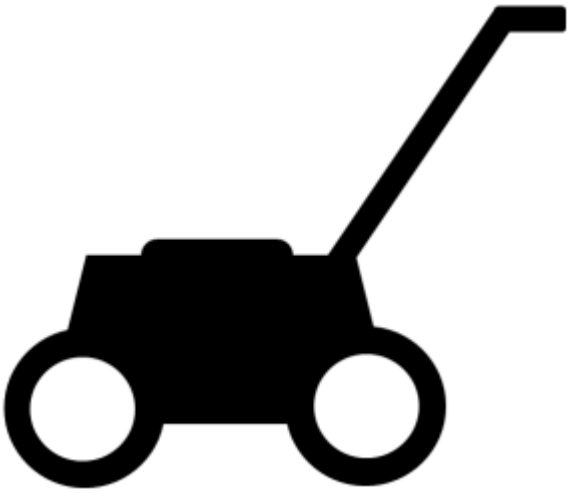
1.A.4.b ii - Residential: Household and Gardening: Mobile

Short description

Under sub-category *1.A.4.b ii - Residential: Mobile Sources in Households and Gardening* fuel combustion activities and resulting emissions from combustion engine driven devices such as motor saws, lawn mowers and small leisure boats are being reported.



Method	AD	EF	Key Category Analysis
T1, T2	NS, M	CS, M, D	**L/-**: CO

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Methodology

Activity data

Activity data are taken from annual fuel delieveries data provided in line 66: 'Households' of the National Energy Balances (NEB) for Germany (AGEB, 2020) [1)].

Table 1: Sources for consumption data in 1.A.4.b ii

Relevant years	Data Source
through 1994	**AGEB** - National Energy Balance, line 79: Households
since 1995	**AGEB** - National Energy Balance, line 66: Households

Here, given the rare statistics on sold machinery, these activity data is of limited quality only (no annual but cascaded trend).

As the NEB only provides primary activity data for *total biomass* used in 'households', but does not distinguish into specific biofuels, consumption data for bioethanol used in NFR 1.A.4.b ii are calculated by applying Germany's official annual shares of biogasoline blended to fossil gasoline.

