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.

Method	AD	EF	Key Category
T1, T2	NS, M	CS, D, M	**L & T**: CO, $PM_{2.5}$, PM_{10}, **L**: BC

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, 2019) [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, 2019) [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. (2019b)) [3] (cf. NFR 1.A.4 - mobile).

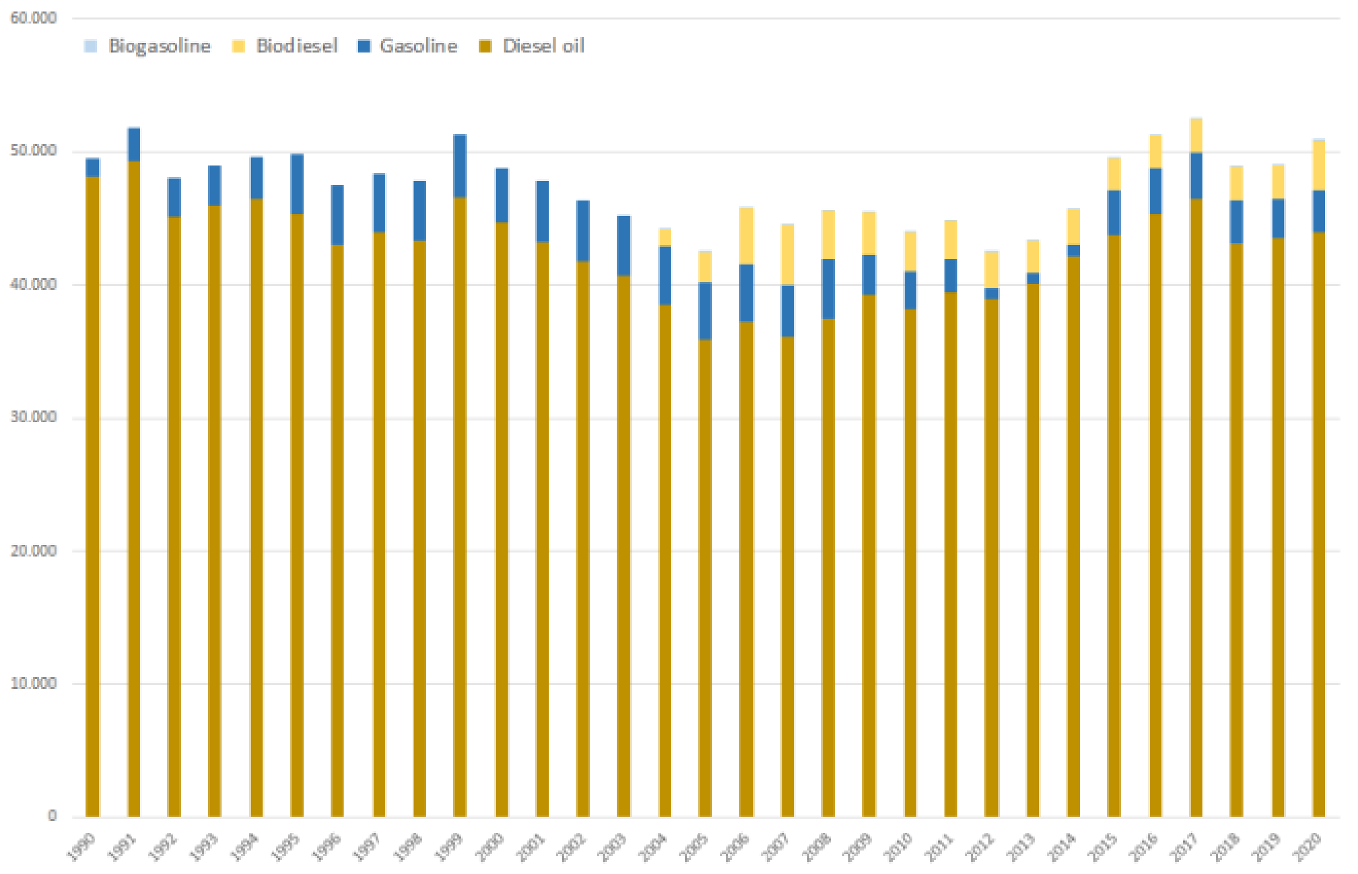
Table 2: Percental annual contribution of 1.A.2.g vii to fuel-specific over-all delivery data provided in NEB line 67

