

Für Mensch & Umwelt

Umwelt 
Bundesamt

Workshop “Low Emission Zones” Ciudad de México 12/2014

Low Emission Zones: Experiences in Germany

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Umweltbundesamt - Federal Environment Agency

Unit II 4.1 - General Aspects of Air Quality Control



Umweltbundesamt - Federal Environment Agency

Low Emission Zones in Germany

Input : Key criteria for implementation of LEZ

Input: Challenges and solutions

Input: Assessment of effectiveness

Input: Measurement

Further Information

The UBA

- Founded 1974 – 40 years Federal Environment Agency
- 1500 employees at 13 sites
- The Mission: early detection of environmental risks and threats and finding solutions
- Topics: Climate, Energy, Air, Soil, Water, Consumption, Resources, Traffic, Chemicals ...
- Gathering data concerning the state of environment
- Investigating interrelationships and making projections
- Providing Federal Ministry of environment with policy advice and the citizens with information

Department Air

Engaged in

- general aspects of air quality control
- experimental investigation of air quality
- assessment of air quality
- impact on terrestrial ecosystem
- air monitoring network



LEZ: Experiences in Germany

Low Emission Zones (LEZ) in EU and Germany

Low emission zone: +urban areas
+traffic related air quality problem
+protection of human health
+stronger polluting combustion-powered vehicles banned

Different LEZ-strictness in EU:
Often only heavy-duty vehicles (HDV), buses affected

In Germany: motorways excluded,
motor bikes and emission-reduced HDV allowed,
normal HDV extra measure

“Stronger polluting combustion-powered vehicles”: primarily Diesel vehicles
EU-Vehicle-Emission-Standards 2009 target 130g CO₂/km (till 2015 already met)
Till 2020: 95g CO₂/km

Euro Standards sets emission limits: CO, HC, NO_x and particulates
Now: real-road data vs. testing cycle data

Effects: Existing traffic amount becomes cleaner
Emission reduction by faster fleet modernization and retrofitting (filter)
-> explicit immission reduction: human health ↑

Health threats of air pollutants NOX/PM

Pulmonary diseases, Cardiovascular disease, heart attack, allergic reactions, premature birth



WHO data
premature deaths/year because of PM pollution:
350.000 (EU), 47.000 (Germany)

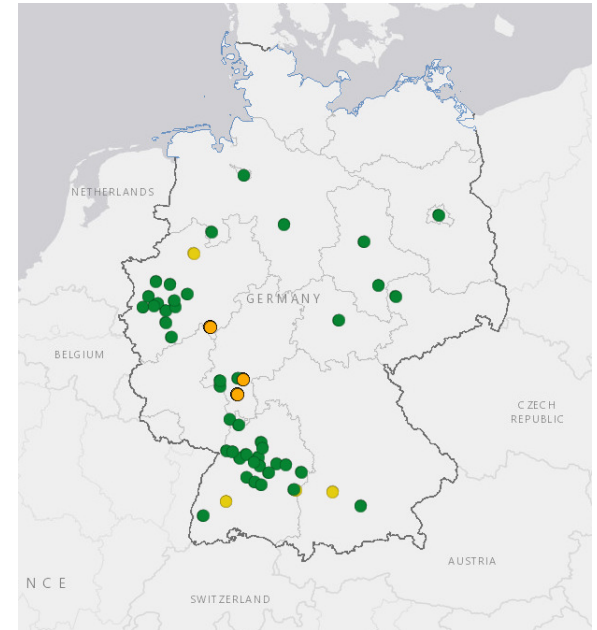
months of life lost:
8,6 (EU), 10,2 (Germany)

Low Emission Zones (LEZ) in Germany - Status

Europa: ca. 300 LEZ
London plans ultra low emission zone 2020

Germany:- 48 LEZ (+2 planned), since 2008

- biggest LEZ: Ruhrgebiet 850 km² - 13 cities 1 LEZ
- biggest city without LEZ Hamburg
- size: 40 LEZ 10-50km², rest 100km²++ (Munich: 15% of city area with 1/3 people)
- label valid in all German cities
- German + Czech sticker mutual acceptance



LEZ: Experiences in Germany

Diversity of measures in Germany

Year 2012:

231 Action-/air quality plans in Germany

Screening:

130 standard measures

Anzahl	Anteil in %	ID_MN	Standardisierte Maßnahme	Quellgruppe
124	5.9%	57	Emissionsarme Antriebsarten im ÖPNV und bei städtischen Fahrzeugen	Kfz-Verkehr
106	5.0%	8	Verkehrsfluß-Optimierung	Kfz-Verkehr
104	5.0%	36	ÖPNV, Attraktivitätssteigerung	Kfz-Verkehr
97	4.6%	2	Fahrradverkehr, Attraktivitätssteigerung	Kfz-Verkehr
64	3.0%	92	Baustellenrichtlinie / Staubminderungsplan	Stationäre Quellen
63	3.0%	53	Bau Ring-, Ausfall- oder Umgehungsstraße	Kfz-Verkehr
58	2.8%	74	Öffentlichkeitsarbeit Luftreinhalteplan / Luftqualität	Kfz-Verkehr
57	2.7%	30	Lkw-Durchfahrtsverbot	Kfz-Verkehr
54	2.6%	23	Umweltzone mit zeitlicher Staffelung	Kfz-Verkehr
41	2.0%	1	Fußgängerverkehr, Attraktivitätssteigerung	Kfz-Verkehr
41	2.0%	44	Mobilitätsberatung	Kfz-Verkehr
39	1.9%	46	Begrünung	Kfz-Verkehr
39	1.9%	85	Fernwärmenetze / Nahwärmenetze, Ausbau	Stationäre Quellen
38	1.8%	37	ÖPNV, Streckennetz-Ausbau	Kfz-Verkehr
37	1.8%	16	Lkw-Routenkonzept	Kfz-Verkehr
37	1.8%	84	Energieeinsparung	Stationäre Quellen
35	1.7%	33	Parkraum-Bewirtschaftung	Kfz-Verkehr
35	1.7%	49	Stadtplanung, Immissionsschutzbelange	Kfz-Verkehr
35	1.7%	89	Umstellung auf regenerative oder emissionsarme Energieträger	Stationäre Quellen
34	1.6%	79	Anlagensanierung - Beste verfügbare Technik	Stationäre Quellen
31	1.5%	18	Tempo 30	Kfz-Verkehr
28	1.3%	35	ÖPNV, Fahrtzeitverkürzung	Kfz-Verkehr
28	1.3%	78	Festbrennstoff-Feuerung	Stationäre Quellen
27	1.3%	48	Klimatologische Zusammenhänge	Kfz-Verkehr
26	1.2%	6	Tangentiale Ableitung des Durchgangsverkehrs	Kfz-Verkehr
26	1.2%	50	Verkehrsentwicklungsplan	Kfz-Verkehr
25	1.2%	11	Verkehrslenkung, dynamisch	Kfz-Verkehr
24	1.1%	61	Erdgasfahrzeuge	Kfz-Verkehr
22	1.0%	34	Parkraum-Management	Kfz-Verkehr
21	1.0%	40	Car Sharing	Kfz-Verkehr
21	1.0%	62	Fahrbahnbelag, Sanierung	Kfz-Verkehr
21	1.0%	109	Festbrennstoff-Feuerung / Öffentlichkeitsarbeit	Stationäre Quellen
21	1.0%	88	Grüngut-Verbrennung, Verbot	Sonstige Quellen
19	0.9%	80	Emissionsgrenzwerte, EU	Stationäre Quellen
19	0.9%	76	Mobile Maschinen und Geräte, emissionsarm	Sonstige Quellen
18	0.9%	67	EU-Emissionsgrenzwerte	Kfz-Verkehr
18	0.9%	75	Straßennassreinigung	Kfz-Verkehr
18	0.9%	97	Straßenreinigung	Kfz-Verkehr
17	0.8%	41	Fahrgemeinschaften / Pendlerportal	Kfz-Verkehr
16	0.8%	2	Kreisverkehr statt Ampel	Kfz-Verkehr
16	0.8%	27	Umweltzone ohne zeitliche Staffelung	Kfz-Verkehr