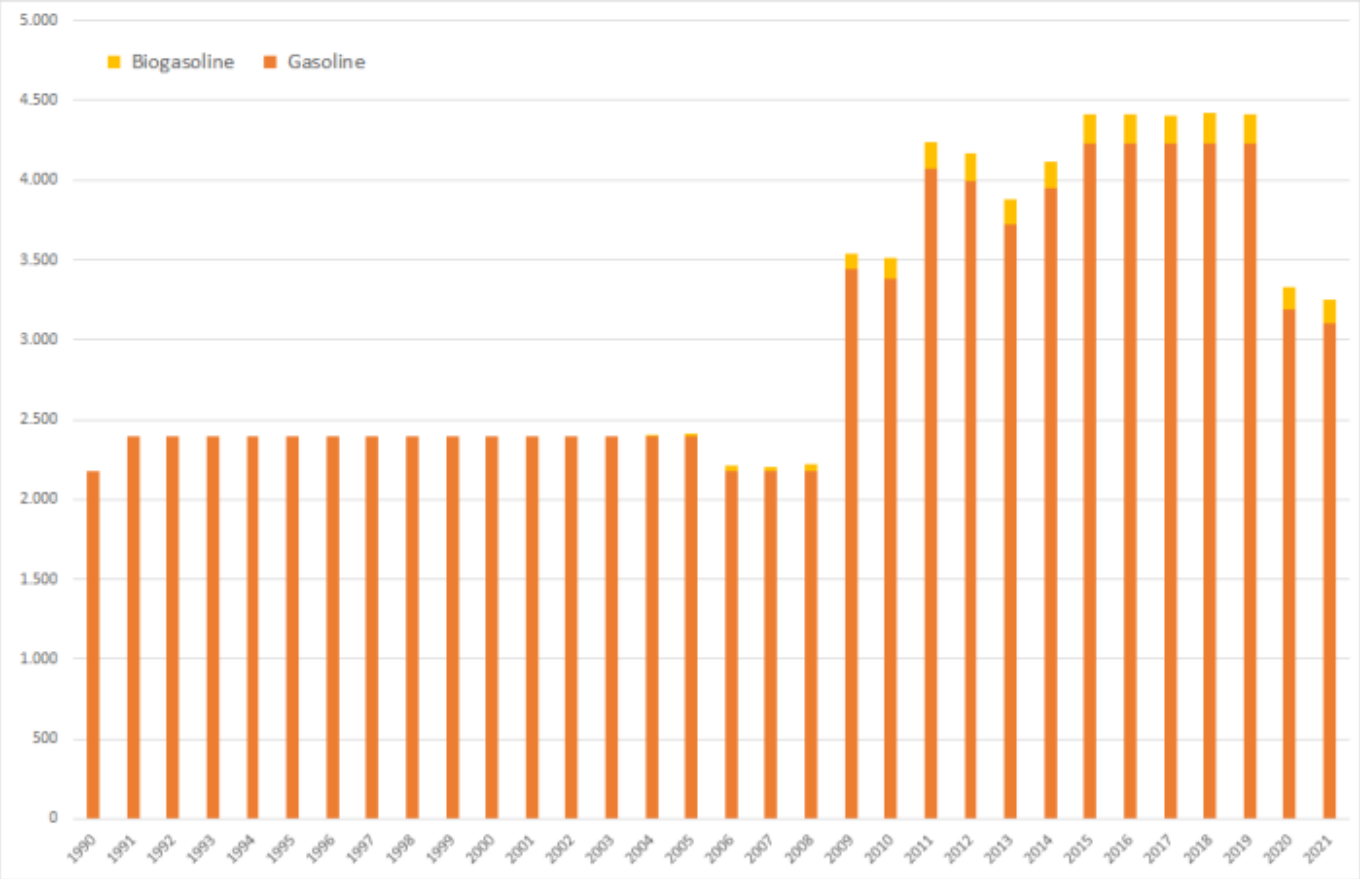
Please note: *Data on gasoline used in households* as provided in the National Energy Balances represents *a "residual item"* following the allocation of the majority of this fuel to road and military vehicles. Here, fuel sales to road vehicles might also include gasoline acquired on filling stations but used for household equipment.

Due to these reasons, activity data for gasoline consumption in households machinery and, hence, several emission estimates *show no realistic trend but a stepwise development* with significant jumps.

Table 2: Annual over-all fuel deliveries to residential mobile sources, in terajoules

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gasoline	2,177	2,395	2,395	2,395	3,379	4,069	3,995	3,720	3,946	4,228	4,228	4,228	4,228	4,228	3,186	3,099
Biogasoline				16.5	131	167	177	159	172	183	184	178	190	182	145	147
Σ 1.A.4.b ii	**2,177**	**2,395**	**2,395**	**2,411**	**3,510**	**4,236**	**4,172**	**3,879**	**4,118**	**4,411**	**4,412**	**4,406**	**4,418**	**4,410**	**3,332**	**3,247**

source: AGEB, 2020 [2)] and TREMOD MM [3)]



These primary activity data can be distributed onto 2- and 4-stroke engines used in households via annual shares from Knörr et al. (2020b) [4)].

Table 3: Annual shares of 2- and 4-stroke engines

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2-Stroke Machinery	25.0%	43.7%	58.4%	61.8%	66.0%	66.4%	67.0%	67.3%	67.3%	67.3%	67.3%	67.3%	67.3%	67.2%	67.2%	67.2%
4-Stroke Machinery	63.7%	44.2%	29.5%	27.0%	23.3%	22.7%	21.6%	20.8%	20.5%	20.3%	20.0%	19.8%	19.6%	19.5%	19.4%	19.2%
2-Stroke Boats	10.1%	10.3%	8.80%	5.61%	2.16%	2.19%	2.23%	2.28%	2.31%	2.34%	2.37%	2.39%	2.40%	2.41%	2.43%	2.45%
4-Stroke Boats	1.2%	1.8%	3.3%	5.6%	8.5%	8.8%	9.2%	9.5%	9.8%	10.1%	10.3%	10.5%	10.7%	10.9%	11.0%	11.1%
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

source: TREMOD MM [5)]

