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, 2021) [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

As a result, activity data can fluctuate strongly from year to year.

However, this effect can be explained with the fact that large ocean-going ships do not need to bunker fuels on every single harbour but can go on for weeks without any additional fuel uptake.

This can be further increased with increasing differences in fuel prices.

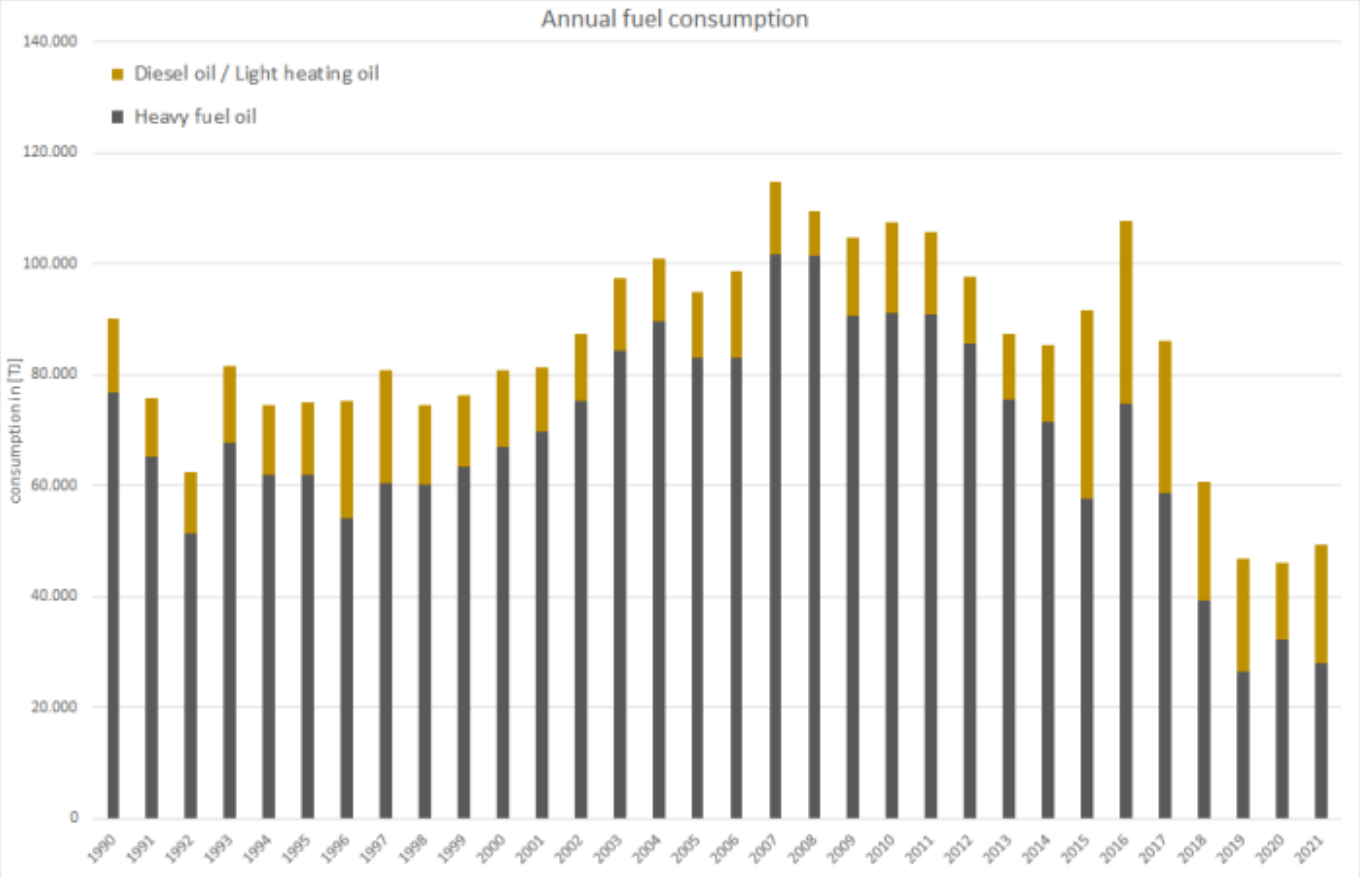
Table 1: Annual fuel consumption, in terajoules

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Diesel & Light Heating Oil	13,162	13,096	13,709	11,820	16,417	15,020	12,181	11,875	13,801	33,958	32,832	27,463	21,473	20,231	13,896	20,231
Heavy fuel oil	76,942	62,066	67,080	83,224	91,169	90,779	85,586	75,559	71,598	57,792	74,807	58,707	39,308	26,565	32,253	26,565
Σ 1.A.3.d i	**90,104**	**75,162**	**80,789**	**95,044**	**107,586**	**105,799**	**97,768**	**87,434**	**85,398**	**91,750**	**107,639**	**86,169**	**60,781**	**46,796**	**46,150**	**46,796**

source: own estimates based on underlying BSH model (Deichnik, K. (2021)) [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. (2021)).

