

# 1.A.3.b i - iv - Emissions from fuel combustion in Road Vehicles (OVERVIEW)

## Short description

This overview chapter provides information on the emissions from fuel combustion activities in road transport sub-categories 1.A.3.b i, ii, iii, and iv.

NFR-Code	Name of Category
1.A.3.b i	<a href="#">Passenger Cars</a>
1.A.3.b ii	<a href="#">Light Duty Vehicles</a>
1.A.3.b iii	<a href="#">Heavy Duty Vehicles</a>
1.A.3.b iv	<a href="#">Mopeds &amp; Motorcycles</a>

## Methodology

### Activity data

Basically, total inland fuel deliveries are available from the National Energy Balances (NEBs) (AGEB, 2021) <sup>1)</sup>, line 62: Straßenverkehr (Road Transport) as compiled by the Association of the German Petroleum Industry (MWV) <sup>2)</sup>.

Based upon these primary activity data, specific consumption data for the different types of road vehicles are generated within TREMOD <sup>3)</sup>.



For further details see main chapter [1.A.3.b - Road Transport](#) as well as the sub-category chapters linked above.

### Emission factors

The majority of emissions factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, version 4.1) <sup>4)</sup> where they are provided on a tier3 level mostly and processed within the TREMOD software used by the party <sup>5)</sup>.



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>1)</sup>

As it is not possible to present these tier3 values in a comprehensible way, the NFR sub-chapters linked above provide sets of fuel-specific implied emission factors instead.

For heavy-metal (other than lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from (EMEP/EEA, 2019) <sup>6)</sup> have been applied. Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) <sup>7)</sup> are used instead.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Trends of exhaust emissions from road transport vehicles

For **ammonia emissions**, the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.

The observed trends for **NO<sub>x</sub>**, **NM VOC** and **CO emissions** represent the changes in legislative emission limits and the regarding implementation of mitigation technologies. The following table provides an overview of the implementation of Euro norms in Germany.

Table 1: Overview of Euro norms and their implementation in Germany

	Type Approval for new vehicle types	Type Approval for new vehicles	Testing Cycle
<b>PASSENGER CARS &amp; LIGHT-DUTY VEHICLES: DIESEL</b>			
<b>Euro Norm 1</b>	since 01. Juli 1992	since 01. Januar 1993	NEFZ
<b>Euro 2</b>	since 01. Januar 1996	since 01. Januar 1997	NEFZ
<b>Euro 3</b>	since 01. Januar 2000	since 01. Januar 2001	NEFZ
<b>Euro 4</b>	since 01. Januar 2005	since 01. Januar 2006	NEFZ
<b>Euro 5a<sup>8)</sup></b>	since 01. September 2009	since 01. Januar 2011	NEFZ
<b>Euro 5b</b>	since 01. September 2011	since 01. Januar 2013	NEFZ
<b>Euro 6b<sup>9)</sup></b>	since 01. September 2014	since 01. September 2015	NEFZ
<b>Euro 6c</b>	since 01. September 2017	since 01. September 2018	WLTC
<b>Euro 6d-Temp</b>	since 01. September 2017	since 01. September 2019	WLTC
<b>Euro 6d</b>	Freiwillige Einstufung	Freiwillige Einstufung	WLTC
<b>Euro 6d-ISC-FCM</b>	since 01.01.2020 (36AP) / 10.01.2021 (36AQ-AR)	Ab 01.01.2021 (36AP) / 01.01.2022 (36AQ-AR)	WLTC
<b>PASSENGER CARS &amp; LIGHT-DUTY VEHICLES: GASOLINE</b>			
<b>Abgasnorm Euro 1</b>	since 01. Juli 1992	since 01. Januar 1993	NEFZ
<b>Euro 2</b>	since 01. Januar 1996	since 01. Januar 1997	NEFZ
<b>Euro 3</b>	since 01. Januar 2000	since 01. Januar 2001	NEFZ
<b>Euro 4</b>	since 01. Januar 2005	since 01. Januar 2006	NEFZ
<b>Euro 5a<sup>10)</sup></b>	since 01. September 2009	since 01. Januar 2011	NEFZ
<b>Euro 6b<sup>11)</sup></b>	since 01. September 2014	since 01. September 2015	NEFZ
<b>Euro 6c</b>	since 01. September 2017	since 01. September 2018	WLTC
<b>Euro 6d-Temp</b>	since 01. September 2017	since 01. September 2019	WLTC
<b>Euro 6d</b>	Freiwillige Einstufung	Freiwillige Einstufung	WLTC
<b>Euro 6d-ISC-FCM</b>	since 01.01.2020 (36AP) / 10.01.2021 (36AQ-AR)	Ab 01.01.2021 (36AP) / 01.01.2022 (36AQ-AR)	WLTC
<b>MOPEDS</b>			
<b>Euro 1</b>	since 17. Juni 1999		ECE R47
<b>Euro 2</b>	since 17. Juni 2002		ECE R47
<b>Euro 4</b>	since 01. Januar 2017	since 01. Januar 2018	ECE R47
<b>Euro 5</b>	since 01. Januar 2020	since 01. Januar 2021	WMTC
<b>MOTORCYCLES</b>			
<b>Euro 1</b>	since 17. Juni 1999		ECE R47
<b>Euro 2</b>	since 17. Juni 2002		ECE R47
<b>BUSES &amp; TRUCKS</b>			
<b>Euro I</b>	01. Jan 92		ESC R-49
<b>Euro II</b>	01. Okt 96		ESC R-49
<b>Euro III</b>	01. Okt 00		ESC&ELR, ETC
<b>Euro IV</b>	01. Okt 05		ESC&ELR, ETC
<b>Euro V</b>	01. Okt 08		ESC&ELR, ETC
<b>Euro VI<sup>12)</sup></b>	01. Okt 13		WHTC, WHSC

Trends for **sulphur dioxide** show characteristics very different from those shown above. Here, the strong dependence on increasing fuel qualities leads to a cascaded downward trend of **SO<sub>2</sub> emissions**, influenced only slightly by increases in fuel consumption and mileage.

