1.A.2.g vii - Mobile Combustion in Manufacturing Industries and Construction

Short description

Under NFR *1.A.2.g vii - Mobile Combustion in Manufacturing Industries and Construction*, emissions from Off-Road Construction Vehicles and Construction Machinery are reported in the German inventory.

Category Code	**Method**					**AD**					**EF**				
1.A.2.g vii	T1,T2					NS, M					CS, D, M				
Key Category	**NOx**	**NMVOC**	**SO2**	**NH3**	**PM2_5**	**PM10**	**TSP**	**BC**	**CO**	**PB**	**Cd**	**Hg**	**Diox**	**PAH**	**HCB**
1.A.2.g vii	-/-	-/-	-/-	-/-	L/T	-/T	-/-	L/-	L/-	-/-	-/-	-/-	-/-	-/-	-

Methodology

Activity data

Sector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2021) [1)]

Table 1: Sources for primary fuel-delivery data

through 1994	**AGEB** - National Energy Balance, line 79: 'Haushalte und Kleinverbraucher insgesamt'
as of 1995	**AGEB** - National Energy Balance, line 67: 'Gewerbe, Handel, Dienstleistungen u. übrige Verbraucher'

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2021) [2)], the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4. ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD-MM (Knörr et al. (2021b)) [3)] (cf. NFR 1.A.4 - mobile).

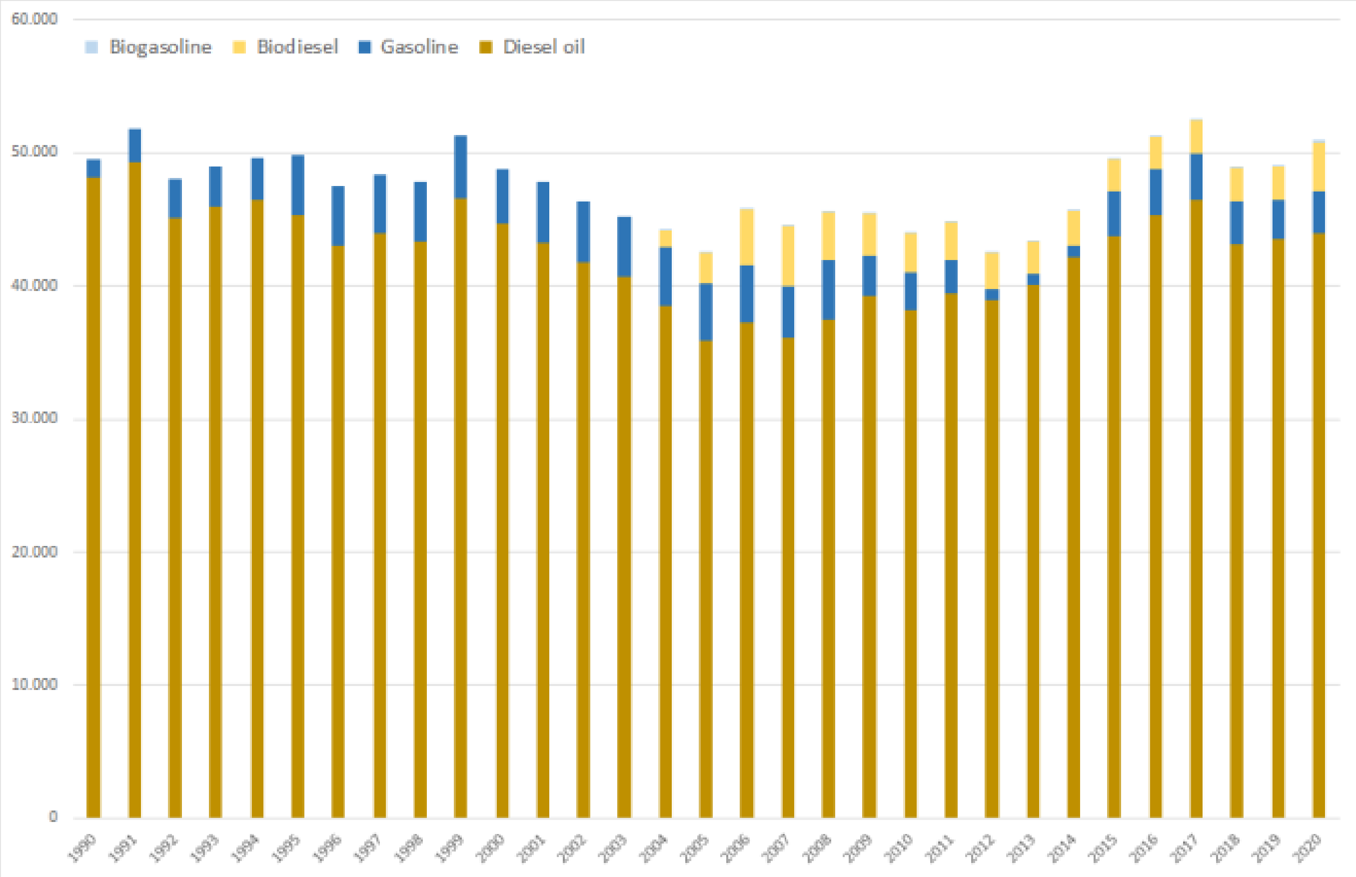
Table 2: Percental annual contribution of 1.A.2.g vii to fuel-specific over-all delivery data provided in NEB line 67

