1.A.3.d ii - National Navigation

Short description

Under category *1.A.3.d ii - National Navigation* emissions from national navigation (both inland and maritime) are reported.

Category Code	Method	AD	EF
1.A.3.d ii	T1, T2, T3	NS, M	CS, D, M
covering emissions in:			
Domestic maritime navigation	T1, T2, T3	NS, M	CS, D, M
Domestic inland navigation	T1, T2, T3	NS, M	CS, D, M

Method(s) applied	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific
PS	Plant Specific
M	Model / Modelled
C	Confidential

NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/F**	**B(a)P**	**B(b)F**	**B(k)F**	**I(x)P**	**PAH1-4**	**HCB**	**PCBs**
L/-	-/-	-/-	-/-	**L/T**	**-/T**	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

L/-	key source by **L**evel only
-/T	key source by **T**rend only
L/T	key source by both **L**evel and **T**rend
-/-	no key source for this pollutant
IE	emission of specific pollutant **I**ncluded **E**lsewhere (i.e. in another category)
NE	emission of specific pollutant **N**ot **E**stimated (yet)
NA	specific pollutant not emitted from this source or activity = **N**ot **A**pplicable
*	no analysis done

Methodology

Activity data

As described for the over-all sector 1.A.3.d and all other navigational activities in the superordinate chapter, specific fuel consumption data for NFR 1.A.3.d ii is included in the primary fuel deliveries data provided in NEB lines 6 ('International

Maritime Bunkers') and 64 ('Coastal and Inland Navigation') [1)].

Here, the annual fuel consumption for domestic *maritime* navigation are modelled within [2)] based on AIS data and deduced from NEB lines 6 and 64 respectively, depending on whether or not a certain ship is registered by the International Maritime Organization (IMO). Here, fuels consumed by large, IMO-registered and sea-going ships and vessels are included in NEB line 6 whereas fuels consumed by smaller ships without IMO-registration are included in NEB line 64. After these deductions, the amounts of fuels remaining in NEB 64 are allocated to domestic *inland* navigation.

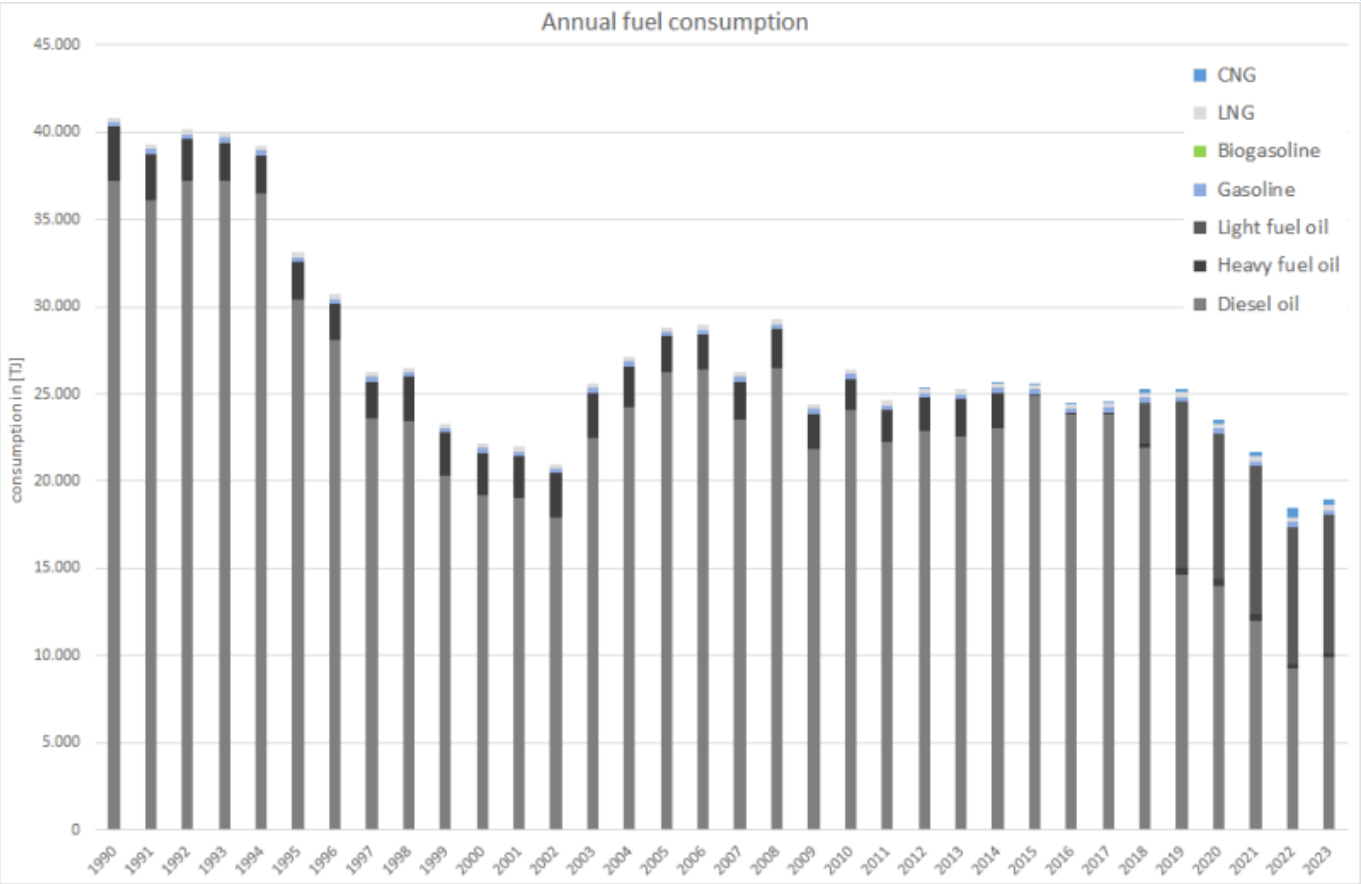
The small amounts of LNG used almost entirely in ferries are not yet included in the NEB but are estimated directly in the BSH model.

