Towards clean vehicles – the future of the internal combustion engine

What has changed after Dieselgate?

Dr. Martin Lange
Section I 3.2 / Pollution Abatement and Energy Saving in Transport
Scientific Policy Advisor
Agenda

1 NO$_2$-AIR QUALITY PROBLEMS IN CITIES AND TOWNS

2 NO$_x$-EMISSIONS OF TRANSPORT IN GENERAL AND IN PARTICULAR DIESEL PASSENGER CARS

3 DEVELOPMENT OF THE EU-EMISSION LEGISLATION FOR LIGHT DUTY VEHICLES

4 NATIONAL FORUM DIESEL AND OTHER MEASURES / PROJECTIONS FOR NO$_2$

5 CURRENT STATUS, SUMMARY AND OUTLOOK

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Status quo of nitrogen dioxide (NO₂) in Germany

In 2017 the air monitoring sites on streets in 65 cities lie over the year-averaged EU limit value of NO₂ (40 µg/m³; share of about 45% of the measurement sites at streets).

Main source for NO₂ air pollution are diesel vehicles, particularly diesel-fueled passenger cars.

Source: UBA 2018.
Development of average nitrogen dioxide (NO\textsubscript{2}) concentrations in Germany from 1995 to 2016

NO\textsubscript{2}-air quality problems in cities and towns

Nitrogen dioxide (NO\textsubscript{2}) concentrations in µg/m\textsuperscript{3} (yearly average)

- Average below limit, but not all measurement sites/cities
- EU limit since 2010: 40 µg/m\textsuperscript{3}

Source: UBA 2018

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NO₂-air quality problems in cities and towns

**Measurement sites close to transport – 2017 levels**

<table>
<thead>
<tr>
<th>Mean yearly average for NO₂, 2017</th>
<th>*gaps or passive collectors that are not yet updated. Here with 2016 value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All measurement sites for traffic</td>
<td></td>
</tr>
</tbody>
</table>

Extremely high polluted; 2017 “No. 1”

Above the limit but not main polluted cities

Limit value = 40µg/m³

2017 “No. 1”

measurement sites close to transport

Mean yearly average for NO₂, 2017

All measurement sites for traffic

*gaps or passive collectors that are not yet updated. Here with 2016 value

Limit value = 40µg/m³

Measurement sites close to transport – 2017 levels

Extremely high polluted; 2017 “No. 1”

Above the limit but not main polluted cities

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Quelle: Umweltbundesamt 2018

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Nitrogen dioxide (NO$_2$) emissions caused by the transport sector in cities in Germany for the year 2015

Reasons for the high share are:
- High diesel-share in Germany that further increased until the Diesel-Gate in 2015
- Bad real-world performance regarding NO$_x$-emissions of diesel cars, in particular for Euro 5 and most of the Euro 6* cars

*without mandatory on-road testing with portable emission measurement systems (PEMS/RDE)

Average real driving nitrogen oxide (NO\textsubscript{x}) emissions of diesel-fueled cars in Germany compared to emissions standards in Europe

![Diagram showing NO\textsubscript{x} emissions for Euro 3, Euro 4, Euro 5, and Euro 6a with corresponding values in mg NO\textsubscript{x}/km.]
Average real world nitrogen oxide (NO$_x$) emissions of diesel-fueled cars compared to emissions standards in Europe

Real world NO$_x$ emission factors for diesel passenger cars compared to EU limits

- Limit for sum of HC and NO$_x$ emissions
- Limit value multiplied with conformity factor

Source: UBA 2017 / HBEFA 3.3.
Emission standards and test procedures within Euro 6 standard: WLTP and Real Driving Emissions (both initiated before Dieselgate)

**Type approval**

- **Role:** Tests before the production and sale of vehicles start // regulated pollutant emissions meet the applicable pollutant limits
- **Up to Euro 6b:** approval with NEDC and "old" test-procedure
- **From Euro 6c on:** New driving cycle & test procedure (WLTP) instead of NEDC and on-road measurement of particulate matter number (PN-RDE)
- **From Euro 6d-TEMP on:** additional on-road measurement of NOₓ-emissions (NOₓ-RDE)