	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Diesel Fuels	43.0%	46.4%	47.0%	43.7%	44.9%	43.3%	44.2%	43.8%	43.1%	43.4%	43.7%	43.2%	43.5%	43.1%	43.0%	42.9%	42.6%	42.4%	42.1%
Gasoline Fuels	31.5%	59.7%	55.1%	58.6%	58.6%	52.9%	62.4%	66.5%	64.5%	64.4%	66.9%	67.1%	66.9%	66.7%	68.4%	68.1%	64.2%	63.2%	59.6%

Table 3: Annual fuel consumption in construction vehicles and mobile machinery, in terajoules

	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Diesel Oil	48,078	45,337	44,668	35,884	37,233	36,089	37,405	39,232	38,160	39,396	38,936	40,083	42,121	43,686	45,281	46,495	43,087	43,509	43,962
Gasoline	1,420	4,453	4,079	4,283	4,330	3,907	4,558	2,991	2,844	2,583	837	826	874	3,363	3,440	3,421	3,220	2,937	3,150
Biodiesel	0	0	0	2,293	4,115	4,441	3,554	3,134	2,926	2,749	2,748	2,377	2,588	2,390	2,401	2,482	2,505	2,478	3,652
Biogasoline	0	0	0	29.4	62.4	52.9	87.1	85.5	110	106	37.1	35.4	38.0	146	149	144	145	127	144
Σ 1.A.2.g vii	**49.497**	**49.791**	**48.747**	**42.489**	**45.741**	**44.490**	**45.605**	**45.443**	**44.039**	**44.834**	**42.558**	**43.321**	**45.622**	**49.585**	**51.272**	**52.542**	**48.956**	**49.050**	**50.907**

> NOTE: The remarkable increase in gasoline consumption after 2014 relates to the strongly increased inland deliveries reported in NEB line 67.



Emission factors

The emission factors used here are of rather different quality: Basically, for all **main pollutants**, **carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM (Knörr et al. (2020b)) [4)] are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

Table 4: Annual country-specific emission factors[1], in kg/TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline fuels															
NH_3	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
NMVOC[2]	77.8	74.8	82.3	100.8	105.8	105.8	105.8	105.8	105.8	105.8	105.8	105.8	105.8	105.8	105.8
NMVOC[3]	678	623	571	563	561	561	561	561	561	561	561	561	561	556	537
NO_x	54.0	68.3	75.9	76.8	76.9	76.9	77.0	77.0	77.0	77.0	77.0	77.0	77.0	75.1	70.4
SO_x	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[5]	0.30	0.27	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
PM[4]	6.03	5.43	4.83	4.72	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71
TSP[6]	2.35	0.82	leaded gasoline out of use since 1997												
CO	38,459	35,290	32,423	32,108	34,681	35,250	35,791	36,289	36,661	36,840	36,918	36,973	37,010	36,701	35,466
Pb	1.47	0.52	leaded gasoline out of use since 1997												
Diesel fuels															
NH_3	0.16	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
NMVOC	185	155	131	87.4	57.4	53.4	50.0	46.6	43.0	39.8	36.8	34.1	31.7	29.4	27.3
NO_x	1,043	1,010	968	755	520	482	450	425	403	386	367	348	332	316	297
SO_x	79.6	60.5	14.0	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[5]	78.5	64.0	51.0	36.1	27.3	26.1	25.0	23.7	22.1	20.6	19.0	17.5	16.0	14.6	13.0
PM[4]	149	121	94.1	59.9	38.5	35.9	33.7	31.6	29.2	27.0	24.9	22.9	20.9	19.1	17.0
CO	584	576	545	414	318	307	299	292	286	281	277	273	269	265	258