Table 4: Resulting estimates for fuel consumption in 2- and 4-stroke engines, in terajoules

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
2-stroke machinery																
Gasoline	545	1,046	1,400	1,480	2,231	2,700	2,677	2,505	2,656	2,845	2,844	2,844	2,844	2,842	2,140	2,084
Biogasoline	0.00	0.00	0.00	10.2	86.2	111	119	107	116	123	124	120	128	123	97.7	99.1
4-stroke machinery																

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gasoline	1,387	1,059	705	646	787	922	861	775	810	857	847	838	830	824	617	596
Biogasoline	0.00	0.00	0.00	4.44	30.4	37.8	38.2	33.2	35.2	37.2	36.8	35.3	37.3	35.5	28.2	28.3
2-stroke boats																
Gasoline	25.6	43.0	79.2	134	287	359	367	355	388	428	437	446	453	460	351	344
Biogasoline	0.00	0.00	0.00	0.92	11.1	14.7	16.3	15.2	16.9	18.5	19.0	18.8	20.4	19.8	16.0	16.4
4-stroke boats																
Gasoline	220	248	211	134	73.1	88.9	89.2	84.7	91.3	99.1	100	101	102	102	77.4	75.8
Biogasoline	0.00	0.00	0.00	0.92	2.82	3.65	3.95	3.63	3.97	4.30	4.35	4.25	4.57	4.40	3.53	3.61
Σ 1.A.4.b ii	**2,177**	**2,395**	**2,395**	**2,411**	**3,510**	**4,236**	**4,172**	**3,879**	**4,118**	**4,411**	**4,412**	**4,406**	**4,418**	**4,410**	**3,332**	**3,247**

Emission factors

The emission factors used here are of rather different quality: For all **main pollutants**, **carbon monoxide** and **particulate matter**, annually changing values computed within TREMOD-MM (Knörr et al. (2020b)) [6)] are used, representing the development of mitigation technologies and the effect of fuel-quality legislation.

Here, as no such specific EF are available for biofuels, the values used for gasoline are applied to bioethanol, too.

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 [7)].)

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

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
4-stroke machinery																
NH_3 [1]	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	0.09
NMVOC - exhaust[1, 2]	727	819	809	790	806	803	799	795	791	786	782	777	772	765	751	731
NMVOC - evaporation[1, 3]	475	1.289	1.604	1.650	1.647	1.646	1.645	1.643	1.640	1.638	1.634	1.631	1.628	1.624	1.620	1.616
NO_x [1]	51.1	85.3	103	108	122	124	126	129	131	132	133	134	135	134	129	123
SO_x [1]	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	0.37
BC [2, 5]	0.31	0.27	0.24	0.23	0.24	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
$PM_{2.5}$ [2, 4]	6.30	5.46	4.85	4.62	4.87	4.94	5.00	5.06	5.11	5.15	5.19	5.22	5.24	5.25	5.25	5.26
PM_{10},	6.30	5.46	4.85	4.62	4.87	4.94	5.00	5.06	5.11	5.15	5.19	5.22	5.24	5.25	5.25	5.26
TSP - exhaust[2]	6.30	5.46	4.85	4.62	4.87	4.94	5.00	5.06	5.11	5.15	5.19	5.22	5.24	5.25	5.25	5.26
TSP - leaded fuel[6]	2.35	0.82														
CO [1]	40.044	32.179	28.352	27.158	27.988	28.274	28.551	28.808	29.042	29.245	29.413	29.544	29.642	29.609	29.252	28.653
2-stroke machinery																
NH_3 [1]	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
NMVOC - exhaust[1, 2]	6.121	5.907	5.877	5.813	5.829	5.367	4.323	3.632	3.471	3.314	3.163	3.024	2.899	2.796	2.718	2.656
NMVOC - evaporation[1, 3]	1.387	1.128	510	392	280	288	305	317	321	325	328	331	334	335	337	340
NO_x [1]	19.8	25.7	36.3	53.4	63.8	61.9	57.1	55.0	55.9	56.8	57.5	58.2	58.7	59.2	59.8	60.2
SO_x [1]	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	0.37
BC [2, 4]	6.91	6.13	5.13	4.93	4.79	4.93	5.22	5.41	5.49	5.55	5.61	5.67	5.71	5.75	5.77	5.80
$PM_{2.5}$ [2, 4]	138	123	103	99	96	99	104	108	110	111	112	113	114	115	115	116
PM_{10}	138	123	103	99	96	99	104	108	110	111	112	113	114	115	115	116
TSP - exhaust[2]	138	123	103	99	96	99	104	108	110	111	112	113	114	115	115	116
TSP - leaded fuel[6]	2.35	0.82														
CO [1]	20.271	18.743	16.255	15.480	14.693	15.061	15.883	16.429	16.610	16.788	16.958	17.115	17.256	17.377	17.474	17.553
4-stroke leisure boats																