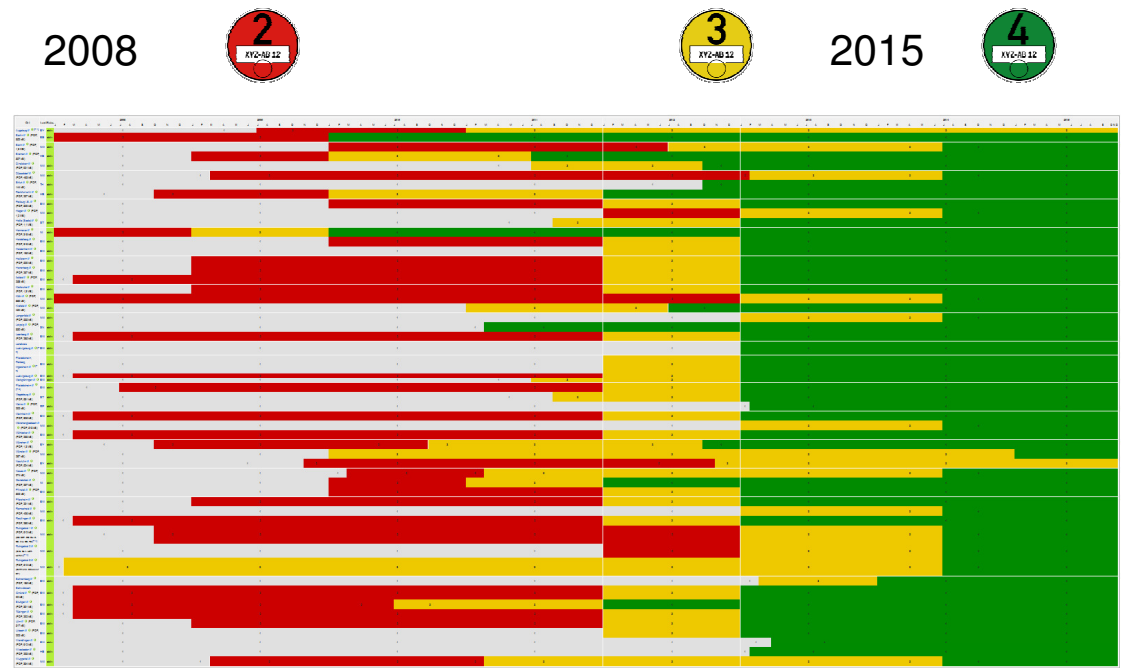
Diegmann et al. 2014 (UBA-Texte 26/2014)

LEZ: Experiences in Germany

LEZ classification

x-coordinate: Timeline 2008-15

y-coordinate: German cities



Low Emission Zones (LEZ) in Germany - Environmental/traffic regulatory

Measure corresponds to EU Subsidiary principle: Memberstate Responsibility + Autonomy

„local problems: local solutions and measures“

EU: 2008/50/EG air quality directive - WHO recommendations influences limit values

Germany:

39.BImSchV +road traffic regulations, monetary fine catalog

Municipality responsible for compliance

LEZ anchored in local air quality plan ...

35. BImSchV (labelling-ordinance): vehicle classification (four classes) and exceptions

visual control (sticker with license plate number on front shield)

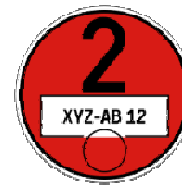
Vehicle classification and colour code labeling - 35. BImSchV

diesel-engined car Euro 1 (I)

O

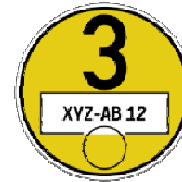
0 LEZ

diesel-engined car Euro 2 (II)
or 1 + particle filter



0 LEZ

diesel-engined car Euro 3 (III)
or 2 + particle filter



4 LEZ

diesel-engined car Euro 4 (VI) or 3
and gasoline- cars with controlled catalytic converter



44 LEZ
2 planned

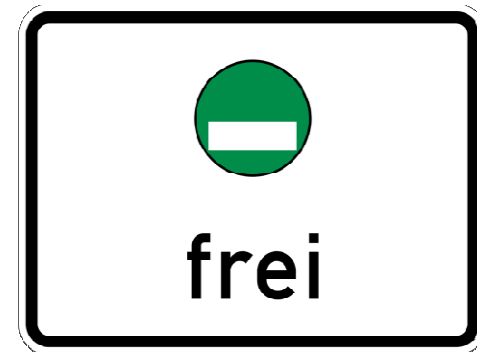
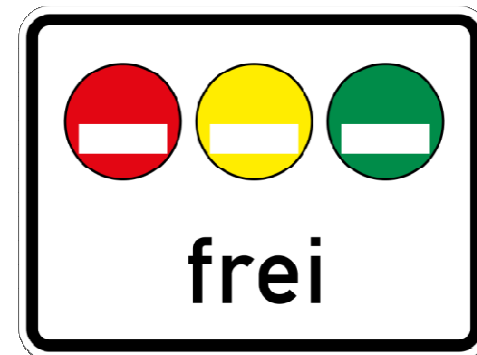
Stickers available (5 €): internet, repair shops, Dekra, TÜV, licensing offices