**Conformity of production**

- **Role:** ensures that all products of a type are in compliance with type approval specifications
- Quality management systems and tests on production samples
- **Improvements:** Will include new test/procedures and advances statistics

**In-service conformity**

- **Role:** ensure that the products are compliant during their normal useful life
- Up to now: tasked by OEM, done by TS and reported to type approval authorities (TAA)
- **New:** Will include WLTP/RDE and tests for RDE partly done at TAA
New test procedure WLTP and real driving emissions RDE

WLTP: Test cycle + plenty changes in the test procedure

RDE
Real Driving Emissions
Measurements on public roads and in daily traffic with Portable Emission Measurement System (PEMS) for NOx and particulate matter (Number)

Development of the EU-emission legislation for light duty vehicles

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Real world NO\textsubscript{x} emission factors for diesel passenger cars compared to EU limits

<table>
<thead>
<tr>
<th>Euro Level</th>
<th>Real world NO\textsubscript{x} emission factors (HBEFA)</th>
<th>EU NO\textsubscript{x} emission limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro 1</td>
<td>0.7</td>
<td>0.1</td>
</tr>
<tr>
<td>Euro 2</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>Euro 3</td>
<td>0.6</td>
<td>0.1</td>
</tr>
<tr>
<td>Euro 4</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Euro 5</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Euro 6 a/b/c</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Euro 6d-TEMP</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Euro 6d</td>
<td>0.02</td>
<td>0.1</td>
</tr>
</tbody>
</table>

* Limit for sum of HC and NO\textsubscript{x} emissions
** Limit value multiplied with conformity factor

Source: UBA 2017 / HBEFA 3.3.

Expectation with new mandatory on road testing

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SOFTWARE UPDATES FOR EURO 5 AND EURO 6 LIGHT DUTY VEHICLES

- 5,3 Mio. vehicles (of ~46.5 Mio. PC) with updates expected
- VW-vehicles are included (~2.2 Mio. LDV; mandatory recall)
- NO\textsubscript{x} reductions of 30% are proposed by OEM; but no proofed values are published until now
- Also for the number of Updates for non-VW cars („voluntary updates“) the realization is not clear

EXCHANGE PREMIUM FOR NEW LDV BY RETURNING OLD DIESEL

- Programs organized by OEM only
- Trade-in or scrapping of Euro 4 Diesel or older in exchange to money if new (in some cases also young used) car is bought
- sometimes in addition to current discount or instead of them
- Non-official value indicate that 10% to 20% of all new cars are bought using it

Reductions are expected to be not enough (~2-4 µg/m\textsuperscript{3})
Immediate Programm „Clean Air 2017-2020“ and Model Towns and Cities

MEASURES OF THE IMMEDIATE PROGRAM „CLEAN AIR 2017-2020“
1 Bill. Euro for all cities and regions above the NO₂-limits
aim: avoid car bans

• Electrification of urban car fleets (e.g. busses, taxis, delivery fleets, etc.) and building of charging structure
• Digitalization of the transport system
• Retrofit of Diesel-Busses in public transport with more advanced exhaust after-treatment systems

MODEL TOWNS AND CITIES
130 Mio. Euro for 5 selected towns and cities

• Bonn, Essen, Mannheim, Reutlingen and Herrenberg
• Examples to swift and effective measures
  • e.g. 1€ ticket for local public transport
  • Park and Ride services
  • 50 more dedicated cycling roads
**Current Reference Scenario:**
Yearly Averaged NO₂-levels for two streets in two cities


NO₂-concentration for Munich, Landshuter Allee

NO₂-concentration for Mainz, Parcusstraße

<table>
<thead>
<tr>
<th>Year</th>
<th>NO₂ in µg/m³ (year averaged)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>80</td>
</tr>
<tr>
<td>2020</td>
<td>60</td>
</tr>
<tr>
<td>2025</td>
<td>40</td>
</tr>
<tr>
<td>2030</td>
<td>20</td>
</tr>
</tbody>
</table>

Measured values

Reference case (with Updates and discounts)
Current situation (variety of new proposals popping up)

DRIVING BANS FOR DIESEL CARS IN SOME CITIES:

- **Selected streets in Hamburg** (in place) for all cars/trucks older than Euro 6/VI
- **Within environmental zone in Stuttgart** (planned) for all cars Euro 4 and older (inclusion of Euro 5 will be decided)
- **Within environmental zone in Frankfurt** (court decision; currently under appeal)