Table 1: Annual over-all fuel consumption for domestic navigation, in terajoule

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Diesel Oil	37,199	30,389	19,231	26,241	24,060	24,874	23,863	23,866	21,897	14,660	14,029	12,003	9,275	9,887
Light Fuel Oil									2,361	9,497	8,329	8,475	7,879	7,922
Heavy fuel oil	3,103	2,186	2,382	2,054	1,810	108	37.0	81.1	262	394	378	392	237	237
LNG						22.0	64.4	58.8	197	153	276	293	513	382
Gasoline	272	272	272	274	261	265	265	266	262	265	269	273	275	276
Biogasoline				1.90	10.1	10.7	10.8	10.8	11.3	10.9	12.0	12.9	12.8	13.0
LPG	7.00	7.00	7.00	7.02	7.08	7.10	7.25	7.06	7.13	7.16	7.40	7.51	7.55	7.61
Σ 1.A.3.d ii	**40,582**	**32,854**	**21,892**	**28,577**	**26,149**	**25,286**	**24,248**	**24,290**	**24,997**	**24,988**	**23,299**	**21,456**	**18,199**	**18,724**

Table 2: Specific fuel consumption data for domestic maritime and inland navigation, in terajoule

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NATIONAL MARITIME NAVIGATION														
Diesel Oil	9,484	6,828	7,367	6,399	5,690	8,980	9,335	8,960	7,084					
Light Fuel Oil									2,361	9,497	8,329	8,475	7,879	7,922
Heavy fuel oil	3,103	2,186	2,382	2,054	1,810	108	37.0	81.1	262	394	378	392	237	237
LNG						22.0	64.4	58.8	197	153	276	293	513	382
NATIONAL INLAND NAVIGATION														
Diesel Oil	27,716	23,562	11,864	19,842	18,370	15,894	14,529	14,907	14,813	14,660	14,029	12,003	9,275	9,887
Gasoline	272	272	272	274	261	265	265	266	262	265	269	273	275	276
Biogasoline				1.90	10.1	10.7	10.8	10.8	11.3	10.9	12.0	12.9	12.8	13.0
LPG	7.00	7.00	7.00	7.02	7.08	7.10	7.25	7.06	7.13	7.16	7.40	7.51	7.55	7.61
Σ 1.A.3.d ii	**40,582**	**32,854**	**21,892**	**28,577**	**26,149**	**25,286**	**24,248**	**24,290**	**24,997**	**24,988**	**23,299**	**21,456**	**18,199**	**18,724**



Emission factors

The emission factors applied for **national maritime navigation** are derived from different sources and therefore are of very different quality.

For the main pollutants, country-specific implied values are used, that are based on tier3 EF included in the BSH model [3)] which mainly relate on values from the EMEP/EEA guidebook 2023 [4)]. These modelled IEFs take into account the ship specific information derived from AIS data as well as the mix of fuel-qualities applied depending on the type of ship and the current state of activity.

Here, for **sulphur dioxide** and **particulate matter**, annual values are available representing the impact of fuel sulphur legislation. In addition, regarding $_2$, the increasing operation of so-called scrubbers in order to fullfil emission limits especially within SECA areas is reflected for heavy fuel oil.

