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.

Method	AD	EF	Key Category
T1, T2, T3	NS, M	CS, D, M	**L & T**: PM,,10,, & PM,,2.5,,, **L**: NO,,x,,

Methodology

Activity data

As described for the over-all sector 1.A.3.d and all other navigational activities here], 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.

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

	= 1990	= 1995	= 2000	= 2005	= 2006	= 2007	= 2008	= 2009	= 2010	= 2011	= 2012	= 2013	= 2014	= 2015	= 2016	= 2017	= 2018
~ Diesel Oil	> 36,604	> 29,855	> 18,648	> 18,596	> 16,895	> 17,232	> 16,517	> 16,615	> 16,183	> 16,954	> 16,601	> 16,824	> 18,532	> 22,781	> 24,167	> 22,400	> 22,492
~ Biodiesel	> 0	> 0	> 0	> 268	> 310	> 474	> 476	> 729	> 691	> 757	> 708	> 647	> 705	> 697	> 461	> 520	> 523
~ Heavy fuel oil	> 11,723	> 8,041	> 8,577	> 7,172	> 7,004	> 7,425	> 7,797	> 6,733	> 6,114	> 5,961	> 6,410	> 6,376	> 6,046	> 50,0	> 7,05	> 7,01	> 283
Σ 1.A.3.d ii	~ 48,326	~ 37,896	~ 27,224	~ 26,036	~ 24,209	~ 25,131	~ 24,790	~ 24,077	~ 22,988	~ 23,673	~ 23,719	~ 23,846	~ 25,282	~ 23,528	~ 24,635	~ 22,927	~ 23,298

gallery size="medium" : 1A3dii_AD.png gallery

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

	= 1990	= 1995	= 2000	= 2005	= 2006	= 2007	= 2008	= 2009	= 2010	= 2011	= 2012	= 2013	= 2014	= 2015	= 2016	= 2017	= 2018
< National Maritime Navigation																	
~ Diesel Oil	> 15,940	> 11,258	> 11,860	> 9,962	> 9,845	> 10,395	> 10,834	> 9,486	> 8,685	> 8,489	> 9,046	> 9,047	> 9,965	> 13,359	> 16,295	> 15,221	> 15,856
~ Biodiesel	> 0	> 0	> 0	> 79	> 104	> 169	> 195	> 238	> 205	> 202	> 215	> 192	> 210	> 167	> 146	> 134	> 135

~ Heavy fuel oil	> 11,723	> 8,041	> 8,577	> 7,172	> 7,004	> 7,425	> 7,797	> 6,733	> 6,114	> 5,961	> 6,410	> 6,376	> 6,046	> 50	> 7,05	> 7,01	> 283
< National Inland Navigation																	
~ Diesel Oil	> 20,664	> 18,597	> 6,788	> 8,634	> 7,050	> 6,836	> 5,683	> 7,129	> 7,497	> 8,466	> 7,556	> 7,777	> 8,567	> 9,422	> 7,873	> 7,179	> 6,636
~ Biodiesel	> 0	> 0	> 0	> 189	> 205	> 305	> 281	> 491	> 486	> 555	> 493	> 454	> 495	> 530	> 315	> 385	> 388
Σ 1.A.3.d ii	~ 48,326	~ 37,896	~ 27,224	~ 26,036	~ 24,209	~ 25,131	~ 24,790	~ 24,077	~ 22,988	~ 23,673	~ 23,719	~ 23,846	~ 25,282	~ 23,528	~ 24,635	~ 22,927	~ 23,298

