DeNOx- System-
Failures and Manipulations

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EU Air Quality Directive 2008/50/EC

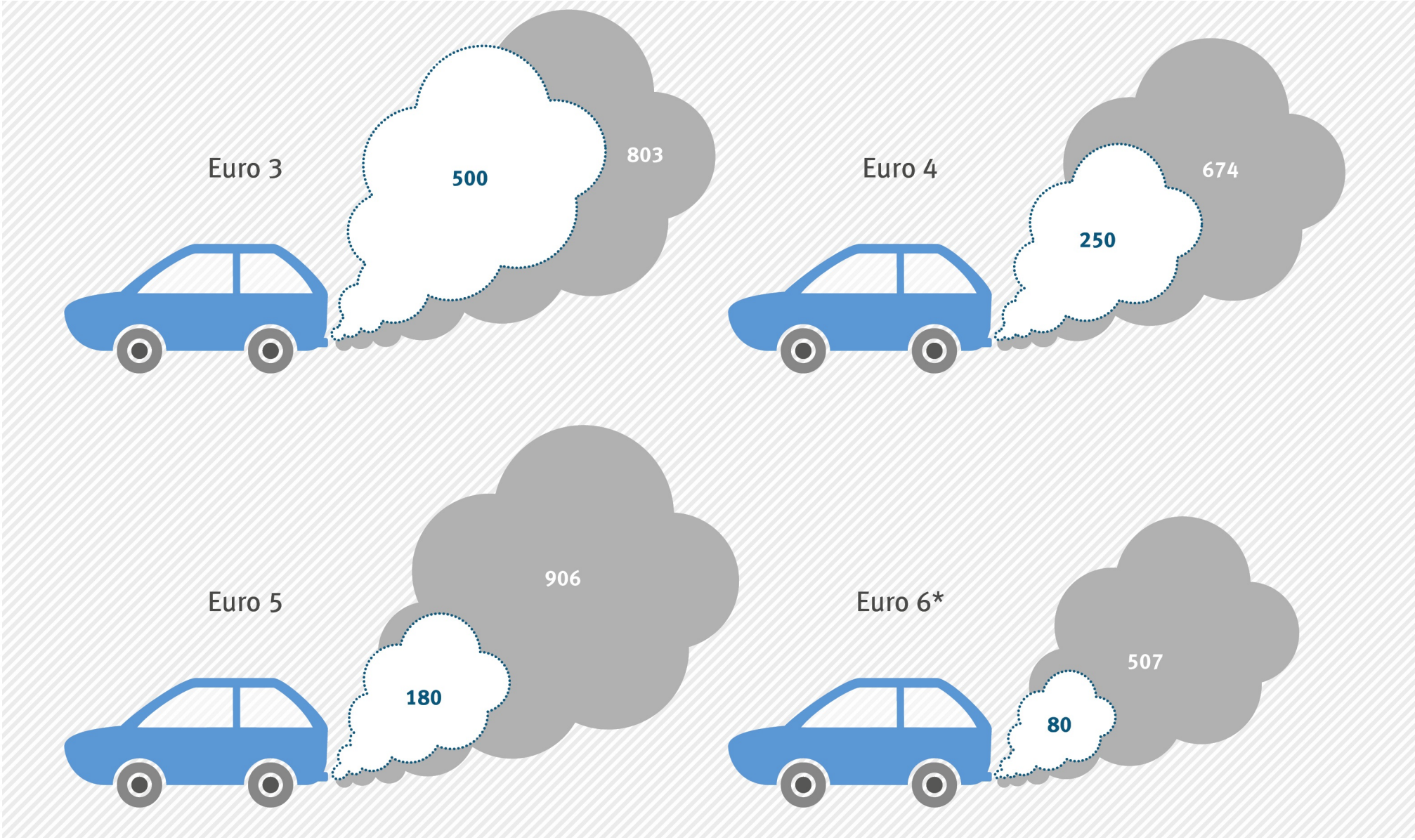
Pollutant	*Concentration*	*Averaging period*	*Legal nature*	*Permitted exceedences each year*
Fine particles (PM2.5)	25 µg/m3***	1 year	Target value entered into force 1.1.2010 Limit value enters into force 1.1.2015	n/a
Nitrogen dioxide (NO2)	200 µg/m3	1 hour	Limit value entered into force 1.1.2010	18
	40 µg/m3	1 year	Limit value entered into force 1.1.2010*	n/a
PM10	50 µg/m3	24 hours	Limit value entered into force 1.1.2005**	35
	40 µg/m3	1 year	Limit value entered into force 1.1.2005**	n/a

EU Euro 5 and Euro 6 Emission Limits for Diesel Passenger Car

Diesel emission limits [mg/km over NEDC cycle]					
Pollutant	**CO**	**NO_x**	**PM**	**THC+NO_x**	**PN [#/km over NEDC cycle]**
Euro 5a	500	180	5.0	230	-
Euro 5b/b+	500	180	4.5	230	6.0E11
Euro 6b/6c	500	80	4.5	170	6.0E11

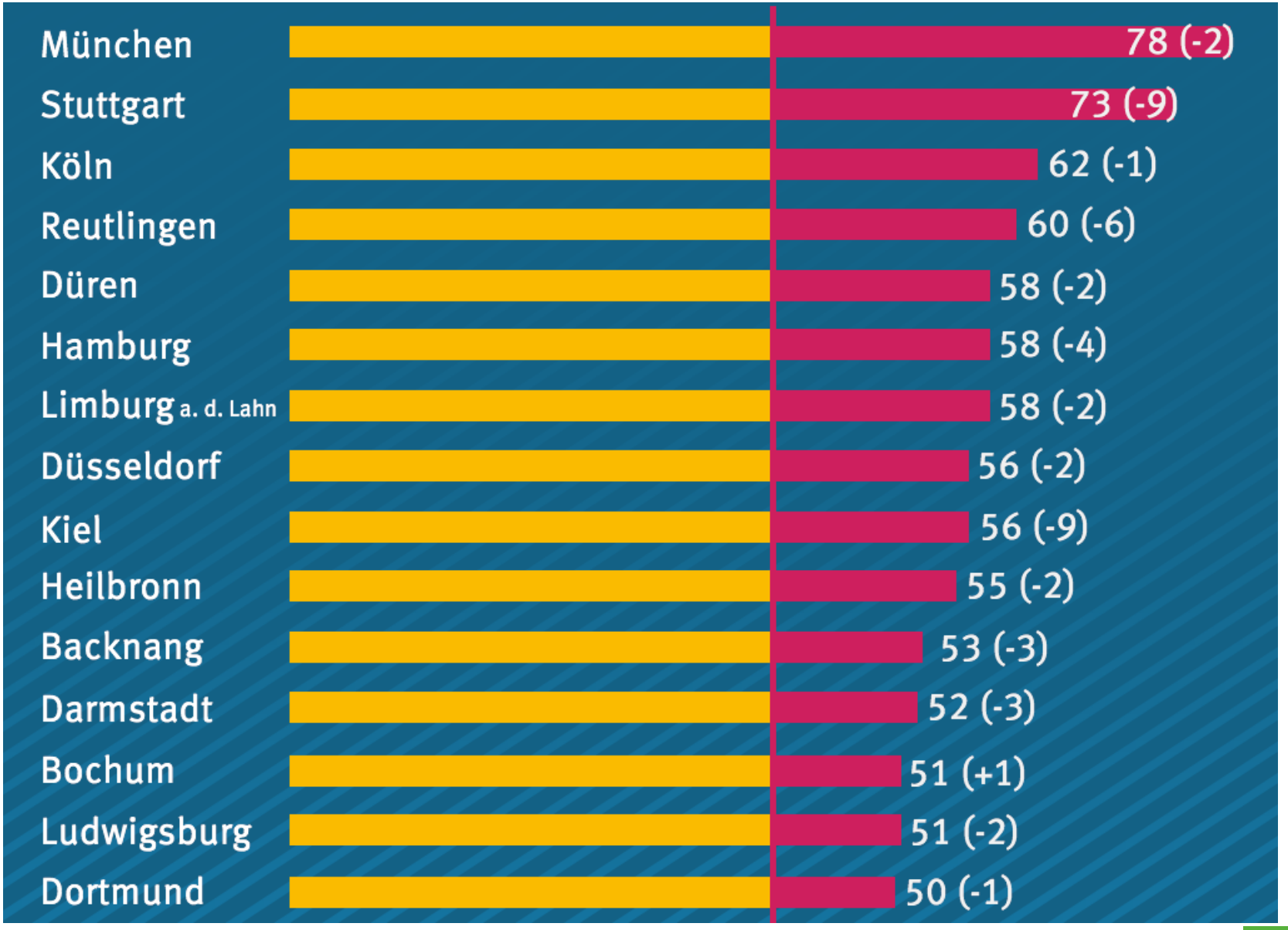
Source: Vicente Franco, Francisco Posada Sánchez, John German, and Peter Mock, ICCT 2014