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	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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	0.32	0.32	
NMVOC	48.5	48.4	48.4	48.4	48.4	48.4	48.4	47.7	44.9	44.4	43.9	44.2	43.8	44.0	44.0	
NO_x	1,101	1,101	1,101	1,101	1,101	1,101	1,119	1,126	1,155	1,184	1,183	1,189	1,200	1,199	1,169	
SO_x	466	419	233	186	69.8	65.2	54.8	52.9	51.1	37.2	37.2	37.2	37.2	37.2	37.2	
BC[1]	110	99.1	55.0	44.0	16.5	15.5	15.4	15.3	15.3	17.4	17.7	17.7	17.3	17.5	16.8	
$PM_{2.5}$	354	320	177	142	53,3	49,9	49,8	49,3	49,4	56,2	57,1	57,1	55,9	56,5	54,2	
PM_{10}	378	342	190	152	57,1	53,4	53,3	52,7	52,9	60,1	61,1	61,1	59,8	60,4	58,0	
TSP[2]	378	342	190	152	57,1	53,4	53,3	52,7	52,9	60,1	61,1	61,1	59,8	60,4	58,0	
CO	128	128	128	128	128	129	128	128	130	140	142	141	139	140	138	
HEAVY FUEL OIL																
NH_3	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34	
NMVOC	43.0	42.8	42.9	42.9	42.8	42.7	42.8	41.6	42.3	26.1	30.2	33.7	32.5	32.7	37.4	
NO_x	1,368	1,368	1,368	1,368	1,368	1,367	1,367	1,384	1,433	1,487	1,440	1,479	1,480	1,507	1,509	
SO_x	1,319	1,332	1,323	1,336	496	496	496	495	506	48.6	49.2	48.1	45.9	46.5	48.1	
BC[1]	70.8	71.2	70.8	71.6	26.5	26.5	26.5	25.6	25.6	14.2	18.0	20.1	19.1	18.9	21.4	
$PM_{2.5}$	590	594	590	596	221	221	221	213	213	118	150	168	159	158	179	
PM_{10}	649	653	649	656	243	243	243	234	235	130	165	184	175	173	197	
TSP[2]	649	653	649	656	243	243	243	234	235	130	165	184	175	173	197	

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CO	179	179	179	179	179	179	179	175	173	144	162	157	156	150	151	

[1] estimated from f-BCs as provided in [3)]: f-BC (HFO) = 0.12, f-BC (MDO/MGO) = 0.31 as provided in [4)], 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 [5)], 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.