Table 3: Country-specific emission factors applied for fuels used in domestic maritime navigation, in [kg/TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL OIL & LIGHT FUEL OIL[1]														
NH_3	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
NMVOC	71.9	72.1	72.0	72.0	72.1	81.5	82.7	83.2	75.0	80.3	78.2	81.4	79.8	77.4
NO_x	1,199	1,198	1,199	1,199	1,198	1,115	1,111	1,115	1,095	1,106	1,090	1,098	1,098	1,095
SO_2	466	419	233	186	69.8	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
BC[2]	110	99.1	55.0	44.0	16.5	17.4	17.7	17.7	17.3	17.5	16.8	16.9	17.1	16.9
$PM_{2.5}$	354	320	177	142	53.3	56.2	57.1	57.1	55.9	56.5	54.2	54.6	55.2	54.6
PM_{10}	378	342	190	152	57.1	60.1	61.1	61.1	59.8	60.4	58.0	58.5	59.0	58.4
TSP[3]	378	342	190	152	57.1	60.1	61.1	61.1	59.8	60.4	58.0	58.5	59.0	58.4
CO	128	128	128	128	128	140	142	141	139	140	138	140	140	142
HEAVY FUEL OIL														
NH_3	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.35	0.34
NMVOC	96.6	96.5	96.5	96.5	96.5	104	117	131	156	172	168	156	165	166

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
NO_x	1,604	1,602	1,603	1,603	1,602	1,216	1,572	1,300	1,332	1,242	1,368	1,385	1,439	1,408
SO_x	1,319	1,332	1,323	1.336	496	48.6	49.2	48.1	45.9	46.5	48.1	47.0	47.6	47.2
BC^2	70.8	71.2	70.8	71.6	26.5	14.2	18.0	20.1	19.1	18.9	21.4	21.3	23.2	23.4
$PM_{2.5}$	590	594	590	596	221	118	150	168	159	158	179	178	194	195
PM_{10}	649	653	649	656	243	130	165	184	175	173	197	195	213	214
TSP^3	649	653	649	656	243	130	165	184	175	173	197	195	213	214
CO	179	179	179	179	179	144	162	157	156	150	151	147	144	142
LIQUEFIED NATURAL GAS (LNG)														
NH_3	NA					NE								
NMVOC	NA					49.3	48.5	44.4	43.3	58.5	53.7	48.9	56.2	53.2
NO_x	NA					112	112	112	112	112	112	112	112	112
SO_x	NA					NE								
BC^2	NA					NE								
$PM_{2.5}$,PM_{10},TSP	NA					2.41	2.41	2.41	2.41	2.41	1.51	1.51	1.51	1.48
CO	NA					157	157	157	157	157	156	154	154	145

[1] identical EF applied for diesel oil and light fuel oil
[2] estimated from f-BCs as provided in [5)]: f-BC (HFO) = 0.12, f-BC (MDO/MGO) = 0.31 as provided in [6)], chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2
[3] ratio of $PM_{2.5}$: PM_{10} : TSP derived from the tier1 default EF as provided in [7)], chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2

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

For main pollutants and particulate matter from **national inland navigation**, modelled emission factors are available from TREMOD (Knörr et al. (2024a)) [8)]. Here, for *SO_2*, and *PM*, annual values reflect the impact of fuel-sulphur legislation.

Table 4: Country-specific emission factors for diesel fuels used in domestic inland navigation, in [kg/TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
DIESEL OIL														
NH_3	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
NMVOC	96.4	87.9	77.7	72.3	66.6	61.2	60.3	59.4	58.5	58.0	57.1	56.4	55.4	54.5
NO_x	1,327	1,331	1,336	1,289	1,231	1,175	1,164	1,152	1,141	1,135	1,124	1,115	1,093	1,070
SO_x	85.2	60.5	60.5	60.5	60.5	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC^1	17.5	16.0	14.1	11.8	9.17	8.14	7.99	7.83	7.67	7.58	7.44	7.31	7.12	6.95
PM^2	56.5	51.7	45.6	38.1	29.6	26.3	25.8	25.2	24.7	24.4	24.0	23.6	23.0	22.4
CO	417	387	337	299	256	229	225	221	216	213	209	206	203	200
GASOLINE														
NH_3	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 (exh.)	952	1036	1269	1373	1196	897	853	813	779	753	734	722	714	710
NMVOC (evap.)	28.8	55.3	131	164	196	186	185	185	184	184	184	185	187	188
NO_x	383	375	353	345	338	341	325	299	276	256	238	223	210	199
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
BC^1	2.33	2.33	2.33	2.33	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
PM^2	7.50	7.50	7.50	7.50	7.50	7.49	7.49	7.49	7.49	7.49	7.49	7.49	7.49	7.49
CO	30,204	30,817	32,595	33,248	26,105	18,536	17,387	16,286	15,336	14,583	13,995	13,565	13,241	12,996
LPG														
NH_3	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
NMVOC	147	147	145	145	145	145	145	145	145	144	141	134	126	116
NO_x	1,346	1,342	1,325	1,325	1,325	1,325	1,325	1,325	1,325	1,316	1,284	1,225	1,144	1,056
SO_x	0.42	0.42	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
BC[1]	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
PM[2]	0.85	0.85	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
CO	114	114	112	112	112	112	112	112	112	112	112	112	112	112