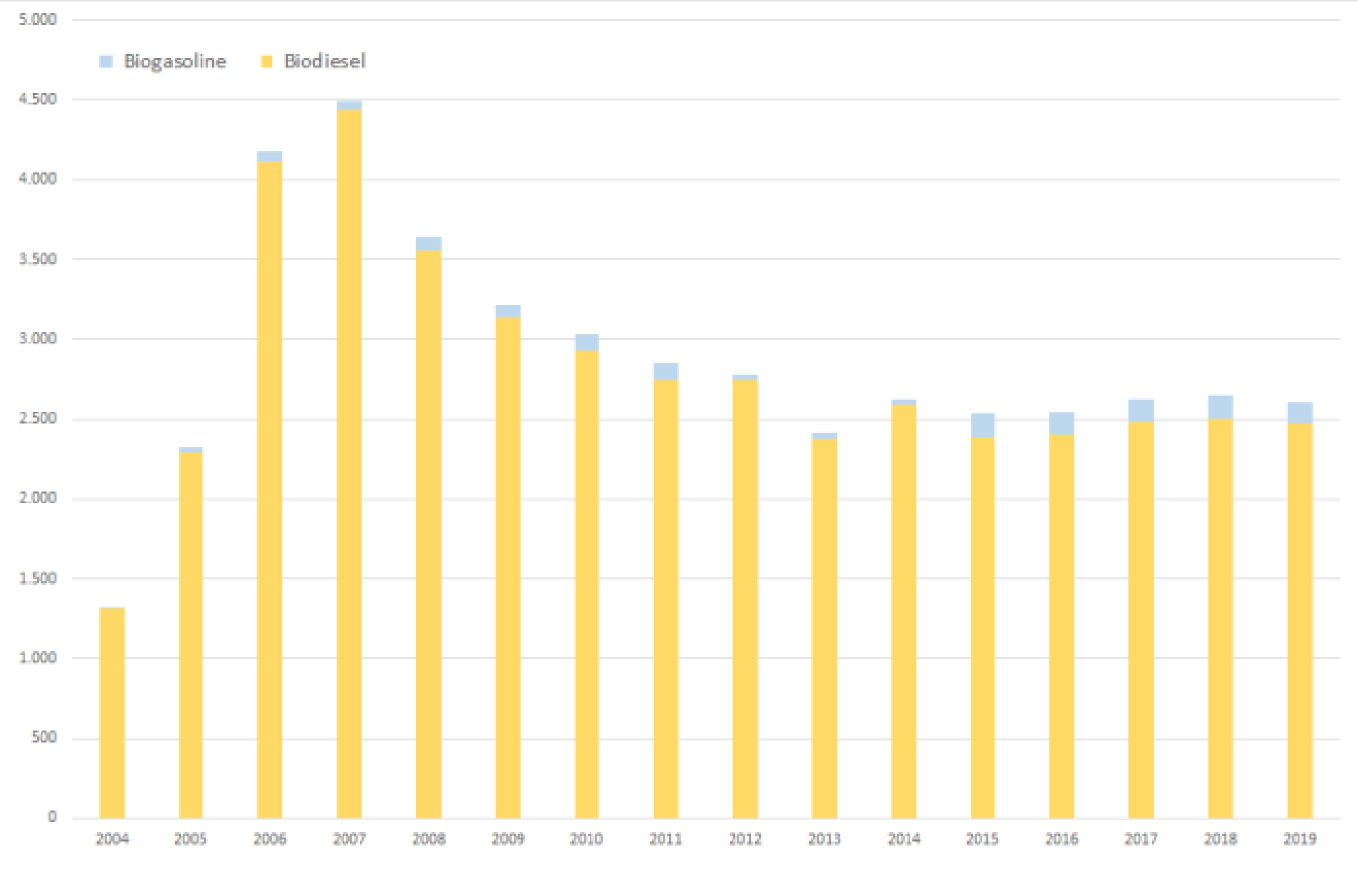
	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Diesel Fuels	43,0%	46,4%	47,0%	43,7%	43,1%	43,4%	43,7%	43,2%	43,5%	43,1%	43,0%	42,9%	42,6%	42,4%
Gasoline Fuels	31,5%	59,7%	55,1%	58,6%	64,5%	64,4%	66,9%	67,1%	66,9%	66,7%	68,4%	68,1%	64,2%	63,2%