Average Real Emission of Nitrogen Dioxide for different EU Emission Standards



Source: HBEFA

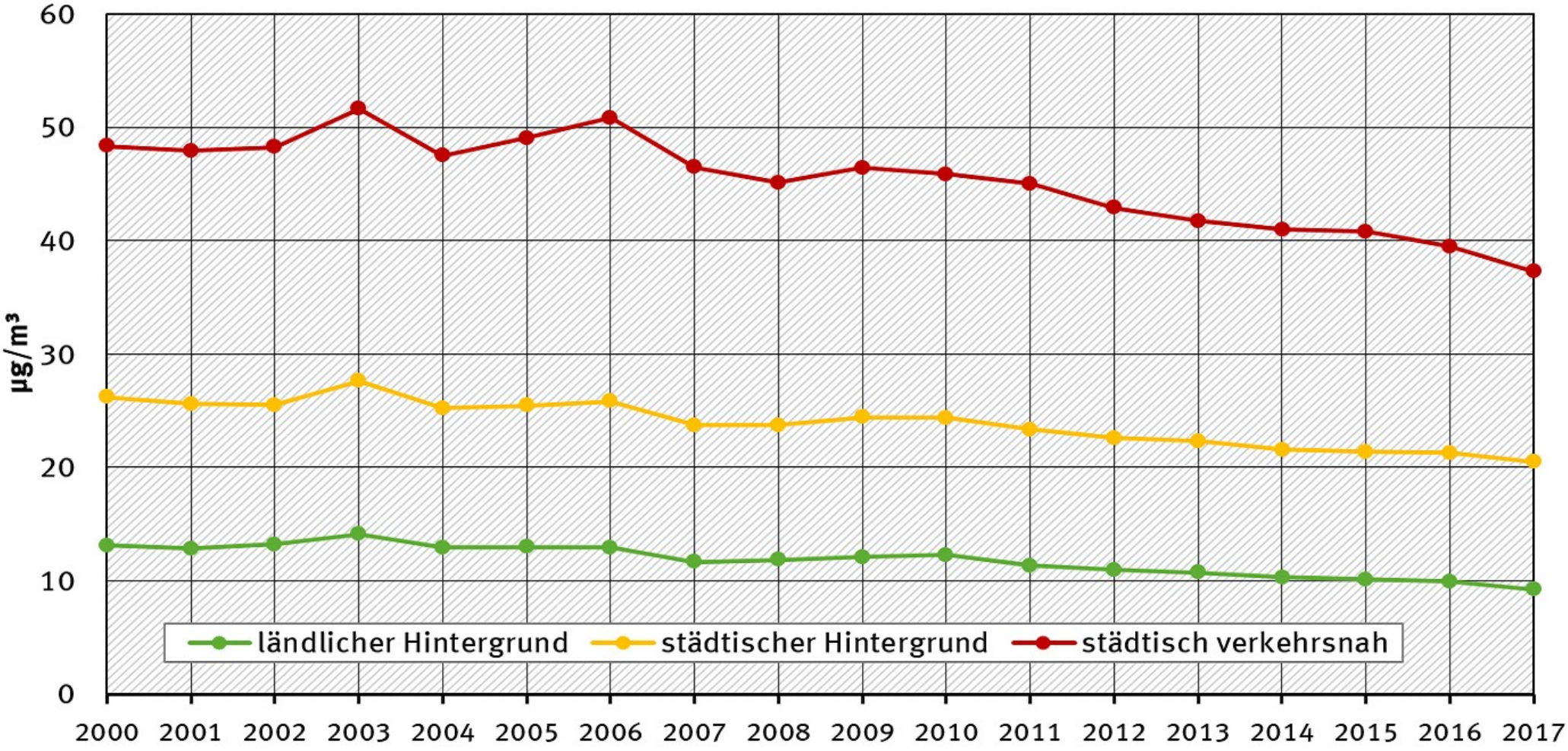
Yearly Average of Nitrogen Dioxide Concentration in German Cities 2017