[1] calculated from f-BC as provided in [9], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii, Table 3-2: f-BC (MDO/MGO) = 0.31
[2] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP from diesel oil combustion consists of $PM_{2.5}$)

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 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 5: Outcome of Key Category Analysis

for:	**NO_x**	**PM_{10}**	**$PM_{2.5}$**
by:	L/-	-/T	L/T

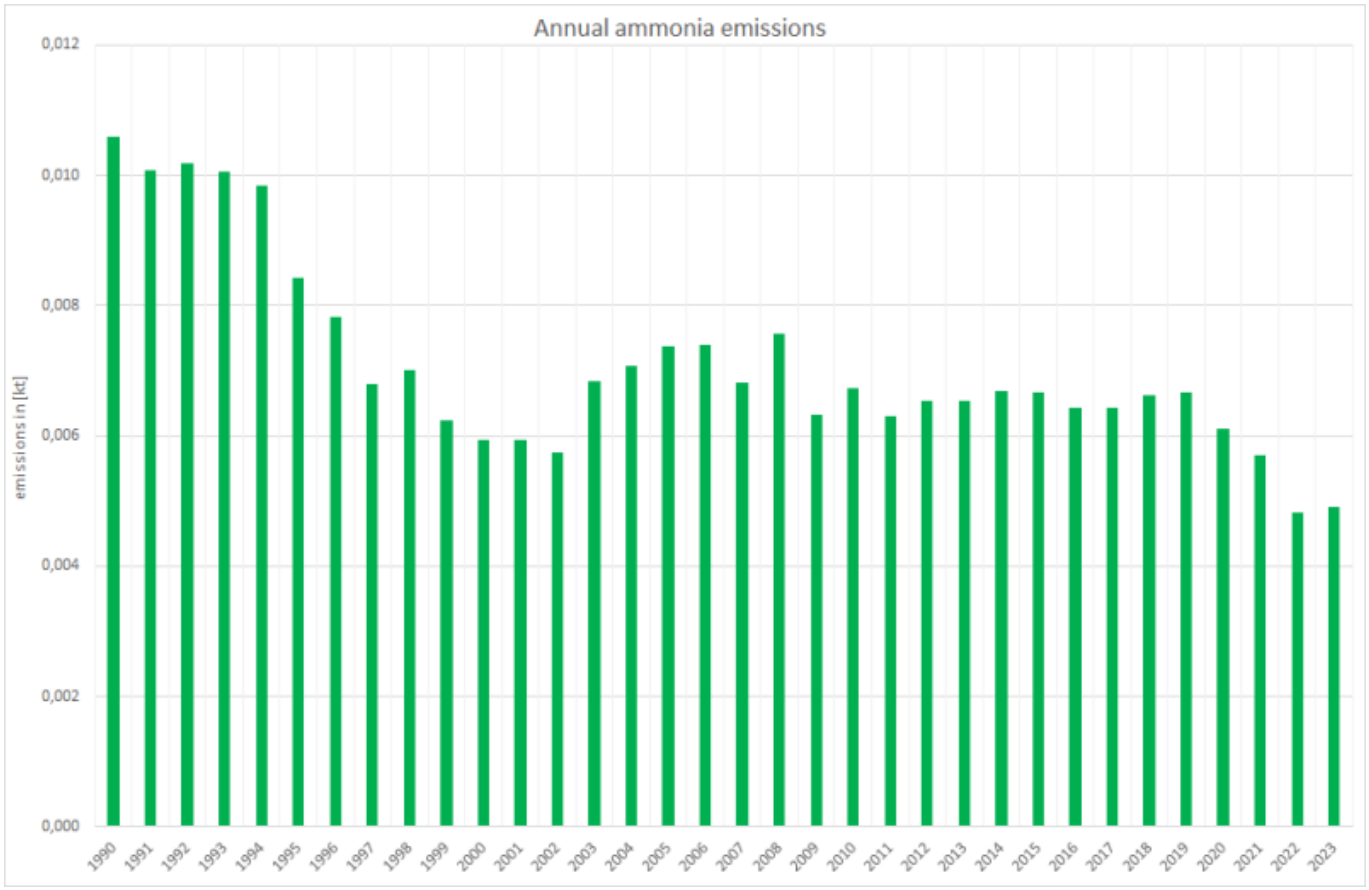
The following tale includes emission limits according to Directive 2004/26/EC [10)] for inland vessels.