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

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Diesel Oil	48.078	45.337	44.668	35.884	38.160	39.396	38.936	40.083	42.121	43.686	45.281	46.495	43.089	43.431
Gasoline	1.420	4.453	4.079	4.272	2.799	2.537	791	782	834	3.326	3.406	3.393	3.123	2.992
Biodiesel	0	0	0	2.293	2.926	2.749	2.748	2.377	2.588	2.390	2.401	2.482	2.505	2.473
Biogasoline	0	0	0	29	108	104	35	34	36	144	148	143	140	129
Σ 1.A.2.g vii	**49.497**	**49.791**	**48.747**	**42.478**	**43.992**	**44.786**	**42.510**	**43.275**	**45.580**	**49.546**	**51.236**	**52.513**	**48.857**	**49.025**

> 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. (2019b)) 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*, in kg/TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gasoline fuels														
NH_3	0.089	0.092	0.093	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	
$NMVOC_{exhaust}$	77.8	74.8	82.3	101	106	106	106	106	106	106	106	106	106	
$NMVOC_{evapor.}$	678	623	571	563	561	561	561	561	561	561	561	561	561	
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	
SO_x	10.1	8.3	3.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
BC	0.302	0.271	0.241	0.236	0.236	0.236	0.236	0.236	0.235	0.235	0.235	0.235	0.235	
PM	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	
TSP	2.35	0.82	0	0	0	0	0	0	0	0	0	0	0	
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	
Pb	1.471	0.516	0	0	0	0	0	0	0	0	0	0	0	
Diesel fuels														
NH_3	0.161	0.164	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	
NMVOC	185	157	134	90	59	55	52	48	44	41	38	35	32	
NO_x	1,047	1,012	970	757	523	484	449	417	386	357	325	292	263	
SO_x	79.6	60.5	14.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
BC	78.5	64.1	51.1	36.4	27.6	26.5	25.3	23.8	22.1	20.5	18.8	17.2	15.7	
PM	149	121	94	60	39	36	34	32	29	27	25	22	20	
CO	585	579	552	421	324	313	304	296	289	283	278	272	267	

1. 1 due to lack of better information: similar EF are applied for fossil and biofuels
2. 2 from fuel combustion
3. 3 from gasoline evaporation
4. 4 EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
5. 5 estimated via a f-BCs as provided in [4], 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. 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 [5].

