1.A.3.d i (i) - International maritime navigation

Short description

Under NFR category **1.A.3.d i (i)**, emissions from international maritime navigation fuelling in and starting form German harbours are reported.

Category Code	Method	AD	EF
1.A.3.d i (i)	T1, T2, T3	NS, M	CS, M

Key Category	SO_2	NO_x	NH_3	NMVOC	CO	BC	Pb	Hg	Cd	Diox	PAH	HCB	TSP	PM_{10}	$PM_{2.5}$
1.A.3.d i (i)	*not included in key category analysis*														

T = key source by Trend **L** = key source by Level

Methods	
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 the group specific chapters.

AD - Data Source for Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific data
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential

EF - Emission Factors	
D	Default (EMEP Guidebook)
C	Confidential
CS	Country Specific
PS	Plant Specific data
M	Model / Modelled

Methodology

Activity data

Primary fuel delivery data (primary activity data, PAD) for *international maritime navigation* is included in line 6 - 'International Deep-Sea Bunkers' of the National Energy Balances (NEB) (AGEB, 2020) [1)] together with respective data for IMO-registered ships used in *national maritime transport* (see 1.A.3.d ii (a)), *fishing* (see NFR 1.A.4.c iii) and *military navigation* (see NFR 1.A.5.b iii).

The AD applied for *international maritime navigation* therefore represents the remains of primary fuel delivery data from NEB line 6 minus the modelled consumption data estimated for non-IMO ships in *1.A.3.d ii (a)*, *1.A.4.c iii* and *1.A.5.b iii*:

$AD_{1.A.3.d\ i} = PAD_{NEB\ line\ 6} - AD_{1.A.3.d\ ii\ (a)\ -\ IMO} - AD_{1.A.4.c\ iii\ -\ IMO} - AD_{1.A.5.b\ iii\ -\ IMO}$	with * $AD_{1.A.3.d\ i}$ - tier1 activity data for International maritime navigation * $PAD_{NEB\ line\ 6}$ - primary over-all fuel deliveries data from NEB line 6 - 'International Maritime Bunkers' * $AD_{1.A.3.d\ ii\ (a)\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in national maritime navigation * $AD_{1.A.4.c\ iii\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in national fishing * $AD_{1.A.5.b\ iii\ -\ IMO}$ - tier3 activity data for IMO-registered ships involved in military navigation

