Evaluation of the effectiveness of measures to improve quality air applied in northern and central Europe

Claire Holman
University of Birmingham/Brook Cottage Consultants

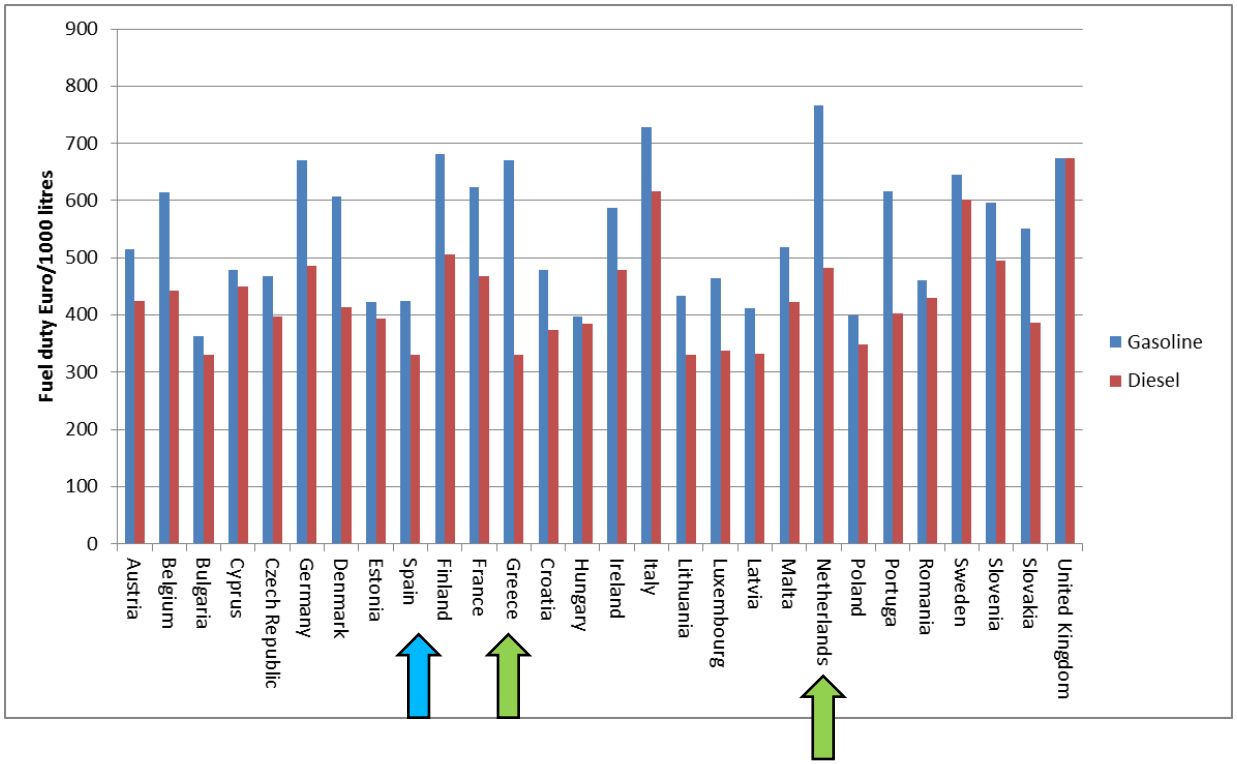
Mitigation Measures from Northern /Central Europe

1. Low emission zones (LEZs)
2. Discourage diesel cars
3. Taxation/pricing strategies to encourage electric, hybrid electric and gas vehicles
4. NOx abatement from road vehicles
5. Eco-efficient car labels
6. Efficacy of road cleaning
7. Efficacy of dust suppressants
8. Domestic and agricultural biomass burning
9. Shipping emissions
10. Interference and synergy of air quality and climate

