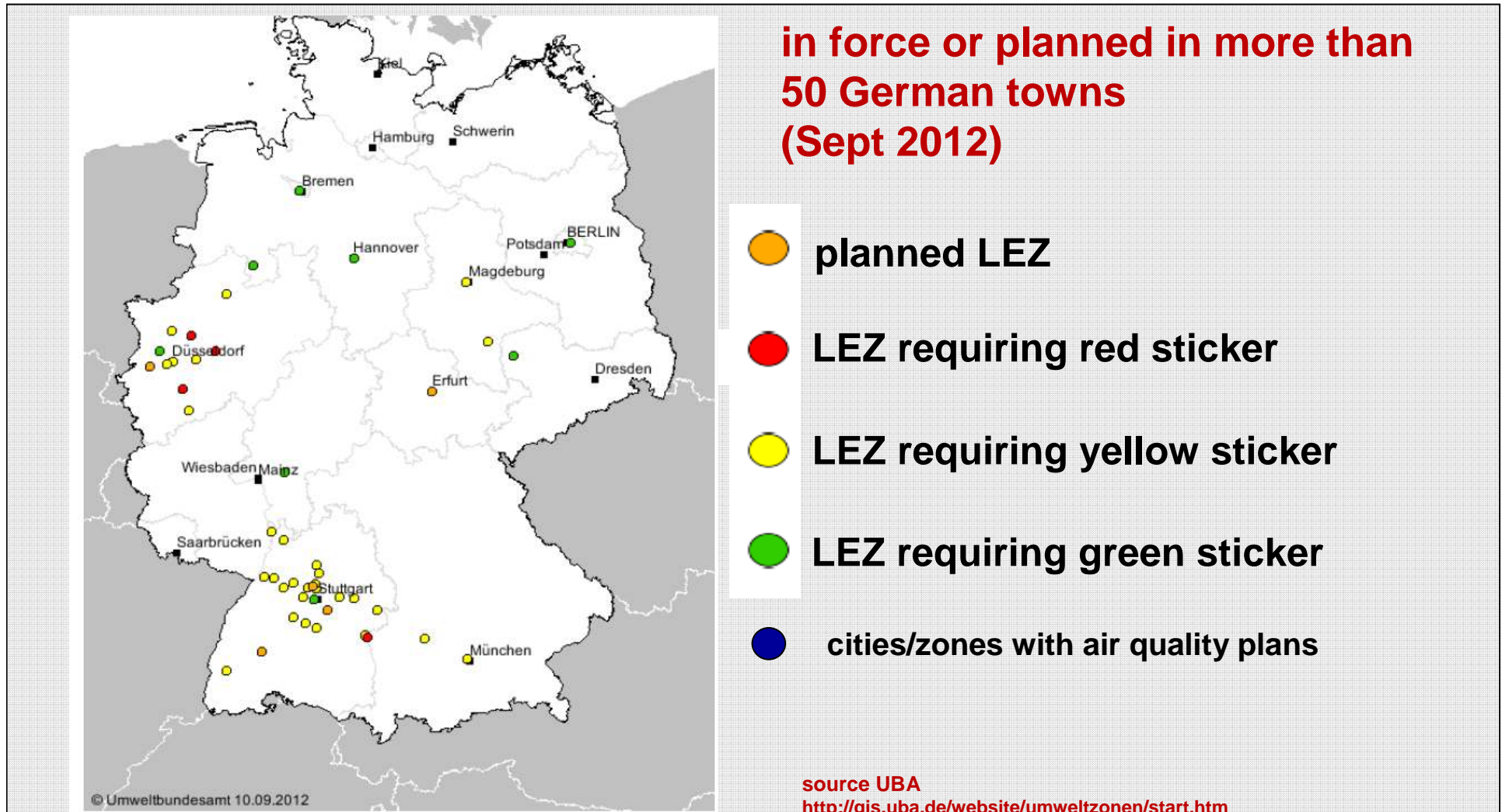
■ **Stage 2: since 1.1.2010**

Diesel: Particle emission Euro 4:

- 👉 cars: **Euro 3 + particle filter** or better
- 👉 goods vehicles: also **retrofit** of Euro 1-3 towards Euro 4_{Particle}
- 👉 **10% of the vehicle fleet affected**
- 👉 **>80% could be upgraded by filter retrofit**

👉 **LEZ** in force or planned in **56** German towns with differing ambition levels

Low emission zones Germany



Berlin's Low Emission Zone stage 2

👉 affected vehicles end of 2009



■ Diesel Passenger cars:

↪ 14.000 PC (7%) with red sticker



→ can barely be retrofitted to

↪ 60.000 PC (30%) with yellow sticker



→ can be retrofitted to



■ commercial Diesel vehicles:

↪ 10.000 LDV/HDV (12%) with red sticker



→ can be partly retrofitted to

↪ 25.000 LDV/HDV (30%) with yellow sticker



→ can be retrofitted to



affected vehicles in total: **ca. 124.000**
by 2011: **more 60.000 Diesel vehicles retrofitted with DPF**
25% Diesel PC & 20% LGV/HGV!

LEZ – real impact analysis

questions & approach

1. impact on traffic flows?

- has road traffic decreased within the LEZ?
- has road traffic been re-routed to areas outside the LEZ?
- has road traffic been avoided?

 **monitoring of traffic flows**

2. effect on the vehicle fleet composition?

- change in the characteristic of the registered vehicle fleet?
- change in the real fleet on the roads in & outside the LEZ?

 **evaluation of vehicle registration data base**

 **monitoring of real vehicle fleet**

3. impact on the pollution emissions from road traffic?

 **calculation of the exhaust emissions**

 **comparison with default fleet and situation before/after LEZ**

4. impact on the air quality?

 **evaluation of the routine air quality monitoring data: PM10, PM2.5, NO, NO2, NOx**

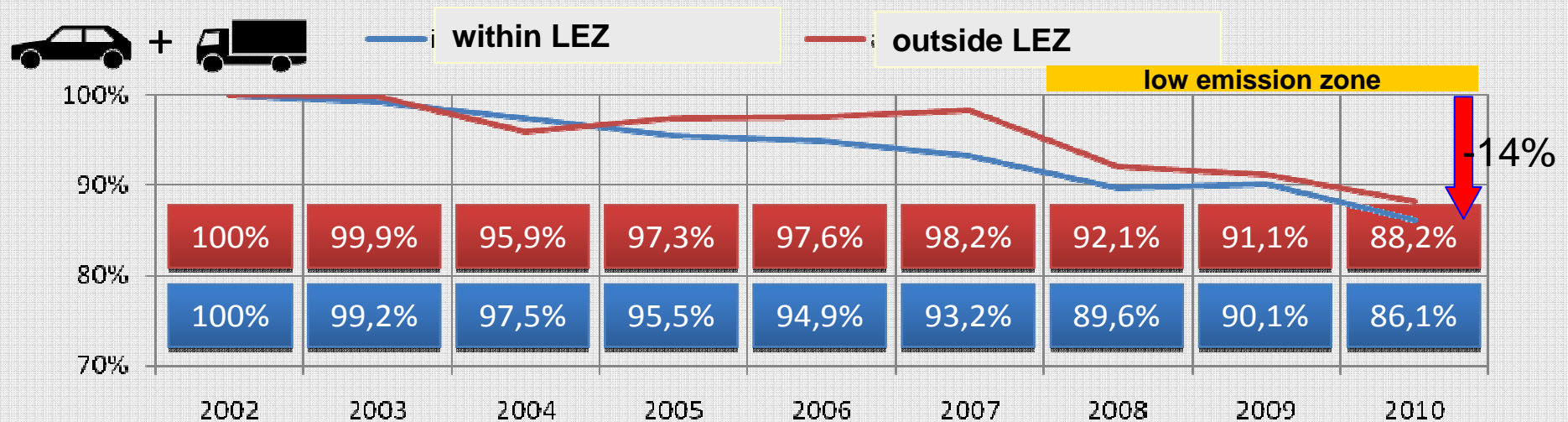
 **evaluation of extra AQ measurements: PM-species (EC, OC, sec. PM, passive samplers)**

