Evaluation of the effectiveness of measures to improve quality air applied in Northern and Central Europe

Claire Holman, Roy Harrison, Xavier Querol
REPORTS PRODUCED (OR TO BE PRODUCED) FROM ACTION B8

http://airuse.eu/en/outreach-dissemination/reports/

- Street cleaning
- Dust suppressants
- Low emission zones
- Electric, hybrid and gas vehicles
- Diesel car/fuel taxation
- Vehicle Eco-efficiency
- NOx reduction technologies applied to traffic
- Biomass burning abatement in Northern Europe
- Shipping abatement measures
- Interference and synergy of air quality and climate
SOLUTIONS: ENCOURAGING THE USE OF CLEANER CARS

- Discouraging diesel cars
- Low Emission Zones (LEZs)
- Encouraging BEVs, HEVs PHEVs and gas vehicles
- Mandatory eco-label
DISCOURAGING DIESEL CARS

Fuel duty (2015)

EU minimum rates:
- Diesel 330 €/1000 litres
- Petrol 360 €/1000 litres
DISCOURAGING DIESEL CARS

New car sales by fuel (2014)
DISCOURAGING DIESEL CARS

- Car purchase and/or ownership taxes - CO₂ based in most MS
- Diesel taxation and pump prices - greater for 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 CO₂ 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

**New Cars: % Diesel**

**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 CO₂ based since 2008
Norway EV market leader due to Government support for 20+ years
Incentives added sequentially until market responded

<table>
<thead>
<tr>
<th>% new cars</th>
<th>Battery EVs</th>
<th>Plug-in hybrids</th>
<th>Hybrids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>12.6</td>
<td>1.2</td>
<td>6.9</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.9</td>
<td>3.1</td>
<td>3.7</td>
</tr>
<tr>
<td>Spain</td>
<td>0.1</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>EU-28</td>
<td>0.3</td>
<td>0.2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Norway 5.8%; Netherlands 5.4%; EU-28 0.4% (2013)
ELECTRIC NEW CAR MARKET IN NORWAY

- 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

RECOMENDATIONS: Starting with advantages and support to comercial vehicles with high km/day in cities
VEHICLE ECO-LABEL

- Mandatory EU car CO₂ 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 CO₂ emission bands (gasoline cars) used in the energy efficiency rating systems

Source: ADAC, 2005
VEHICLE ECO-LABEL

- Mandatory EU wide scheme
- Treat NOx, PM and CO₂ 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)

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

* Excludes large number of LEZs in communities in Lombardy region

**Source:** http://urbanaccessregulations.eu
## LEZ SUMMARY

| Area | Range >1,000 km² to individual roads  
<table>
<thead>
<tr>
<th></th>
<th>Local LEZ embodied in regional LEZ with differing requirements (e.g. Milan)</th>
</tr>
</thead>
</table>
| 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  
|            | Retrofiting 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 (e.g. Germany)  
|              | Automatic number plate recognition (e.g. London) |
| National Framework | National framework  
|                  | National framework with local options  
|                  | Local decision |
DIFFICULTIES IN ASSESSING EFFECT OF LEZS

LEZ

Vehicle composition

Traffic exhaust Emissions

Air quality

EU limit value compliance

Confounding factors

'Natural' fleet turnover
   Economy
   Fiscal incentives
   Taxation policy
   Urban traffic restrictions
   Media (e.g. diesel vs gasoline)

Traffic volume
   Congestion
   Topography
   Vehicle maintenance

Meteorology
   Regional/city background
   Other emissions sources (e.g. non exhaust traffic emissions, construction sites)
ABATEMENT OF 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
**Efficacy of LEZs**

- Difficult to determine
- Confounders e.g. weather, other policy measures, recession

- $\text{PM}_{10} \leq 7\%$
- Munich (LEZ + HDV ban) $\text{PM}_{10}$ ca. 13%↓
- $\text{NO}_2 \leq 10\%$
- But not all robust studies
- Early phases studied