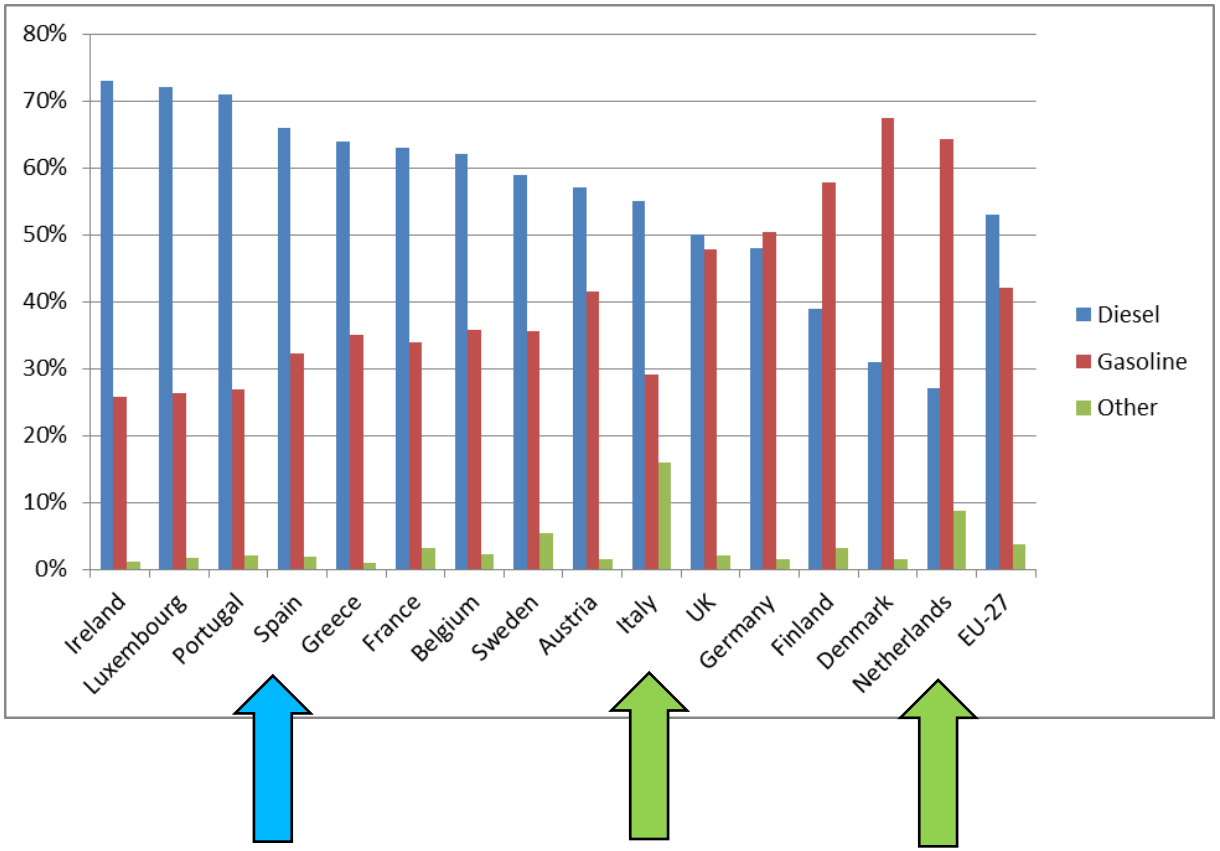
Solutions: Encouraging the use of cleaner cars

- Discouraging diesel cars
- Encouraging cleaner vehicles
- Mandatory eco-label
- Low Emission Zones (LEZs)

Fuel duty (2015)



New car sales by fuel (2014)



Discouraging diesel cars

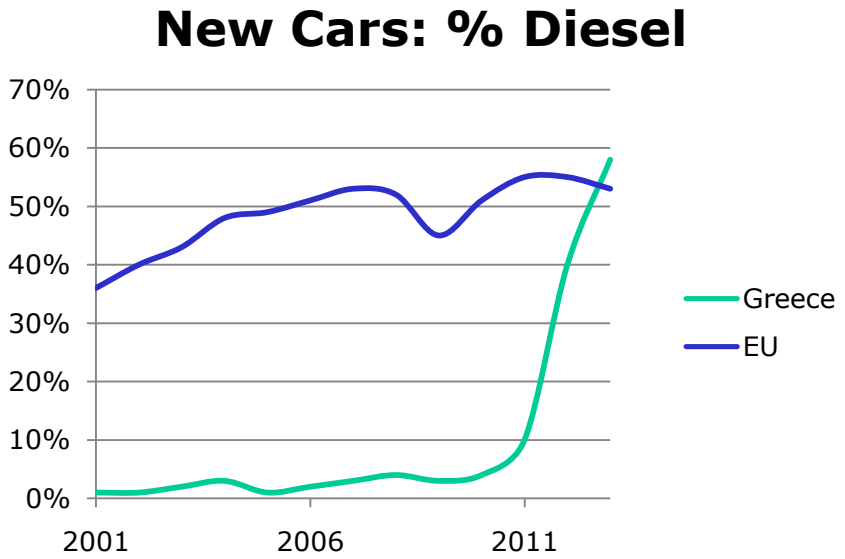
- Car purchase and/or ownership taxes - CO_2 based in most MS
- Diesel taxation and pump prices - greater than gasoline in most MS.
- Favours purchase and use of diesel cars
- But taxation/diesel car sales relationship is complex.