 **dispersion modelling with LEZ-related emission reduction**

Berlin LEZ – impact analysis

👉 traffic volumes

trend in traffic volumes 2002-2010 in Berlin
2002 = 100%



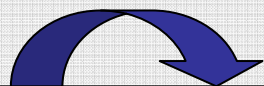
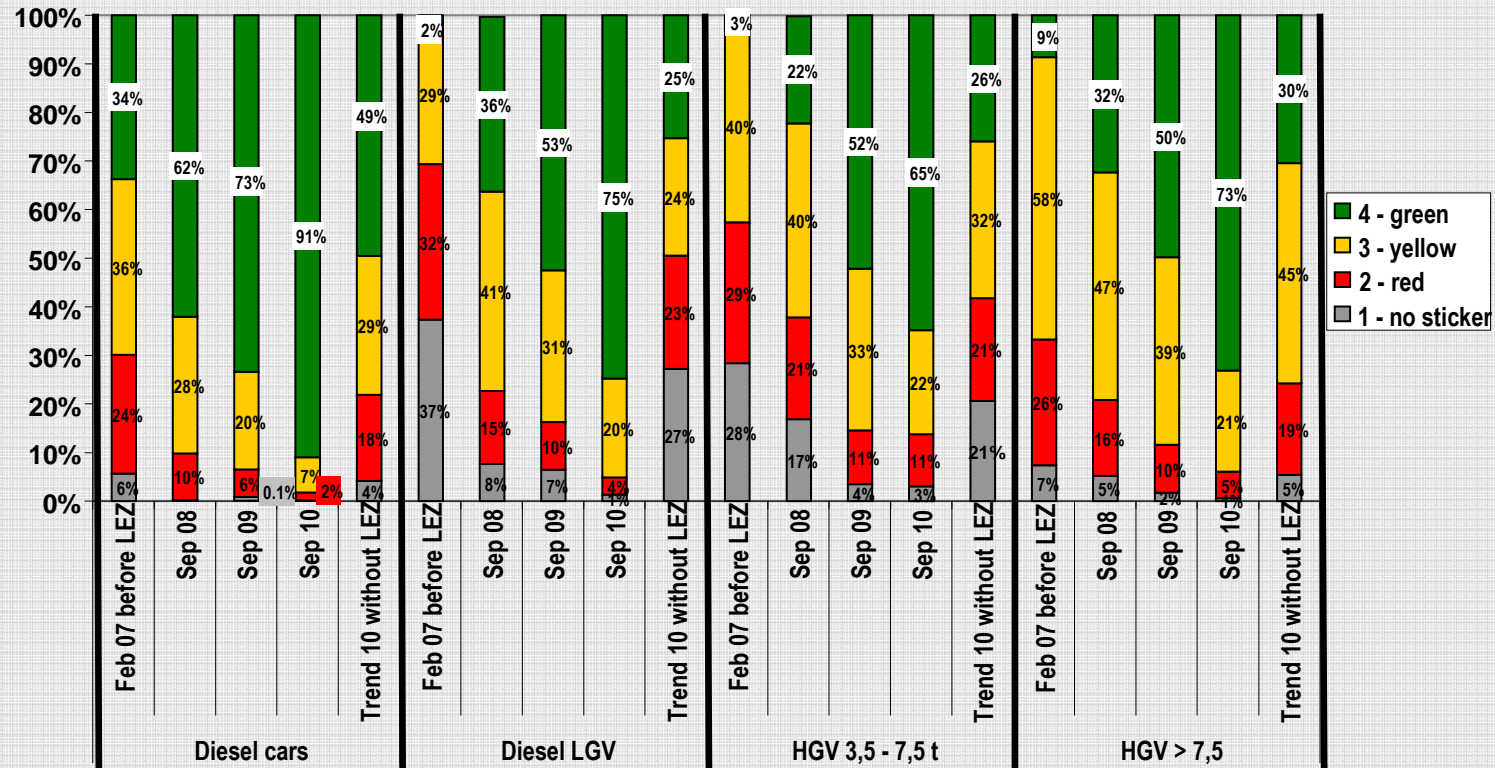
Conclusion: No traffic re-routing or traffic calming due to LEZ, because

- general decrease of traffic volumes over many years
- significant reduction between 2007 und 2008 mainly outside the LEZ

Berlin LEZ – impact analysis

👉 vehicle fleet composition

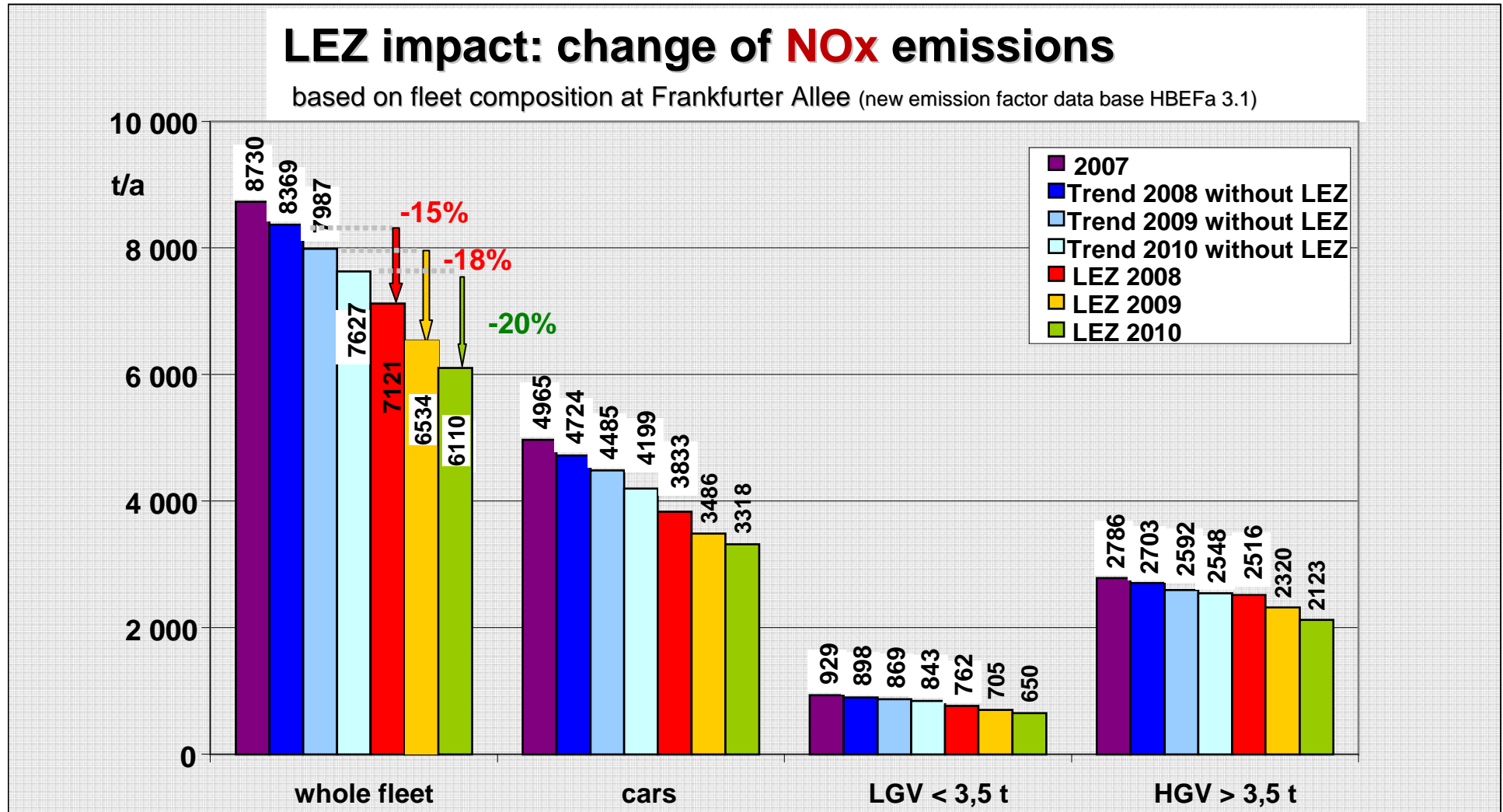
change of the vehicle fleet composition on the road (from number plate recognition)



decrease: cat.1 (no sticker) by 70-90 %; **Cat 2 (red) by 50-80 %**
 increase: **category 4 (green) by factor 1,5 to 3**