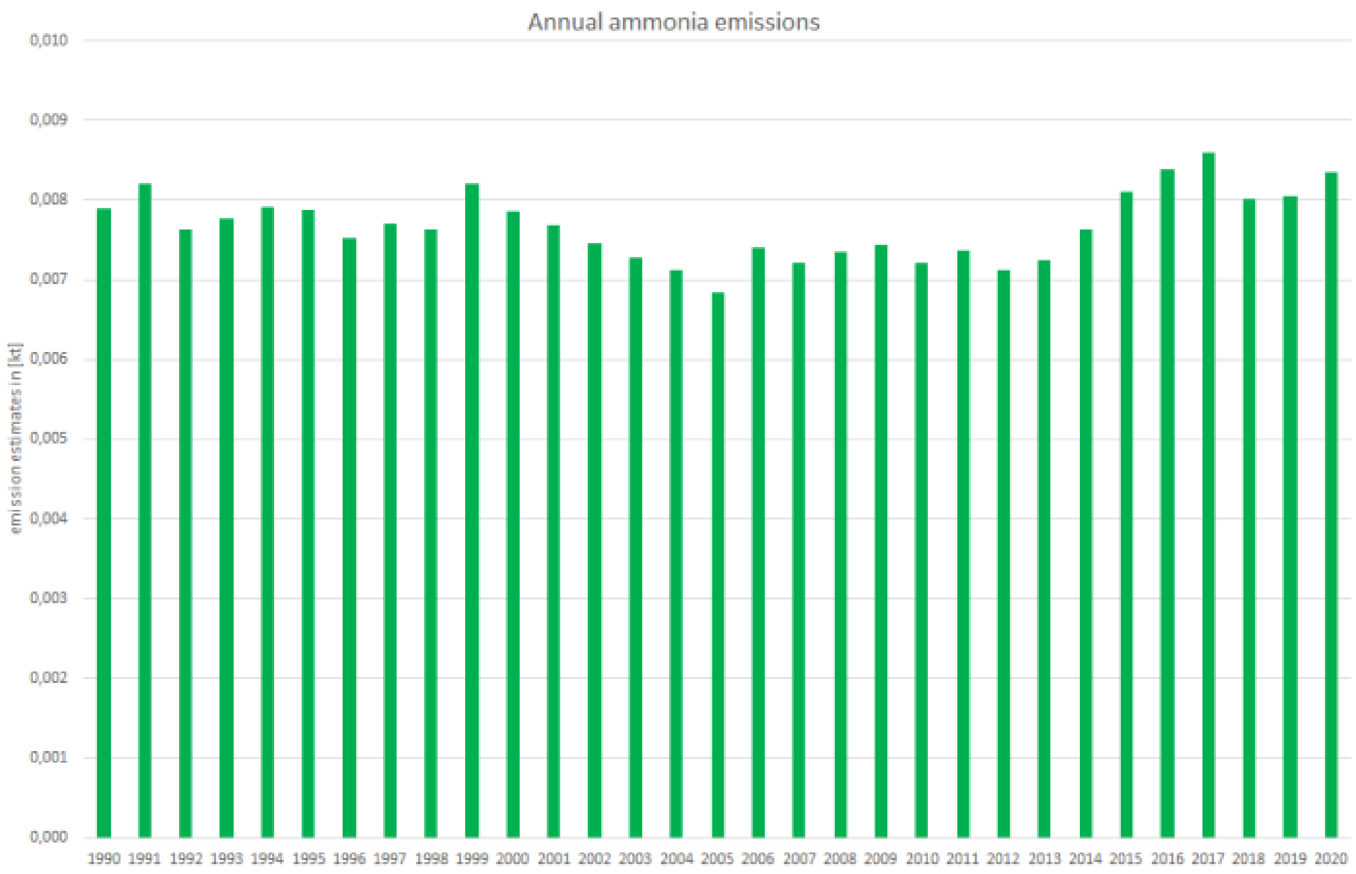
For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