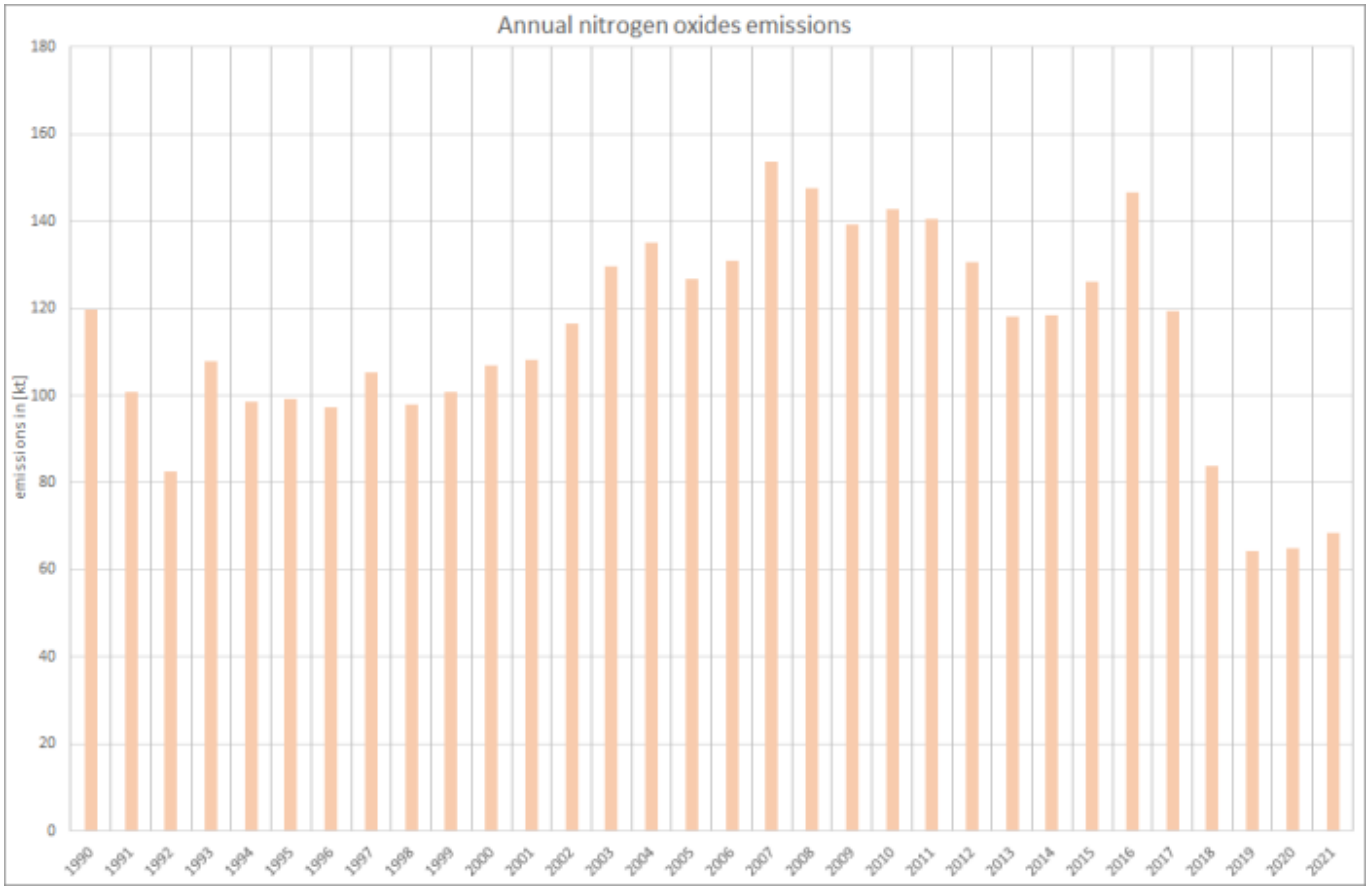
Discussion of emission trends

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

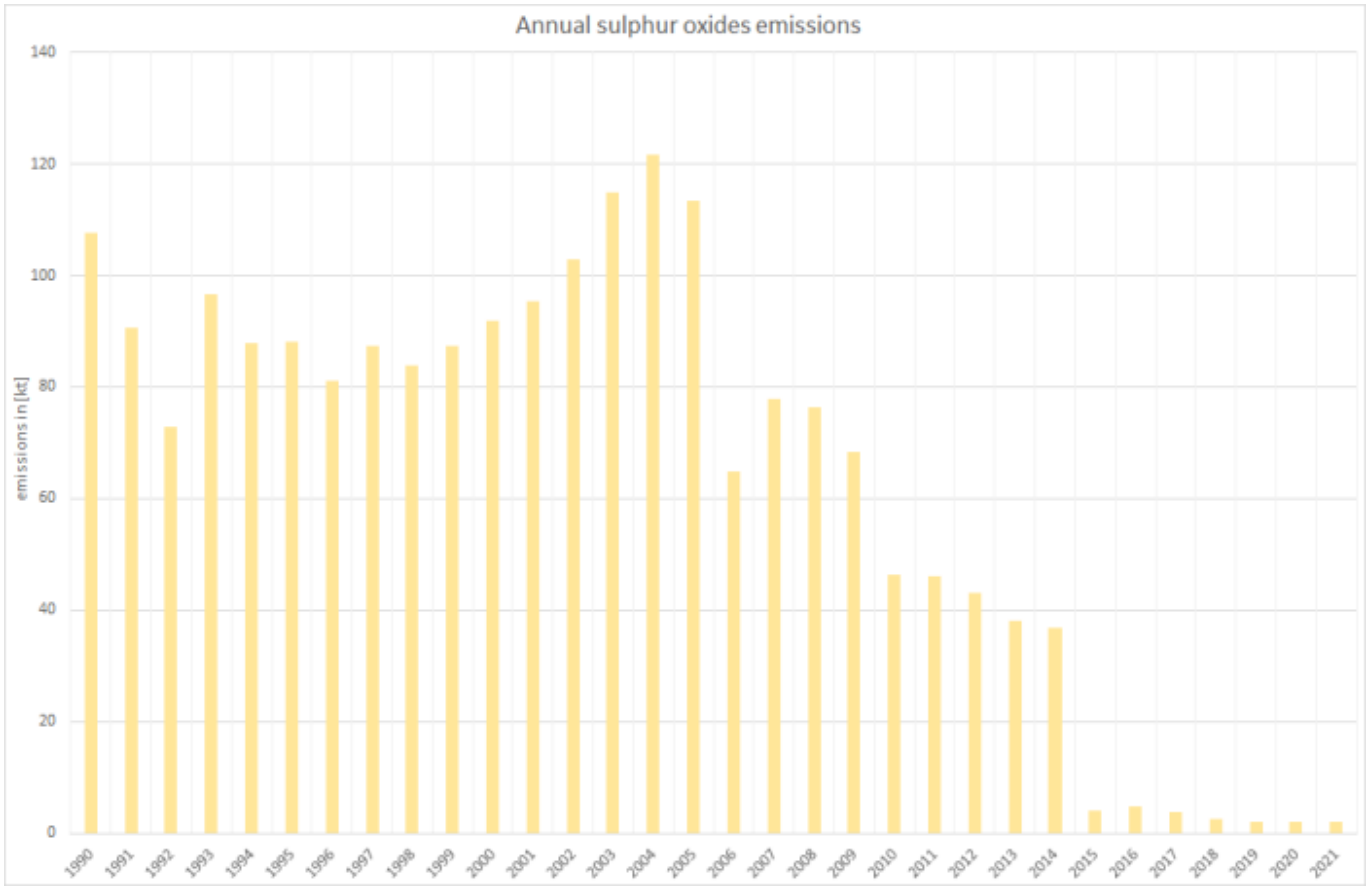
Basically, with no significant technical improvements with respect to mitigation technologies, trends in emissions depend more or less directly the amounts of fuels bunkered in German harbours and the contributions of diesel oil/light heating oil and heavy fuel oil to the over-all fuel input.