Berlin LEZ – impact analysis

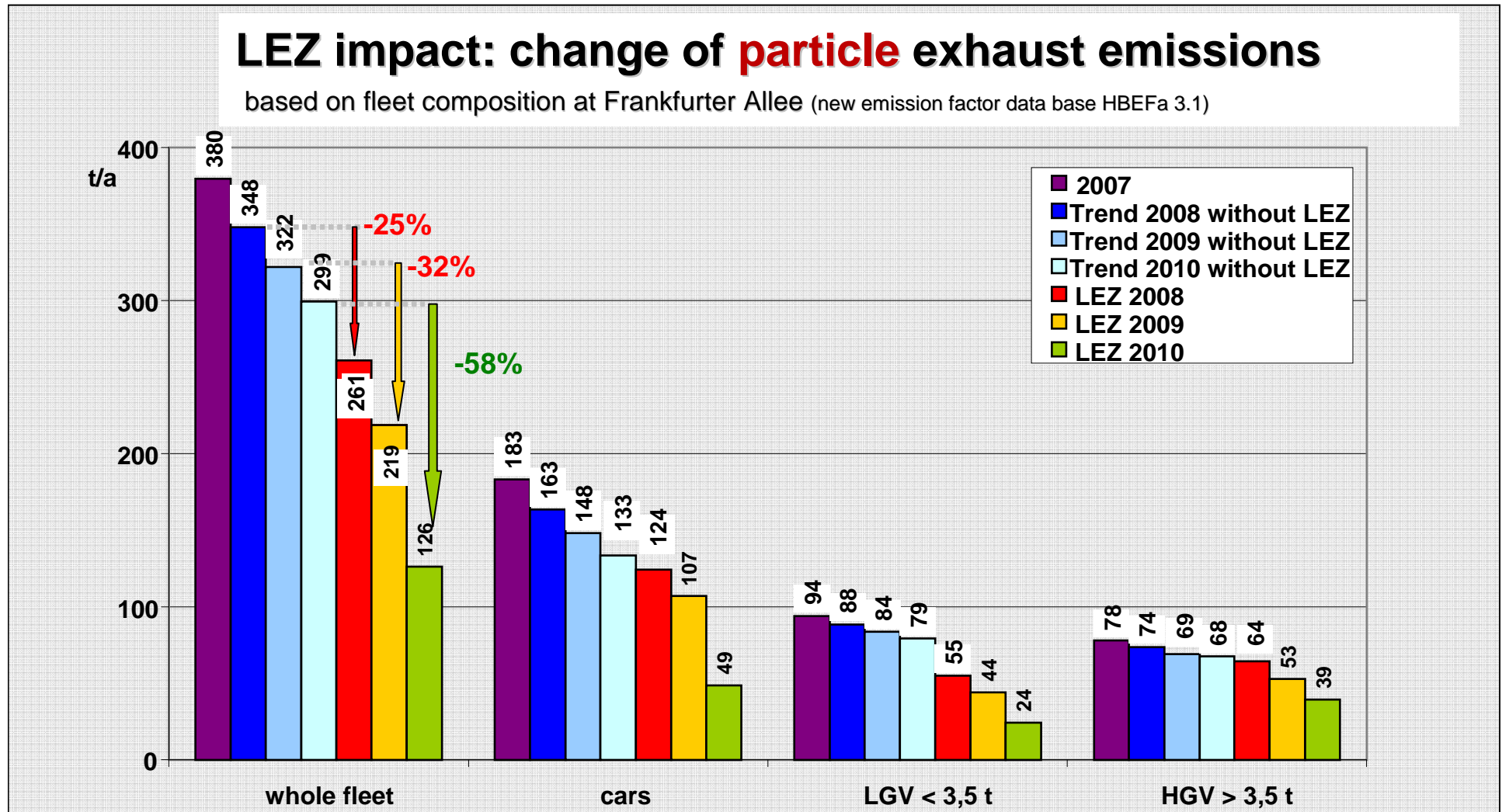
👉 NOx emissions



emissions extrapolated to the entire main road network based on the fleet composition at Frankfurter Allee (with DPF-retrofit, only warm emissions, no cold start impact)

Berlin LEZ – real impact analysis

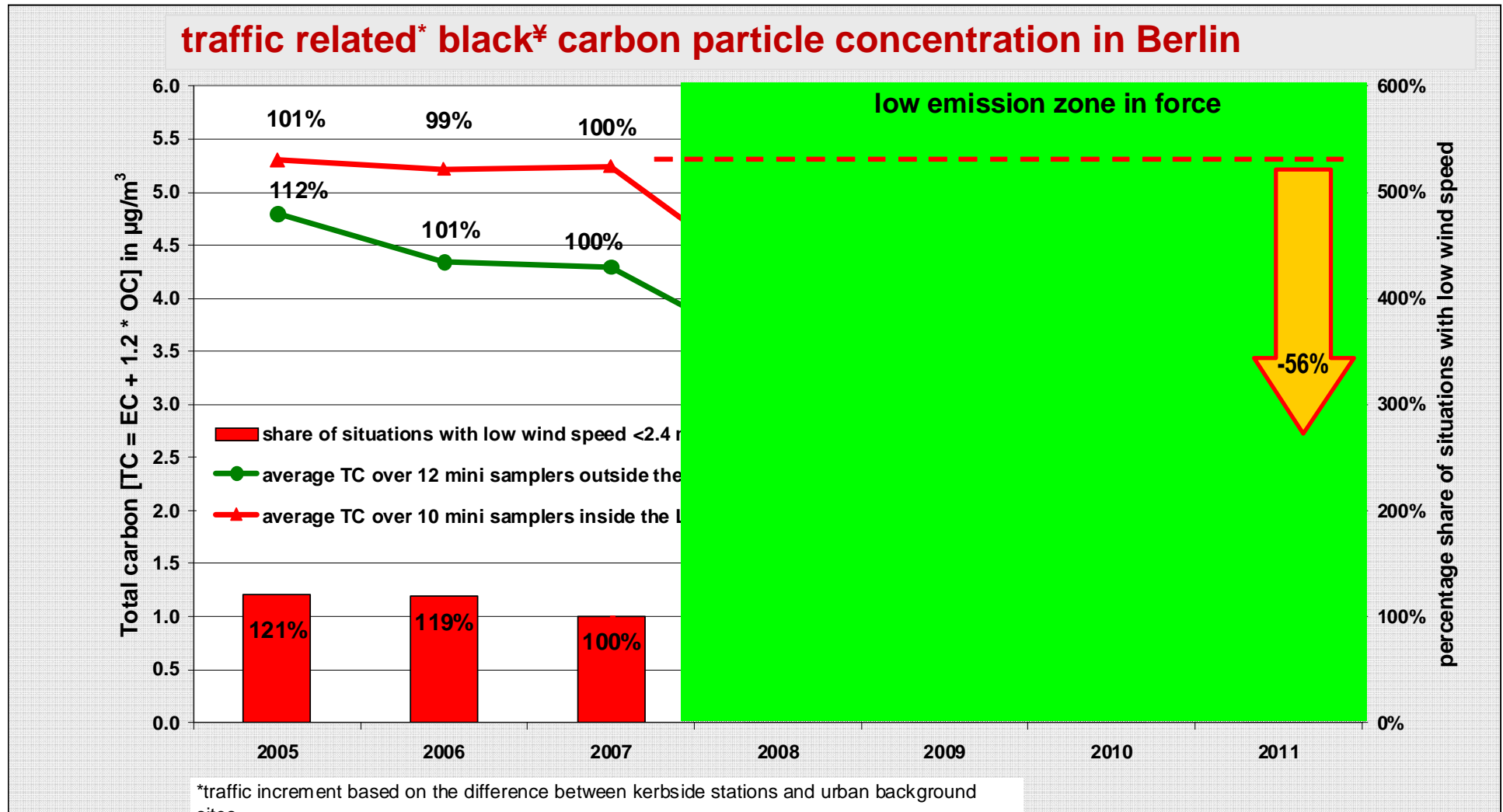
👉 particle tailpipe (diesel soot) emissions



emissions extrapolated to the entire main road network based on the fleet composition at Frankfurter Allee (with DPF-retrofit, only warm emissions, no cold start impact)