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NH_3[1]	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
NMVOC - exhaust[1, 2]	952	1.036	1.269	1.373	1.212	1.136	1.067	1.003	946	895	849	806	770	740	717	701
NMVOC - evaporation[1, 3]	28.8	55.3	131	164	202	197	194	190	187	185	183	181	179	177	176	176
NO_x[1]	383	375	353	345	337	338	339	340	341	341	325	299	276	256	237	222
SO_x[1]	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	0.37
BC[2, 5]	0.09	0.05	0.15	0.18	0.27	0.28	0.29	0.31	0.32	0.33	0.34	0.33	0.32	0.31	0.29	0.28
$PM_{2.5}$[2, 4]	1.74	0.97	3.00	3.57	5.37	5.63	5.89	6.16	6.42	6.65	6.75	6.61	6.41	6.15	5.86	5.55
PM_{10}	1.74	0.97	3.00	3.57	5.37	5.63	5.89	6.16	6.42	6.65	6.75	6.61	6.41	6.15	5.86	5.55
TSP - exhaust[2]	1.74	0.97	3.00	3.57	5.37	5.63	5.89	6.16	6.42	6.65	6.75	6.61	6.41	6.15	5.86	5.55
TSP - leaded fuel[6]	2.35	0.82														
CO[1]	30.204	30.817	32.595	33.248	26.208	24.417	22.738	21.186	19.774	18.519	17.352	16.229	15.256	14.476	13.858	13.396
2-stroke leisure boats																
NH_3[1]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
NMVOC - exhaust[1, 2]	5.614	5.674	5.835	5.952	4.254	3.797	3.364	2.960	2.589	2.253	1.931	1.624	1.359	1.134	961	831
NMVOC - evaporation[1, 3]	159	169	191	204	200	200	200	200	200	200	200	200	200	200	200	200
NO_x[1]	74.4	74.1	73.0	71.9	72.9	73.6	74.5	75.5	76.5	77.5	75.9	71.6	67.5	63.7	59.9	56.4
SO_x[1]	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	0.37
BC[2, 4]	21.1	21.1	21.1	21.1	21.6	21.9	22.3	22.7	23.1	23.5	23.9	24.3	24.6	24.9	25.1	25.2
$PM_{2.5}$[2, 5]	422	422	422	422	432	438	446	454	462	471	479	486	492	498	501	504
PM_{10}	422	422	422	422	432	438	446	454	462	471	479	486	492	498	501	504
TSP - exhaust[2]	422	422	422	422	432	438	446	454	462	471	479	486	492	498	501	504
TSP - leaded fuel[6]	2.35	0.82														
CO[1]	15.101	15.160	15.311	15.415	12.700	11.909	11.135	10.389	9.684	9.029	8.433	7.904	7.446	7.060	6.775	6.574
Pb - leaded fuel[7]	1.471	516														

[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 [8)], 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. [9)]

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 [10)].

