CLEAN AIR COPENHAGEN

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Background

Copenhagen violated the PM10 (daily average) and NO2 (annual average) air quality limits in the air quality directive (AQD) in 2005 and 2010, respectively.

In September 2008 and July 2009, it introduced a low emission zone (LEZ) in two steps. Step one: Filter requirements for buses. Step two: Filter requirements for EURO III heavy-duty vehicles as well as all buses. Furthermore, the area was renewed at the large street close to the measuring station in the autumn 2008. The PM10 air quality limit has been fulfilled since 2009 (when corrected for sea salt and winter salting). However, the NO2 air quality limit is still violated. Hence, a stricter LEZ is needed in order to fulfill the NO2 air quality limit and thereby the AQD.

The new estimates for health effects underline that only about 25 extra premature deaths in Copenhagen can be explained by the general PM2.5 pollution from traffic inside the city. However, about 10-30 times as many i.e. about 230-500 extra premature deaths is estimated when taking the observed excess mortality caused by air pollution close to larger streets into account. The divergence clearly underlines that PM2.5 is not a good indicator for health effects related to local air pollution in cities, even though PM2.5 seems to be a good indicator for health effects on a larger regional scale.

Key pollutants

<table>
<thead>
<tr>
<th>Chemical term</th>
<th>Units</th>
<th>Air quality limit</th>
<th>Enforcement</th>
<th>2012 concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse particles</td>
<td>PM10</td>
<td>µg/m³</td>
<td>Daily average: 50 (超标)</td>
<td>50% (超标)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Annual average: 40</td>
<td>10%</td>
</tr>
<tr>
<td>Fine particles</td>
<td>PM2.5</td>
<td>µg/m³</td>
<td>Daily average: 25</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Annual average: 20 (超标)</td>
<td>10-15%</td>
</tr>
<tr>
<td>Ultrafine particles</td>
<td>PM0.1</td>
<td>Number/cm³</td>
<td>No air quality limit</td>
<td>90%</td>
</tr>
<tr>
<td>Elementary carbon</td>
<td>EC</td>
<td>µg/m³</td>
<td>Hourly average: 200 (超标)</td>
<td>50%</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>NO2</td>
<td>µg/m³</td>
<td>Hourly average: 80 (超标)</td>
<td>50%</td>
</tr>
</tbody>
</table>

PM2.5 concentrations from local traffic: 2012 concentrations: from local exhaust: 2012 concentrations: from local exhaust:

- Exceeded less than 35 times
- Exceeded less than 18 times

Effects of LEZs

From the table above it is clear, that LEZs focusing on exhaust emissions will only contribute to a minor reduction in the concentration of PM10 and PM2.5 in the city air. However, LEZs can contribute significantly to the reduction of PM1.1, EC and NO2. The emission of PM1.1 and EC from local traffic can be reduced above 95% by retrofitting diesel vehicles and direct injection gasoline cars with closed particulate filters. The emission of NO2 from heavy duty vehicles can be reduced by more than 80% by installing SCR systems (with electrical heater) on buses and trucks.

In Copenhagen, as expected, no measured any significant reduction in PM10 and PM2.5 in the city air after introducing a LEZ with filters requirements for heavy duty vehicles. A reduction of 0-71 µg/m³ has been estimated. To comparison, in Copenhagen the PM10 reduction was 7 µg/m³. However, at significant reductions over 20-25% was observed for PM1.1 due to the LEZ. EC was not measured before the LEZ was introduced. The LEZ reduced NO2 around 10% since many small heavy duty vehicles were replaced by new vehicles with lower NOx emissions.

The right indicator

Health effects are underestimated by a factor 10-20 when using PM2.5 as an indicator for traffic pollution in cities i.e. the PM2.5 pollution can only explain 5-10% of the observed extra premature deaths related to air pollution from traffic. This is due to the fact that the PM2.5 levels do not reflect the local air pollution from traffic exhaust since PM2.5 (and PM10) mainly are from non-exhaust source. This is clearly illustrated in the diagram to the right showing that the PM2.5 concentration in rural background and on city streets are similar whereas the NO2 and EC are several orders of magnitude higher than rural background and thereby much better representing the high local pollution from city traffic. The relative index in the figure is based on daily averages. The significance would be much higher for PM1.1 and EC if the index were based on the pollution in the working hours i.e. the inhaled pollution. Furthermore, both PM1.1 and EC are directly related to exhaust and thereby representing the most particles believed to be most toxic. EC has been found to be 10 times more toxic per µg/m³ compared to PM2.5. Due to the high local variation in the number of PM1.1 and thereby the high uncertainty in the exposure it has not yet been possible to establish a similar correlation between health effects and number of PM1.1. However, PM0.1 is still one of the best indicators of exhaust particles from traffic. Hence, the efficiency of LEZs should be evaluated from their ability to reduce exhaust particles (EC and PM0.1) and not on their ability to reduce non-exhaust particles like PM10 and PM2.5.

Exhaust particles

The diagram to the left shows measurements of PM0.1 inside a class room (first floor) at a school in the central Copenhagen. After 33 minutes after the window has been closed is still measured a significant air pollution with exhaust particles inside the room.

Actions to fulfill the AQD

The NO2 air quality limit in Copenhagen can easily be fulfilled by a stricter LEZ:

1. Public buses on the most polluted streets must fulfill the EURO VI standard.
2. Other heavy duty vehicles must have an SCR-system (with electrical heater).
3. Light duty vehicles and diesel cars (≤3.5 tons) must fulfill the euro 4 standard.
4. Gasoline cars must fulfill the euro 1 standard.

Further information:

Later this year the Danish Ecocouncil will publish a free booklet about LEZs to fulfill the AQD and health effects of exhaust particles. Mail kaare@ecocouncil.dk and get the booklet.

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