1.A.3.d - Navigation

Short description

Category *1.A.3.d - Navigation* includes emissions from national and international inland and maritime navigation.

NFR-Code	Name of Category	Method	AD	EF	Key Category
1.A.3.d	**Navigation**	*see sub-category details*			
consisting of / including source categories					
1.A.3.d i (ii)	International Inland Waterways	*Germany does not report emissions from this sub-category.*			
1.A.3.d ii	National Navigation (Shipping)	*see sub-category details*			
1.A.3.d i (i)	International Maritime Navigation	*see sub-category details*			

Methodology

Activity Data

Primary fuel deliveries data for the entire navigation sector (maritime and inland waterways) is included in lines 6 ('International Maritime Bunkers') and 64 ('Coastal and Inland Navigation') of the National Energy Balance (NEB) (AGEB, 2019) [1)]. (For comparison, official mineral-oil data of the Federal Office of Economics and Export Control (BAFA, 2019) [2)] and sales data of the German Petroleum Industry Association (MWV, 2019) [3)] are used, too.)

Data on the consumption of *biodiesel* is provided in NEB line 64 from 2004 onward. However, as this data appears to be rather inconsistent, the consumption of biofuels is calculated within TREMOD via the official annual blending rates.

Table 1: Primary fuel deliveries as listed in the National Energy Balance, in terajoules

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
NEB line 6 - Maritime Bunkers ('Hochseebunkerungen')														
Diesel / Light heating oil	23,336	20,426	21,542	18,636	22,483	21,046	18,617	18,333	20,898	43,376	42,606	36,872	31,406	
Heavy fuel oil	80,230	64,382	69,578	85,370	93,063	92,649	87,595	77,754	73,729	57,900	74,844	58,788	39,570	
NEB line 64 - Coastal and Inland Navigation ('Küsten- und Binnenschifffahrt')														
Diesel oil	27,710	23,562	11,864	12,831	11,182	12,050	11,322	11,635	12,112	13,321	11,131	10,150	9,383	
Biodiesel	0	0	0	281	725	790	739	674	734	720	481	538	542	
TOTAL Navigation	**131,276**	**108,370**	**102,984**	**117,118**	**127,453**	**126,535**	**118,273**	**108,396**	**107,473**	**115,317**	**129,062**	**106,348**	**80,901**	

source: National Energy Balances

As the statistical allocation of fuels delivered to the navigation (shipping) sector follows tax aspects, NEB line 6 ('International Maritime Bunkers') includes all fuel deliveries to IMO-registered ship involved in both national and international maritime activities. On the other hand, NEB line 64 ('Coastal and Inland Navigation') includes all fuel deliveries to ship involved in inland and non-IMO maritime navigation.

Table 2: Allocation of for subsector-specfic fuel deliveries data in the NEB

NEB line	including fuel deliveries to navigation sub-sectors...
6 - 'International Maritime Bunkers'	...international maritime navigation / national maritime navigation (IMO) / national fishing (IMO) / military navigation (IMO)
64 - 'Coastal and Inland Navigation'	...national inland navigation / national maritime navigation (non-IMO) / national fishing (non-IMO) / military navigation (non-IMO)

Therefore, the amounts of fuels listed in NEB lines 6 and 64 have to be broken down on several sub-sectors. Regarding all national maritime activities, taking place in National Maritime Navigation], 1.A.4.c iii - National fishing], and 1.A.5.b iii - Military navigation]), a newly implemented approach allows for estimating tier3 fuel consumption data based on ship movement information (AIS signal) for IMO- and non-IMO ships. In contrast to this bottom-up approach, fuel consumption in

both *international maritime navigation* and *national inland navigation* are calculated as simple tier1 estimates. The following equations and charts try to illustrate the way of deducing these tier1 activity data:

Estimating the tier1 activity data for International maritime navigation:

math AD_\text{ 1.A.3.d i} = PAD_\text{ NEB line 6} - AD_\text{ 1.A.3.d ii (a) - IMO} - AD_\text{ 1.A.4.c iii - IMO} - AD_\text{ 1.A.5.b iii - IMO} math

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

Estimating the tier1 activity data for National inland navigation:

math AD_\text{ 1.A.3.d ii (b)} = PAD_\text{ NEB line 64} - AD_\text{ 1.A.3.d ii (a) - non-IMO} -AD_\text{ 1.A.4.c iii - non-IMO} - AD_\text{ 1.A.5.b iii - non-IMO} math

with AD ,,1.A.3.d ii (b),, - tier1 activity data for National inland navigation PAD ,,NEB line 64,, - primary over-all fuel deliveries data from NEB line 64 - 'Coastal and Inland Navigation' AD ,,1.A.3.d ii (a), non-IMO,, - tier3 activity data for non-IMO ships involved in national maritime navigation AD ,,1.A.4.c iii, non-IMO,, - tier3 activity data for non-IMO ships involved in national fishing AD ,,1.A.5.b iii, non-IMO,, - tier3 activity data for non-IMO ships involved in military navigation

Table 3: Resulting breakdown of primary fuel deliveries onto the different navigation sub-sectors, in terajoules