Berlin LEZ – impact analysis

👉 total carbon concentration

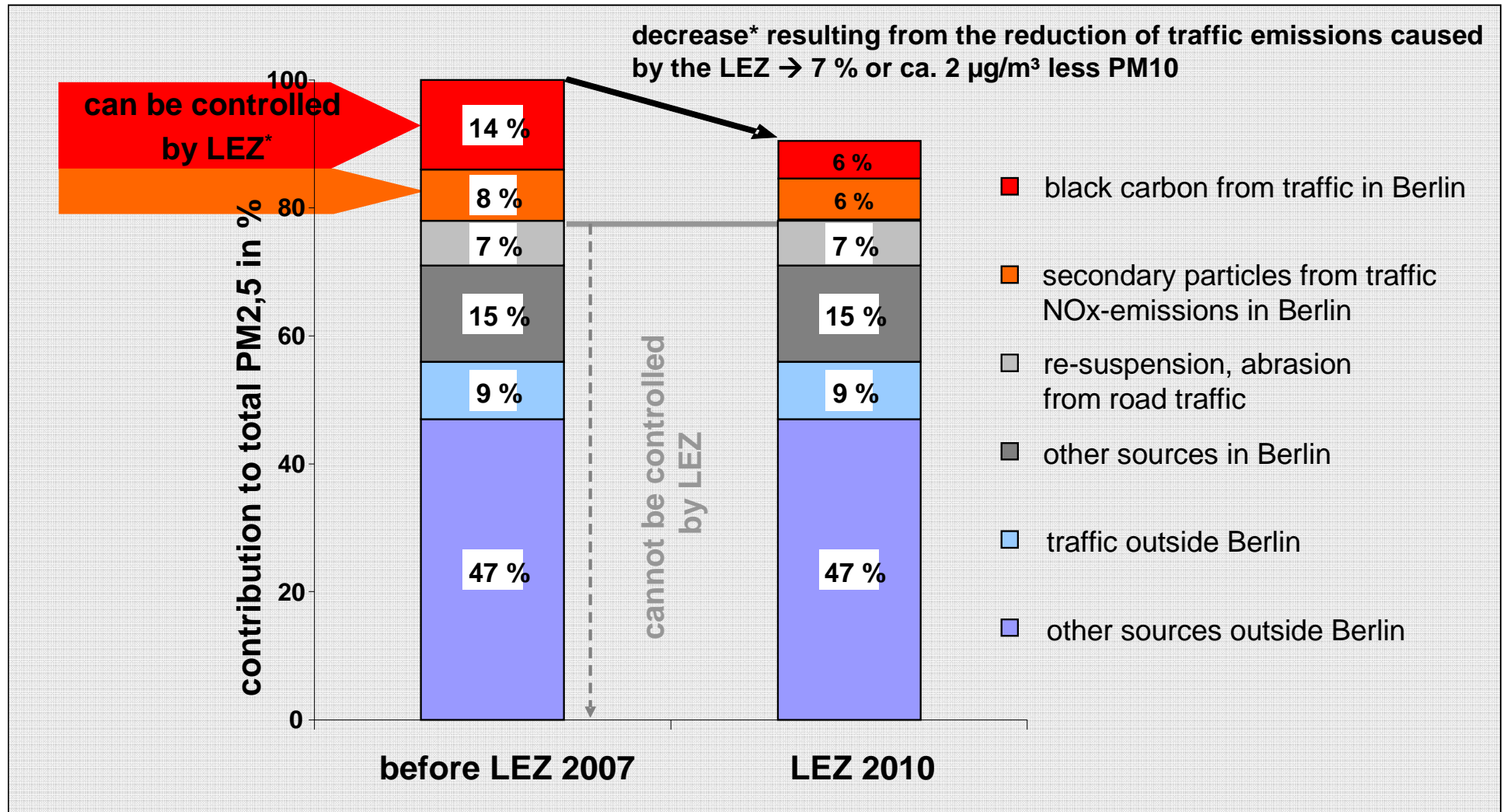


* local BC increment at traffic sites, adjusted to traffic volumes trend relative to 2007 before LEZ came into force

‡ elemental carbon (EC) particles plus other deposited organic compounds (OC)

Berlin LEZ – impact analysis

👉 reduction of particulate matter (PM10) concentration



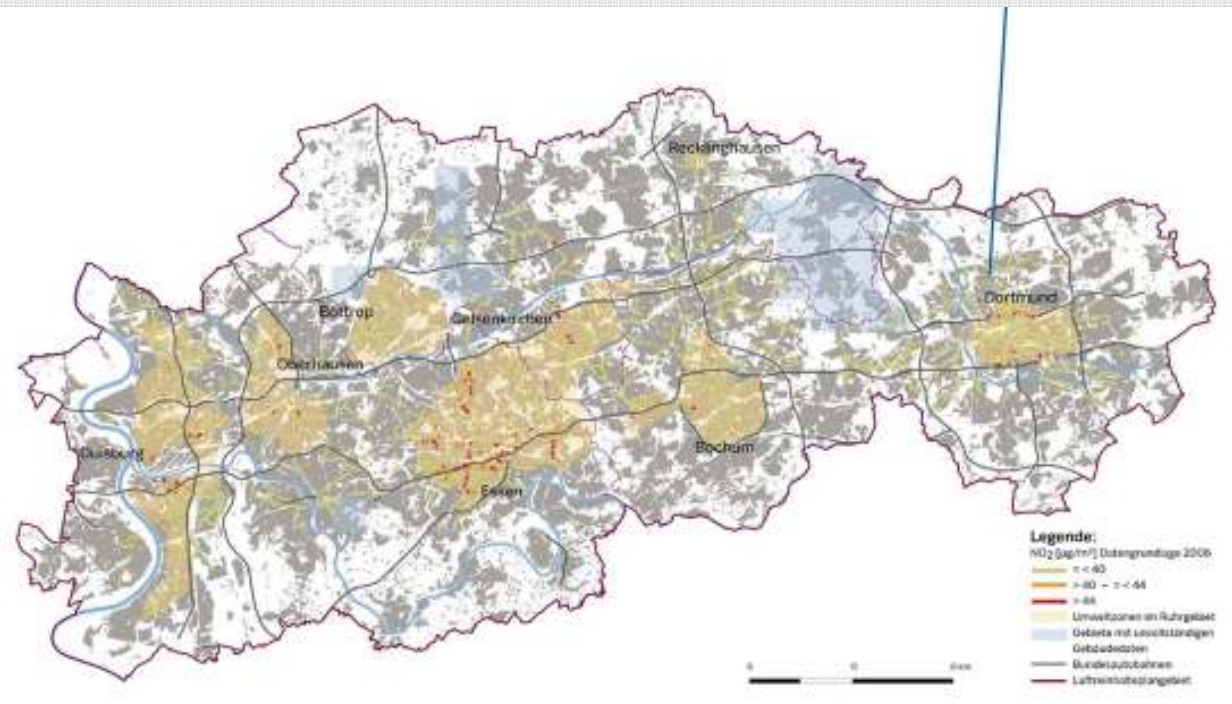
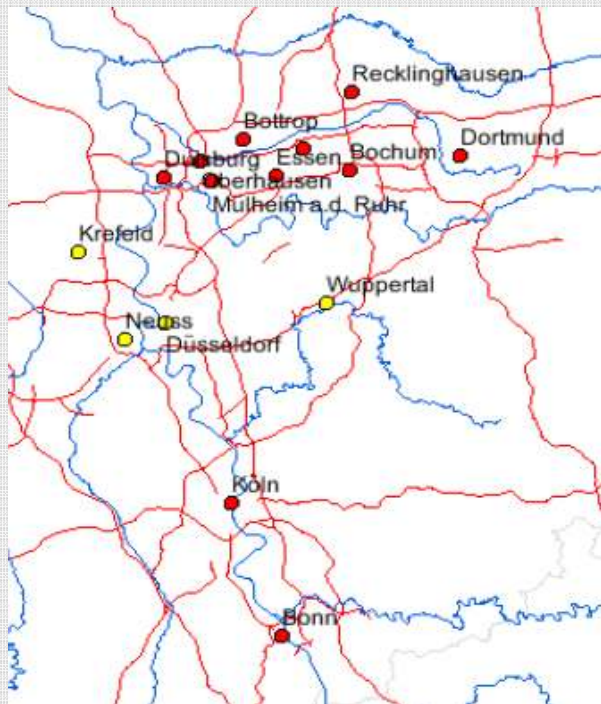
* related to PM2,5-levels in a busy main road in Berlin's city centre in 2007 before the LEZ