> **NOTE:** For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

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

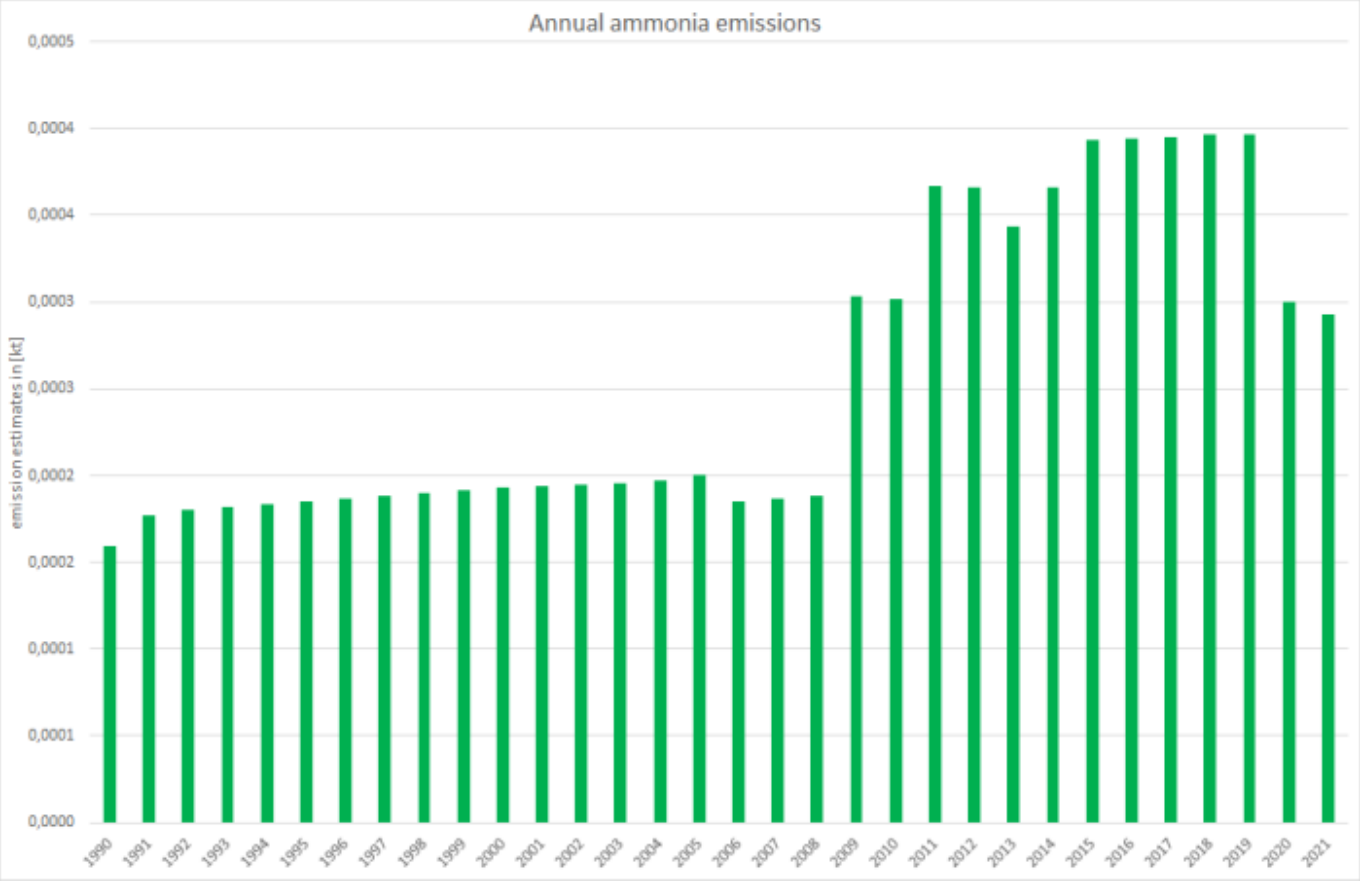
Table: Outcome of Key Category Analysis

for:	**CO**
by:	Level & Trend

Given the limited quality of gasoline-deliveries data from NEB line 66, the following emission trends are of limited significance only.

Unregulated pollutants (Ammonia, HMs, POPs, ...)