* (Difference to 2016) Air Quality Standard 40 microgram/m^3

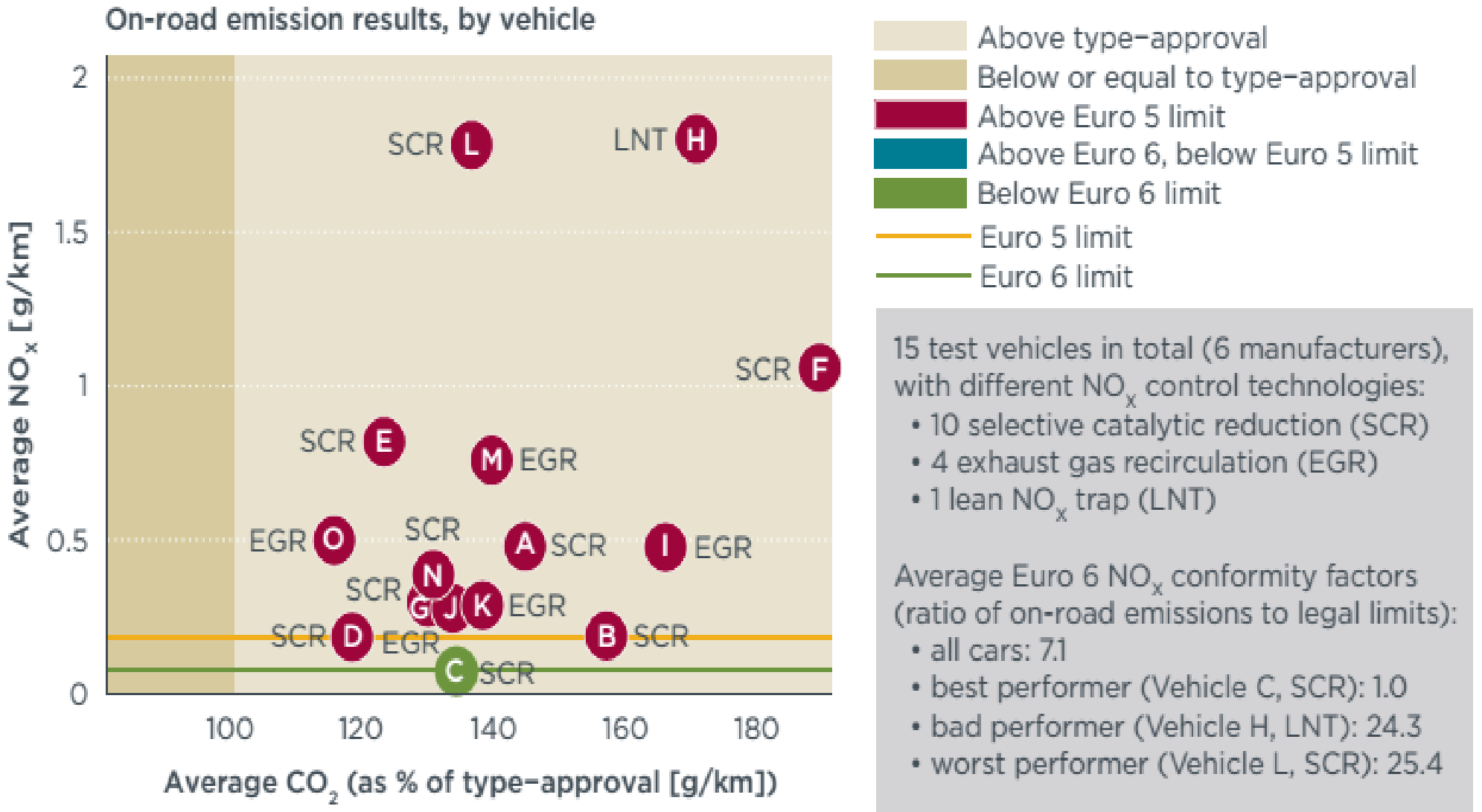
Umwelt Bundesamt

Yearly Average of Nitrogen Dioxide Concentration at Air Quality Measurement Stations in Germany



Source: Umweltbundesamt2018

Overview of on-road NO_x and CO_2 Emission Results for all Vehicles under Test



15 test vehicles in total (6 manufacturers), with different NO_x control technologies:

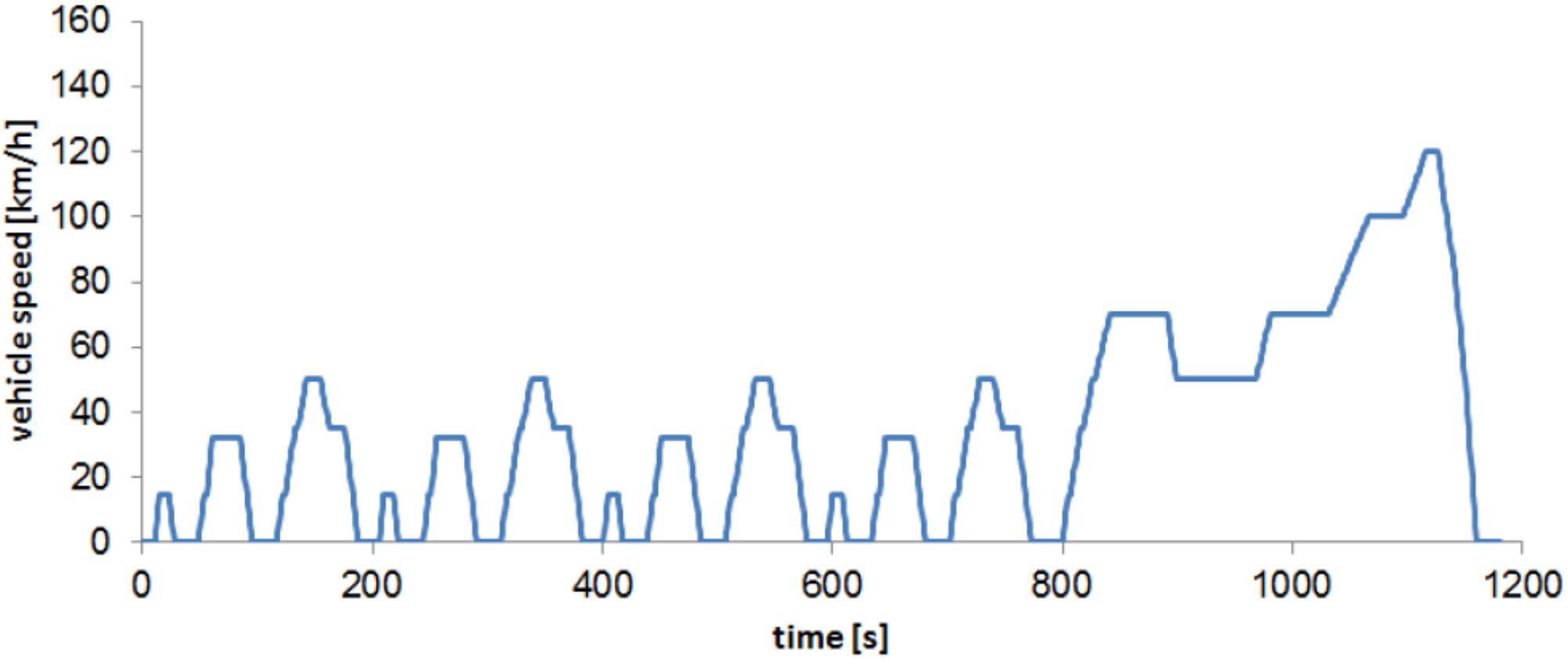
- 10 selective catalytic reduction (SCR)
- 4 exhaust gas recirculation (EGR)
- 1 lean NO_x trap (LNT)

Average Euro 6 NO_x conformity factors (ratio of on-road emissions to legal limits):

- all cars: 7.1
- best performer (Vehicle C, SCR): 1.0
- bad performer (Vehicle H, LNT): 24.3
- worst performer (Vehicle L, SCR): 25.4

Source: Vicente Franco, Francisco Posada Sánchez, John German, and Peter Mock, ICCT 2014

Test Cycle – New European Drive Cycle (NEDC)