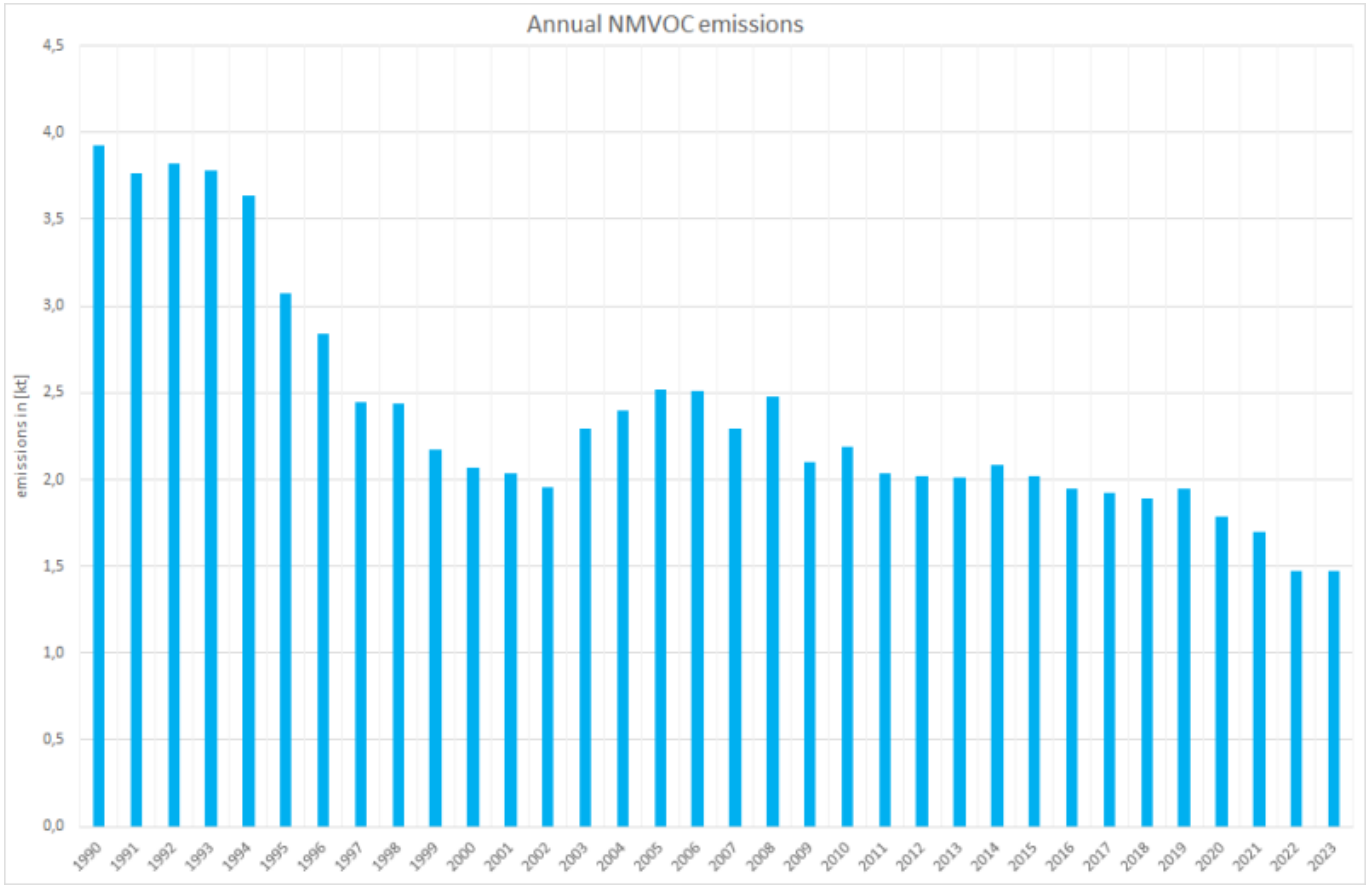
Table 6: Overview of emission limits, in [g/kWh]