- Gap between type approval and real world CO_2 emissions (2014)
  - 42% diesel
  - 37% gasoline
  - 50% hybrid
- Diesel - high NOx and PM emissions
- Diesel Benefits overstated

Banning diesel cars

Greece

- 1991 until 2011 – diesel cars banned in Athens and Thessaloniki
- Diesel 20% cheaper than gasoline
- Rapid increase in diesel car sales since ban lifted



London

2014: Attempts to ban diesel cars from London LEZ dropped due to public opposition

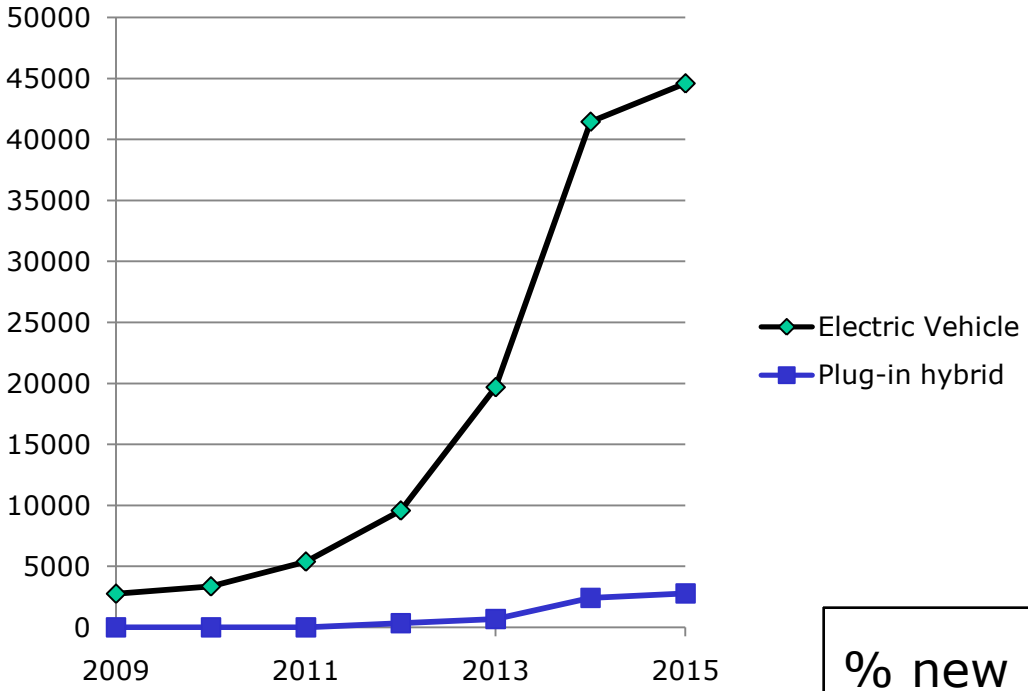
Paris

2015: Media announced *Mayor to ban most diesel vehicles from the city by 2020*; reality gasoline and diesel will be treated the same in LEZ from 2017

Diesel cars in the Netherlands

- 20-28% new cars diesel from 2001 to 2014
- Highest duty on gasoline in the EU
- Diesel 22% cheaper than gasoline at pump.
- Long term policy to penalise diesel cars
- 1998 the National Environmental Policy target to **reduce** the share of diesel vehicles from 11% in 1998 to 5% in 2010 (actually 20% in 2010
- Car taxation primarily CO_2 based since 2008. A penalty for diesel cars

Electric new car market in Norway



Norway EV market leader due to Government support for 20+ years
Incentives added sequentially until market responded

% new cars	Battery EVs	Plug-in hybrids	Hybrids
Norway	12.6	1.2	6.9
Netherlands	0.9	3.1	3.7
Spain	0.1	0	1.4
EU-28	0.3	0.2	1.4

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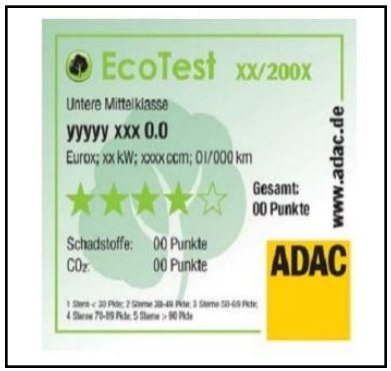
Norway electric car market

- Incentives added sequentially until the market responded.
- The price difference between BEV and petrol car can be €1,000.