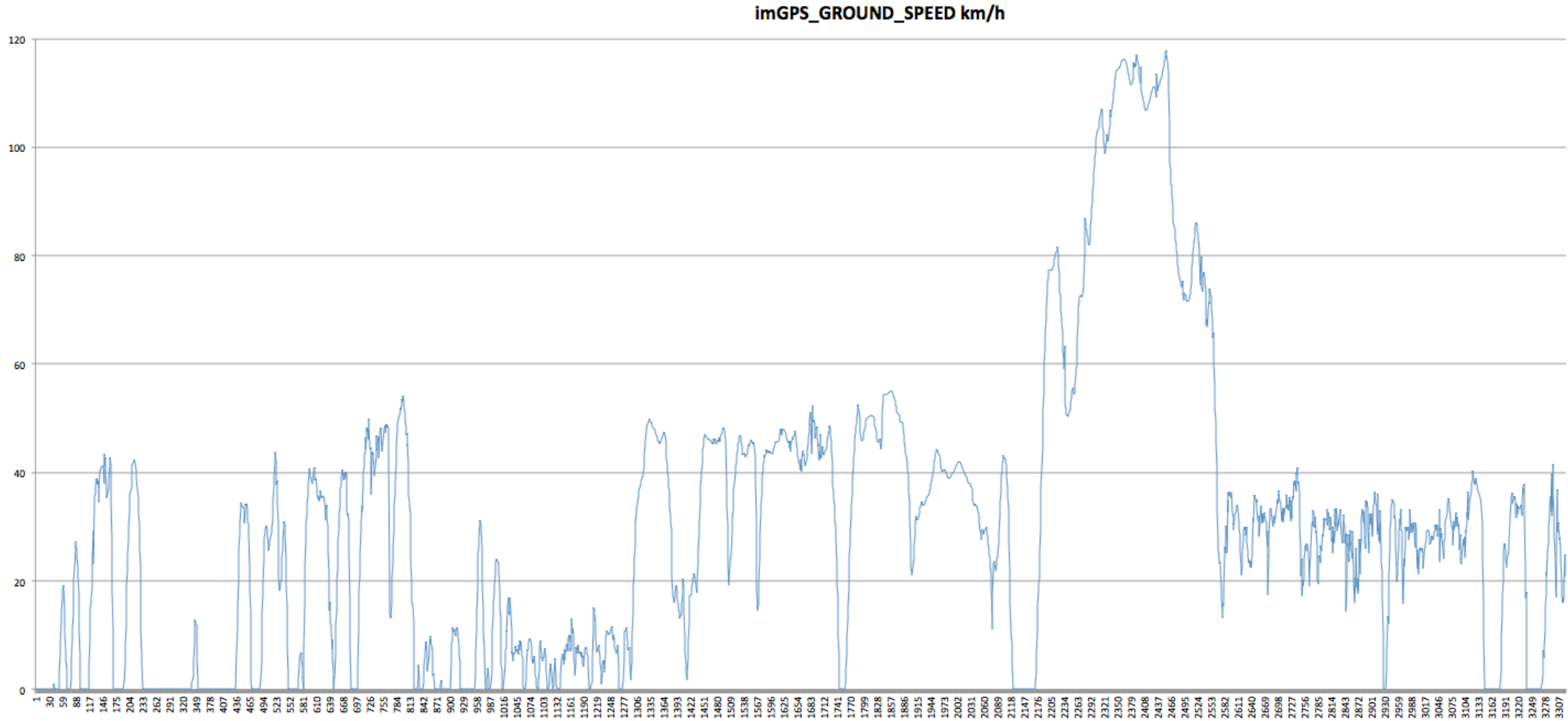
EKI

Deutsche Umwelthilfe

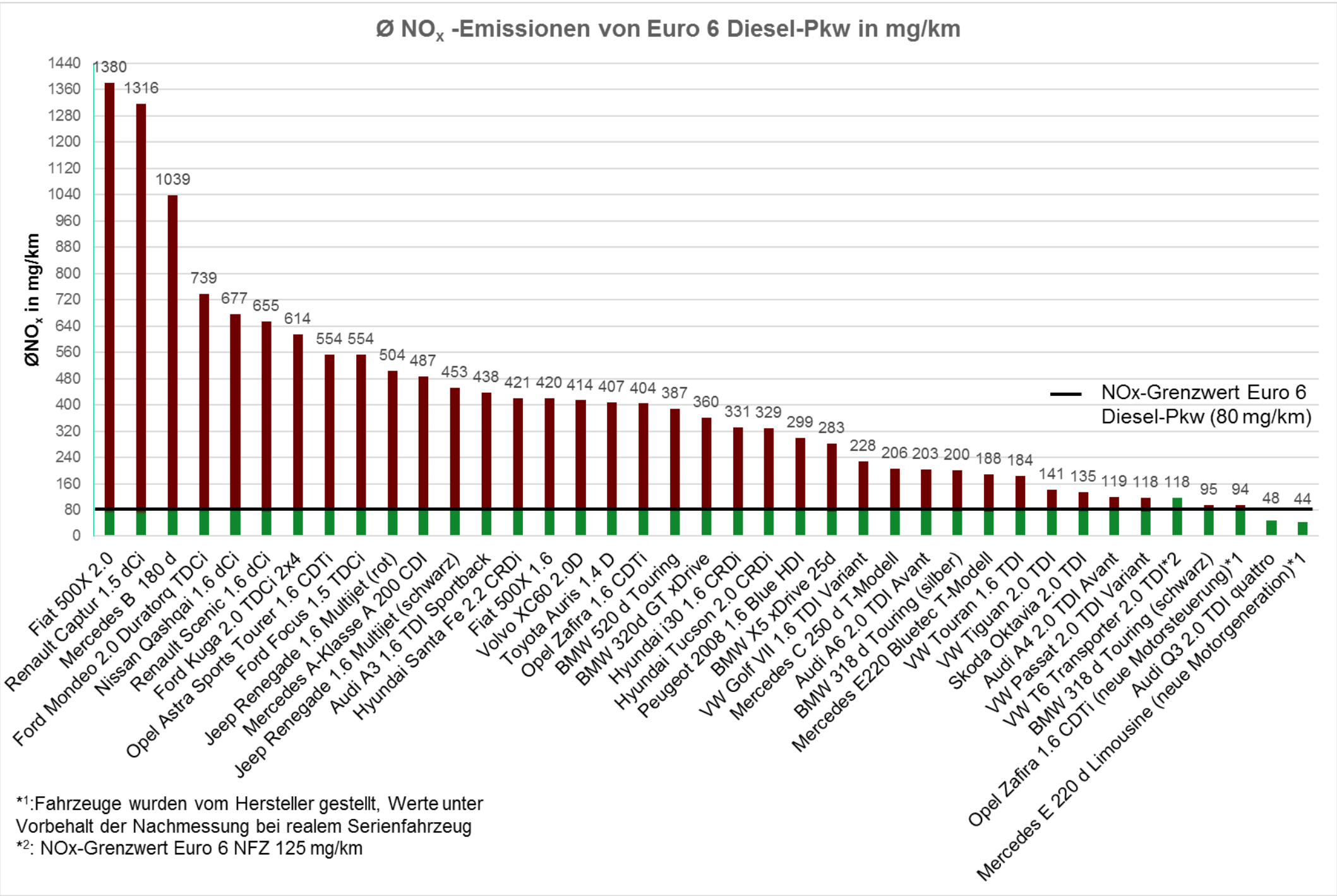
PEMS Track


Strandbad Wannsee
BEZIRK
STEGLITZ-ZEHLENDORF
ZEHLENDORF
Westlicher Düppeler Forst
WANNSEE
BERLIN
BRANDENBURG
Kleinmachnow
Teltow
Stahnsdorf
Parforceheide
STERN
POTSDAM SÜDOST
RUHLSDORF
Argentinische Allee
Machnower Str.
Ruhlsdorfer Str.
L76
L761
L794
L40
1