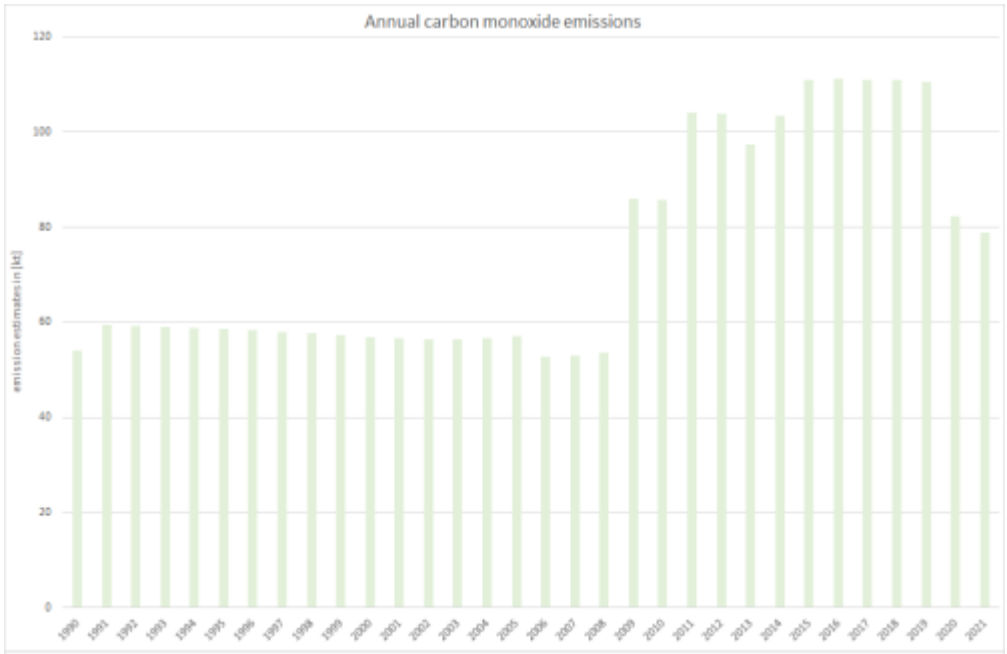
For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

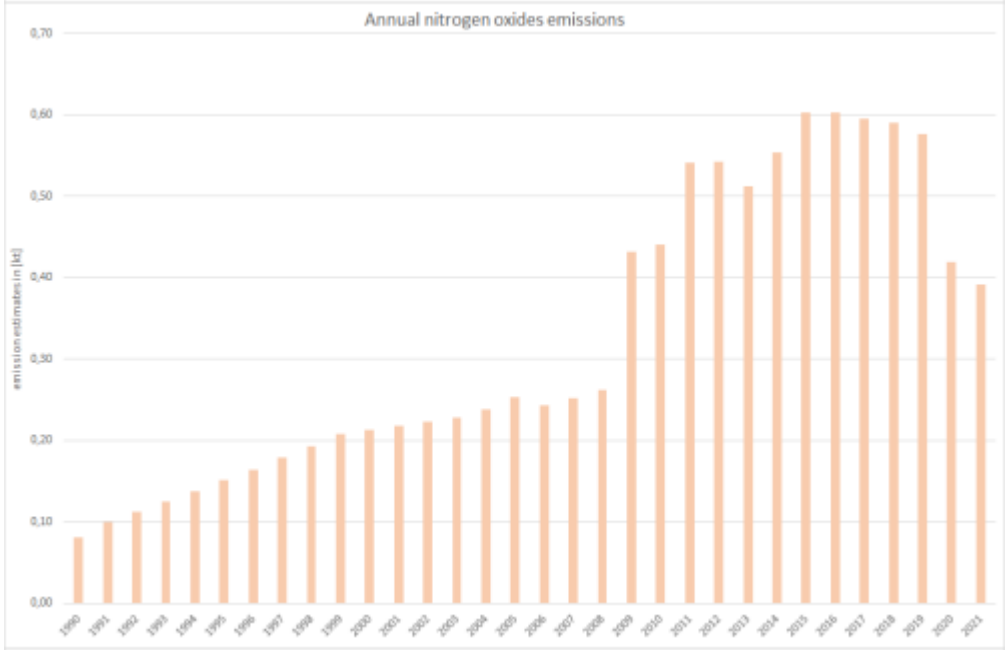


Here, as the emission factors for heavy metals (and POPs) are derived from tier1 default values, the emission's trend is stronlgy influenced by the share of 2-stroke gasoline fuel (containing lube oil with presumably higher HM content) consumed.