The following table provides the development of sulphur contents over the years for Old (OGL) and New German Länder (NGL) and Germany (GER).

Table 2: Development of fuel sulphur contents in Germany

Area covered	Year(s) covered	Gasoline	Diesel oil
EAST GERMANY (DDR)	until 1988	500 ppm	6,000 ppm
	1989-1990	500 ppm	6,000 ppm
WEST GERMANY (BRD)	until 1984	250 ppm	2,700 ppm
	1985		2,500 ppm
	1986		2,100 ppm
	1987		
	1988		1,700 ppm
	1989		
	1990	220 ppm	
	1991	220 ppm	1,300 ppm
GERMANY	1992		
	1993		
	1994		
	1995	180 ppm	600 ppm
	1996		
	1997		400 ppm
	1998-2000	70 ppm	300 ppm
	2001	55 ppm	250 ppm
	2002	25 ppm	40 ppm
	since 2003	8 ppm	8 ppm

For **exhaust particulate matter emissions** from diesel road vehicles, the party assumes that nearly all particles emitted are within the PM<sub>2.5</sub> range, resulting in similar emission values for PM<sub>2.5</sub>, PM<sub>10</sub>, and TSP. Excumptions from this assumption can be observed for gasoline road vehicles for the years until 1997 when **additional TSP emissions** resulted from the use of **leaded gasoline** that was banned in 1997. Furthermore, **black carbon** emissions are estimated via implied emission factors derived from fractions of PM as provided in <sup>13)</sup>.

For **Heavy Metals** and **PAHs**, emissions are calculated with tier1 default EF from <sup>14)</sup> resulting in trends that simply reflect the annual fuel consumption.

Table 3-86: Heavy metal emission factors for all vehicle categories in ppm/wt fuel

Category	Pb	Cd	Cu	Cr	Ni	Se	Zn	Hg	As
Passenger cars, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
Passenger cars, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
LCVs, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
LCVs, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
HDVs, petrol	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003
HDVs, diesel	0.0005	5 E-05	0.0057	0.0085	0.0002	0.0001	0.018	0.0053	0.0001
L-category	0.0016	0.0002	0.0045	0.0063	0.0023	0.0002	0.033	0.0087	0.0003

Here, the only excumption are **lead emissions from leaded gasoline** that was in use until 1996 with lead contents provided in the table below:

Table 3: Development of gasoline's lead content in Germany

Area covered	Year(s) covered	Lead content
EAST GERMANY (GDR)	1989-1990	126 mg/l
WEST GERMANY (BRD)	1990	42 mg/l

Area covered	Year(s) covered	Lead content
GERMANY	1991	29 mg/l
	1992	20 mg/l
	1993	16 mg/l
	1994	11 mg/l
	1995	8 mg/l
	1996	4 mg/l
	since 1997	0 mg/l (banned)

## Recalculations

Recalculations of exhaust-emissions are mainly based on annual routine revisions of the underlying TREMOD model. For more information, please see the specific chapters linked above.

<sup>1)</sup> AGEB (2021): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; URL: <https://ag-energiebilanzen.de/7-0-Bilanzen-1990-2019.html>, Köln & Berlin, 2021.

<sup>2)</sup> MWV (2021): Association of the German Petroleum Industry (Mineralölwirtschaftsverband, MWV): Annual Report 2019, page 65, Table 'Sektoraler Verbrauch von Dieselmotorkraftstoff 2012-2019'; URL: [https://www.mwv.de/wp-content/uploads/2020/09/MWV\\_Mineraloelwirtschaftsverband-e.V.-Jahresbericht-2020-Webversion.pdf](https://www.mwv.de/wp-content/uploads/2020/09/MWV_Mineraloelwirtschaftsverband-e.V.-Jahresbericht-2020-Webversion.pdf), Berlin, 2020.

<sup>3), 5)</sup> Knörr et al. (2021a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg & Berlin, 2020.

<sup>4)</sup> Keller et al. (2017): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: <http://www.hbefa.net/e/index.html> - Dokumentation, Bern, 2017.

<sup>6), 13), 14)</sup> EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019; <https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view>; Copenhagen, 2019.

<sup>7)</sup> Rentz et al., 2008: Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, January 2008 - URL: <http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>

<sup>8), 9), 10), 11)</sup> EUR-Lex, 2007: REGULATION (EC) No 715/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information - <https://data.europa.eu/eli/reg/2007/715/oj>

<sup>12)</sup> EUR-Lex, 2009: REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC - <https://data.europa.eu/eli/reg/2009/595/oj>

<sup>1)</sup> During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.