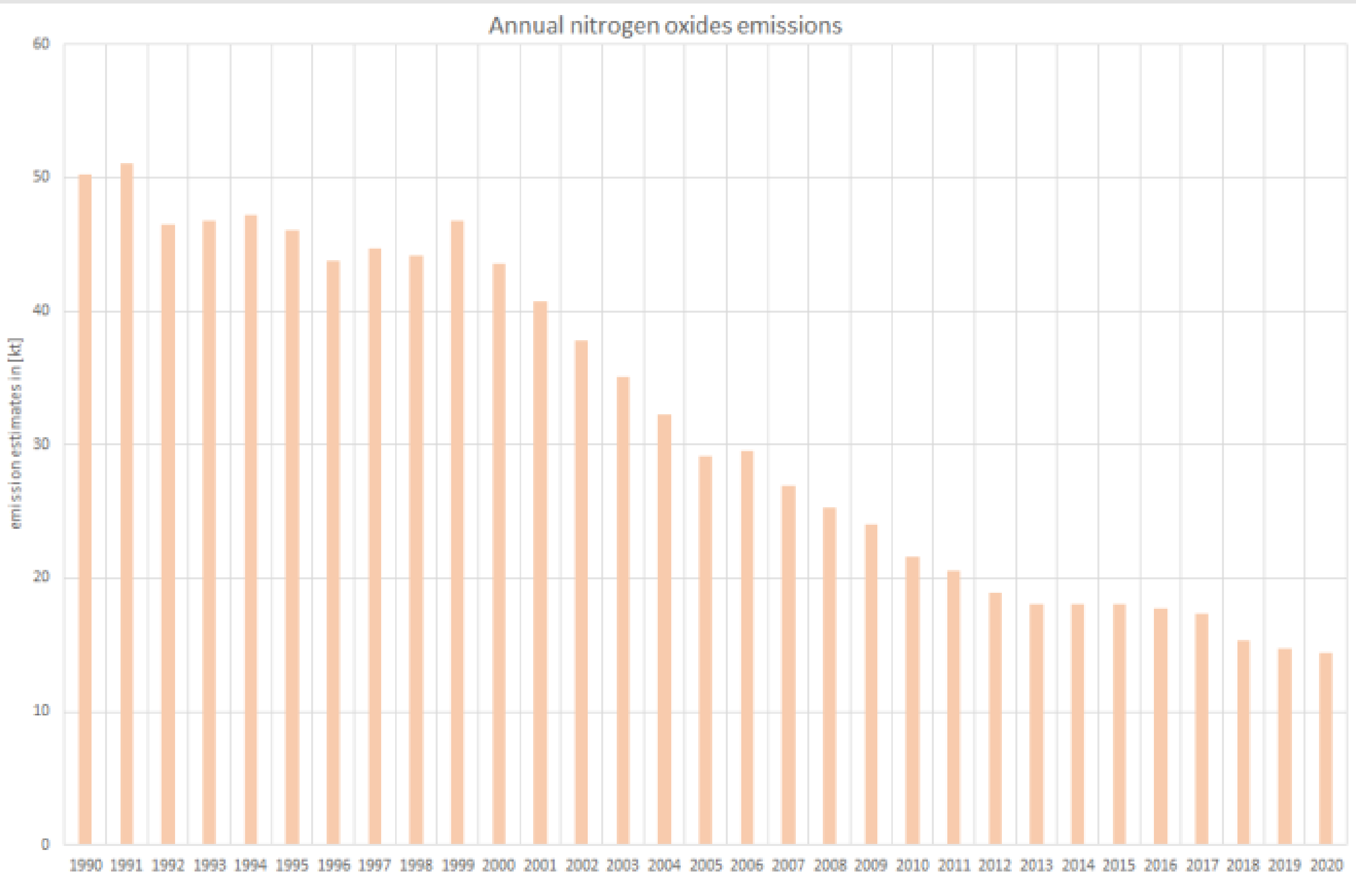
Discussion of emission trends

> **NFR 1.A.2.g vii** is key source for emissions of **PM,,2.5,,**, **PM,,10,,** and **BC**.

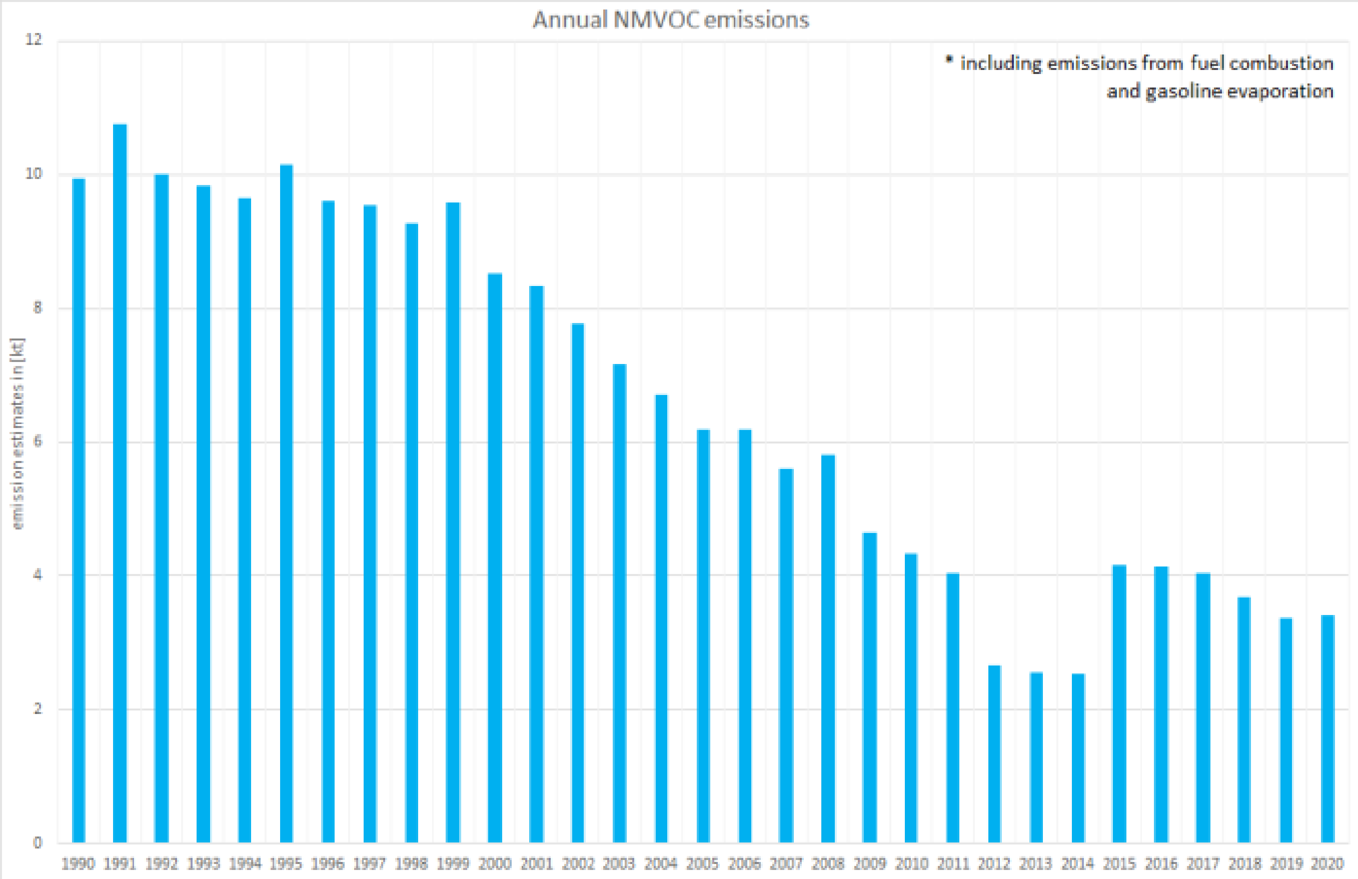
For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