Speed Track


imGPS_GROUND_SPEED km/h
120
100
80
60
40
20
0
1 30 59 88 117 146 175 204 233 262 291 320 349 378 407 436 465 494 523 552 581 610 639 668 697 726 755 784 813 842 871 900 929 958 987 1016 1045 1074 1103 1132 1161 1190 1219 1248 1277 1306 1335 1364 1393 1422 1451 1480 1509 1538 1567 1596 1625 1654 1683 1712 1741 1770 1799 1828 1857 1886 1915 1944 1973 2002 2031 2060 2089 2118 2147 2176 2205 2234 2263 2292 2321 2350 2379 2408 2437 2466 2495 2524 2553 2582 2611 2640 2669 2698 2727 2756 2785 2814 2843 2872 2901 2930 2959 2988 3017 3046 3075 3104 3133 3162 3191 3220 3249 3278 3307

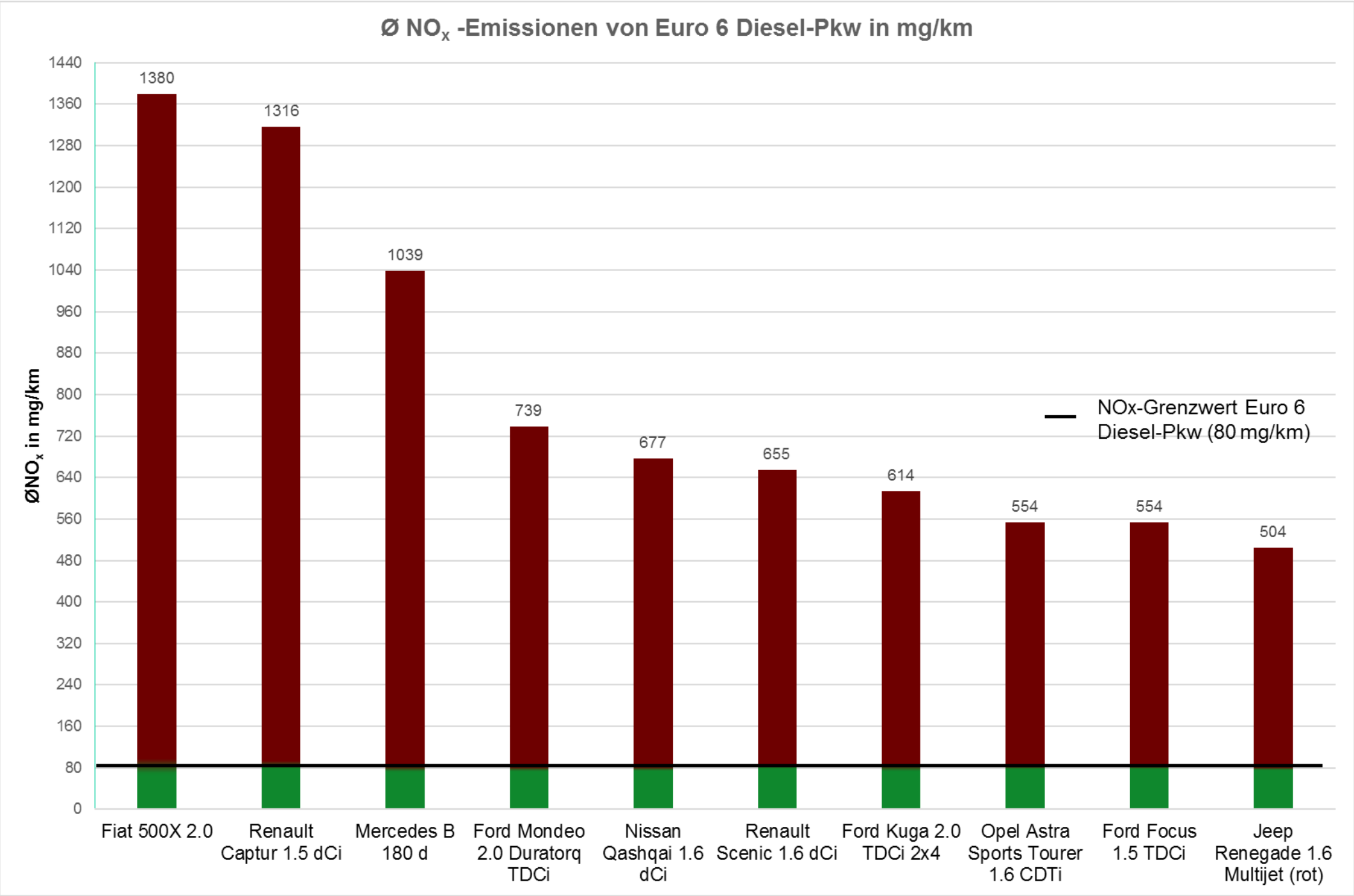
PEMS- Measurements



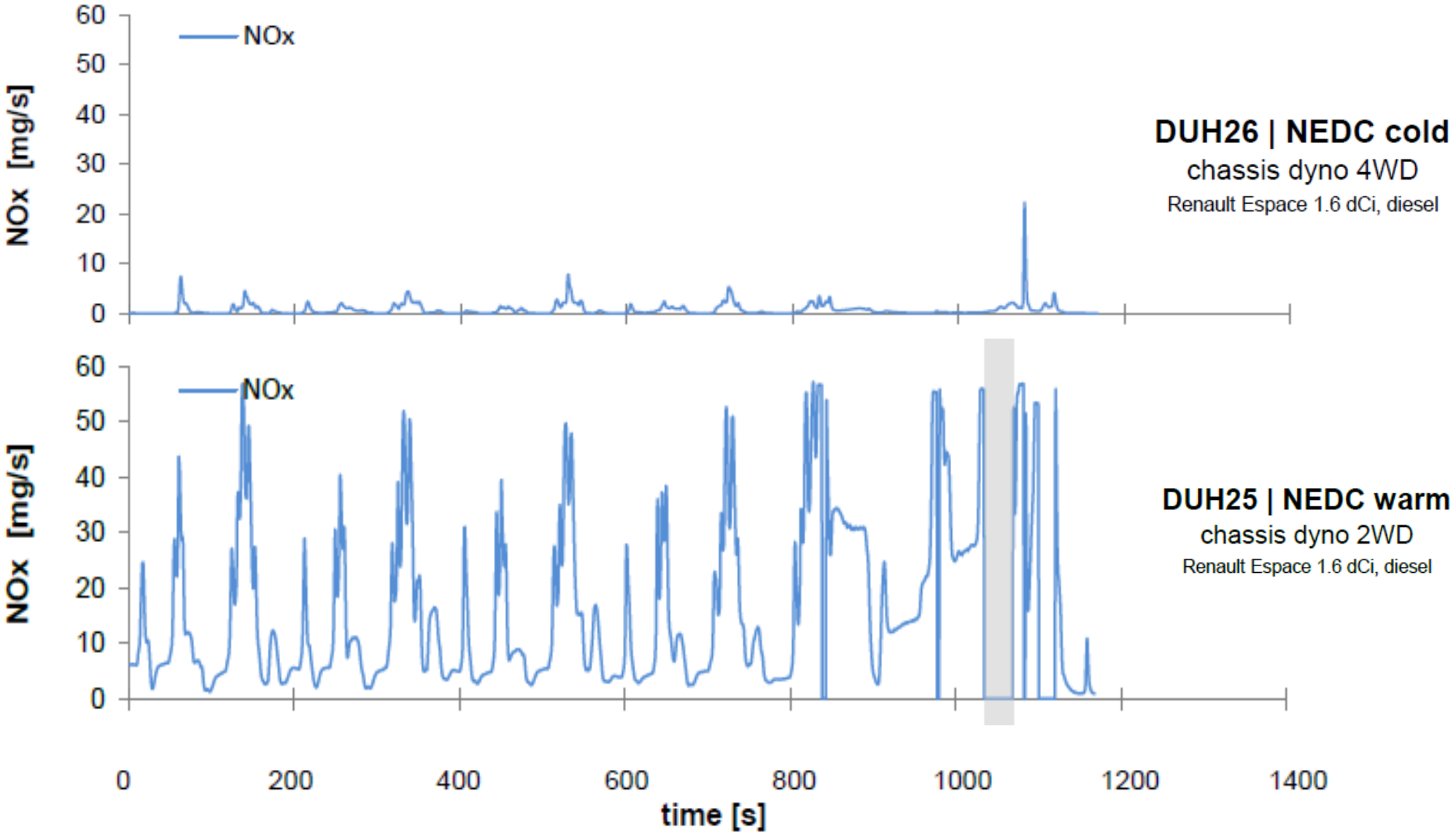
*1:Fahrzeuge wurden vom Hersteller gestellt, Werte unter Vorbehalt der Nachmessung bei realem Serienfahrzeug

*2: NOx-Grenzwert Euro 6 NFZ 125 mg/km

Superemitter



Renault Espace 1.6 dCi Euro 6b



Road Measurements

Renault Captur 1.5 dCi

Deutsche Umwelthilfe

Engine volume	1.461 cm^3
Power	81 kW
Fuel	Diesel
Emission limit	EURO 6
Abatement technology	Oxi-Kat, AGR
Kilometers	17.723
Day of first registration	03.2016

Average of three measurements
≤ 17 Grad Celsius

Average CO_2 in g/km	**118**
Average NO_x in mg/km	**1.316**
Factor to emission limit NO_x Euro 6 Diesel (80 mg/km)	**16,5**

Deutsche Umwelthilfe

Road measurements
Fiat 500X 2.0

Engine volume	1.956 cm^3
Power	103 kW
Fuel	Diesel
Emission limit	EURO 6
Abatement technology	NOx-Speicherkat
Kilometer	17.613
Day of first registration	06.2016

Average of ten measurements

Average CO_2 in g/km	**160**
Average NO_x in mg/km	**1.380**
Factor to the emission limt NO_x Euro 6 Diesel (80 mg/km)	**17,2**