- Exempt from
  - vehicle registration tax
  - road tolls
  - VAT (normally 25%)
- Bus lane access
- BEVs -reduced annual tax
- Reduced rates on the main coastal ferries

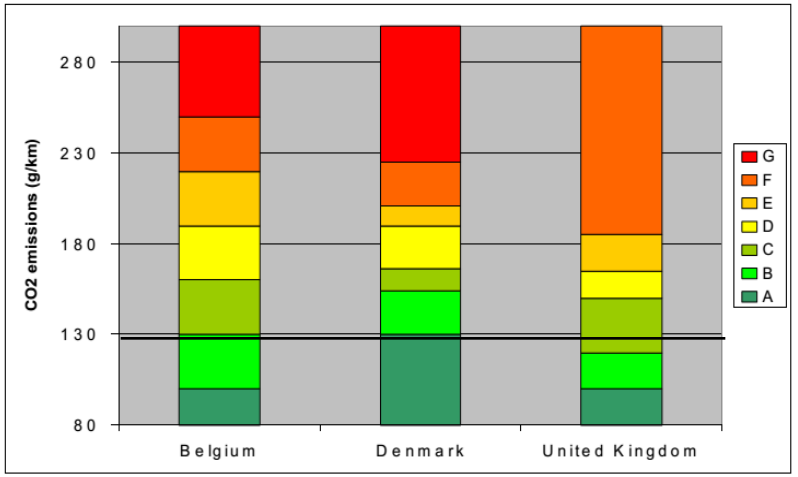
Vehicle eco-label

- Mandatory EU car CO_2 label applied differently in each Member State
- Many use A-F / G classes
- Can rank same car very differently
- Motoring organisations have separate eco-labels include NOx/PM



Comparison of the CO_2 emission bands (gasoline cars) used in the energy efficiency rating systems

Source: ADAC, 2005



Proposed vehicle eco-label

- Mandatory EU wide scheme
- Treat NOx, PM and CO_2 emissions equally
- Apply to new & used vehicles
- To take account of real-world emissions
- 'Well to tank' to enable ICEs and EVs to be compared
- Based on domestic appliances label (A to G rating) with running costs.
- Updated on annual basis by allocating a fixed percentage of models to each band.
- Long term public education is required to support the eco-label

Europe's LEZs (December 2015)

Country	Number of LEZs	Applicable vehicles	National Framework
Austria	7	HGVs	Yes
Denmark	4	HGVs + buses	Yes
Finland	1	Buses/refuse trucks	NO
France	2	HGVs	No
Germany	73	All 4 or more wheeled vehicles	Yes
Greece	1	All vehicles	No
Italy	Approx. 100*	Various	No
Netherlands	13	HGVs	Yes
Portugal	1	Cars & HGVs	No
Sweden	8	HGVs + buses	Yes
UK	5	Various	No

* Excludes large number of LEZs in communities in Lombardy region

Source: http://urbanaccessregulations.eu

LEZ Summary

Area	Range >1,000 km² to individual roads Local LEZ embodied in regional LEZ with differing requirements (e.g. Milan)
Vehicles	Generally HGVs and/or buses Germany: all except 2-wheeled Italy: focus on 2-stroke 2 -wheeled Many established LEZs extending types restricted Exempt vehicles e.g. EVs/hybrids, residents, emergency services)
Emissions	Generally Euro 1-4/ Euro I to IV Diesel standards more stringent than gasoline Retrofitting DPF generally allowed Some based on vehicle weight (e.g. Athens)
Operation	24/7 Daytime only e.g. (07:30 - 19:30) Everyday/ weekdays only All year/winter only (e.g. October-April)
Enforcement	Manually by police (eg Germany) Automatic number plate recognition (eg London)
National Framework	National framework National framework with local options Local decision