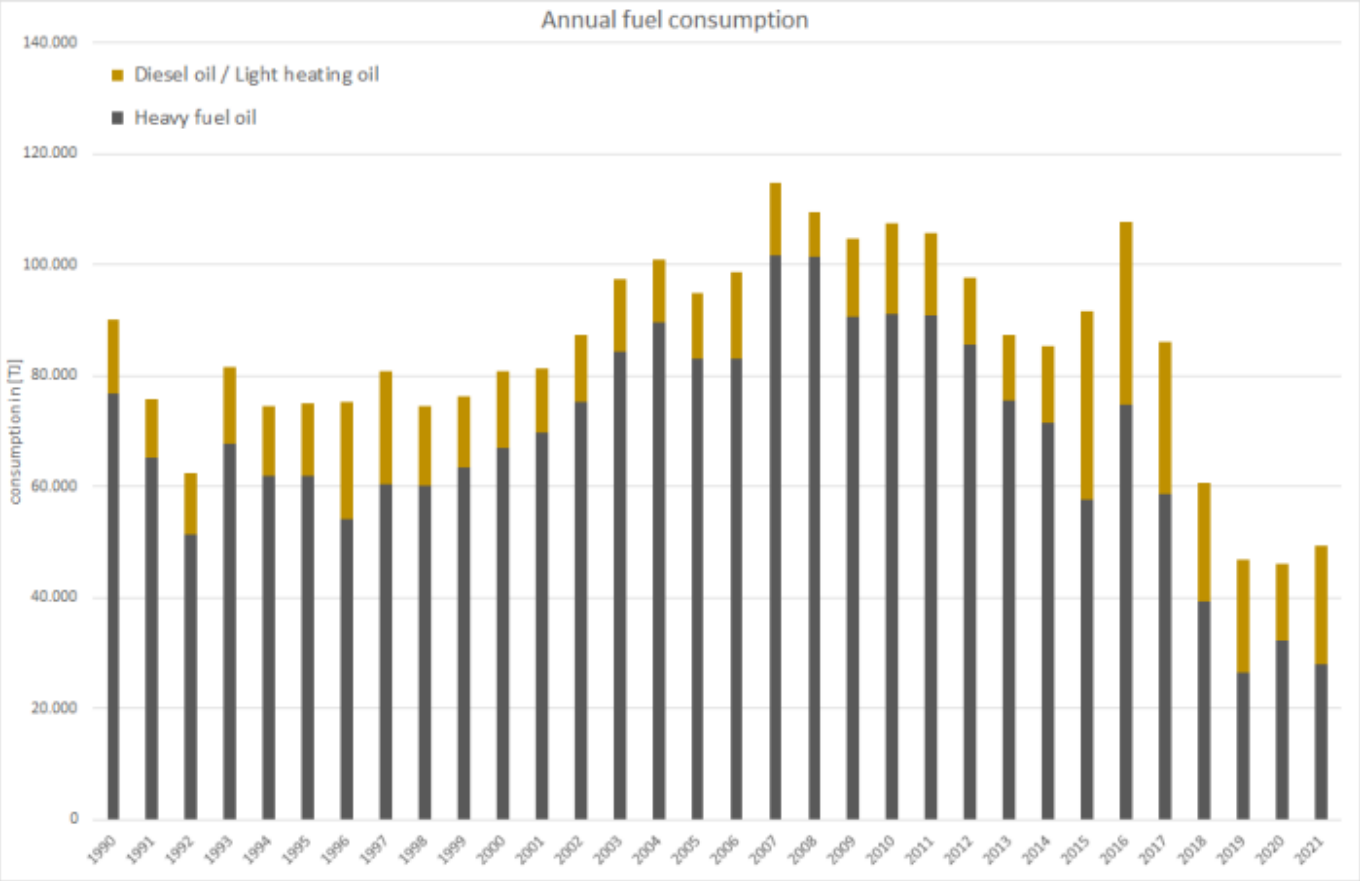
Table 1: Annual fuel consumption, in terajoules

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Diesel Oil	13,162	13,096	13,709	11,820	15,629	12,954	8,075	14,095	16,417	15,020	12,181	11,875	13,801	33,958	32,832	27,463	21,473	20,231	13,896
Heavy fuel oil	76,942	62,066	67,080	83,224	83,164	101,820	101,466	90,542	91,169	90,779	85,586	75,559	71,598	57,792	74,807	58,707	39,308	26,565	32,253
Σ 1.A.3.d i	**90,104**	**75,162**	**80,789**	**95,044**	**98,793**	**114,774**	**109,542**	**104,637**	**107,586**	**105,799**	**97,768**	**87,434**	**85,398**	**91,750**	**107,639**	**86,169**	**60,781**	**46,796**	**46,150**

source: own estimates based on underlying BSH model (Deichnik, K. (2020)) [2)]

Consumption of heavy oil has been increasing since 1984 as a result of high petroleum prices, global increases in transports and increasing maritime use of diesel engines that can run on heavy oil. The emissions fluctuations that occurred in the navigation sector in 1992 and 1996 were caused by trade and oil crises.

Furthermore, after 2014, with ever stricter legislation espacially regarding fuel sulphur content, an ongoing shift from heavy fuel oil to maritime diesel oil can be observed.



Emission factors

For **main pollutants** and **particulate matter**, modelled emission factors are available from (Deichnik, K. (2020)) [3)].