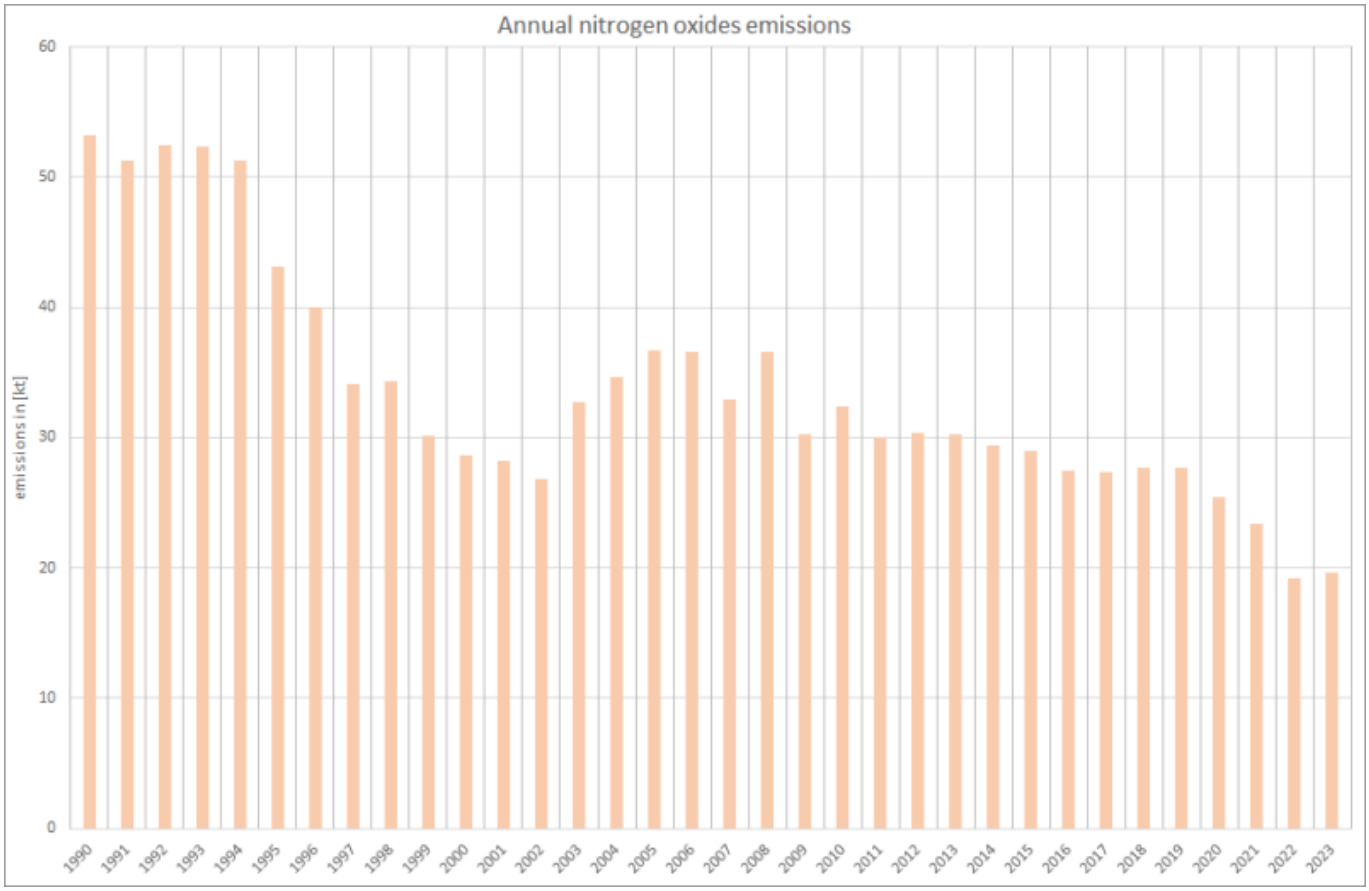
Category: swept volume/net power (SV/P)	**Carbon monoxide**	**∑ Hydrocarbons + Nitrogen oxides**	**Particulates**
(litres per cylinder/kW)	(CO)	($HC+NO_x$)	(PT)
V1:1; SV < 0,9; P ≥ 37 kW	5.0	7.5	0.40
V1:2; 0.9 ≤ SV < 1.2	5.0	7.2	0.30
V1:3 1.2 ≤ SV < 2.5	5.0	7.2	0.20
V1:4; 2.5 ≤ SV < 5	5.0	7.2	0.20
V2:1; 5 ≤ SV < 15	5.0	7.8	0.27
V2:2; 15 ≤ SV < 20; P < 3300 kW	5.0	8.7	0.50
V2:3; 15 ≤ SV < 20; P ≥ 3300 kW	5.0	9.8	0.50
V2:4; 20 ≤ SV < 25	5.0	9.8	0.50
V2:5; 25 ≤ SV < 30	5.0	11.0	0.50

However, Directive 2004/26/EC has been replaced by Regulation (EU) 2016/1628 in 2016 [11)].