Exceptions for vehicles

general:

- Mobile machinery and equipment
- Work machines
- Agriculture and forestry traction engines
- Two-wheeled and tricar motor vehicles
- Vehicles of handicapped persons
- Vehicles of ambulance, army
- Old-timer

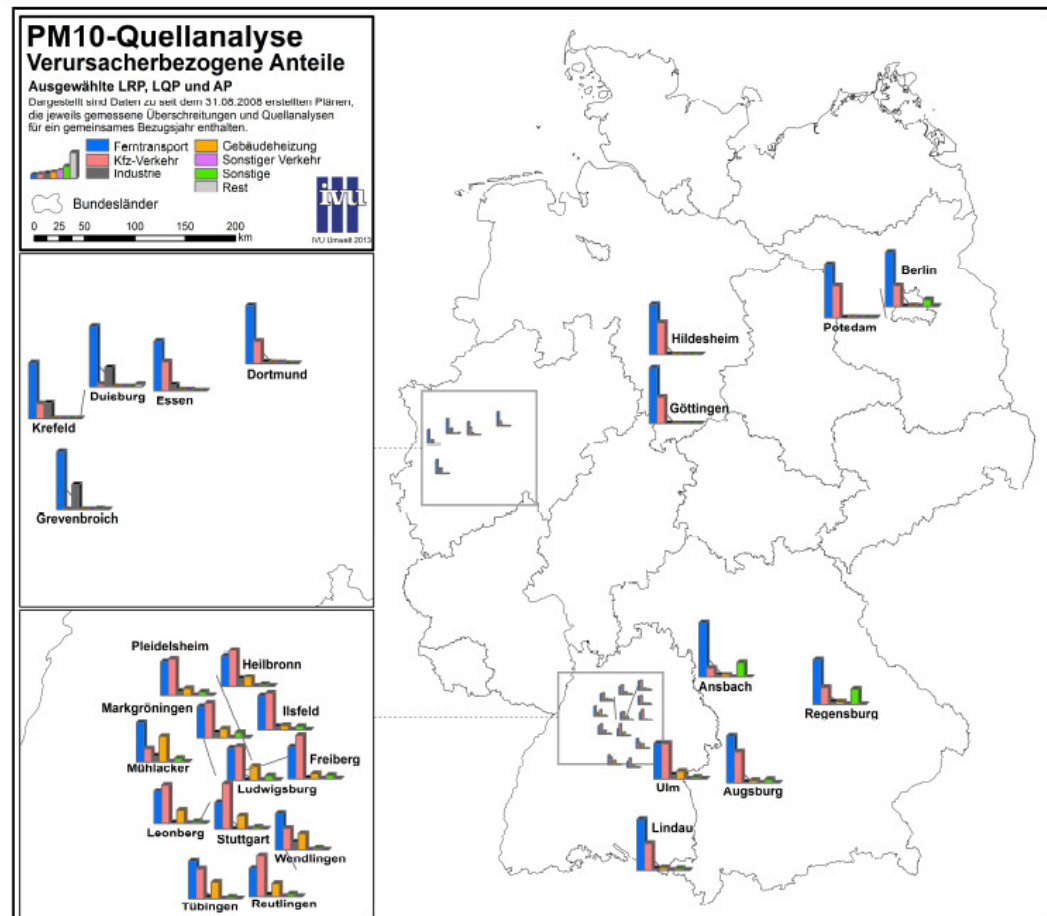
individual: request necessary (hardship case)



Air pollutants: Origin-related PM10 source analysis

Average values (94 air quality plans):

Long-range-transport	53 %
Motor vehicle traffic	30 %
Industry	6 %
Heating	5 %



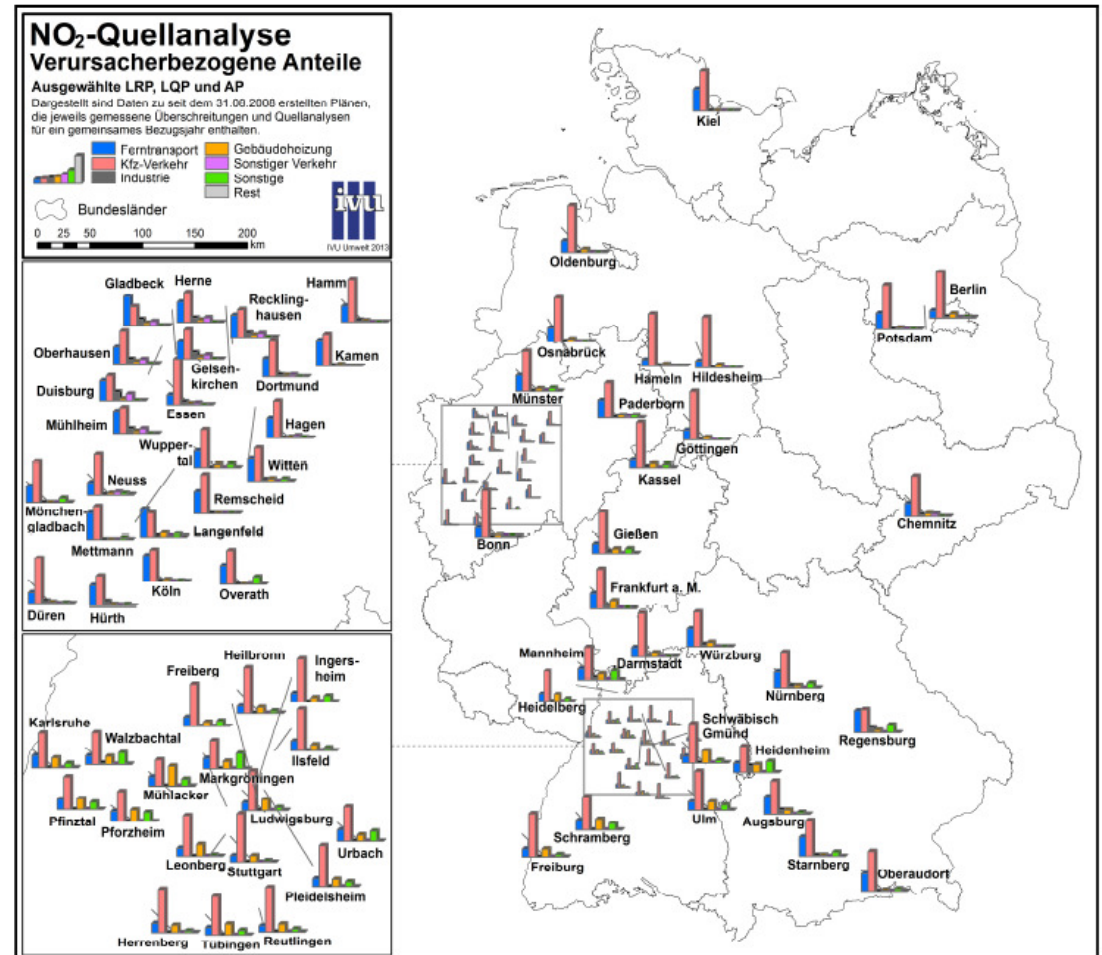
Diegmann et al. 2014
(UBA-Texte 26/2014)