Here, for **sulphur dioxide** and **particulate matter**, annual values are available representing the impact of fuel sulphur

legislation. In addition, regarding SO_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 2: Annual country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
DIESEL OIL																		
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	0,33	0,32	0,32	0,32	0,32
NMVOC	48,7	48,7	48,7	48,7	48,7	48,7	48,7	48,7	48,7	48,7	48,7	48,4	48,0	44,8	44,7	45,0	45,2	45,2
NO_x	1.070	1.070	1.070	1.070	1.070	1.070	1.070	1.069	1.069	1.069	1.069	1.073	1.077	1.151	1.132	1.157	1.128	1.128
SO_x	465,5	419,0	232,8	186,2	186,2	186,2	139,7	69,8	69,8	65,2	54,5	52,6	50,5	40,7	40,6	40,7	40,8	40,8
BC[1]	109,2	98,6	54,7	43,8	43,8	43,8	32,8	16,4	16,4	15,4	15,3	15,2	15,2	16,3	16,9	16,9	16,5	16,5
$PM_{2.5}$	352,4	318,0	176,5	141,2	141,3	141,3	105,9	53,0	53,0	49,6	49,5	49,1	49,1	52,7	54,5	54,5	53,1	53,1
PM_{10}	377,1	340,3	188,9	151,0	151,2	151,2	113,3	56,7	56,7	53,0	53,0	52,5	52,6	56,4	58,3	58,3	56,9	56,9
TSP[2]	377,1	340,3	188,9	151,0	151,2	151,2	113,3	56,7	56,7	53,0	53,0	52,5	52,6	56,4	58,3	58,3	56,9	56,9
CO	127	128	128	128	128	128	128	128	128	128	128	127	128	134	139	138	136	136
HEAVY FUEL OIL																		
NH_3	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,34	0,35	0,33	0,33	0,34	0,35	0,35
NMVOC	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	36,6	37,6	37,8	30,0	36,8	30,4	28,3	28,3
NO_x	1.379	1.378	1.378	1.378	1.378	1.378	1.378	1.378	1.378	1.377	1.379	1.382	1.393	1.348	1.245	1.360	1.503	1.503
SO_x	1.319	1.332	1.323	1.336	744	742	742	744	496	496	496	496	506	47,5	49,3	46,4	49,8	49,8
BC[1]	57,4	58,0	57,6	58,2	32,4	32,3	32,3	32,4	21,6	21,6	21,6	22,1	22,4	18,1	24,7	18,3	14,7	14,7
$PM_{2.5}$	479	483	480	485	270	269	269	270	180	180	180	184	187	151	205	153	123	123
PM_{10}	526	532	528	533	297	296	296	297	198	198	198	203	206	166	226	168	135	135
TSP[2]	526	532	528	533	297	296	296	297	198	198	198	203	206	166	226	168	135	135
CO	162	162	162	162	162	162	162	162	162	162	162	162	167	165	198	167	134	134

[1] estimated from f-BCs as provided in [4)]: f-BC (HFO) = 0.12, f-BC (MDO/MGO) = 0.31 as provided in [5)], chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2

[2] ratios $PM_{2.5}$: PM_{10} : TSP derived from the tier1 default EF 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