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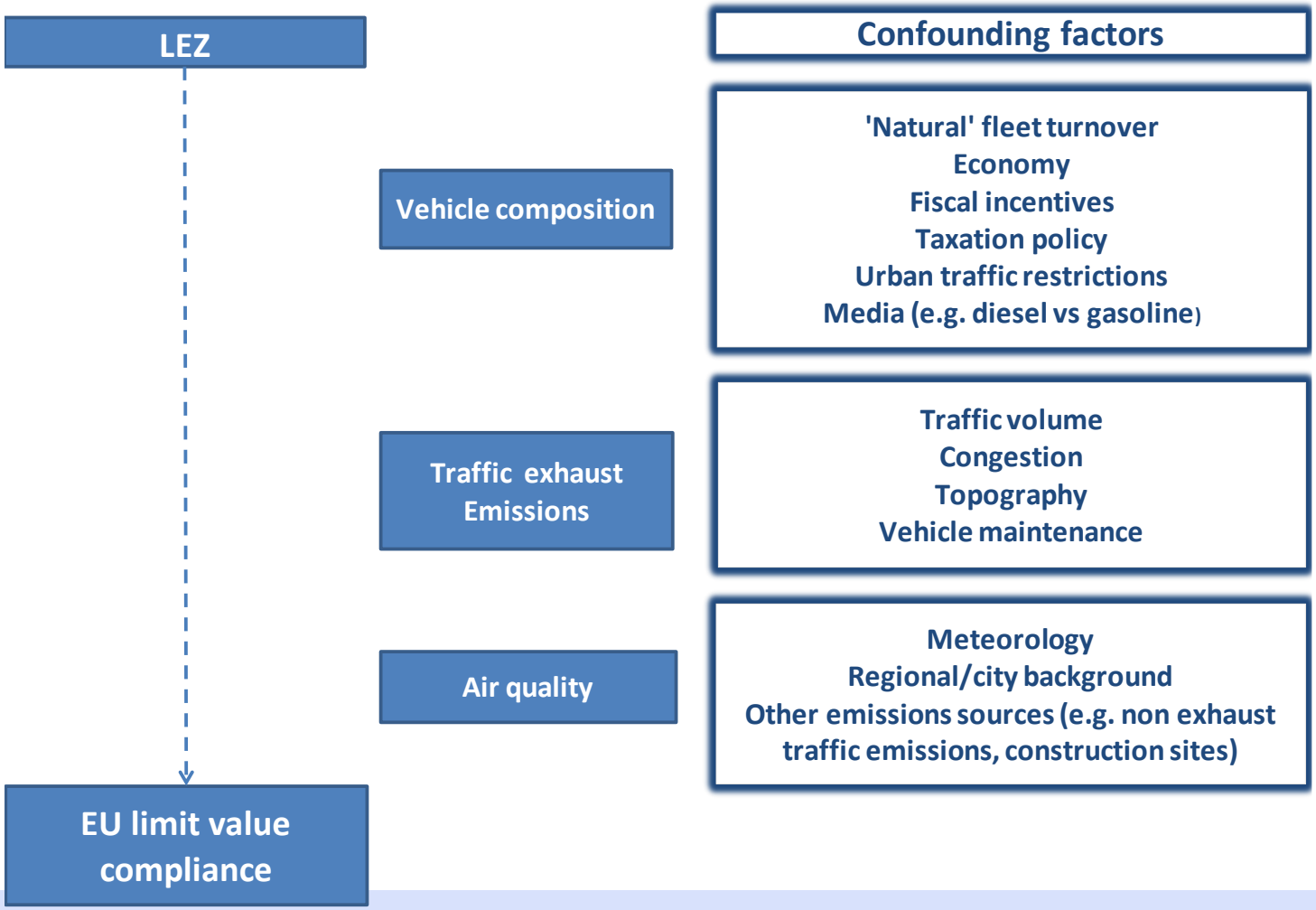
Difficulties in assessing effect of LEZs



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German LEZs

Green sticker

- Diesel at least Euro 4 or IV, or Euro 3 or III with a DPF
- Gasoline at least Euro 1 standard

Yellow sticker

- Diesel at least Euro 3 or III, or Euro 2 or II with a DPF

Red sticker

- Diesel vehicles meeting at least Euro 2 or II or Euro 1 plus DPF.