LEZ Ruhr Area

👉 impact analysis 2009

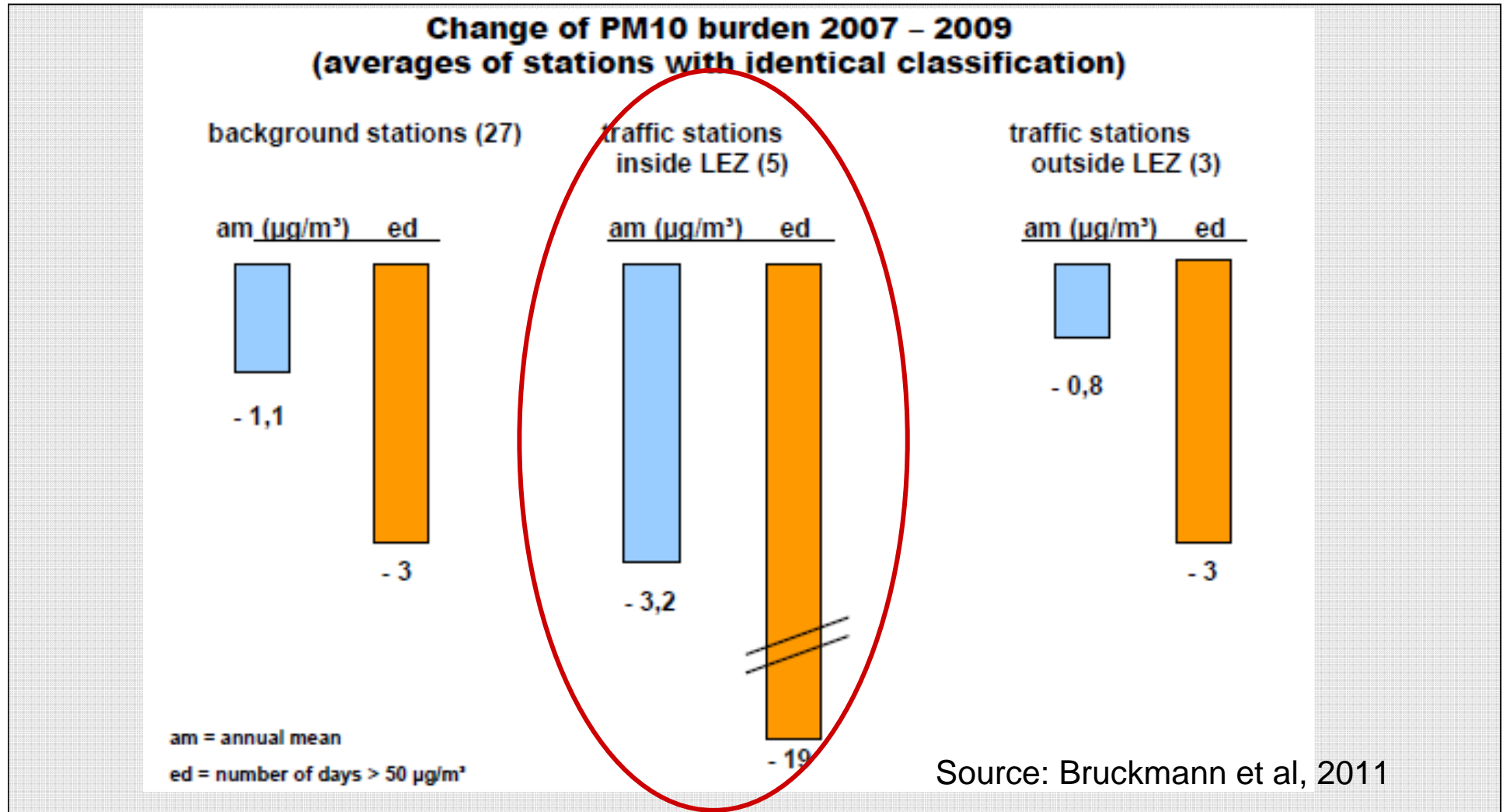
Low emission zones in the Ruhr Area

↪ in force since 10/2008 with
↪ area 230 km²



LEZ Ruhr Area impact analysis 2009

👉 Change in particulate matter (PM10)



LEZ Ruhr Area impact analysis 2009

Change in **particulate matter (PM10)**

Impact of LEZ Ruhr (Δ 2007 – 2009) corrected by reference stations


PM10:	<u>averages:</u>	
	- 2,4 $\mu\text{g}/\text{m}^3$ (annual means)	based on traffic stations outside LEZ
	- 16 days > 50 $\mu\text{g}/\text{m}^3$	
	- 2,1 $\mu\text{g}/\text{m}^3$ (annual means)	based on background levels outside LEZ
	- 16 days > 50 $\mu\text{g}/\text{m}^3$	
<u>individual stations:</u>		
range from -8 $\mu\text{g}/\text{m}^3$ to +1 $\mu\text{g}/\text{m}^3$ (annual means)		