Air pollutants: Origin-related NO₂ source analysis

Average values (107 air quality plans):

Long-range-transport	21 %
Motor vehicle	64 %
Industry	3 %
Heating	7 %

Diegmann et al. 2014
(UBA-Texte 26/2014)



Low Emission Zones in Germany - Reasons to establish LEZ Leipzig

City of Leipzig:

exceedance of limit values PM10 (since 2005) and NO2(since 2010) from 2008/50/EG

yearly average value	PM10 and NO2	40 $\mu\text{g}/\text{m}^3$	
daily average value	PM10	50 $\mu\text{g}/\text{m}^3$	(35 d/a exceedance allowed)
1h average value	NO2	200 $\mu\text{g}/\text{m}^3$	(18 h/a exceedance allowed)

motorized road traffic

No.2-PM-source (35%)

No.1-NO2-Source (80%)

2011 LEZ implementation 184km²

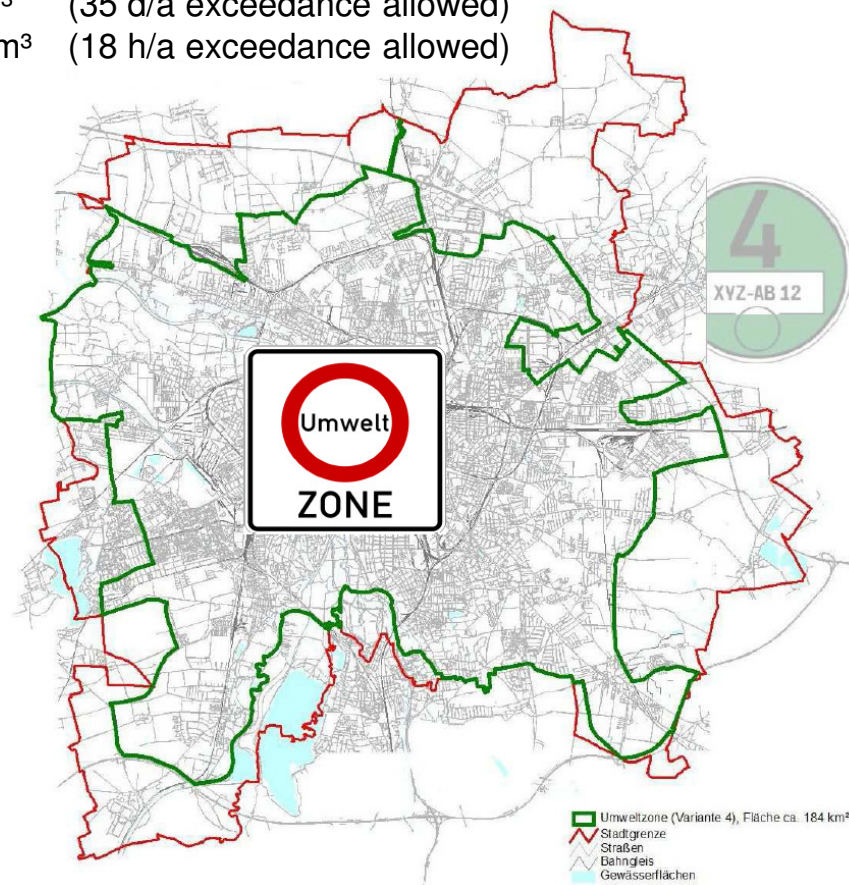
62 % of area

Proof: 30% less toxic, traffic related soot

Despite LEZ: new tourist-record +6%

No business insolvencies: LEZ exceptions

Infringement s: 1st year 7000; 2nd year 3000



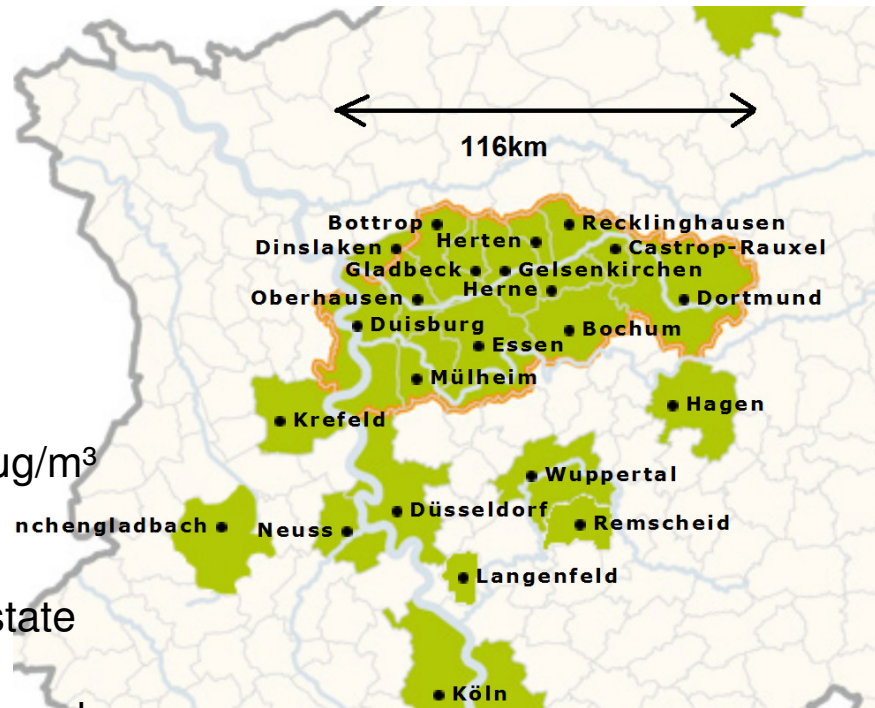
Low Emission Zones in Germany - LEZ Ruhrgebiet

Population 5,1 Mio. – 4.400 km²
Coal, iron and steel industry
Biggest German LEZ covers 13 cities
850 km², 116km east-west
Started 2008 rag rug- single citycenters
Autobahn free
01.2012 connected area