For **ammonia**, **NMVOC**, and **nitrogen oxides** as well as **carbon monoxide**, emission trends more or less represent the trend in over-all fuel consumption.

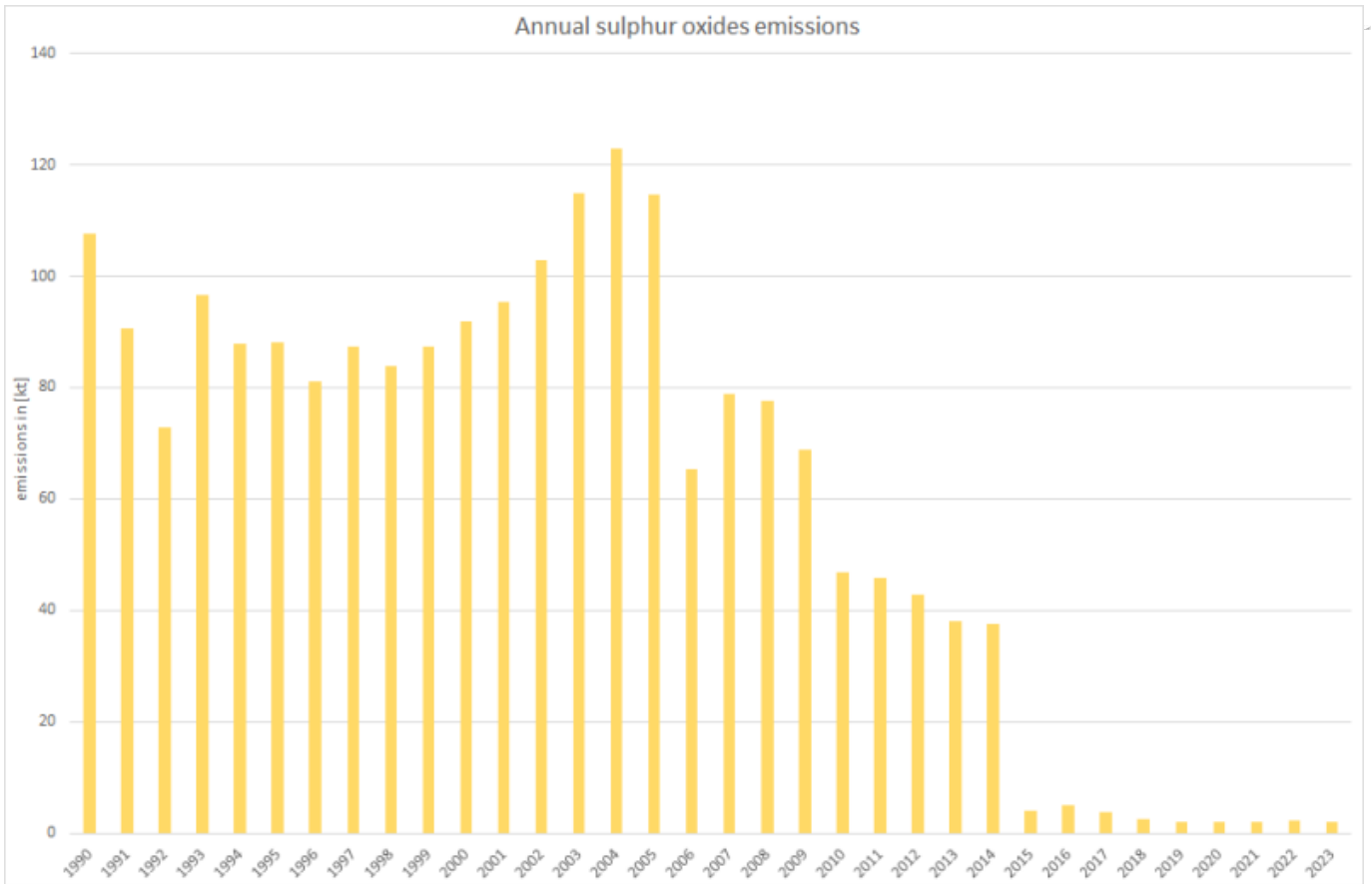

Annual ammonia emissions
emissions in [kt]
0,012
0,010
0,008
0,006
0,004
0,002
0,000
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


Annual NMVOC emissions
emissions in [kt]
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023



Nonetheless, for these pollutants, annual emission factors from BSH [12)] and TREMOD [13)] have been applied for national *maritime* and *inland* navigation, respectively, reflecting the technical development of the German inland navigation fleet.