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 2019 [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 SO,,x,,, 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	= 2006	= 2007	= 2008	= 2009	= 2010	= 2011	= 2012	= 2013	= 2014	= 2015	= 2016	= 2017	= 2018
< Diesel fuels	**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	> 0.33	> 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
~ 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
~ SO,,x,,	> 465.5	> 419.0	> 232.8	> 186.2	> 186.2	> 186.2	> 139.7	> 69.8	> 69.8	> 65.18	> 54.53	> 52.56	> 50.48	> 40.74	> 40.61	> 40.74	> 40.76
~ BC	> 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
~ 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
~ 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
~ TSP	> 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
~ CO	> 127	> 128	> 128	> 128	> 128	> 128	> 128	> 128	> 128	> 128	> 128	> 127	> 128	> 134	> 139	> 138	> 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
~ 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
~ 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

~ 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	
~ BC	> 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	
~ PM,,2.5,,	> 479	> 483	> 480	> 485	> 270	> 269	> 269	> 270	> 180	> 180	> 180	> 184	> 187	> 151	> 205	> 153	> 123	
~ PM,,10,,	> 526	> 532	> 528	> 533	> 297	> 296	> 296	> 297	> 198	> 198	> 198	> 203	> 206	> 166	> 226	> 168	> 135	
~ TSP	> 526	> 532	> 528	> 533	> 297	> 296	> 296	> 297	> 198	> 198	> 198	> 203	> 206	> 166	> 226	> 168	> 135	
~ CO	> 162	> 162	> 162	> 162	> 162	> 162	> 162	> 162	> 162	> 162	> 162	> 162	> 167	> 165	> 198	> 167	> 134	
1																		
2																		
3																		

> **NOTE:** 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. (2019a)) [5)]. 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]^^1^^

	= **1990**	= **1995**	= **2000**	= **2005**	= **2006**	= **2007**	= **2008**	= **2009**	= **2010**	= **2011**	= **2012**	= **2013**	= **2014**	= **2015**	= **2016**	= **2017**	= **2018**				
~ 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	> 0.23	> 0.23	> 0.23				
~ NMVOC	> 96.4	> 87.9	> 77.7	> 66.7	> 64.9	> 62.8	> 60.3	> 58.8	> 58.0	> 56.9	> 55.7	> 54.7	> 53.6	> 52.6	> 51.6	> 50.6	> 49.7				
~ NO,,x,,	> 1,327	> 1,331	> 1,336	> 1,303	> 1,290	> 1,269	> 1,243	> 1,227	> 1,208	> 1,198	> 1,183	> 1,171	> 1,153	> 1,136	> 1,119	> 1,102	> 1,085				
~ SO,,x,,	> 86.4	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 0.37	> 0.37	> 0.37	> 0.37	> 0.36	> 0.38	> 0.37	> 0.37				
~ PM	**2**		> 56.5	> 51.7	> 45.6	> 37.5	> 35.9	> 34.5	> 32.8	> 31.8	> 31.1	> 30.4	> 29.6	> 29.0	> 28.3	> 27.7	> 27.1	> 26.6	> 26.0		
~ BC	**3**		> 17.5	> 16.0	> 14.1	> 11.6	> 11.1	> 10.7	> 10.2	> 9.86	> 9.63	> 9.43	> 9.17	> 8.99	> 8.78	> 8.59	> 8.42	> 8.24	> 8.07		
~ CO	> 417	> 387	> 337	> 274	> 262	> 250	> 237	> 229	> 223	> 217	> 211	> 206	> 200	> 195	> 190	> 185	> 180				
1																					
2																					
3																					

> **NOTE:** 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.footnote 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. footnote
>
> 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 ii** is key category for emissions of **NO,,x,,**, **PM,,2.5,,** and **PM,,10,,**.

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

Nonetheless, for these pollutants, annual emission factors from BSH [6)] and TREMOD [7)] have been applied for national *maritime* and *inland* navigation, respectively, reflecting the technical development of the German inland navigation fleet.

gallery size="medium" : EM_1A3dii_NH3.png : EM_1A3dii_NMVOC.png : EM_1A3dii_NOx.png : EM_1A3dii_CO.png gallery

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

gallery size="medium" : EM_1A3dii_SO2.png : EM_1A3dii_PM.png gallery

+ Recalculations

Major changes in **activity data** result from the revision of the National Energy Balance 2017 and revised shares of biodiesel mixed to diesel oil in 2016 and 2017.