[1] due to lack of better information: similar EF are applied for fossil and biofuels

[2] from fuel combustion
[3] from gasoline evaporation
[4] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
[5] estimated via a f-BCs as provided in [5)], Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery
[6] from leaded gasoline (until 1997)

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. [1)]

For lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions are are calculated from 1990 to 1997 based upon contry-specific emission factors from [6)].

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.

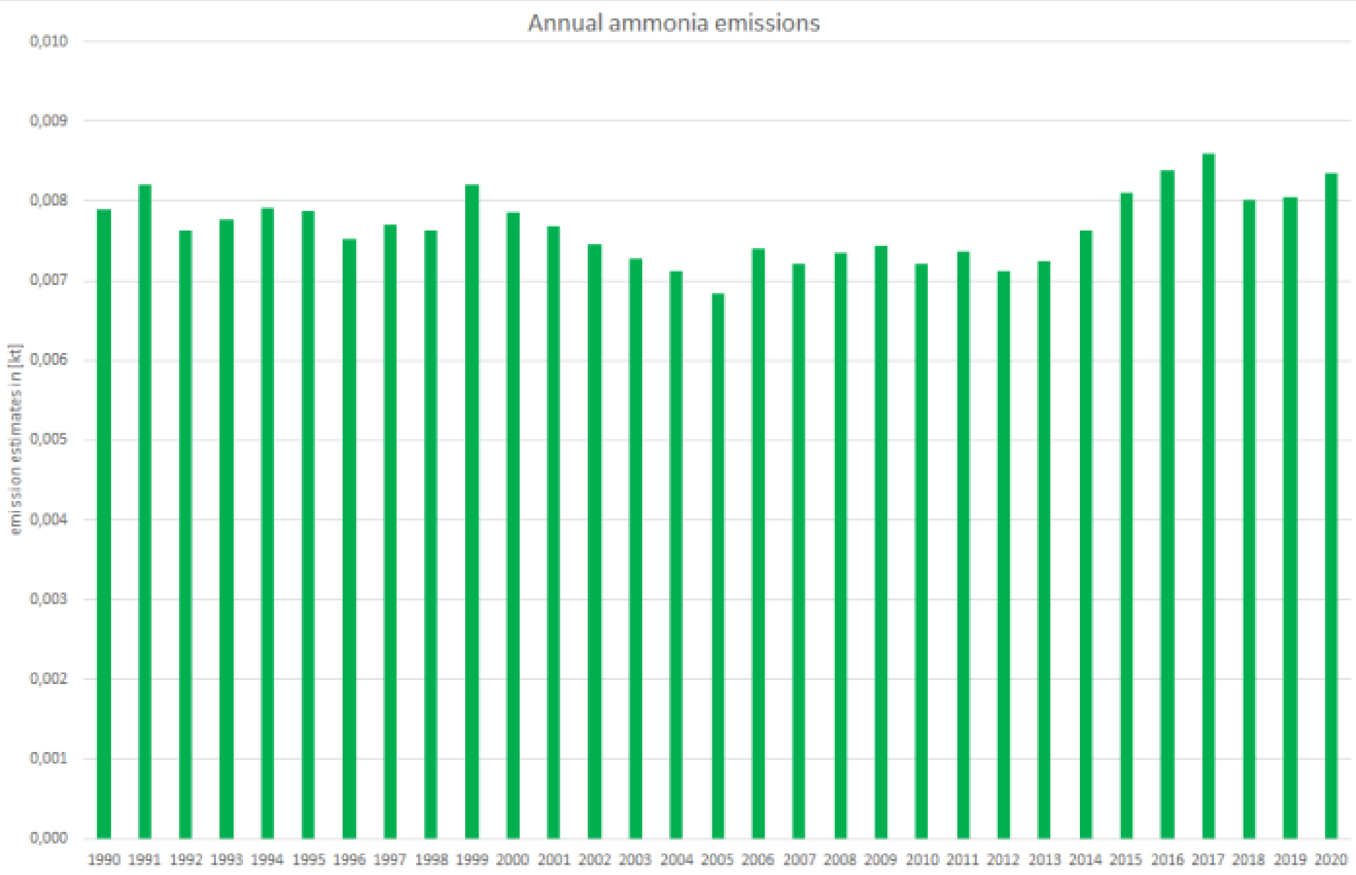
Discussion of emission trends

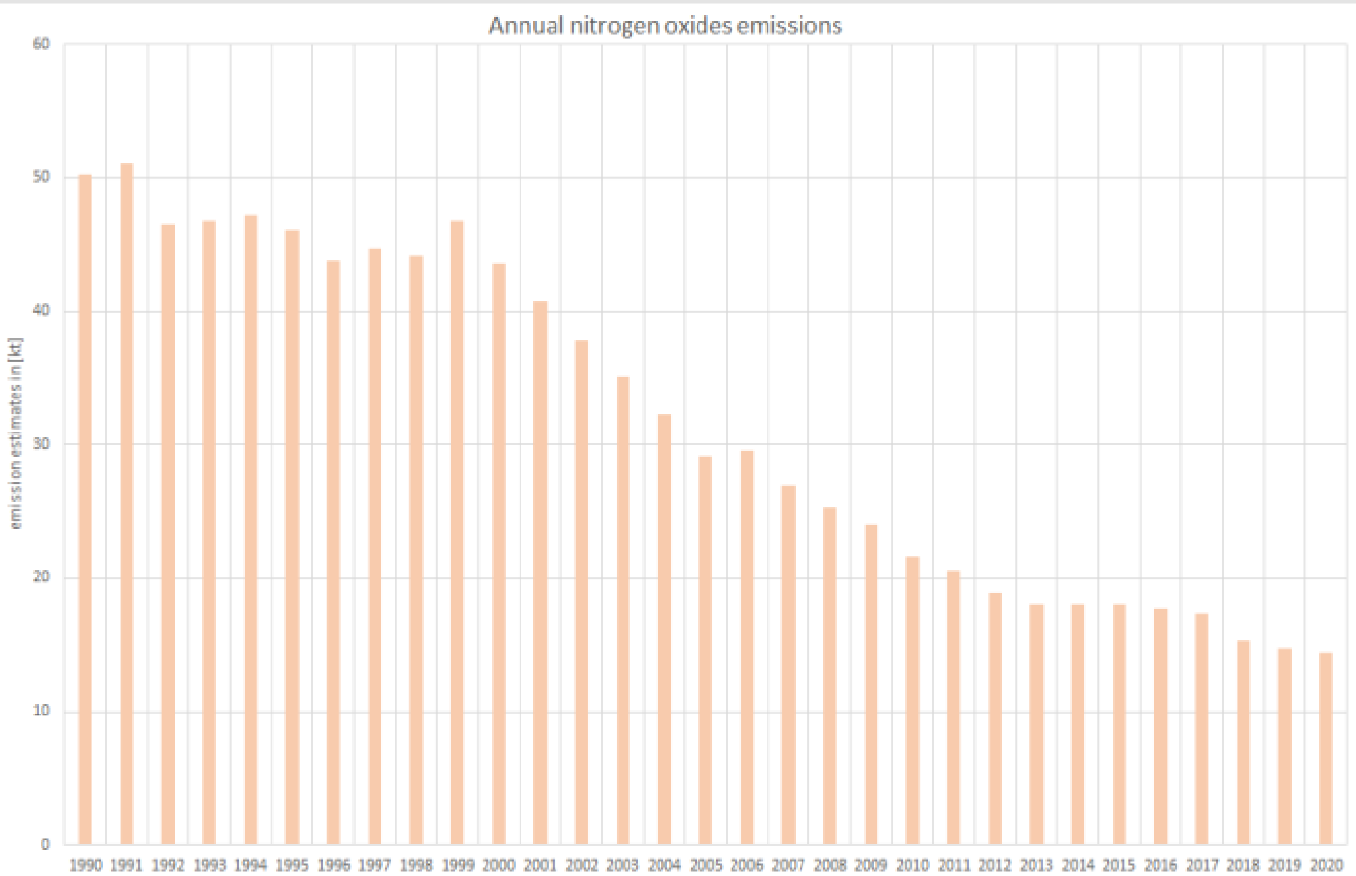
Table: Outcome of Key Category Analysis

for:	**CO**	**BC**	**PM_{10}**	**$PM_{2.5}$**
by:	Level	L	Trend	L & T

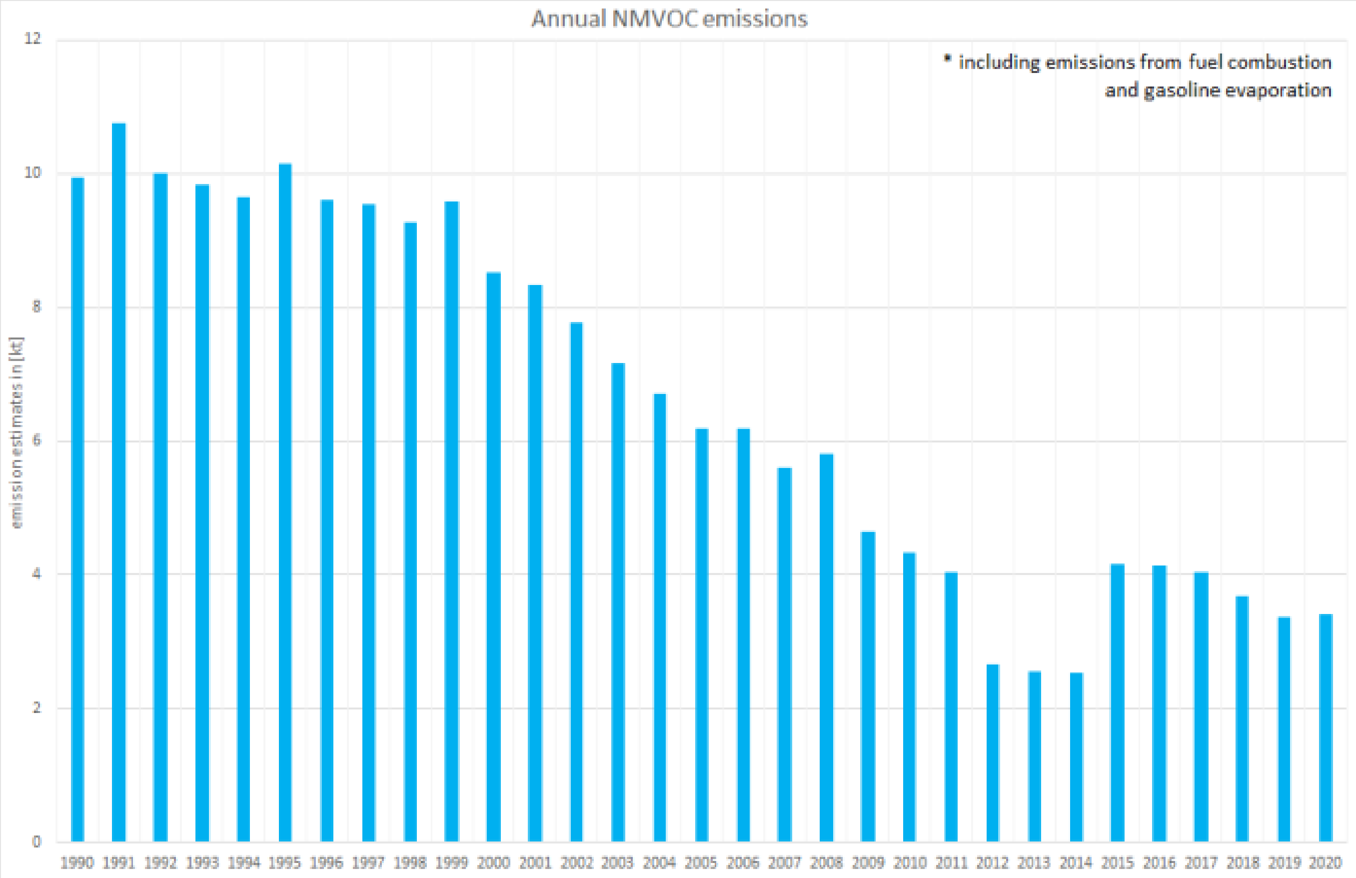
For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