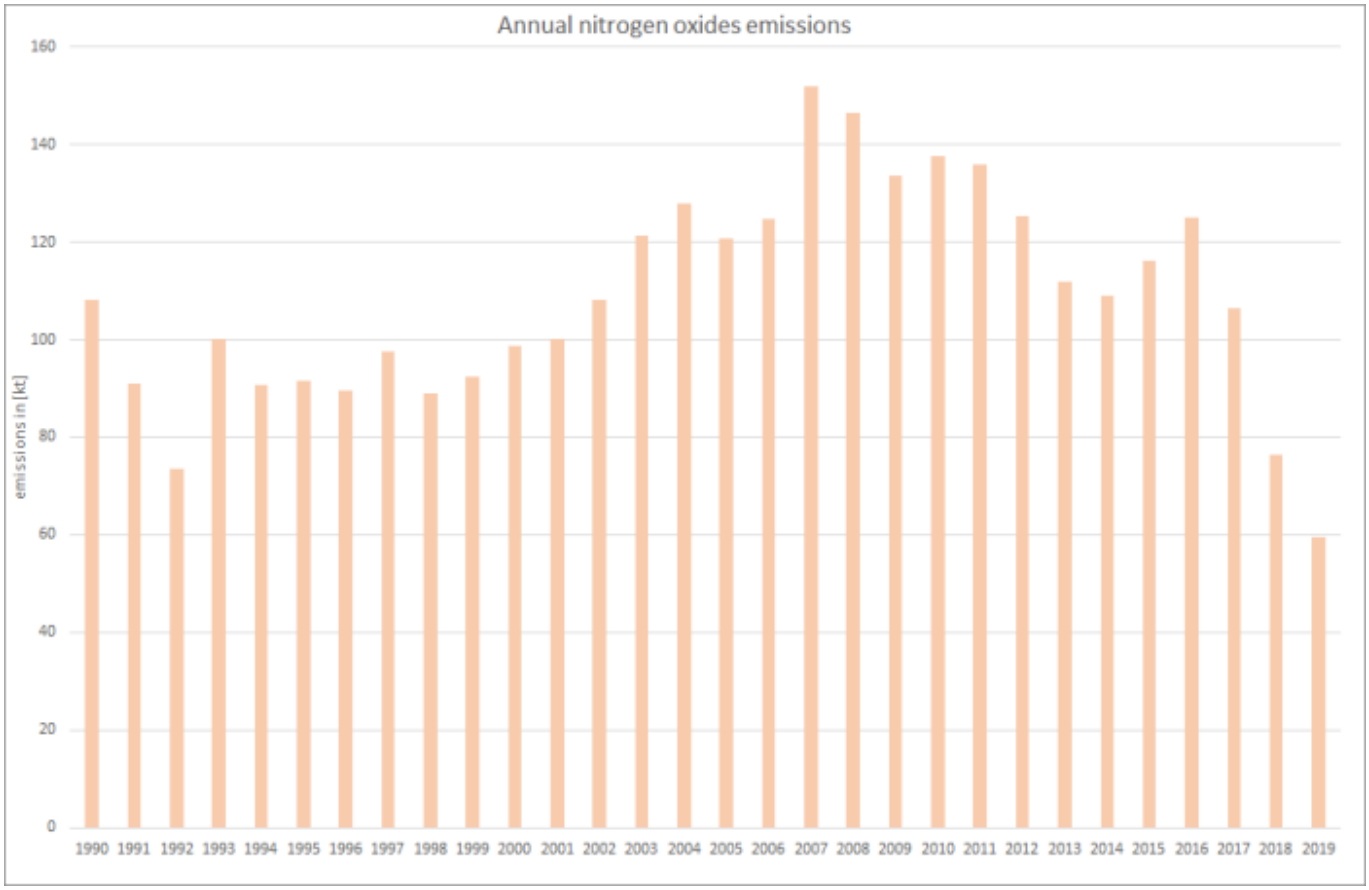
For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

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.