Deutsche Umwelthilfe

Road measurements

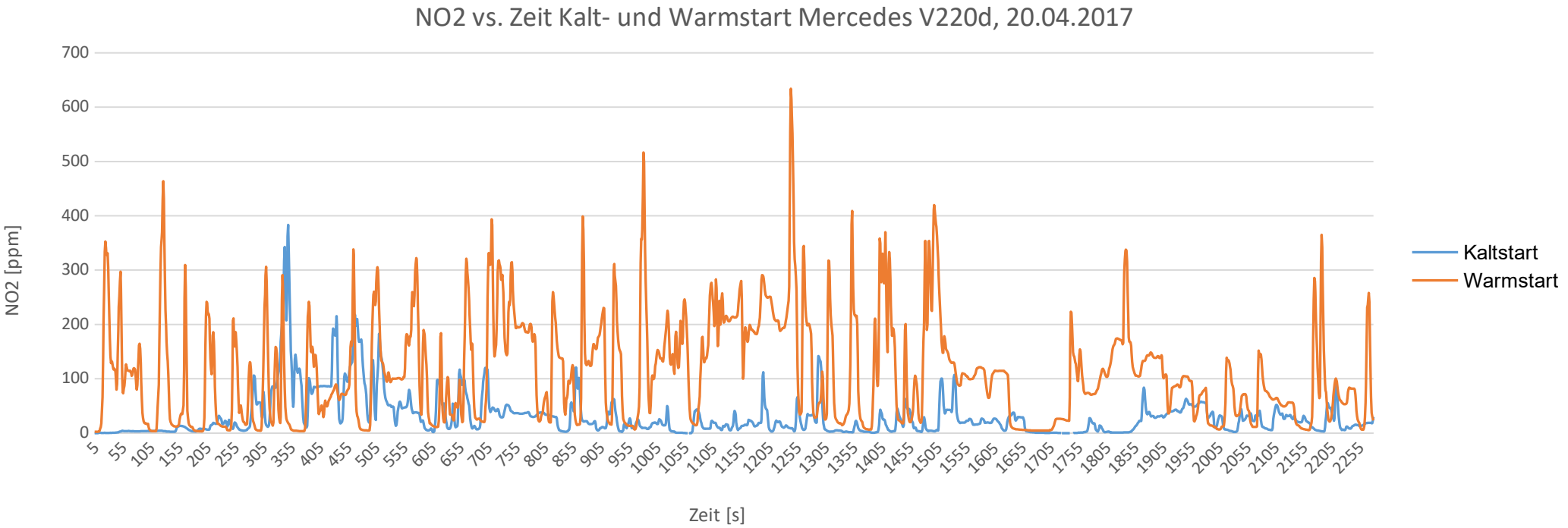
Mercedes-Benz B- Class, B 180d

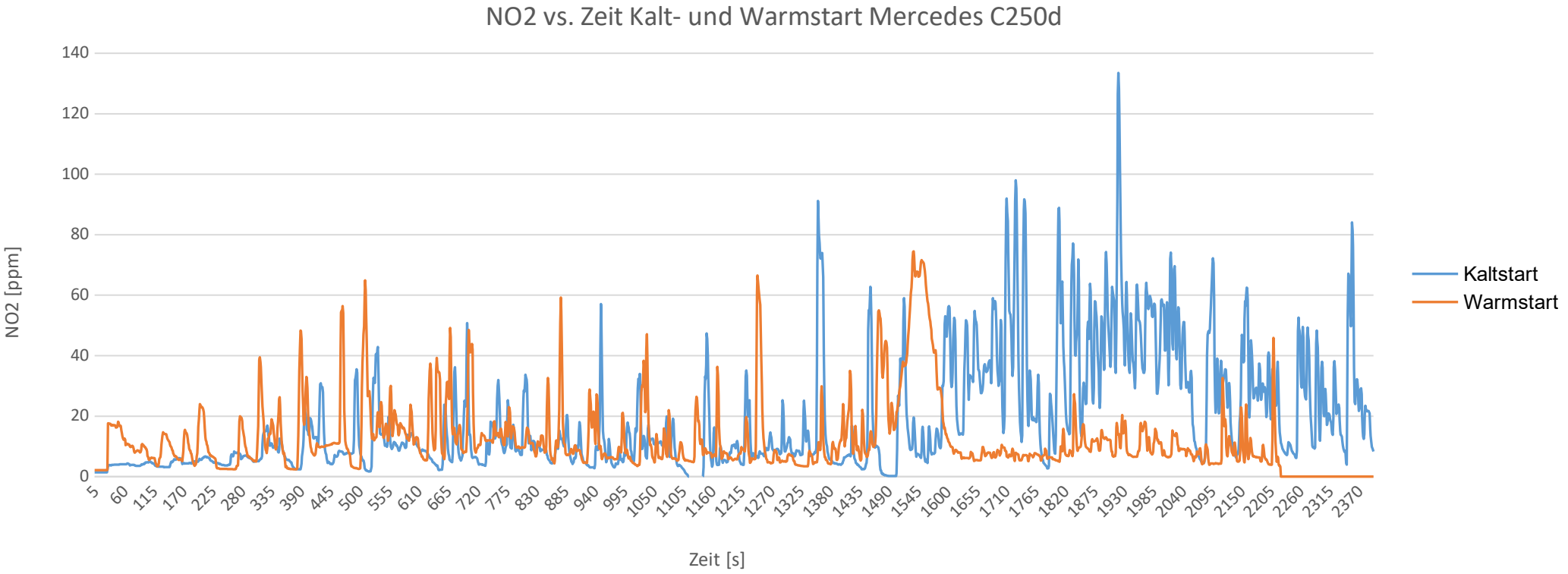
Engine volume	1.461 cm^3
Power	80 kW
Fuel	Diesel
Emission limit	EURO 6
Abmatement technology	NOx-Speicherkat