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.

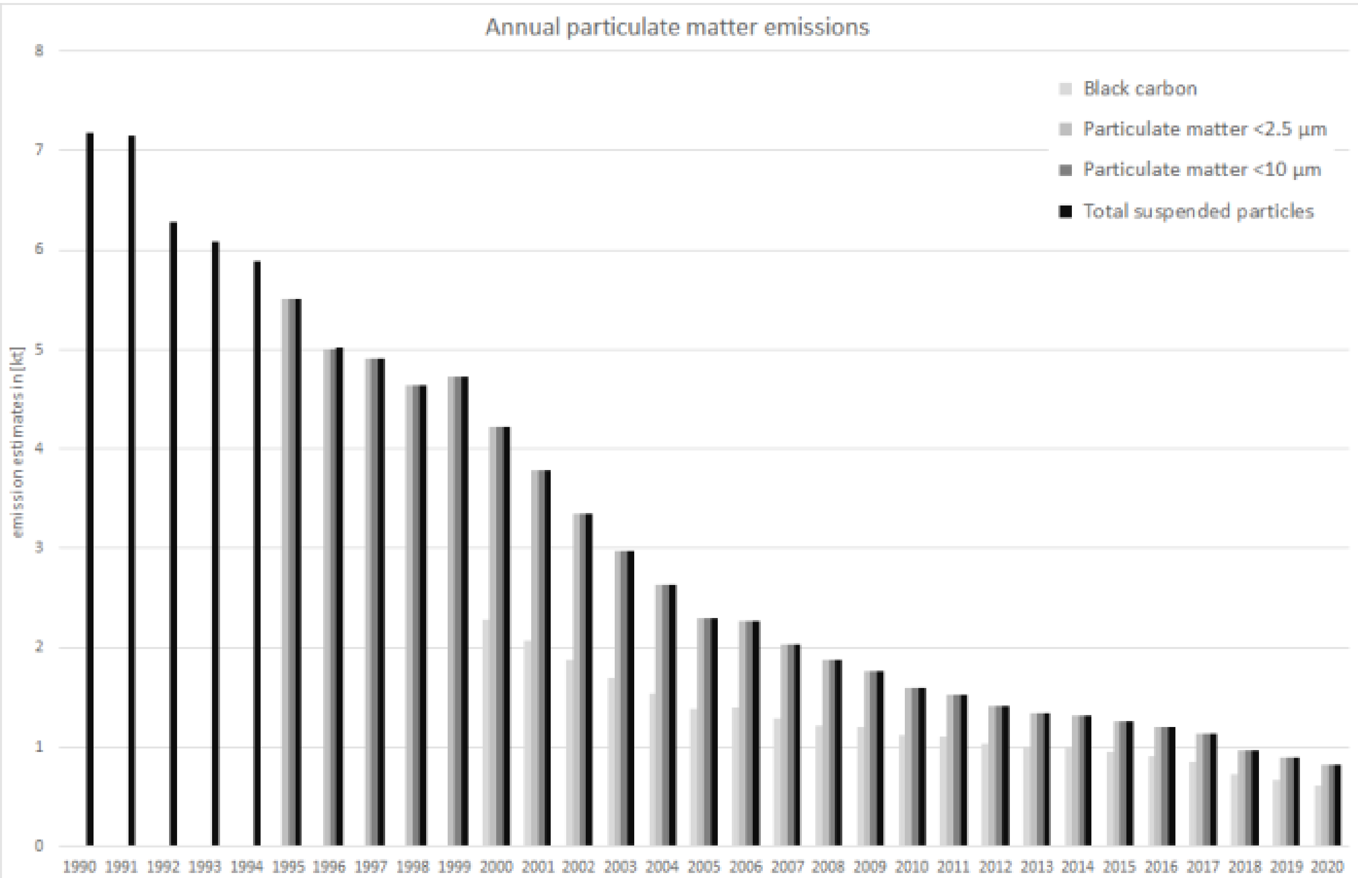




Here, as NMVOC emissions are dominated by gasoline fuels, the trend shows the same strong decline after 2011 as the underlying activity data (see above and NFR 1.A.4 - mobile, Table 1.) The remarkable increase after 2014 relates to the strongly increased gasoline inland deliveries reported in NEB line 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 NCVs and biofuel shares (2015-2017) as well as the implementation of primary activity data from the now finalised NEB 2018.

Table 6: Revised activity data, in terajoules

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018
diesel fuels													
Submission 2021	48.078	45.337	44.668	38.177	41.085	42.145	41.684	42.460	44.710	46.075	47.682	48.977	45.594
Submission 2020	47.301	44.401	42.286	33.615	37.154	38.387	37.932	39.357	41.335	42.516	44.012	45.175	41.976
absolute change	776	937	2.382	4.562	3.931	3.758	3.752	3.104	3.375	3.559	3.670	3.802	3.618
relative change	1,64%	2,11%	5,63%	13,57%	10,58%	9,79%	9,89%	7,89%	8,16%	8,37%	8,34%	8,42%	8,62%
gasoline fuels													
Submission 2021	1.420	4.453	4.079	4.302	2.907	2.641	826	815	870	3.471	3.554	3.536	3.263
Submission 2020	1.420	4.453	4.079	4.288	2.886	2.619	819	808	861	3.431	3.512	3.491	3.419
absolute change	0,00	0,00	0,00	13,96	20,98	21,66	7,06	7,67	9,04	39,6	41,8	45,1	-155
relative change	0,00%	0,00%	0,00%	0,33%	0,73%	0,83%	0,86%	0,95%	1,05%	1,15%	1,19%	1,29%	-4,55%
over-all fuel consumption													
Submission 2021	49.497	49.791	48.747	42.478	43.992	44.786	42.510	43.275	45.580	49.546	51.236	52.513	48.857
Submission 2020	48.721	48.854	46.364	37.903	40.040	41.006	38.752	40.164	42.197	45.947	47.524	48.666	45.395
absolute change	776	937	2.382	4.576	3.952	3.780	3.759	3.111	3.384	3.599	3.712	3.847	3.462
relative change	1,59%	1,92%	5,14%	12,07%	9,87%	9,22%	9,70%	7,75%	8,02%	7,83%	7,81%	7,91%	7,63%

source: own estimates based on [6] and [7]

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)) [8].

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 [9] and [10] 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.

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[1] (AGEB, 2019: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; URL: http://www.ag-energiebilanzen.de/7-0-Bilanzen-1990-2017.html, Köln & Berlin, 2019.)
[2] (BAFA, 2019: Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; URL: http://www.bafa.de/bafa/de/energie/mineraloel_rohoel/amtliche_mineraloeldaten/index.html, Eschborn, 2019.)
[3] (Knörr et al. (2019b): Knörr, W., Heidt, C., Gores, S., & Bergk, F. (2019b): ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2019, Heidelberg, 2019.)
[4] (bibcite 3)
[5] (bibcite 3)
[6] (bibcite 1)
[7] (bibcite 3)
[8] (bibcite 6)
[9] (bibcite 4)
[10] (bibcite 5)
[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.