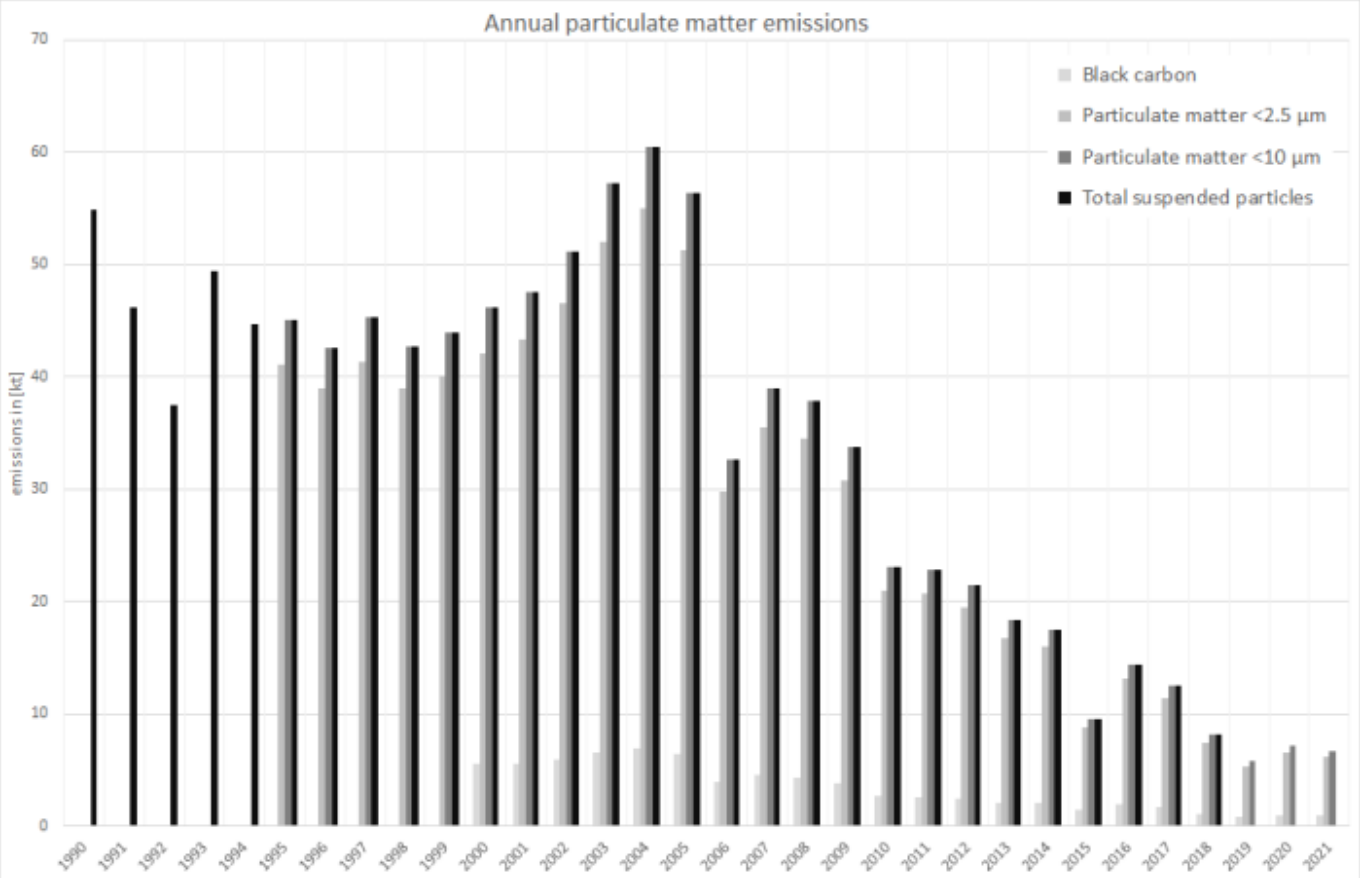
Here, as the amounts of fuels allocated to international maritime navigation represent the remains of annual over-all inland fuel deliveries minus fuel consumption in domestic shipping, activity data and, hence, emissions, fluctuate strongly from year to year (see also information on activity data as stated above).