Table 5: Revised fuel consumption data 2016 & 2017, in terajoules

=		= **Diesel oil**		= **Biodiesel**		= **Heavy fuel oil**		= **Over-all fuel consumption**
=	= **2016**	= **2017**	= **2016**	= **2017**	= **2016**	= **2017**	= **2016**	= **2017**
~ Submission 2020	> 24,167	> 22,400	> 461	> 520	> 7,05	> 7,01	> 24,635	> 22,927
~ Submission 2019	> 24,167	> 23,245	> 524	> 539	> 7,05	> 7,01	> 24,698	> 23,790
~ absolute change	> 0.00	> -844	> -62.5	> -19.3	> 0.00	> 0.00	> -62.5	> -864
~ relative change	> 0.00%	> -3.63%	> -11.9%	> -3.57%	> 0.00%	> 0.00%	> -0.25%	> -3.63%

Furthermore, the country-specific **emission factors** applied for diesel fuels used in **domestic inland navigation** have been revised within TREMOD [8)]:

Table 6: Revised country-specific emission factors for diesel fuels used in domestic inland navigation, in [kg/TJ]^^1^^

	= **1990**	= **1995**	= **2000**	= **2005**	= **2006**	= **2007**	= **2008**	= **2009**	= **2010**	= **2011**	= **2012**	= **2013**	= **2014**	= **2015**	= **2016**	= **2017**
< **Ammonia - NH,,3,,**																
~ Submission 2020	> 0.234	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233
~ Submission 2019	> 0.234	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.233	> 0.234