In contrast, for all regulated pollutants (such as NOx, SOx, NMVOC and particles), emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation.

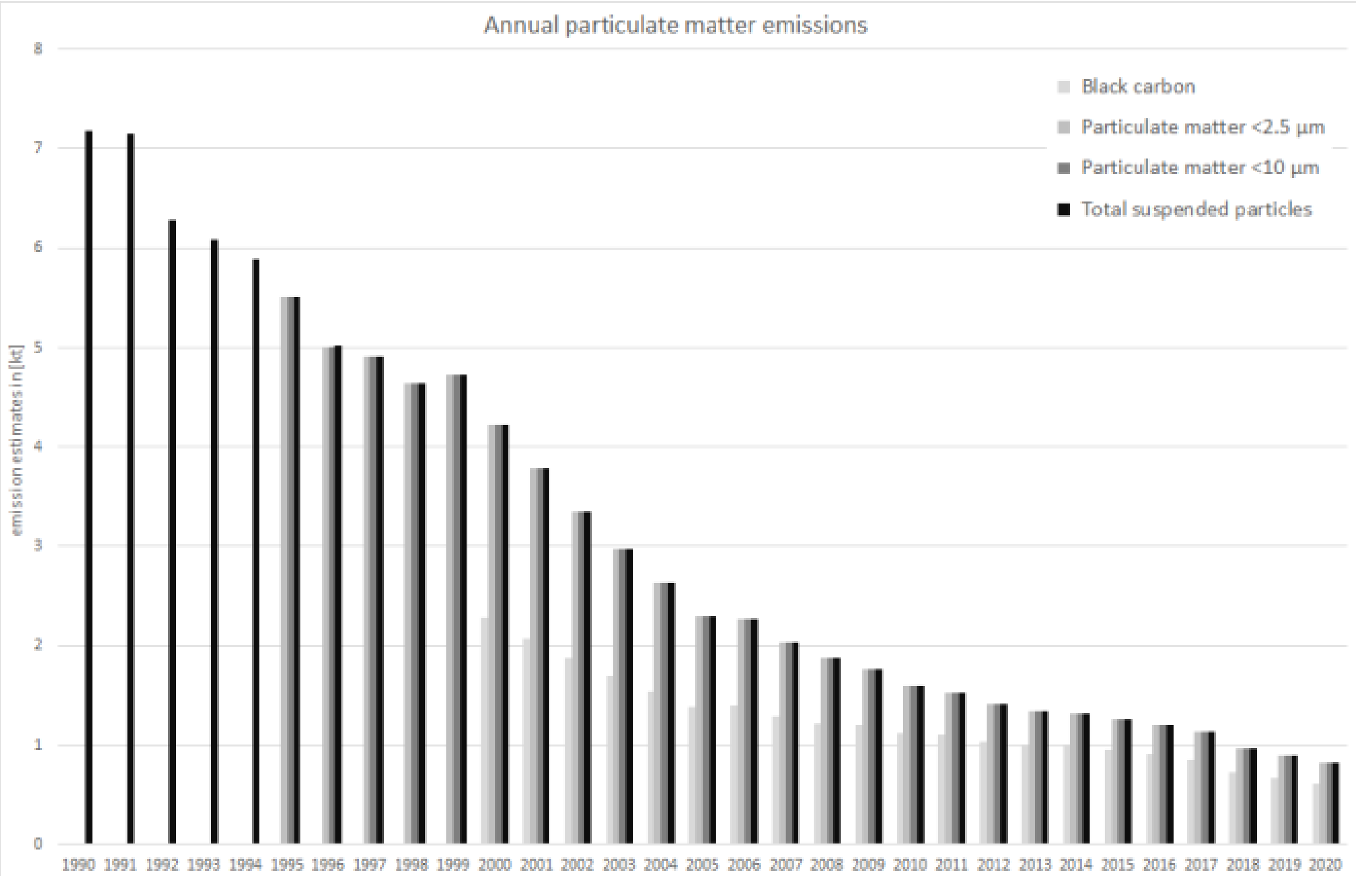




Here, as NMVOC emissions are dominated by gasoline fuels, the trend shows the same strong decline after 2011 as the underlying activity data (see above and NFR 1.A.4 - mobile, Table 1.) The remarkable increase after 2014 relates to the strongly increased gasoline inland deliveries reported in NEB line 67. (see table 3 above). This noticeable increase will be checked by the compiler of the National Energy Balance.



Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.



Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

Recalculations

Revisions in **activity data** result from slightly adapted EBZ67 shares as well as the implementation of primary activity data from the now finalised NEB 2019. Furthermore, for gasline fuels, all activity data have been revised due to a correction in NFR 1.A.5.b with impact on all sources included in NEN line 67.

Table 6: Revised activity data, in terajoules

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
DIESEL FUELS																		
Submission 2022	48,078	45,337	44,668	38,177	41,348	40,530	40,960	42,366	41,085	42,145	41,684	42,460	44,710	46,075	47,682	48,977	45,591	45,987
Submission 2021	48,078	45,337	44,668	38,177	41,348	40,530	40,960	42,366	41,085	42,145	41,684	42,460	44,710	46,075	47,682	48,977	45,594	45,904
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.06	-2.55	82.5
relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	0.18%
GASOLINE FUELS																		
Submission 2022	1,420	4,453	4,079	4,312	4,393	3,959	4,645	3,077	2,954	2,689	874	861	912	3,509	3,590	3,565	3,365	3,063
Submission 2021	1,420	4,453	4,079	4,302	4,373	3,946	4,622	3,041	2,907	2,641	826	815	870	3,471	3,554	3,536	3,263	3,121
absolute change	0.00	0.00	0.00	10.7	20.1	13.3	22.9	36.1	47.0	48.0	48.0	45.6	41.7	38.6	35.6	28.7	101	-57.4