Evaluation data 2011:
PM10 yearly average value reduction 2,4µg/m³
= 7% less
16 exceedance days less
modernization of fleet faster as in rest of state

NO₂: although 2 µg/m³ more rural background
1,2 µg/m³ less NO₂ in LEZ because of this measure
(Source: UMID 4 2011 S.29)

numerical modeling: 2009 1/3 of heavy emission charged roads outside LEZ
7% of roads with PM limit value exceedance
12% of roads with PM limit value exceedance



Input : Key criteria for implementation of LEZ (1)

No universal/general statement how to build a successful LEZ:

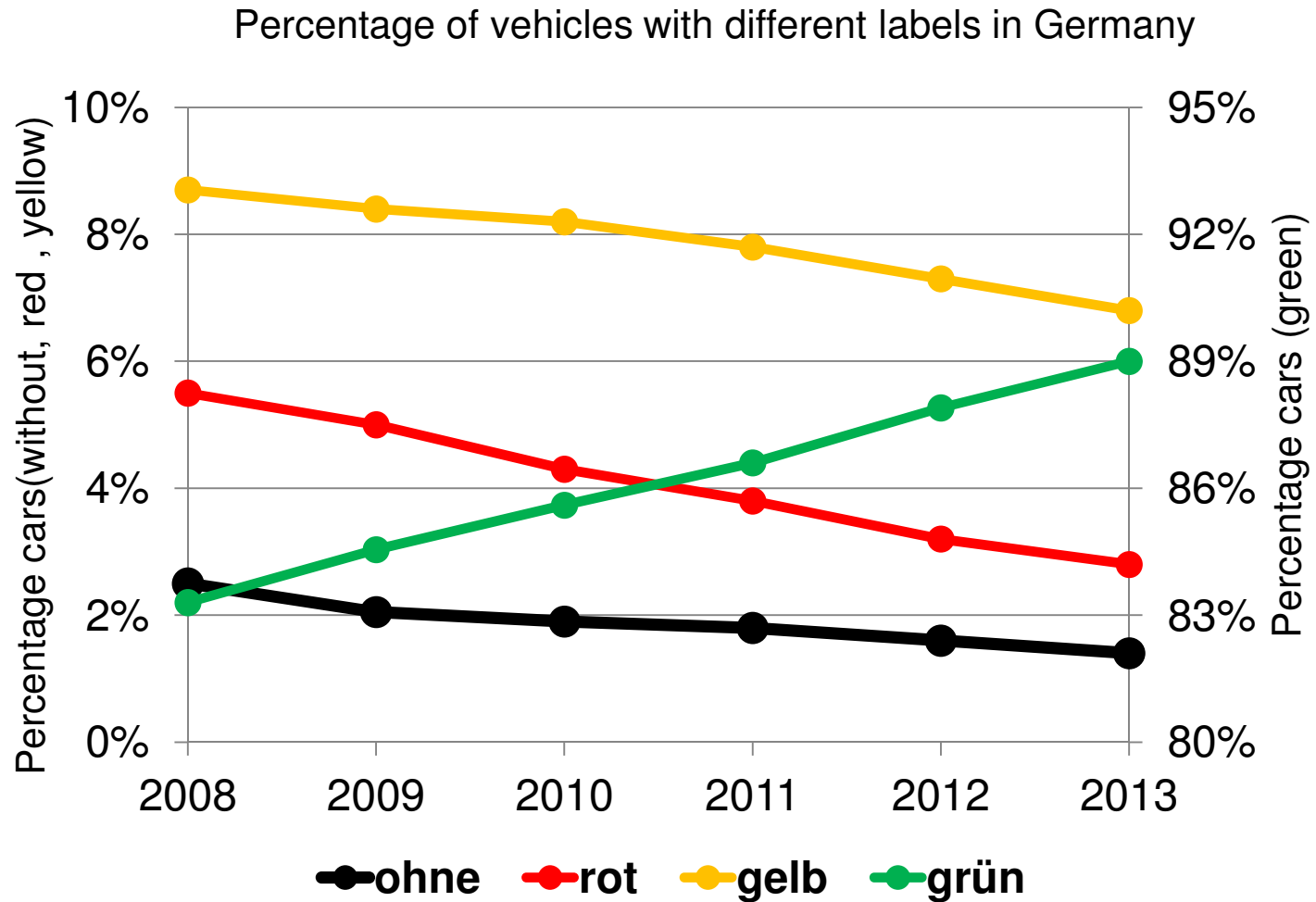
Always particular case inspection

- Learn about the emissions/composition of the local fleet (e.g. motorbikes not relevant in Germany)
- Determine traffic-related pollutants + fingerprinting/source apportionment)
- Measurement and numeric modelling
 - > Deploy dense measure network before and during the LEZ implementation
- Early LEZ drafting stage involve stakeholders and public
- Make the laws and set ambitious limit values
- Invitation for public and expert comments to laws and LEZ design
- Public hearing, participation
- Prepare court-proof watertight design of the LEZ and argumentation following your law and constitution is crucial.

Input : Key criteria for implementation of LEZ (2)

- Consider local circumstances (traffic and town planning, urban layout, social justice)
- Design the LEZ: big enough and with strict requirements (similar Euro 4 or better)
 - > include a big part of the fleet, so peripheral emissions can't dominate
 - > peripheral area changes fleet too
- Start soon, because of technical progress (graphic)
- guarantee the compliance: Controll the driving and parked cars for correct stickers (graphic)
- Avoid too many exceptions
- Check future trend (new emission standards and car classifications ...) and develop LEZ to prioritize future low-emission vehicles
- Apply other measures (Improve: traffic flow, public transport, car and bike sharing, restoration)