~ 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
~ relative 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%	> -0.59%
< NMVOC																
~ Submission 2020	> 96.4	> 87.9	> 77.7	> 66.7	> 64.9	> 62.8	> 60.3	> 58.8	> 58.0	> 56.9	> 55.7	> 54.7	> 53.6	> 52.6	> 51.6	> 50.6
~ Submission 2019	> 96.4	> 88.0	> 78.4	> 67.6	> 65.7	> 63.5	> 61.2	> 59.6	> 57.4	> 56.4	> 55.2	> 54.3	> 53.3	> 52.3	> 51.4	> 50.6
~ absolute change	> 0.00	> -0.09	> -0.63	> -0.81	> -0.79	> -0.79	> -0.83	> -0.83	> 0.53	> 0.49	> 0.43	> 0.43	> 0.31	> 0.34	> 0.23	> 0.00
~ relative change	> 0.00%	> -0.11%	> -0.81%	> -1.20%	> -1.20%	> -1.24%	> -1.36%	> -1.39%	> 0.92%	> 0.86%	> 0.78%	> 0.80%	> 0.58%	> 0.65%	> 0.44%	> -0.01%
< NO,,x,,																
~ Submission 2020	> 1.327	> 1.331	> 1.336	> 1.303	> 1.290	> 1.269	> 1.243	> 1.227	> 1.208	> 1.198	> 1.183	> 1.171	> 1.153	> 1.136	> 1.119	> 1.102
~ Submission 2019	> 1.327	> 1.331	> 1.335	> 1.303	> 1.291	> 1.270	> 1.245	> 1.230	> 1.205	> 1.195	> 1.180	> 1.169	> 1.152	> 1.135	> 1.119	> 1.102
~ absolute change	> 0.00	> 0.28	> 0.27	> -0.27	> -0.39	> -0.64	> -2.34	> -3.11	> 2.60	> 2.77	> 2.38	> 2.13	> 1.02	> 1.31	> 0.23	> 0.01
~ relative change	> 0.00%	> 0.02%	> 0.02%	> -0.02%	> -0.03%	> -0.05%	> -0.19%	> -0.25%	> 0.22%	> 0.23%	> 0.20%	> 0.18%	> 0.09%	> 0.12%	> 0.02%	> 0.00%
< Sulphur oxides - SO,,x,,																
~ Submission 2020	> 86.4	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 0.37	> 0.37	> 0.37	> 0.37	> 0.36	> 0.38	> 0.37
~ Submission 2019	> 86.4	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 60.5	> 0.37	> 0.37	> 0.37	> 0.37	> 0.36	> 0.38	> 0.37
~ 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
~ relative 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%
< Black carbon - BC																
~ Submission 2020	> 17.5	> 16.0	> 14.1	> 11.6	> 11.1	> 10.7	> 10.2	> 9.9	> 9.63	> 9.43	> 9.17	> 8.99	> 8.78	> 8.59	> 8.42	> 8.24
~ Submission 2019	> 17.5	> 16.1	> 14.3	> 11.8	> 11.3	> 10.9	> 10.4	> 10.0	> 9.52	> 9.31	> 9.07	> 8.90	> 8.71	> 8.51	> 8.36	> 8.24
~ absolute change	> 0.00	> -0.02	> -0.13	> -0.17	> -0.17	> -0.17	> -0.18	> -0.18	> 0.12	> 0.11	> 0.10	> 0.10	> 0.07	> 0.08	> 0.06	> 0.00
~ relative change	> 0.00%	> -0.12%	> -0.90%	> -1.45%	> -1.50%	> -1.56%	> -1.75%	> -1.82%	> 1.24%	> 1.21%	> 1.09%	> 1.10%	> 0.83%	> 0.94%	> 0.67%	> -0.01%
< Particulate matter - PM																
~ Submission 2020	> 56.5	> 51.7	> 45.6	> 37.5	> 35.9	> 34.5	> 32.8	> 31.8	> 31.1	> 30.4	> 29.6	> 29.0	> 28.3	> 27.7	> 27.1	> 26.6
~ Submission 2019	> 56.5	> 51.8	> 46.0	> 38.1	> 36.5	> 35.0	> 33.4	> 32.4	> 30.7	> 30.0	> 29.3	> 28.7	> 28.1	> 27.4	> 27.0	> 26.6
~ absolute change	> 0.00	> -0.06	> -0.41	> -0.55	> -0.55	> -0.55	> -0.58	> -0.59	> 0.38	> 0.36	> 0.32	> 0.32	> 0.23	> 0.26	> 0.18	> 0.00
~ relative change	> 0.00%	> -0.12%	> -0.90%	> -1.45%	> -1.50%	> -1.56%	> -1.75%	> -1.82%	> 1.24%	> 1.21%	> 1.09%	> 1.10%	> 0.83%	> 0.94%	> 0.67%	> -0.01%

< **Carbon monoxide - CO**																
~ Submission 2020	> 417	> 387	> 337	> 274	> 262	> 250	> 237	> 229	> 223	> 217	> 211	> 206	> 200	> 195	> 190	> 185
~ Submission 2019	> 417	> 388	> 340	> 279	> 267	> 255	> 242	> 233	> 220	> 214	> 208	> 203	> 198	> 193	> 188	> 185
~ absolute change	> 0.00	> -0.59	> -3.49	> -4.55	> -4.49	> -4.47	> -4.79	> -4.82	> 3.07	> 2.93	> 2.58	> 2.56	> 1.87	> 2.06	> 1.42	> -0.02
~ relative change	> 0.00%	> -0.15%	> -1.02%	> -1.63%	> -1.68%	> -1.76%	> -1.98%	> -2.07%	> 1.40%	> 1.37%	> 1.24%	> 1.26%	> 0.94%	> 1.07%	> 0.76%	> -0.01%

In contrast, the country-specific **emission factors** applied for fuels used in **national maritime navigation** remain unaltered.

> For more information on **recalculated emission estimates for Base Year and 2017**, 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

> With the next annual submission **routine revisions of the models** used for maritime [10)] and inland navigation [11)] are scheduled.

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[10)] (bibcite 4)
[11)] (bibcite 5)