Kilometer	5.046
Day of registration	08.2016

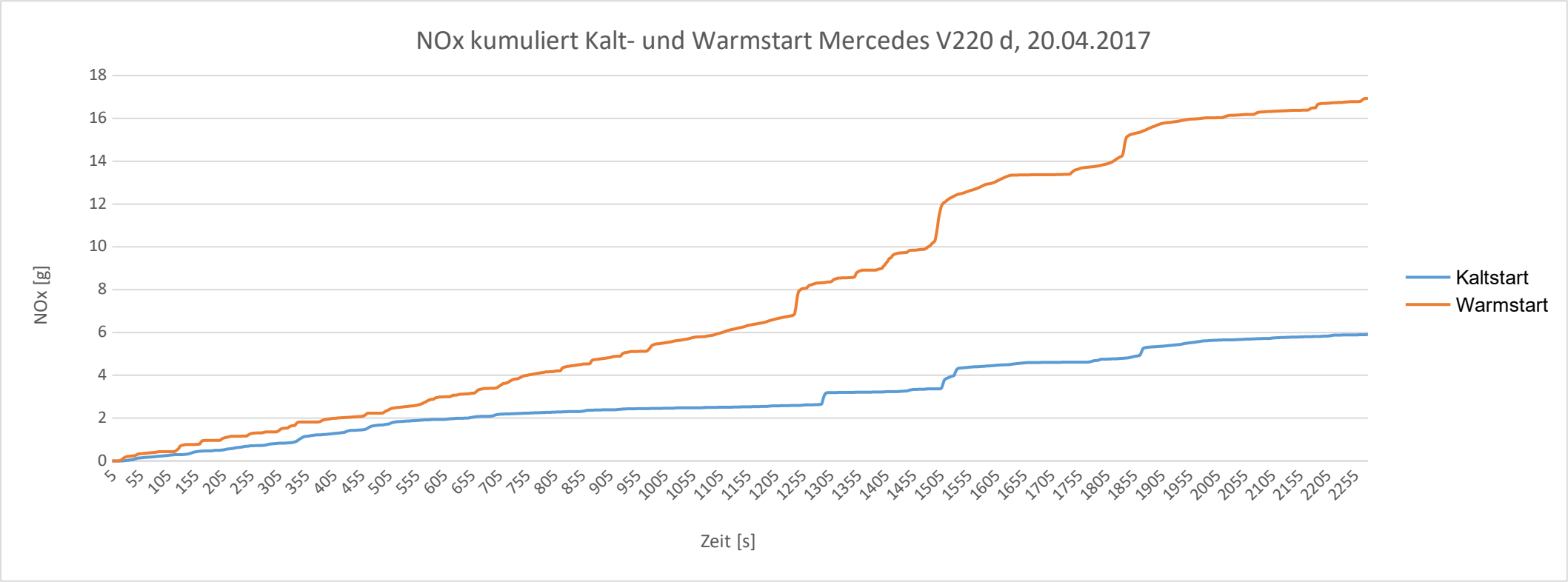
Average the ten measurements

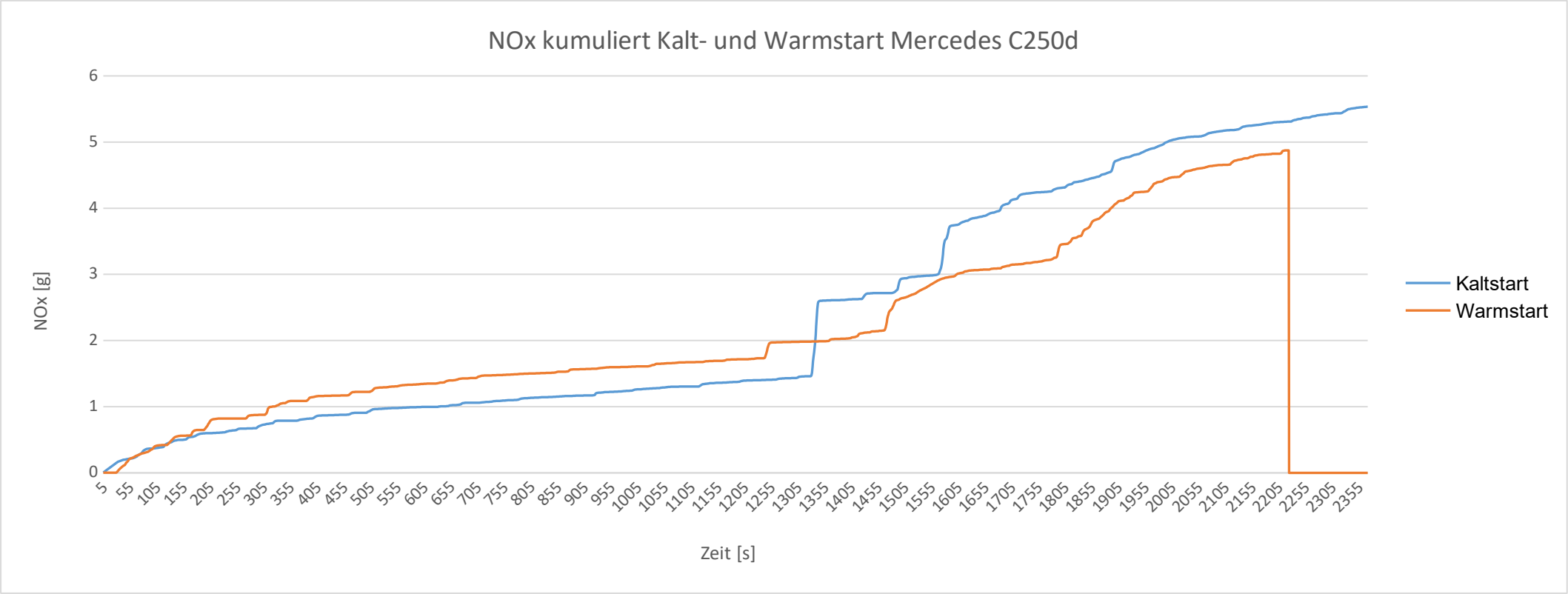
Average CO_2 in g/km	**134**
Average NO_x in mg/km	**1.039**
Factor to emission limt NO_x Euro 6 Diesel (80 mg/km)	**13**