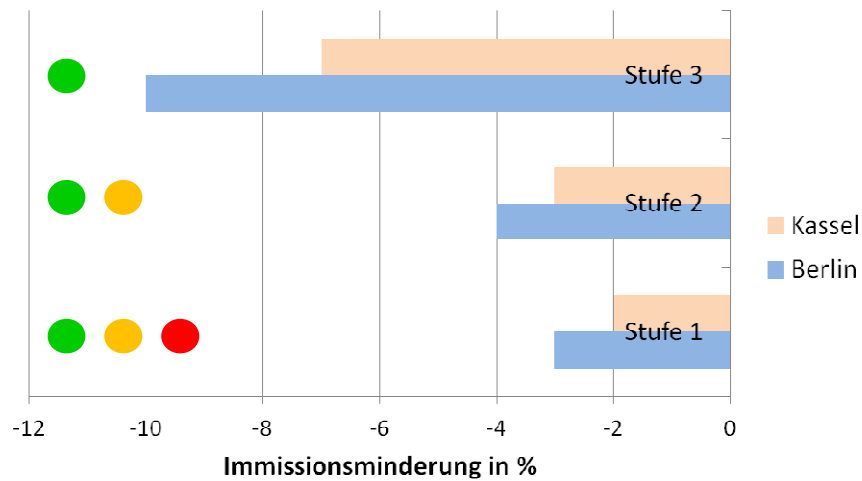
Time of implementation – „Start soon“



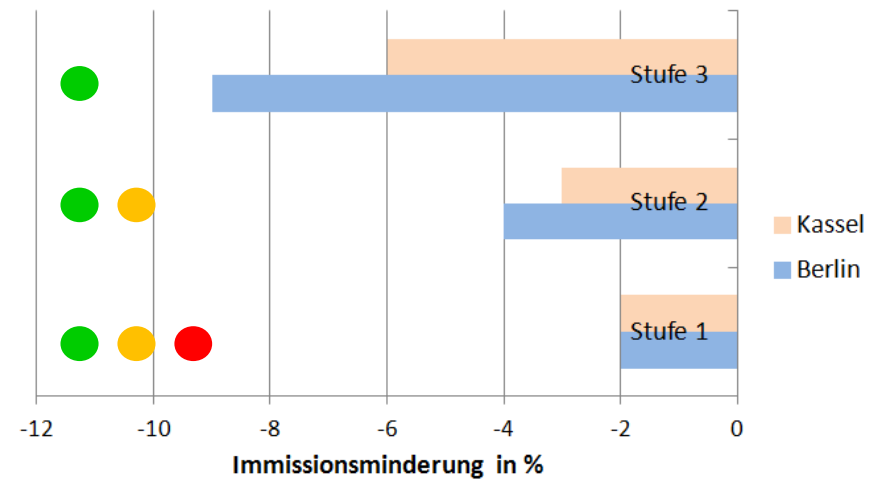
nach Diegmann et al. 2014

Effectiveness of early implemented LEZ : model results

Potential of reduction PM10 2007



Potential of reduction PM10 2010



Datengrundlage: UBA-Text 22/07: Maßnahmen zur Reduzierung von Feinstaub und Stickstoffdioxid

Compliance rate & control intensity

Kreis/Stadt	2008	2009	2010	2011
Augsburg		1359	6144	5071
Berlin	5608	6011	8369	11563
Böblingen		6		
Bochum		2937	1957	1493
Bonn			127	70
Bottrop		614	246	225
Bremen		10309	3682	4460
Dortmund		1402	1288	1285
Duisburg		1949	164	575
Düsseldorf		4432	2852	2158
Essen		3830	1541	1579
Frankfurt a.M.		5098	4881	5219
Freiburg im Breisgau			1	3
Gelsenkirchen		1020	837	428
Hannover	71	3388	3353	3884
Heidelberg			76	151
Heilbronn		69	15	4
Karlsruhe		73	14	9
Kassel		9		
Köln		5	5	31

Quantity of reported label infringement

Berlin: 3,4 Mio. residents
Köln: 1,0 Mio. residents

UBA-Texte 26/2014

Input: Challenges and solutions

LEZ is unpopular (“bureaucratic sanction”) and will be jurisdictionally attacked.

Car driver want a fundamental right of individual automotive mobility!

Local business/economy see the additional costs.

Opponents of LEZ : local economic representative IHK , ADAC, automotive industry pro driver

Opponents deny efficiency and proportionality/ commensurability

Court-proof watertight design/argumentation following your law and constitution is crucial.

The human health should be focused, not the driving freedom.

Lawsuits in Germany:

LEZ must be: necessary, suitable and commensurate

LEZ critics aim often at the commensurability

No German LEZ withdrawal

Until now, in all courts affirmed multiple times

the proportionality of “LEZ” on first and second level of jurisdiction.

2011 a woman took the city of Wiesbaden to court
because of the bad air quality.

She won because of her right for clean air
and the city must set up air quality plan and a LEZ was implemented.



Input: Challenges and solutions

Only long range transport responsible of limit value exceedance

“local measures avoid nothing”

And **urban PM-pollution almost equal natural background** pollution (next slide picture)

PM: longlife(slow reduction): long-range-> high background

But: Hotspot/Rural-difference = 50% (around $10\mu\text{g}/\text{m}^3$) - > that's not “equal”

Other sources more important: (bei NO_x ist traffic essencial; PM auch Abrieb and Aufwirbelung)
Industrial plants and heating für die Luftverschmutzung mitverantwortlich und das mit einem nicht zu unterschätzenden Prozentsatz.

Yes, traffic is in overall-emissions not so big source, but traffic is very important: In the streets are the limit-value-exceeding Hotspots

Emission≈Immission, the emission is almost undiluted at nose-level

The big industrial emissions are far from the cities and diluted.

No Impact – useless (ADAC) Other measure have more impact „Clean air YES – LEZ NO“ :

SRU (German expert council environment): LEZ highest red. potential of all local measures

LEZ have related to Immissions only a <10% reduction potential

Related to emissions it's more relevant

Input: Challenges and solutions

Pollution regimes

RED

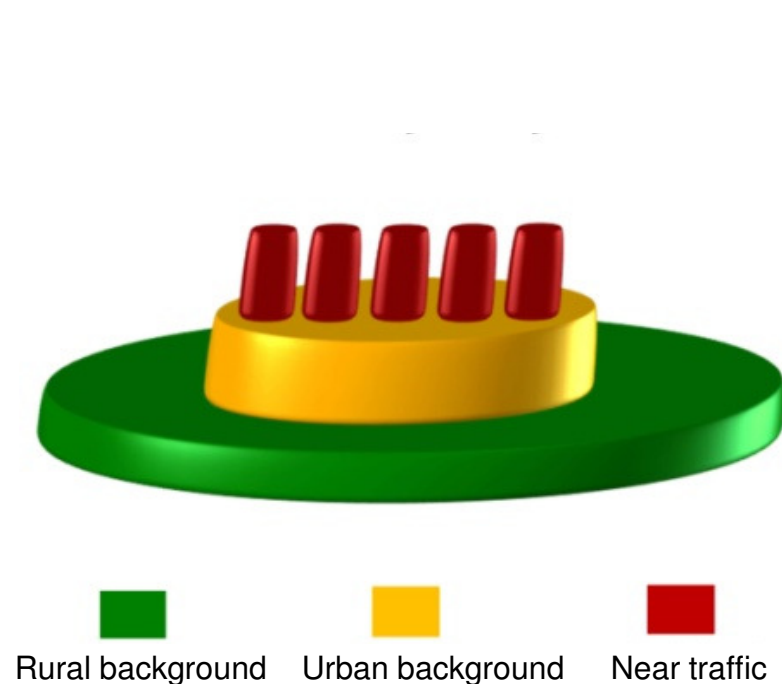
Pollution dominated by traffic

YELLOW

Pollution dominated by all urban sources,
not dominated by a single source

GREEN

Air quality widely unaffected by local sources



Input: Challenges and solutions

Administration and public effort (retrofitting/new car) too high:

Tremendous additional costs for companies, medium-sized businesses, citizens and the state

Hidden/cold robbery, because some 2005er cars forbidden

substantial economy costs: administrative costs

industry-oriented “Center Automotive Research” data:

overall cost -launch LEZ: ca. 12.100.000.000 Euro

-primary costs (administrative costs + stickers): ca. 89.600.000 Euro

-second. costs (loss in financial value of the old cars): ca. 11.900.000.000 Euro

Clean air not for free - industry-oriented calculations validity?

rip off/Abzocke

monetary fine 80,- € vehicle without valid sticker

State of the art and progress:

Because of technical progress is the air pollution sinking, even without LEZ

intensification of LEZ is purposeless because there are almost no cars with red and yellow classification

Actual system can't prioritise extrem emission-reduced vehicles

-> classification development (new sticker colour)

Input: Challenges and solutions

criticism on “mass related limit value” :

meaningless limit value -> meaningless measure
because it's a “non-material-specific limit value”

Stoffspezifisch (PM)

particle size + shape + chemical composition + mass = toxicological effect
(health supporting natural seasalt aerosols)

Complex measurement (expensive)

but:

Epidemiologic result: PM mass is important

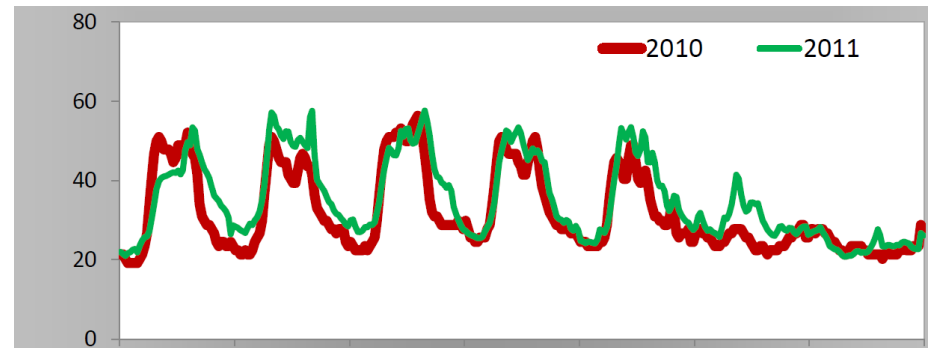
Moreover particle number reduction through mass-specific limit value

.... Some results next page ...

Challenges: Mass- vs. Materialbased limit values / LEZ - Effectiveness

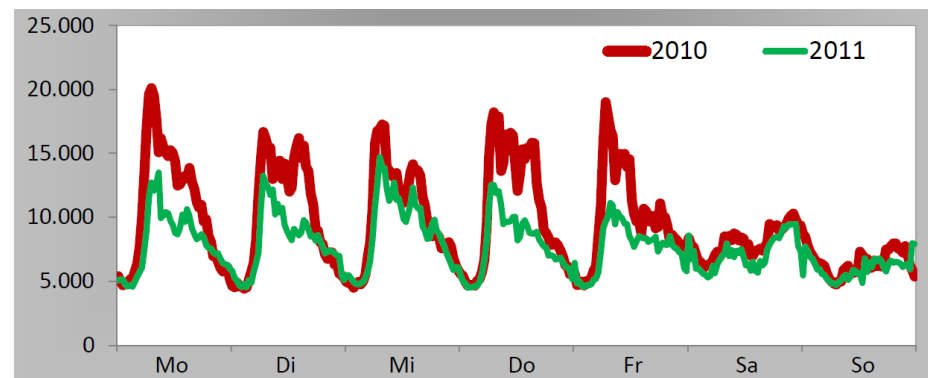
PM10 reduction in Leipzig
Average weekly load curve

[in $\mu\text{g}/\text{m}^3$]



PN 30-200 nm number
reduction in Leipzig
Average weekly load curve

[in $1/\text{cm}^3$]



Datengrundlage: LfULG and TROPOS <https://publikationen.sachsen.de/bdb/artikel/18590>

Input: Challenges and some solutions

Unrealistic testing cycle:

automobile emissions Euro 5/6 standard: testing cycle emissions << real-life emissions

Euro-Norm compliance during vehicle testing, but not on-road

Some Euro-6-vehicles can have emissions seven times worse than in testing cycle.

Other problems:

- Increased NO₂-percentage in particle-filters.
- Too many vehicle exceptions in LEZ-area: no effect
- Temporary sources: e.g. big construction site

Meteorological conditions falsify results:

Meteorological conditions: inversions (next page)

- atmospheric chemistry and stratification of the atmosphere
- flow direction (transboundary long-range transport of pollutants)
- wind speed and wash out processes
- Indirect: Higher motor-emissions in cold months