Regulated pollutants

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation. However, especially for CO and NOx, trends are strongly influenced by the changes in annual fuel deliveries as provided in NEB line 66.


Annual carbon monoxide emissions
emission estimates in [kt]
120
100
80
60
40
20
0


Annual nitrogen oxides emissions
emission estimates in [kt]
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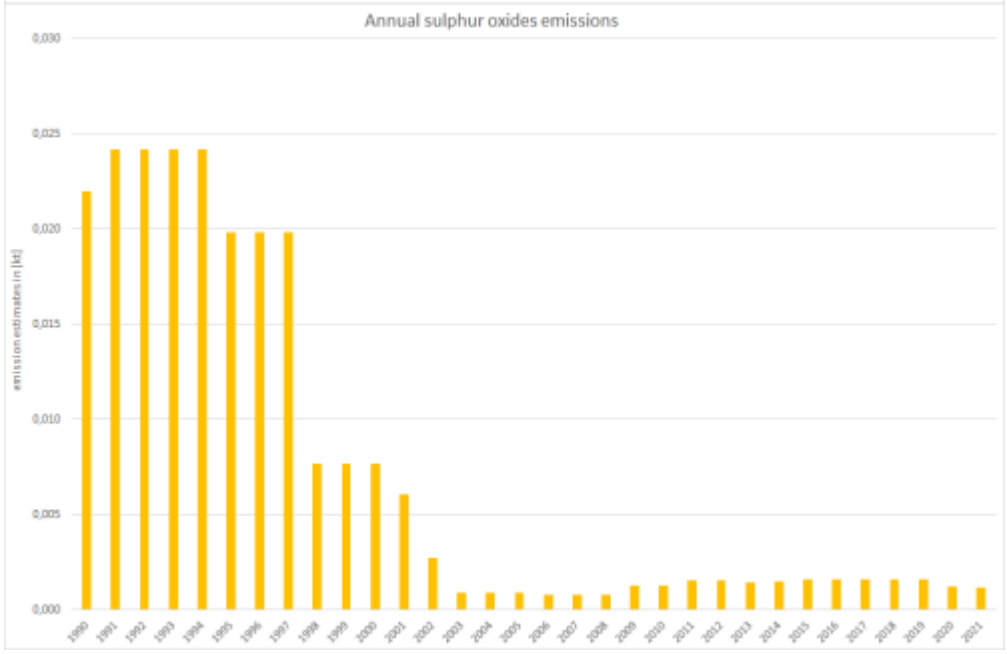
0,60
0,50
0,40
0,30
0,20
0,10
0,00


Annual sulphur oxides emissions
emission estimates in [kt]
0,030
0,025
0,020
0,015
0,010
0,005
0,000

Particulate matter

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.

Here, as the EF(BC) are estimated via fractions provided in [11)], black carbon emissions follow the corresponding emissions of $PM_{2.5}$.

Recalculations

Primary activity data fro NEB line 66 were revised for 2018 and 2019.

Furthermore, the percental shares of 2- and 4-stroke engines have been revised as leisure boats have been reported separately for the first time, resulting in revised specific **activity data**.