Source: Bruckmann et al, 2011

NO₂ reduction due to LEZ smaller

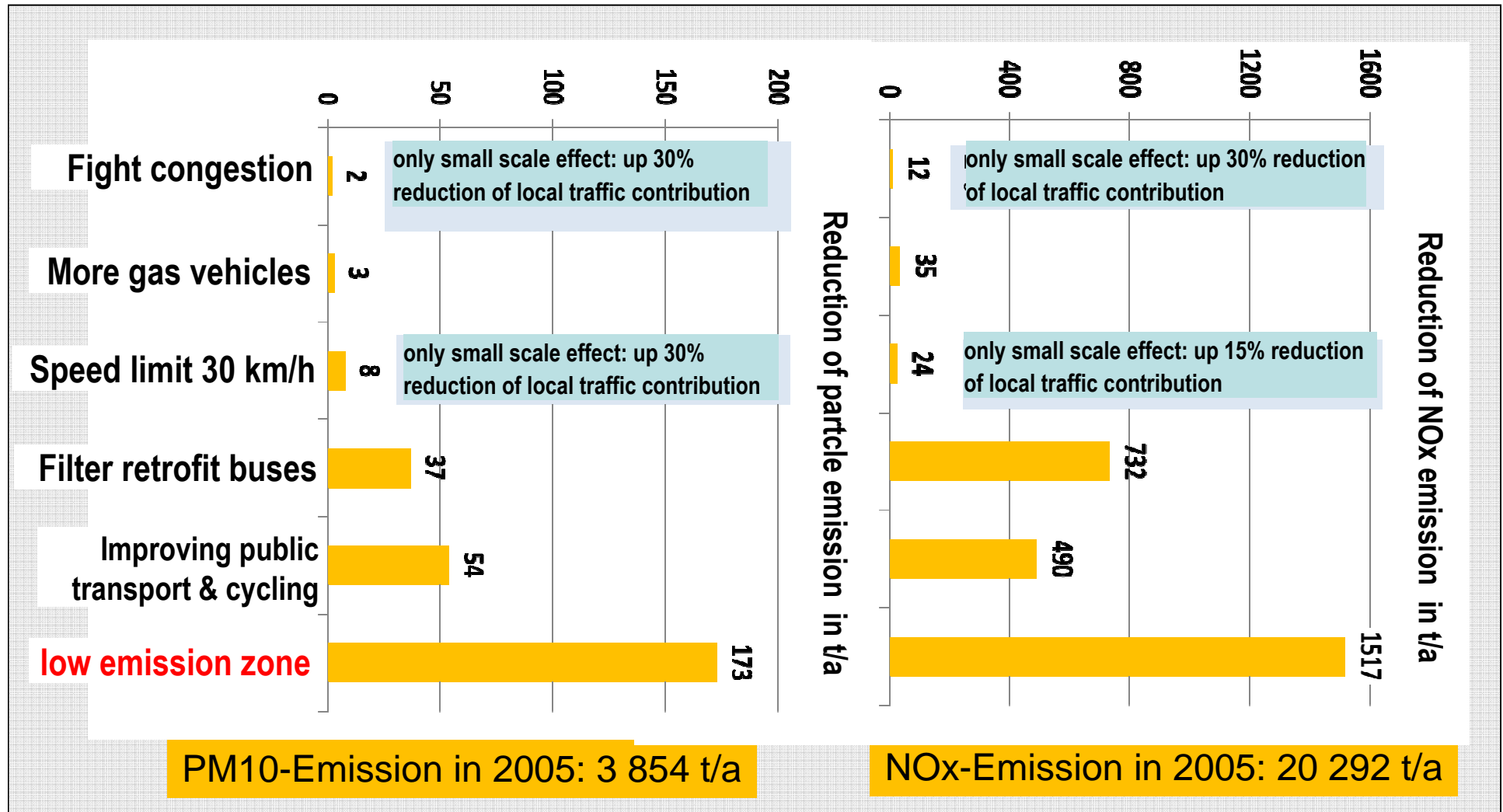
LEZ – impact analysis

👉 résumé

- **no visible shift of traffic** into surrounding areas
 - **significant change in the vehicle fleet composition:**
 - ↪ **a lot more clean vehicles (Euro 4 and better):**
 - ☞ cars 73% instead of 44%, lorries 50% instead of 17-23%
 - ↪ **many vehicles retrofitted** with Diesel particle filters
 - **decrease of traffic emissions** on top of trend :
 - ↪ exhaust particles: - 60%; NOx: - 20%
 - **benefit for the air quality**
 - ☞ **5-10% reduction** of total **PM10/2.5** & NO2,
 - ☞ traffic related decrease of **black carbon ~50%**
 - ☞ ~10 less excess days > 50 µg/m³ PM10
 - **LEZ is most effective single measure, if**
 - ↪ based on **ambitious** emission criteria
 - ↪ covering a **larger** area
 - ↪ introduced **not** too late
 - ↪ exemptions are **limited**
 - ↪ **Diesel passenger cars & light goods vehicles are included**
- ☞  ~2010-12

Impact of different measures

emission reduction



LEZ in Germany pros & cons

■ Objective:

- ☒ more **cleaner vehicles** on the roads
- ☒ modal shift or **traffic calming not intended**
 - ☞ this is a matter of transport planning & traffic management

■ Disadvantages:

- ☹ benefit **fades away** with increasing share of vehicles with DPF, Euro 5/6
- ☹ **limited** technical means for **NOx control retrofit**: less benefit for NO2
- ☹ financial **burden** for owners of high emitting vehicles
 - ☞ in particular for small business
- ☹ in Germany: virtually every car owner has to buy a **sticker** to facilitate enforcement
- ☹ administrative effort, e.g. for granting single **exemptions**

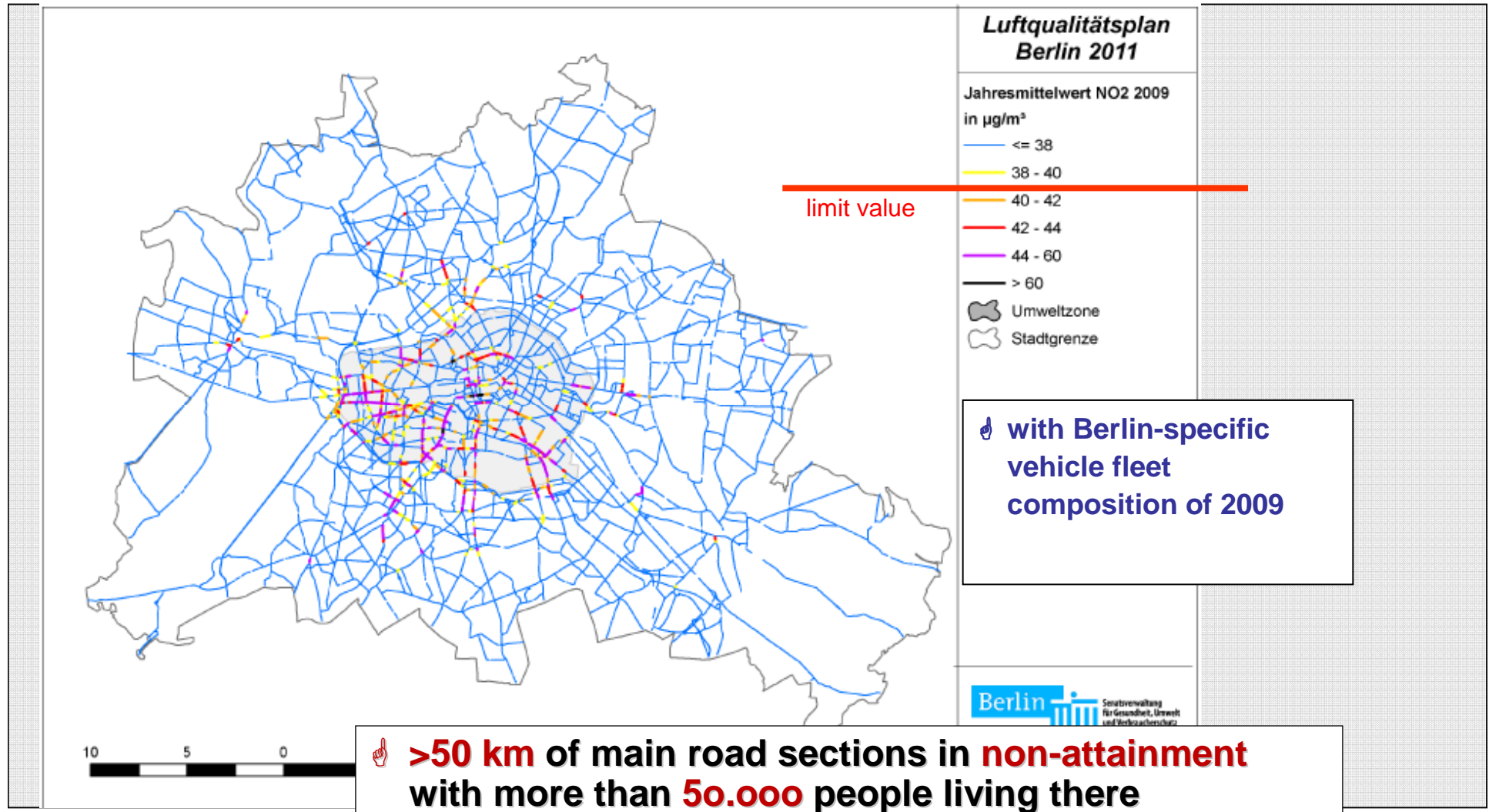
■ Advantages:

- ☺ aims **specifically** at the **most polluting vehicles**
- ☺ **rewards** vehicle owners who invested in **clean vehicles**
- ☺ reduces the emission of the whole vehicle fleet in & around the LEZ → decrease in all streets → decrease of urban background concentrations → **decreasing urban population exposure**
- ☺ **proven decrease** of **most toxic** fine particle components and of NO2



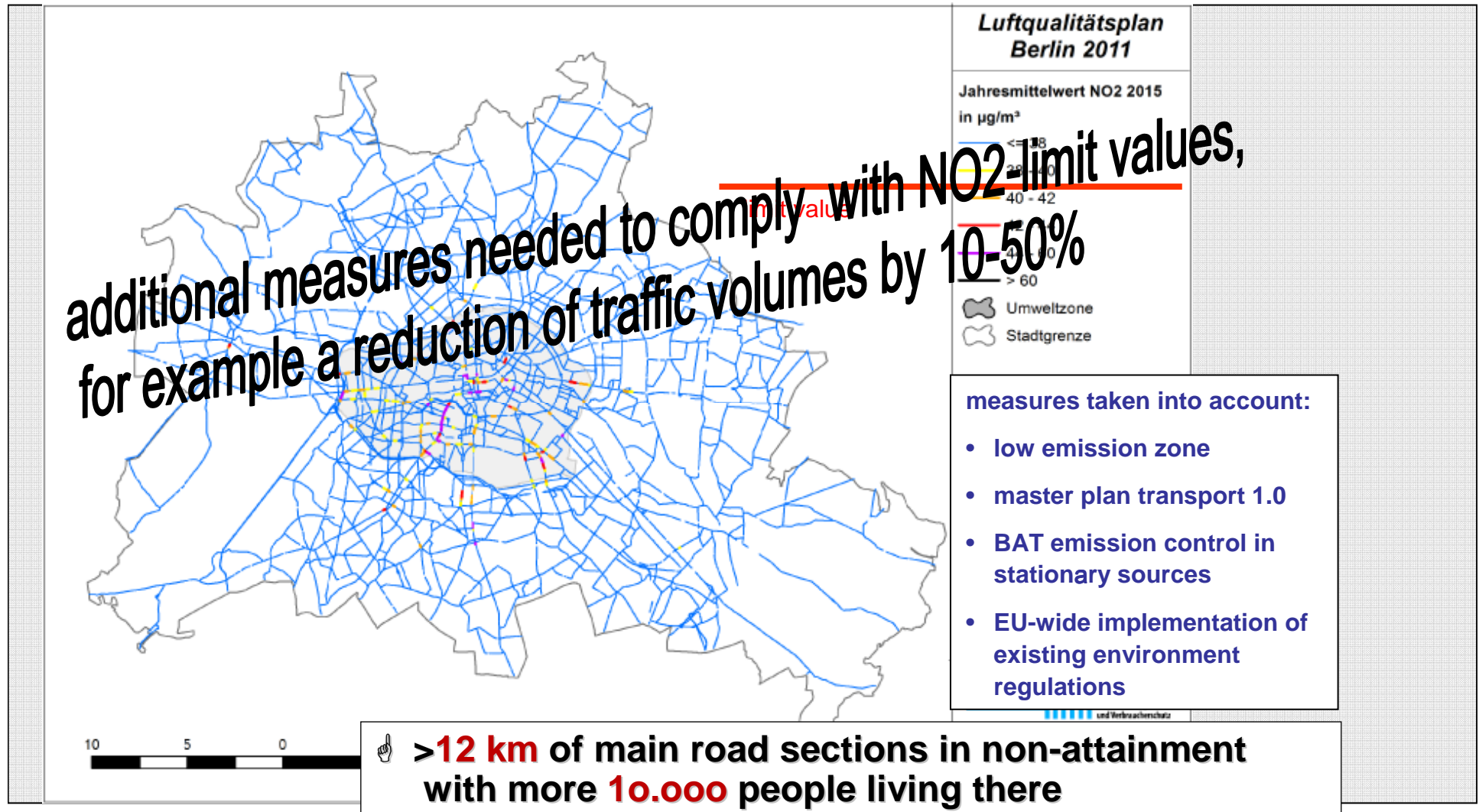
New air quality plan 2011-17

👉 simulated **NO₂** - pollution **2009**



New air quality plan 2011-17

👉 simulated **NO₂** - pollution **trend** scenario **2015**



New air quality plan 2011-17

☞ Stipulated type of **measures**

- Regional-, urban- and landscape planning
- **Traffic** on road, rail and inland waterways
 - ☞ Cleaner vehicle technology and fuels
 - ☞ Traffic **management, incl speed limits**
 - ☞ Avoiding & **shifting** traffic to more **sustainable transport modes**
 - ☞ Transport infrastructure improvement
- Domestic heating
- Off road machinery
- Industry und commerce
- Measures **not** pursued
 - ↪ **no** tightening/extending of the LEZ, **but termination of exemptions**
 - ↪ **no** road pricing/**city toll**/congestion charge
 - ☞ **lacking** legal ground
 - ☞ might **generate** traffic or push it in city areas without road pricing

New air quality plan 2011-17

👉 Action bundle **vehicle technology 2015**

■ **Promotion of retrofit with particle filters/catalysts**

- ↪ with SCR/EGR to control **NOx emissions of Heavy Goods vehicles and busses**

assumption for impact analysis:

- 👉 50% efficiency in urban traffic mode
- 👉 50-80% retrofit quota of Euro IV HGV

- ↪ with **particle filter** in **Euro 4** vehicles

assumption for impact analysis :

- 👉 50-80% retrofit quota of the Euro 4 vehicles, without a filter

- ↪ with **particle filter** in **passenger cruise vessels**

assumption for impact analysis :

- 👉 10-20% reduction of total ship emissions



New air quality plan 2011-17

👉 Action bundle **vehicle technology 2015**

■ **Termination** of all **exemptions** from the LEZ traffic ban

↪ assumption for impact analysis until 2015:

👉 replacement of all Diesel-vehicles with **Euro 3 without DPF** and **worse** by **Euro 6** vehicles

■ **Promotion** of purchase of **Euro 6 vehicles**

↪ assumption for impact analysis until 2015:

👉 **additional** substitution of 20% of Diesel **Euro 3** vehicles with DPF by **Euro 6** vehicles

■ **Promotion electro mobility**

↪ assumption for impact analysis until 2015 :

👉 **1.2%** of **total vehicle mileage** by electric vehicles, without any NOx und diesel soot emissionen, but with emissions from resuspension and abrasion



traffic management measures

👉 potential **impact** on **air quality**

■ **shift modal split** from motor traffic to clean transport modes

↪ Berlin's planning objective:

-10% less motor traffic in 10-15 years
results in up to **-10% NO₂**, **3-4% less of total PM₁₀**

😊 noise ~0.5dB(A)

■ **optimizing traffic flows** (progressive signal systems):

↪ **impact difficult to quantify**

→ local effect, traffic signal coordination works only
in one direction, potentially negative effects on cross-roads

😊 noise ~1 dB(A)

👉 **conflict** with acceleration of bus/tram

👉 risk that gained road capacities will attract more traffic

👉 **small** net gain in pollution control

😊 Noise ~2 dB(A)

■ **truck ban:**

↪ example HEAVEN project: up to **20% less NO₂**, **-7% PM**
→ only **local** effect in single roads,
merely shift to other roads, no net reduction

■ **speed limit 30km/h whole day:**

↪ example Schildhornstraße Berlin: **10 % less NO₂**, **-6% PM**

if traffic light coordination with 30 km/h works well
speed limit is **enforced**

→ also less noise and traffic accidents

😊 Noise ~2 dB(A)