Daimler V220 D
EURO 6


NO2 vs. Zeit Kalt- und Warmstart Mercedes V220d, 20.04.2017
NO2 [ppm]
Zeit [s]
Kaltstart
Warmstart


NO2 vs. Zeit Kalt- und Warmstart Mercedes C250d
NO2 [ppm]
Zeit [s]
Kaltstart
Warmstart


NOx kumuliert Kalt- und Warmstart Mercedes V220 d, 20.04.2017
NOx [g]
Zeit [s]
Kaltstart
Warmstart


NOx kumuliert Kalt- und Warmstart Mercedes C250d
NOx [g]
Zeit [s]
Kaltstart
Warmstart

Possibilities of Cycle Detection

Acceleration sensor (integrated in Airbag)

Wheel sensors (integrated in ABS)

GPS (integrated in navigation system)

Temperatur sensors

Safety belt sensors

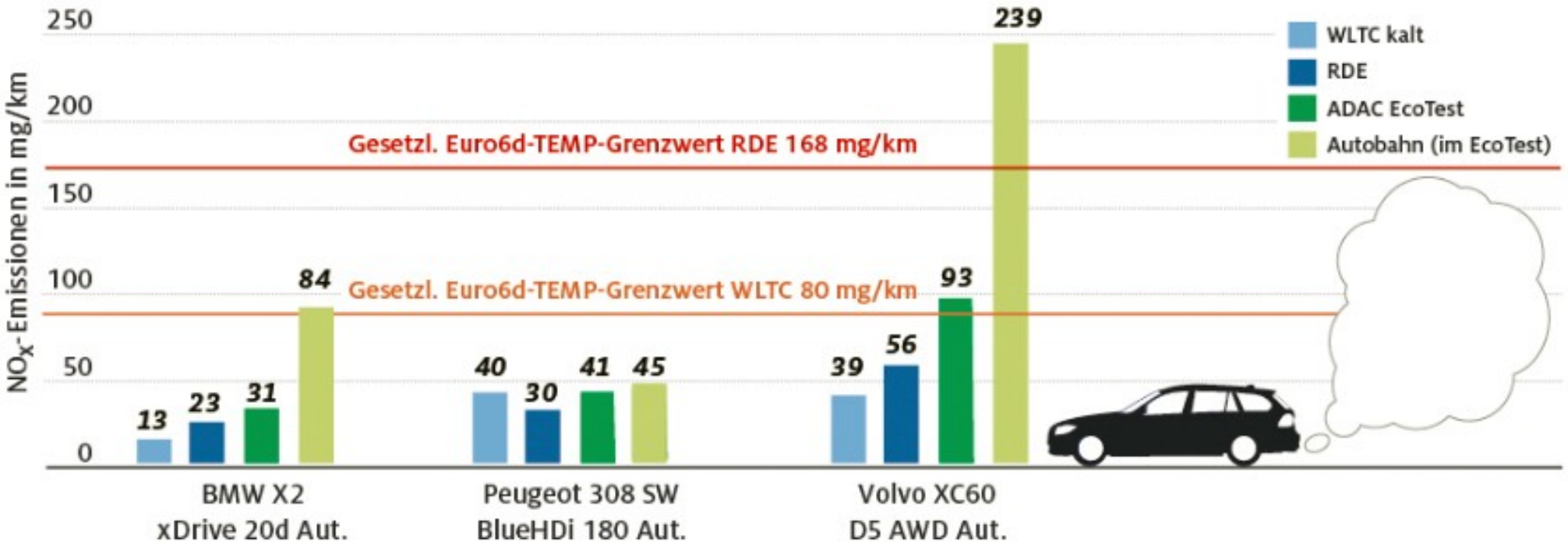
Wheel sensors

etc.

Emission limits and conformity factors

The second package on RDE tests establishes the **emission limits applicable** in these tests and the **dates** when these will apply to new models and to new vehicles.
The final requirements will be introduced in two steps. The first should apply from September 2017 for new models and from September 2019 for new vehicles. During this first period, a **conformity factor of up to 2.1 (110%)** will be allowed for exceeding the NOx emissions limit (80 mg/km). The aim is to give manufacturers time to **gradually adapt** to the new RDE rules.
This first conformity factor will be phased out at the latest in 2021.In a second stage, from January 2020 for new models and from January 2021 for new vehicles, there will still be the possibility to apply a **conformity factor. However this second conformity factor will be only 1 plus the error margin, which is currently set at 0.5. (With a conformity factor of 1.5** the limit could be exceeded by 50%). The error margin reflects **statistical and technical uncertainties** of the tests. This second conformity factor will be **annually reviewed** to take into consideration technical improvements to the test equipment.

Euro 6d temp NO_x Emissions



Source:https://www.adac.de/der-adac/rechtsberatung/fahrzeugkauf-und-verkauf/abgasskandal-dieselthematik/test-euro-6-temp/

Prius IV

PEMS Measurements Prius

Prius 3

Av. NOx emissions: <5 mg/km

Av. CO emissions: 73 mg/km

Av. CO_2 emissions: 106 g/km

Prius 4

Av. NOx emissions: 15 mg/km

Av. CO emissions: 36 mg/km

Av. CO_2 emissions: 76 g/km

Conclusion

If no control exist, manufacturers don‘t follow the legislation if they can save money.

Therefore it is a need to change the certification system of vehicle.

It should rely in future on RDE measurements, self certification by the manufacturers combined with effective penalties. The control of the manufactures data should be done by government agencies,

The system has to be transparent, which means all RDE test data has be published immediately after the tests.

The test- and control cost should be covered by a small fee for the first registration

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Small is beautiful