- Almost all LEZs now require green stickers
- Cars, vans, HDVs restricted
- Generally more stringent than elsewhere
- Manual enforcement by police
- Non compliance - €80 fine + traffic penalty point

German LEZs: Reduction in Annual Mean PM_{10}

- Berlin, Mannheim, Stuttgart, Tubingen, Ludwigsburg - **No effect** (Nierderemaier, 2009)
- Berlin, Cologne **5-7%** (Bruckmann & Lutz, 2010)
- Berlin **3%** (Lutz & Rauterberg-Wuff, 2013)
- Bremen **6%** (Sadler, 2011)
- Cologne **7%** (Sadler, 2011) (interference from construction site?)
- Hannover **1-2%** (Sadler, 2011)
- Leipzig – **no effect** (6-15% summer) (Löschau et al., 2013)
- Munich* **13%** (19.6% in summer; 6.8% in winter) (Fensterer et al., 2014); **5-12%** (Cyrys et al, 2009); **no effect** (Morfeld et al, 2013)
- Ruhr area **4%** (Sadler, 2011)
- Average 9% over several unnamed LEZs (0% for small LEZs to 15% in Berlin) (April-October)(Wolff, 2014)

Largely relate to Phase 1

Most studies have not adequately taken account of factors that influence air quality

* LEZ + HGV ban

Other LEZ Studies- Effects on PM Annual Mean

No effect:

Milan, PM_{10}, $PM_{2.5,}$ PM_1 (very short term study), Invernizzi et al., 2011

Amsterdam, The Hague, Den Bosch, Tilburg, Utrecht , PM_{10}, $PM_{2.5}$, Boogaard et al., 2012

Amsterdam, $PM_{10,}$ Panteliadis et al., 2014

London, $PM_{10,}$ Barrett, 2014

German LEZs: Reduction in Annual Mean Elemental Carbon (EC)

- Berlin **14-16%** (Lutz, 2009)
- Berlin **56%** (traffic contribution) (Lutz & Rauterberg-Wulff, 2013)
- Leipzig **6-14%** (14-29% summer)(Löschau et al., 2013)
- Munich **55%*** (traffic contribution) (Qadir et al., 2013)

*LEZ + HGV ban

Larger effect than for PM_{10}

Traffic contribution greater for EC than for PM_{10}

May be more important determinant of health effects

German LEZs: Reduction in Annual Mean NO_2

- Berlin 7-10% (Lutz & Rauterberg-Wuff, 2013)
- Bremen 6% (Sadler, 2011)
- Cologne 1.5% (Sadler, 2011)
- Hanover 5%(Sadler, 2011)
- Ruhr area 1% (Sadler, 2011)

All Phase 1 studies

Studies have not adequately taken account of factors that influence air quality

German Multi-city studies

Reduction in annual mean concentrations

19 cities

PM_{10}	≤ 0.2 µg/m³	(-1%)
EC	≤ 0.5 µg/m³	(-9%)
OC	≤ 0.3 µg/m³	(-3%)
$PM_{2.5}$	no effect	

17 cities

NO_x	≤ 2 µg/m³	(-4%)

High quality studies

Morfeld et al., (2014), Pneumologie, **68**, 173-186
Morfeld et al., (2014), Plos One, **9** (8) e102999

Shipping emissions

- Emissions poorly controlled
- No emission control area (ECA) for Mediterranean Sea
- Only EU ECAs controls sulphur emissions in North Sea, English Channel and Baltic Sea
- Has been affective at reducing on shore SO_2 concentrations

- Local measures include
  - Emissions based fairways dues and port fees
  - Environmental Ship Index/Clean Shipping Index enables ports to provide a consistent approach to classifying vessels based on their SOx and NOx emissions
  - Shore based power
  - Voluntary agreements e.g. with cruise industry

Conclusions (1)

- Influencing motorists away from diesel unlikely until fiscal incentives change
- Promoting cleaner vehicle technologies requires long term (decades) consistent policies
- Good public information on air quality implications of fuel choice required
- A mandatory eco-label across EU may help public understanding
- Eco-label needs to treat PM, NOx and CO_2 emissions equally

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Conclusions (2)

- Evidence of benefit of German LEZs
- Reduces annual mean PM_{10} and NO_2 concentrations by few percent.
- Elsewhere most early LEZs only restricted HGVs; little robust evidence of benefit.
- Some evidence of a larger impact on carbonaceous particles
- LEZs need to be stringent and include cars to be effective to improve air quality
- Cars - Euro 5 for PM_{10} and Euro 6 for NO_2 (preferably Euro 6c)
- Local measures available to control ship emissions