Table 5: Revised annual shares of 2- and 4-stroke equipment and leisure boats

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4-stroke machinery																		
current submission	0,25	0,44	0,58	0,62	0,63	0,64	0,65	0,66	0,66	0,66	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
previous submission	0,28	0,50	0,66	0,70	0,71	0,72	0,73	0,73	0,74	0,75	0,76	0,76	0,77	0,77	0,77	0,77	0,77	0,78
absolute change	-0,03	-0,06	-0,08	-0,08	-0,08	-0,08	-0,08	-0,08	-0,08	-0,08	-0,09	-0,09	-0,09	-0,10	-0,10	-0,10	-0,10	-0,10
relative change	-11,3%	-12,1%	-12,1%	-11,2%	-11,0%	-10,9%	-10,8%	-10,7%	-10,7%	-11,0%	-11,4%	-11,8%	-12,2%	-12,5%	-12,7%	-12,9%	-13,1%	-13,3%
2-stroke machinery																		
current submission	0,64	0,44	0,29	0,27	0,26	0,25	0,24	0,24	0,23	0,23	0,22	0,21	0,21	0,20	0,20	0,20	0,20	0,19
previous submission	0,72	0,50	0,34	0,30	0,29	0,28	0,27	0,27	0,26	0,25	0,24	0,24	0,23	0,23	0,23	0,23	0,23	0,22
absolute change	-0,08	-0,06	-0,04	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03	-0,03
relative change	-11,3%	-12,1%	-12,1%	-11,2%	-11,0%	-10,9%	-10,8%	-10,7%	-10,7%	-11,0%	-11,4%	-11,8%	-12,2%	-12,5%	-12,7%	-12,9%	-13,1%	-13,3%
4-stroke boats																		
current submission	0,01	0,02	0,03	0,06	0,06	0,07	0,07	0,08	0,09	0,09	0,09	0,10	0,10	0,10	0,10	0,11	0,11	0,11
previous submission	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	0,00	0,00
2-stroke boats																		
current submission	0,10	0,10	0,09	0,06	0,05	0,04	0,03	0,03	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
previous submission	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	0,00	0,00

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4-stroke machinery																		
current submission	545	1.046	1.400	1.491	1.389	1.408	1.436	2.321	2.318	2.810	2.796	2.613	2.772	2.968	2.967	2.964	2.971	2.965
previous submission	614	1.191	1.592	1.679	1.562	1.581	1.610	2.600	2.594	3.158	3.157	2.963	3.155	3.390	3.399	3.404	3.292	3.272
absolute change	-69,2	-145	-193	-188	-173	-173	-174	-279	-277	-347	-361	-350	-383	-422	-432	-440	-321	-307
relative change	-11,3%	-12,1%	-12,1%	-11,2%	-11,0%	-10,9%	-10,8%	-10,7%	-10,7%	-11,0%	-11,4%	-11,8%	-12,2%	-12,5%	-12,7%	-12,9%	-9,7%	-9,4%
2-stroke machinery																		
current submission	1.387	1.058	705	650	575	557	543	842	818	960	899	808	846	894	884	873	867	859

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
previous submission	1.563	1.204	803	733	646	626	609	943	915	1.078	1.015	917	963	1.021	1.012	1.003	961	949
absolute change	-176	-146	-97,1	-82,2	-71,4	-68,4	-65,8	-101	-97,6	-119	-116	-108	-117	-127	-129	-130	-93,6	-89,0
relative change	-11,3%	-12,1%	-12,1%	-11,2%	-11,0%	-10,9%	-10,8%	-10,7%	-10,7%	-11,0%	-11,4%	-11,8%	-12,2%	-12,5%	-12,7%	-12,9%	-9,7%	-9,4%
4-stroke boats																		
current submission	25,6	43,0	79,2	135	138	152	166	285	298	373	383	370	405	446	456	464	473	479
previous submission	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
2-stroke boats																		
current submission	220	248	211	135	106	89,0	73,8	95,8	75,9	92,6	93,2	88,4	95,2	103	104	105	106	106
previous submission	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
OVER-ALL CONSUMPTION																		
current submission	2.177	2.395	2.395	2.411	2.208	2.206	2.219	3.543	3.510	4.236	4.172	3.879	4.118	4.411	4.412	4.406	4.418	4.410
previous submission	2.177	2.395	2.395	2.411	2.208	2.206	2.219	3.543	3.510	4.236	4.172	3.879	4.118	4.411	4.412	4.406	4.253	4.221
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	0,00	165	190
relative change	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	3,9%	4,5%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2019**, please see the recalculation tables following chapter 8.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023 (Knörr et al. (2009)) [12)]: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland”.

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 [13)] 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 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 biodiesel and bioethanol.

[1), 2)] AGEB, 2020: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; URL: http://www.ag-energiebilanzen.de/7-0-Bilanzen-1990-2018.html, (Aufruf: 29.11.2020), Köln & Berlin, 2020

[3), 4), 5), 6), 7)] Knörr et al. (2020b): 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) 2020, Heidelberg, 2020.

[8), 10), 11)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.

[9)] 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.

[12)] 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.

[13)] 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