OTHER MEASURES (SOME ONLY FOR CITIES/TOWNS WITH HIGH LEVELS):

- **Retrofit (Hardware Upgrades) for municipal vehicles and Busses** (agreed)
- **Hardware Upgrades for passenger cars** (under discussion; which cars and who pays for that)
- **Rebuy of cars by the OEM with current value + 20%** (proposed by the ministry of transport)
- **New or prolonged discounts** (potentially also higher) for (new) passenger cars (under discussion)
- **Harmonized environmental zones for NO\textsubscript{x}** (federal level) not discussed
Summary and Outlook

IMPROVEMENT OF THE EMISSIONS LEGISLATION AND THE TYPE APPROVAL FRAMEWORK

- Real-driving emissions (RDE) and new test procedure WLTP for new cars should significantly reduce NO\textsubscript{x}-emissions
- Upcoming Euro 7/VII discussions (possibly more pollutants, more stringent limit values, new instruments/measure, etc.)

TECHNICAL AND NON-TECHNICAL MEASURES TO COMPLY WITH LIMITS AS SOON AS POSSIBLE

- Software Updates and Retrofits as a promising contribution
- Potentially also new harmonization environmental zones on federal level for NO\textsubscript{x}

CLIMATE PROTECTION

- Post2021-discussion for fuel economy- / CO\textsubscript{2}-standards
- Transition of transport system (avoid, shift and improve) and energy transition in transport (alternative fuels and propulsion technologies)

AIR POLLUTANTS
GOOD REAL-WORLD PERFORMANCE
DURABILITY
NEEDED AS COMBUSTION ENGINES WILL STAY ON MARKET FOR A WHILE

APPROPRIATE ACTIONS SHOULD BE INITIATED

NEED FOR CLIMATE ACTION ALSO IN TRANSPORT
Thank you very much!

Martin Lange
Section I 3.2 / Pollution Abatement and Energy Saving in Transport

Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Germany

martin.lange@uba.de
https://www.umweltbundesamt.de/en/topics/transport-noise
Light-blue or dark-blue sticker as an offer for a suitable solution (UBA proposal from March 2018)

**UBA-PROPOSAL**

**LIGHT BLUE STICKER:**
- Diesel Euro 5 (poss. older) with a good technical retrofit
- Diesel Euro 6a/b/c

**DARK BLUE STICKER:**
- Diesel Euro 6d-TEMP and 6d
- Gasoline from Euro 3 on
- Electric cars (battery electric or fuel cell electric)

Süddeutsche Zeitung, 6.3.2018
Software Updates, Hardware-Upgrades und drive bans: improvement of the NO₂-air quality

- Sticker system (LDV and HDV) would already with the light blue sticker secure compliance with the limits before 2020 and on extremly polluted sites well before 2025
- Retrofit options for passanger cars (as discussed) would reduce the number of affected owners

*Nachrüstung garantiert Einhaltung von 432 mg NO₂ pro km in RDE-Tests bis -7°C
Germany has ambitious climate protection targets for 2030 from its “Climate Action Plan 2050”

Fixed transports GHG-emission targets for:
- 40 to - 42% relative to 1990-level
- 1990-level is comparable to the one in 2015!
Adopted measures are not enough to reach the climate targets in transport in 2030

Development of GHG emissions of transport in Germany 1990-2017 and projection until 2030 (only adopted measures)

Climate action plan 2050 –
Target for 2030:
95-98 Mio. t
CO₂-Äquivalente
(-42/40 %
compared to
1990)

Sources: UBA 2018; Projektionsbericht 2017 für Deutschland gemäß Verordnung (EU) Nr. 525/2013.
Ambition climate protection targets in transport require a general transition and an energy transition in the sector.

Reduction of GHG emissions (basis: 1990)

- Avoid + Shift + Improve
- Transition of transport system
- Transition of the energy supply of transport
- Alternative fuels + propulsion technologies

-40% bis -60%

-95%

- GHG mitigation goals above 60% can be only reached with an energy transition in the transport sector.
- For reducing costs of energy transition a transport transition with avoiding, shifting and improving of traffic is needed.