- Little evidence of impact on $\text{PM}_{10}$ and $\text{NO}_2$ concentrations outside Germany
- EC/BC reduced

- LEZs apply to cars as well as HDVs
- Generally more stringent than elsewhere
NO\textsubscript{2} fleet emission factors in urban traffic (share in mileage for AUT)

Total effect of NO\textsubscript{x} and NO\textsubscript{2} fleet emission reduction may not be sufficient to reach NO\textsubscript{2} air quality targets near roads with high traffic volumes until 2015:

NON TECHNOLOGICAL MEASURES ARE NEEDED FOR URBAN AREAS: REDUCING THE NUMBER OF VEHICLES
VEHICLE EMISSIONS AND LEZS

PASSENGER CARS | NO\textsubscript{x}
Results Spring/Summer 2015

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PASSENGER CARS | Euro 6
% of Passenger cars registered since Sept 2014 that are Euro 6
VEHICLE EMISSIONS AND LEZS

PASSENGER CARS | PM (opacity)
Results Spring/Summer 2015

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VEHICLE EMISSIONS AND LEZS

**LGVs | PM**
Results Spring/Summer 2015

**HGVs | NOx**
Results Spring/Summer 2015

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Final AIRUSE Conference, Barcelona, April 18 & 19, 2016
#DIESELGATE

NO$_x$ emissions of common marques & models

<table>
<thead>
<tr>
<th>Marque</th>
<th>Euro 3</th>
<th>Euro 4</th>
<th>Euro 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUDI</td>
<td>A3</td>
<td>A4</td>
<td></td>
</tr>
<tr>
<td>BMW</td>
<td>3-SERIES</td>
<td>XS</td>
<td></td>
</tr>
<tr>
<td>FORD</td>
<td>FOCUS</td>
<td>MONDEO</td>
<td></td>
</tr>
<tr>
<td>LANDROVER</td>
<td>DISCOVERY</td>
<td>C-CLASS</td>
<td></td>
</tr>
<tr>
<td>MERCEDES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEUGEOT</td>
<td>307/308</td>
<td>OCTAVA</td>
<td></td>
</tr>
<tr>
<td>SKODA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAUXHALL</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VOLKSWAGEN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOLVO</td>
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</tbody>
</table>

#DIESELGATE

NO$_x$ emissions by marque & Year of 1$^{st}$ registration

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VEHICLE EMISSIONS AND LEZS

David Carslaw et al., 2016. Faraday Discussions

DOI: 10.1039/C5FD00162E

Fig. 4  Trend in NO₂/NOx ratio by major vehicle and Euro class based on vehicle emission remote sensing data from the 2012 and 2103 London campaigns. The uncertainties show the 95% confidence interval in the mean. The numbers at the bottom of the plot show the sample size.

Fig. 5  Trend in NO₂/NOx ratio for Euro 4 and 5 diesel cars by vehicle age based on a total sample of 25,721 vehicles from the 2012 and 2013 remote sensing data. The uncertainties show the 95% confidence interval in the mean.
NOx EMISSION ABATEMENT TECHNOLOGIES

- World Harmonized Light duty test Procedure (WHLP) has been developed, also Real driving emissions (RDE) tests will be introduced for passenger cars with Euro 6c standards in 2017 and 2018.
- NOx emissions for Euro 6 cars are typically lower than from earlier generations, but they remain on average many times the emission limit.
- A number of measures for HDVs have resulted in Euro VI long distance trucks having low NOx emissions.
- More information is needed on urban bus and distribution vehicle emissions during operation.
- There is evidence that SCR can reduce NO2 as well as NOx emissions significantly, but this needs to be kept under review as the technology develops, and appropriate emission limits legislated if necessary.
- Retrofitting pre Euro VI urban buses and distribution trucks with ‘low NO2 SCRT’ devices may offer a relatively cost-effective way of achieving the ambient NO2 limit value.
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
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
THANK YOU VERY MUCH FOR YOUR ATTENTION!!!!