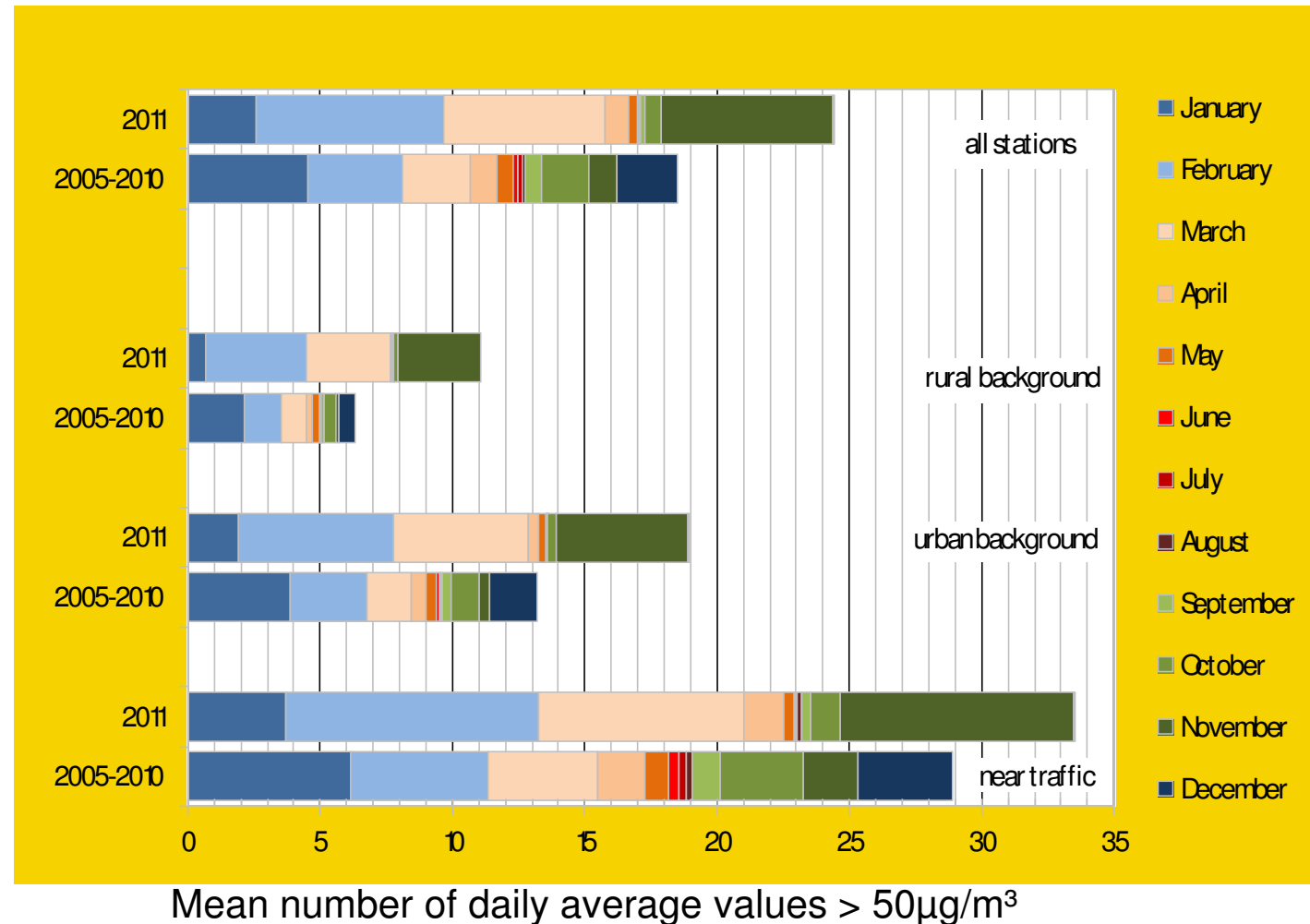
Challenges: High-PM₁₀- episode 2011

meteorological conditions:

inversion layer with low wind speed: pollutants trapped at ground level + record of aridity

>> accumulation

Traffic Hotspots



Input: Assessment of effectiveness - How to assess

Difficult assessment: Traffic, weather, relief shape are complex-dynamic systems

No general rules or assessment standards

Often huge data fluctuation at the single stations

Results allows big space for interpretation

- comparison at temporary and/or spatial level
 - > before/after and comparison of the LEZ-area with a city without LEZ
- Monitor change of traffic flow in and outside LEZ – traffic displacement?
- Monitor change of fleet structure
 - > statistics in license offices (too: reclassification after retrofitting), screening of license plates
- Monitor air pollutant concentrations, identification of their origin
- reference year with similar meteorological conditions
- Dense monitoring network
- Review epidemiologic relevance; Consider disturbance variables / uncertainty of measurement
- analyze first the summarized results, then the single mess station

LEZ: Experiences in Germany

Assessment of effectiveness - status

genuine truth: „the less coffee in aquarium, the more happy the fish“

PM2,5 yearly average value reduction $10\mu\text{g}/\text{m}^3$
„7 Month less life loss“ (Zellner et al.2009)

Munich: 10% less PM10 (Cyrus 2009)

SRU (German expert council environment): LEZ highest red. potential of all local measures

Evaluation data 2011 LEZ **Ruhrgebiet:**

PM10 yearly average value reduction $2,4\mu\text{g}/\text{m}^3 = 7\%$ less, 16 exceedance days less
modernization of fleet faster as in rest of state

NO2: although $2\mu\text{g}/\text{m}^3$ more rural background

$1,2\mu\text{g}/\text{m}^3$ less NO2 in LEZ because of this measure (Source: UMID 4 2011 S.29)

kilometers traveled: equal; no traffic displacement

In main streets in **Berlin** up to 3 % PM10 and 10 % NOx reduction

Soot and particlenumberconcentration higher reductions possible:

Leipzig: toxic, traffic related soot 1/3 less (TROPOS, LfULG)

And: Cities without LEZ benefit from near LEZ: e.g. Potsdam near Berlin and airquality benefits, because in Potsdam they need a sticker if they want to visit Berlin

LEZ: Experiences in Germany

Input: Air pollutant measurement and monitoring

federal state responsibility + UBA background

>250.000 residents: air quality monitoring mandatory

Traffic: minimum area 200 m², no measurement in very narrow streets

Requirements for monitoring (39. BImSchV Annex 3)

Location:

- with the highest pollution and (in+)direct exposure
- representative character for population exposure
- large-scale status: air sample for at least 100m street
- Station windward of main wind direction
- The higher the pollution, the more station and intervalls

Sampling:

- CO, NO₂, NO, SO₂, PM₁₀, ozone, (Pb, PM_{2,5}, Benzol...)
- Inlet 270° without obstacles (buildings, trees 0,5m away); 1,5m-4m high
- Inlet max. 10m from edge of carriageway; min. 25m from congested crossroads

Other factors: accessibility, public/maintenance security , interference, power supply



Summary

LEZ: one instrument for cleaner air

Assessment of effectiveness complex

LEZ are a meaningful and important measure to fight traffic-related air quality problems and protect human health and the environment

LEZ: Experiences in Germany

Vielen Dank für Ihre
Aufmerksamkeit!

SOURCES AND LINKS FOR FURTHER INFORMATION:

<https://www.umweltbundesamt.de/themen/luft/lufts Schadstoffe/feinstaub/umweltzonen-in-deutschland>

<https://www.umweltbundesamt.de/themen/luft>

https://de.wikipedia.org/wiki/F%C3%BCnfunddrei%C3%9Figste_Verordnung_zur_Durchf%C3%BChrung_des_Bundes-Immissionsschutzgesetzes

Register of German LEZ https://de.wikipedia.org/wiki/F%C3%BCnfunddrei%C3%9Figste_Verordnung_zur_Durchf%C3%BChrung_des_Bundes-Immissionsschutzgesetzes#C3.9Cbersicht_der_Verkehrsverbote_in_Deutschland

<https://www.umweltbundesamt.de/publikationen/bestandsaufnahme-wirksamkeit-von-massnahmen-der>

http://www.gesetze-im-internet.de/bimschg/_47.html