Here, the trends in **sulphur dioxide** and **particulate matter** emissions reflect the impact of ongoing fuel-sulphur legislation especially in maritime navigation.



Recalculations

Compared to the previous submission, **activity data** remain unaltered for **national maritime navigation**, whereas fuel consumption data allocated to **inland navigation** has been revised within TREMOD taking into account the finalisation of the National Energy Balance for 2022.

Table 7: Revised over-all fuel consumption data for national navigation, in terajoules

	sea vessels only:			inland vessels only:				
	LIGHT FUEL OIL	**HEAVY FUEL OIL**	**LNG**	**DIESEL OIL**	**GASOLINE**	**BIOETHANOL**	**LPG**	**TOTAL**
current submission	7.879	237	513	9.275	275	12,8	7,55	**18.199**
previous submission	7.879	237	513	9.819	275	12,8	7,58	**18.744**
absolute change	0,00	0,00	0,00	-545	-0,18	-0,01	-0,02	**-545**
relative change	0,00%	0,00%	0,00%	-5,55%	-0,06%	-0,06%	-0,30%	**-2,91%**

In addition, several emission factors have been reviesed. Tho following table provides the most important revisions occurimg for NMOVOC and NO_x in national maritime navigation.

Table 8: Revised emission factors, in kg/TJ

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
NATIONAL MARITIME NAVIGATION: DIESEL OIL & LIGHT FUEL OIL													
NMVOC													
current submission	71.9	72.1	72.0	72.0	72.1	81.5	82.7	83.2	75.0	80.3	78.2	81.4	79.8
previous submission	48.5	48.4	48.4	48.4	48.4	44.4	43.9	44.2	43.8	44.0	44.0	42.1	43.0
absolute change	23.5	23.7	23.6	23.6	23.7	37.1	38.8	38.9	31.3	36.2	34.2	39.3	36.8
relative change	48.4%	48.8%	48.7%	48.6%	48.9%	83.6%	88.5%	88.1%	71.4%	82.3%	77.8%	93.3%	85.7%
NO_x													
current submission	1,199	1,198	1,199	1,199	1,198	1,115	1,111	1,115	1,095	1,106	1,090	1,098	1,098
previous submission	1,101	1,101	1,101	1,101	1,101	1,184	1,183	1,189	1,200	1,199	1,169	1,194	1,181
absolute change	97.8	97.3	97.4	97.5	97.3	-68.6	-71.1	-73.8	-105.8	-92.7	-79.1	-96.1	-83.1
relative change	8.88%	8.84%	8.85%	8.86%	8.83%	-5.79%	-6.01%	-6.20%	-8.82%	-7.73%	-6.77%	-8.05%	-7.03%
NATIONAL MARITIME NAVIGATION: HEAVY FUEL OIL													
NMVOC													
current submission	96.6	96.5	96.5	96.5	96.5	104	117	131	156	172	168	156	165
previous submission	43.0	42.8	42.9	42.9	42.8	26.1	30.2	33.7	32.5	32.7	37.4	37.5	40.7
absolute change	53.6	53.6	53.6	53.6	53.7	77.5	87.2	97.5	123	139	130	118	125
relative change	125%	125%	125%	125%	125%	297%	288%	289%	379%	427%	348%	316%	306%
NO_x													
current submission	1,604	1,602	1,603	1,603	1,602	1,216	1,572	1,300	1,332	1,242	1,368	1,385	1,439
previous submission	1,368	1,368	1,368	1,368	1,368	1,487	1,440	1,479	1,480	1,507	1,509	1,526	1,556
absolute change	236	235	235	235	235	-271	132	-179	-148	-265	-141	-141	-117
relative change	17.2%	17.2%	17.2%	17.2%	17.2%	-18.2%	9.18%	-12.1%	-10.0%	-17.6%	-9.36%	-9.24%	-7.52%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, 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: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by Knörr et al. (2009) [14)].

Planned improvements

Besides the **routine revisions of the models** used for maritime and inland navigation, the percental BC-fractions (f-BC) applied for maritime navigation will be updated in accordance with the information provided in Chapter 1.A.3.d Navigation (shipping) 2023 of the EMEP/EEA GB 2023.

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[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.