relative change	0.00%	0.00%	0.00%	0.25%	0.46%	0.34%	0.50%	1.19%	1.62%	1.82%	5.81%	5.60%	4.79%	1.11%	1.00%	0.81%	3.11%	-1.84%
OVER-ALL FUEL CONSUMPTION																		
Submission 2022	49,497	49,791	48,747	42,489	45,741	44,490	45,605	45,443	44,039	44,834	42,558	43,321	45,622	49,585	51,272	52,542	48,956	49,050
Submission 2021	49,497	49,791	48,747	42,478	45,721	44,476	45,582	45,407	43,992	44,786	42,510	43,275	45,580	49,546	51,236	52,513	48,857	49,025
absolute change	0.00	0.00	0.00	10.7	20.1	13.3	22.9	36.1	47.0	48.0	48.0	45.6	41.7	38.6	35.6	28.6	98.9	25.08
relative change	0.00%	0.00%	0.00%	0.03%	0.04%	0.03%	0.05%	0.08%	0.11%	0.11%	0.11%	0.11%	0.09%	0.08%	0.07%	0.05%	0.20%	0.05%

As in contrast, all **emission factors** remain unrevised compared to last year's susbmission, emission estimates for the years as of 2015 change in accordance with the underlying activity data.

For specific information on recalculated emission estimates for Base Year and 2018, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by (Knörr et al. (2009)) [7)].

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

Planned improvements

Besides a **routine revision** of the **TREMOD MM** model, no specific improvements are planned.

FAQs

Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?

The EF provided in [8] represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained in the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to diesel and biodiesel.

---

[1] AGEB, 2021: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; URL: http://www.ag-energiebilanzen.de/7-0-Bilanzen-1990-2019.html, (Aufruf: 23.11.2021), Köln & Berlin, 2021

[2] (BAFA2021

[3] Knörr et al. (2021b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2021, Heidelberg, 2021.

[5], [8] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.

[7] Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, 2009.

[1]

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (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.