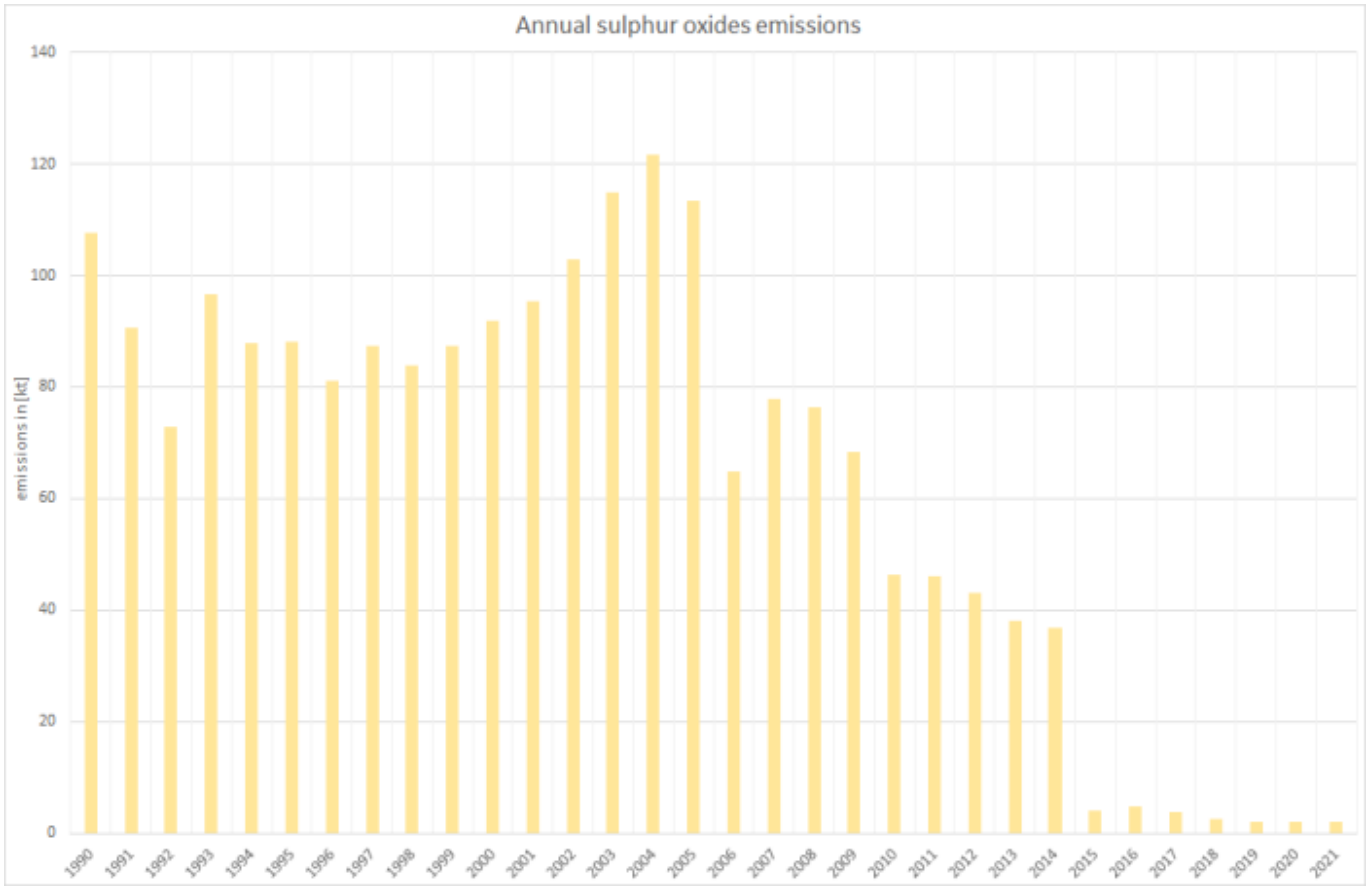
Discussion of emission trends

NFR 1.A.3.d i is **not considered in the key category analysis**.

Emission trends for unregulated pollutants (such as **NH_3**, **NO_x**, **NMVOC** and **CO**, all **HM** and **POPs**) with only slight changes in the annual over-all IEFs applied, follow the trends in fuel consumption and the shares of diesel and heavy fuel oil:



On the other hand, the emission trends for **SO_x** and **PM**, both depending on the fuel's sulphur content, follow not only the trends in fuel consumption but do also reflect fuel-sulphur legislation:



Recalculations

Resulting from changes in the fuel consumption data computed within [7] for *domestic* maritime navigation, the **activity data** for 2018 for *international* maritime navigation have been reviesed.

Table 3: Revised fuel consumption data 2018, in terajoules

	Diesel[1]	Heavy fuel oil	OVER-ALL
Submission 2021	15.213	39.380	54.674
Submission 2020	15.419	39.287	54.788
absolute change	-206	92	-114
relative change	-1,34%	0,24%	-0,21%

[1] as provided in AGEB (2020) [8]: including light heating oil

In contrast, all country-specific and default **emission factors applied remain unrevised** compared to last year's submission.

For more 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) [9].

Planned improvements

Besides routine maintenance and further development of the BSH model, no improvements are planned.

FAQs

[1), 8)] 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, Köln & Berlin, 2020.
[2), 3), 7)] Deichnik, K. (2019): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Bundesamts für Seeschifffahrt und Hydrographie (BSH); Hamburg, 2020.
[4), 5), 6)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, URL: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019; Copenhagen, 2019.
[9)] 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.