Therefore, especially 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:



In contrast, 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 [6] for *domestic* maritime navigation, the **activity data** for *international* maritime navigation have been revised for the entire timeseries.

Table 3: Revised annual fuel consumption data, in terajoules

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
DIESEL OIL															
current submission	13,162	13,096	13,709	11,820	16,417	15,020	12,181	11,875	13,801	33,958	32,832	27,463	21,473	20,231	
previous submission	12,748	12,919	13,664	11,993	16,662	15,370	12,594	12,414	13,674	33,088	28,093	22,924	15,213	18,327	
absolute change	413	176	44.9	-173	-246	-350	-412	-539	126	870	4,738	4,538	6,260	1,904	
relative change	3.24%	1.36%	0.33%	-1.44%	-1.48%	-2.28%	-3.27%	-4.35%	0.92%	2.63%	16.9%	19.8%	41.1%	10.4%	
HEAVY FUEL OIL															
current submission	76,942	62,066	67,080	83,224	91,169	90,779	85,586	75,559	71,598	57,792	74,807	58,707	39,308	26,565	
previous submission	68,484	56,323	60,984	78,182	86,934	86,687	81,171	71,364	67,670	57,850	74,837	58,781	39,380	26,601	
absolute change	8,458	5,743	6,096	5,042	4,236	4,092	4,415	4,195	3,928	-57.9	-30.0	-74.1	-71.7	-35.9	
relative change	12.4%	10.2%	10.0%	6.45%	4.87%	4.72%	5.44%	5.88%	5.80%	-0.10%	-0.04%	-0.13%	-0.18%	-0.14%	
OVER-ALL FUEL CONSUMPTION															
current submission	90,239	75,275	80,910	95,187	107,747	105,958	97,914	87,565	85,527	91,888	107,800	86,299	60,872	46,866	
previous submission	81,354	69,346	74,760	90,310	103,751	102,210	93,905	83,904	81,466	91,075	103,085	81,828	54,674	44,995	

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
absolute change	8,885	5,929	6,150	4,877	3,996	3,748	4,009	3,661	4,060	813	4,715	4,471	6,197	1,871	
relative change	10.9%	8.55%	8.23%	5.40%	3.85%	3.67%	4.27%	4.36%	4.98%	0.89%	4.57%	5.46%	11.3%	4.16%	

[1] as provided in AGEB(2021) [7)], line 6: “Hochseebunkerungen”: including light heating oil

In addition, all country-specific **emission factors have been revised** compared to last year's submission but cannot be displayed here.

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: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by Knörr et al. (2009) [8)].

Planned improvements

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

FAQs

[1), 7)] 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, Köln & Berlin, 2021.
[2), 6)] Deichnik, K. (2021): 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, 2021.
[3), 4), 5)] EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, URL: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019; Copenhagen, 2019.
[8)] 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.