	= 1990	**= 1995**	**= 2000**	**= 2004**	**= 2005**	**= 2006**	**= 2007**	**= 2008**	**= 2009**	**= 2010**	**= 2011**	**= 2012**	**= 2013**	**= 2014**	**= 2015**	**= 2016**	**= 2017**	**= 2018**
= Navigation TOTAL	~ 131,276	~ 108,370	~ 102,984	~ 122,716	~ 117,138	~ 119,172	~ 140,173	~ 134,800	~ 125,238	~ 127,453	~ 126,549	~ 118,274	~ 108,396	~ 107,473	~ 115,317	~ 129,062	~ 106,348	~ 80,901
<																		
< 1.A.3.d i - International maritime navigation																		
~ Diesel oil / Light heating oil	> 12,748	> 12,919	> 13,664	> 11,513	> 11,993	> 15,817	> 17,524	> 13,105	> 14,412	> 16,662	> 15,370	> 12,594	> 12,414	> 13,674	> 33,088	> 28,093	> 22,924	> 15,419
~ Heavy fuel oil	> 68,484	> 56,323	> 60,984	> 83,935	> 78,182	> 78,257	> 96,625	> 96,017	> 85,865	> 86,934	> 86,687	> 81,171	> 71,364	> 67,670	> 57,850	> 74,837	> 58,781	> 39,287
~ Biodiesel	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO
< 1.A.3.d ii (a) - National maritime navigation																		
~ Diesel oil / Light heating oil	> 15,940	> 11,258	> 11,860	> 11,231	> 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
~ Heavy fuel oil	> 11,723	> 8,041	> 8,577	> 8,069	> 7,172	> 7,004	> 7,425	> 7,797	> 6,733	> 6,114	> 5,961	> 6,410	> 6,376	> 6,046	> 50	> 7	> 7	> 283
~ Biodiesel	= NO	= NO	= NO	> 35	> 79	> 104	> 169	> 195	> 238	> 205	> 202	> 215	> 192	> 210	> 167	> 146	> 134	> 135
< 1.A.3.d ii (b) - National inland navigation																		
~ Diesel oil	> 20,664	> 18,597	> 6,788	> 6,921	> 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
~ Heavy fuel oil	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO
~ Biodiesel	= NO	= NO	= NO	> 60	> 189	> 205	> 305	> 281	> 491	> 486	> 555	> 493	> 454	> 495	> 530	> 315	> 385	> 388
< 1.A.4.c iii - Fishing																		
~ Diesel oil / Light heating oil	> 711	> 549	> 531	> 500	> 488	> 474	> 486	> 484	> 482	> 473	> 442	> 431	> 429	> 472	> 555	> 1,117	> 1,208	> 2,455
~ Heavy fuel oil	> 24	> 18	> 18	> 17	> 16	> 16	> 16	> 16	> 16	> 16	> 15	> 14	> 14	> 13	> 0	> 0	> 0	> 0
~ Biodiesel	= NO	= NO	= NO	= 2	= 4	= 5	= 8	= 9	= 13	= 12	= 11	= 11	= 10	= 10	= 10	= 8	= 8	= 8
< 1.A.5.b iii - Military navigation																		
~ Diesel oil / Light heating oil	> 983	> 665	> 563	> 431	> 410	> 383	> 366	> 360	> 349	> 347	> 330	> 313	> 302	> 332	> 273	> 359	> 489	> 423
~ Heavy fuel oil	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO	= NO
~ Biodiesel	= NO	= NO	= NO	> 4	> 9	> 11	> 16	> 18	> 24	> 22	> 21	> 20	> 18	> 19	> 14	> 11	> 11	> 11

> For information on specific fuel consumption data for the covered areas of navigation, please refer to the sub-chapters linked above.

Emission factors

Annual country-specific emission factors have been developed within the underlying models maintained at the ifeu Institute for Energy and Environmental Research (Knörr et al. (2019a): TREMOD) [4)] and the Federal Maritime and Hydrographic Agency (Deichnik (2019): BSH model) [5)].

> For information on these country-specific emission factors, please refer to the sub-chapters linked above.

Furthermore, for heavy metal and POP emissions tier1 EF have been derived from the EMEP/EEA Guidebook 2019 mainly [6)].

> 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].

[!– Table 4 shows the tier1 emission factors for exhaust emissions of **heavy-metals** and **POPs** as applied to all navigation sub-categories in 1.A.3.d as well as NFRs 1.A.4.c iii and 1.A.5.b iii. The listed values have been derived from default values provided in the EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2019) [7)] and (Rentz et al., 2008) [8)].

Here, as the guidebook does not provide source-specific values for **PAHs**, respective values provided for diesel in railways and heavy duty road vehicles have been applied as a gap-filling proxy.

Table 4: Tier1 emission factors for heavy-metal and POP exhaust emissions

	Heavy Metals																	**POPs**	
	Pb	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**B[a]P**	**B[b]F**	**B[k]F**	**I[...]p**	**PAH 1-4**	**PCBs**	**HCB**	**PCDD/F**		
	[g/TJ]							[mg/TJ]						[µg/TJ]					
Diesel oil	3.03 [2]	0.233 [2]	0.698 [2]	0.93 [2]	1.16 [2]														

[2] tier1 defaults from [9)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-2 [3] tier1 defaults from [10)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-1 [4] sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P [5] tier1 defaults from [11)], Chapter: 1.A.3.c Railways: Diesel, Table 3-1 [6] tier1 defaults from [12)], Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel [7] tier1 value derived from [[1)]

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