Speed limit 30 km/h: impact on air quality

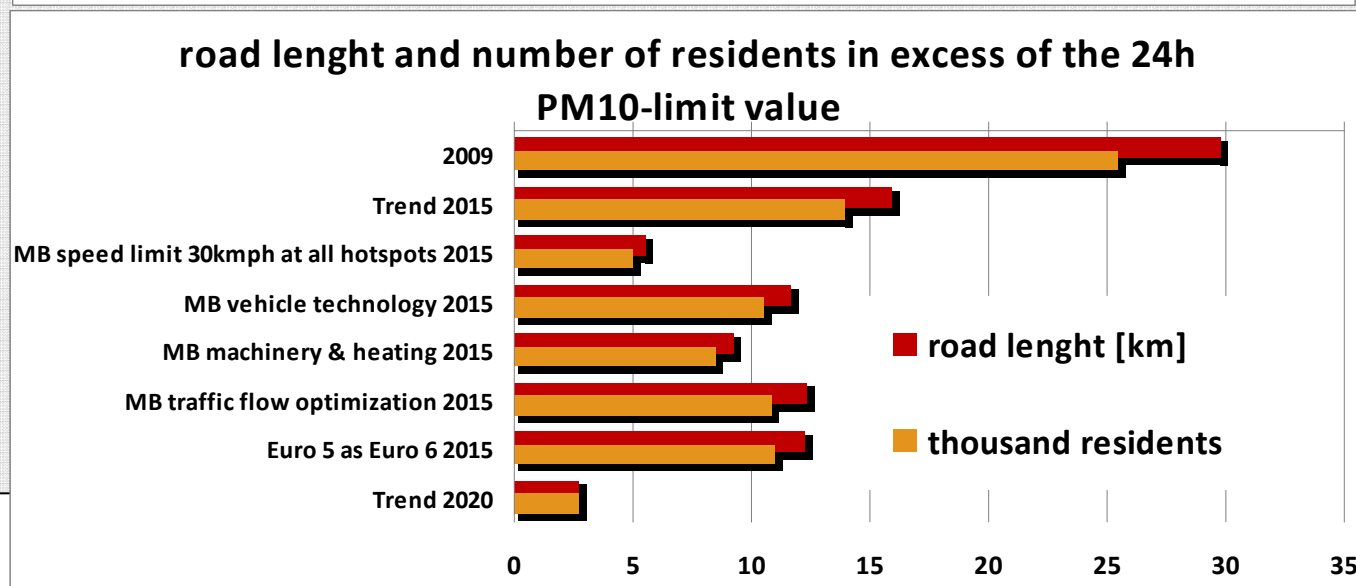
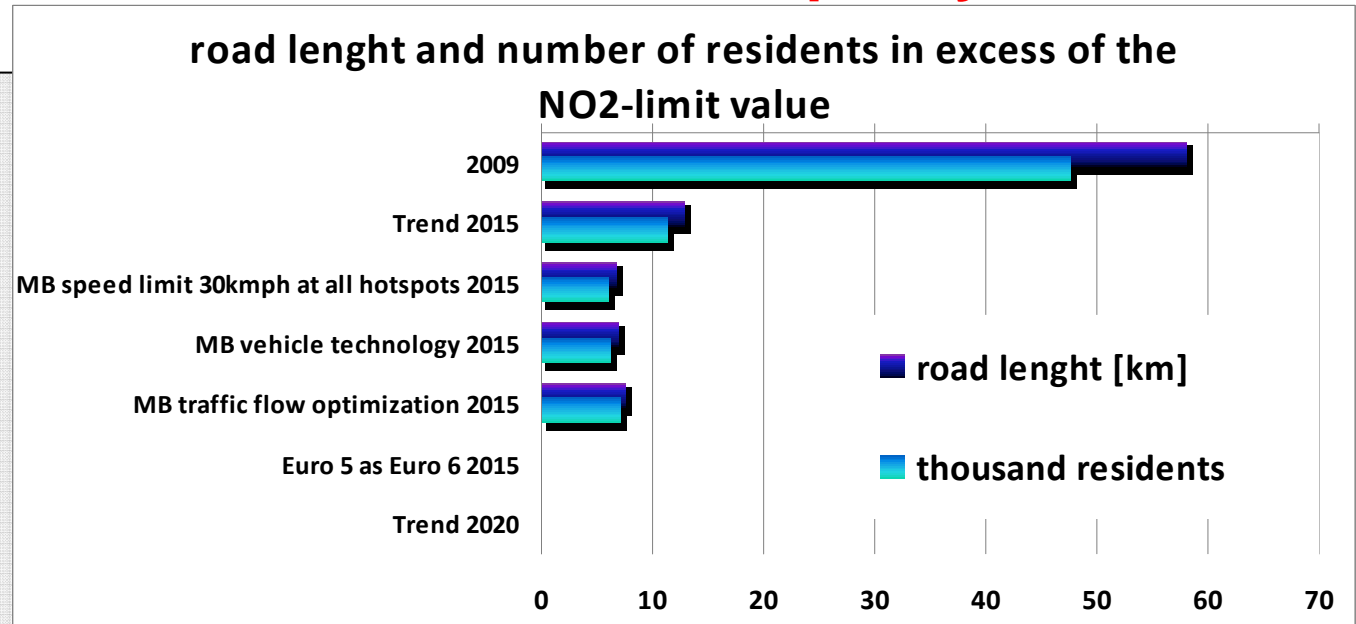
Studies conducted in Berlin:

- **speed limit test Beusselstraße within the „HEAVEN“ project 2002**
 - average speed: - 5 km/h (from 41 km/h) without speed meters,
-10 km/h with regular speed control & enforcement
 - total air pollution levels PM10 and **NO₂: - 3 %**
 - ☞ **noise: - 2 dB(A) day, -1,2 dB(A) night (measured levels!)**
- **durable speed limit Schildhornstraße**
 - average speed: 33 km/h (smooth, steady traffic flow, permanent speed control & enforcement)
 - **NO₂: local traffic contribution: - 15% ; total concentrations: -8 %**
 - **PM10: local traffic contribution: - 30 % ; total concentrations: - 6 %**
 - **EC: local traffic contribution: -19 % ; total concentrations: -10 %**
- **test of recommended 30 km/h Leipziger Straße (IQMobility 2007)**
 - average speed: - 4 km/h (down to 25 km/h) (no enforcement)
 - **NO₂-emission: - 4 %**
 - exhaust particle emissions: - 3 %
 - no measurable change in pollution concentrations
 - largest impact from frequent congestion (road capacity exhausted)

New air quality plan Berlin

👉 impact of various measures on the air quality

impact of
different bundles
of measures on
NO2 and **PM10**
pollution



Berlin AQ management

résumé

■ **efficiency of previous measures**

↪ **visible PM (black carbon) and NO2 reduction** due to **LEZ**

☞ **inclusion of passenger cars** has a **significant** impact

☞ controls the **most toxic PM** component

↪ **LEZ benefit more** than transport planning & traffic management achieved

■ **Focus on new measures**

↪ **Faster** introduction of **Euro 6** vehicles & **alternative** engine concepts

↪ **Exploit (limited) potential of optimizing traffic flows**

↪ **clean up off road machinery & local shipping**

↪ **further shift towards cleaner transport modes, like cycling & PT**

■ **remaining problems**

↪ **long-range** transport of fine particle pollution

☞ **missing national strategy**

↪ **ultimate NO2 compliance difficult** by 2015

☞ **bad performance of Euro 5 vehicles** under **urban** driving conditions

☞ **missing national strategy**



For more information on

- ☞ **Berlin's LEZ see www.berlin.de/umweltzone (also in EN & FR)**
- ☞ **LEZ in Germany see <http://www.umweltbundesamt.de/umweltzonen/index.htm>**
- ☞ **LEZ-cities in Europe visit www.lowemissionzones.eu,
the website of the European Network of LEZ-cities (LEEZEN)**
- ☞ **Berlin's Noise Action Plan see
http://www.berlin.de/sen/umwelt/laerm/laermminderungsplanung/download/laermaktionsplan/noise-reductionplan_berlin.pdf**