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 Analysis
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, 2020) [1)]. (For comparison, official mineral-oil data of the Federal Office of Economics and Export Control (BAFA, 2020) [2)] and sales data of the German Petroleum Industry Association (MWV, 2020) [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	30,214
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	26,959
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	10,619	10,739
TOTAL Navigation	**131,276**	**108,37**	**102,984**	**116,837**	**126,728**	**125,745**	**117,534**	**107,722**	**106,739**	**114,597**	**128,581**	**105,81**	**81,595**	**67,912**

source: National Energy Balances [4)]

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 are broken down on several sub-sectors.

Regarding all national maritime activities, taking place in National Maritime Navigation, national fishing, and military navigation, a country-specific 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 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:

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

Estimating the tier1 activity data for National inland navigation:

$AD_{1.A.3.d\ ii\ (b)} = PAD_{NEB\ line\ 64} - AD_{1.A.3.d\ ii\ (a)\ -\ non\text{-}IMO} - AD_{1.A.4.c\ iii\ -\ non\text{-}IMO} - AD_{1.A.5.b\ iii\ -\ non\text{-}IMO}$	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' * $AD_{1.A.3.d\ ii\ (a)\ -\ non\text{-}IMO}$ - tier3 activity data for non-IMO ships involved in national maritime navigation * $AD_{1.A.4.c\ iii\ -non\text{-}IMO}$ - tier3 activity data for for non-IMO ships involved in national fishing * $AD_{1.A.5.b\ iii\ -\ non\text{-}IMO}$ - tier3 activity data for 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	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Navigation TOTAL	**131,276**	**108,370**	**102,984**	**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	11.993	15.817	17.524	13.105	14.412	16.662	15.370	12.594	12.414	13.674	33.088	28.093	22.924	15.213	18.327
Heavy fuel oil	68.484	56.323	60.984	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	39.380	26.601
< 1.A.3.d ii (a) - National maritime navigation																		
Diesel oil / Light heating 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	
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	7	283	
< 1.A.3.d ii (b) - 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	
Heavy fuel oil	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
< 1.A.4.c iii - Fishing																		
Diesel oil / Light heating oil	711	549	531	488	474	486	484	482	473	442	431	429	472	555	1,117	1,208	2,455	
Heavy fuel oil	24	18	18	16	16	16	16	16	16	15	14	14	13	0	0	0	0	
< 1.A.5.b iii - Military navigation																		
Diesel oil / Light heating oil	983	665	563	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	

> 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. (2020a): TREMOD) [5)] and the Federal Maritime and Hydrographic Agency (Deichnik (2020): BSH model) [6)].

> 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 [7)].

> 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) [8)] and (Rentz et al., 2008) [9)].

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

	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]							
Diesel oil	3.03 [2]	0.233 [2]	0.698 [2]	0.93 [2]	1.16 [2]	20.5 [2]	23.3 [2]	2.33 [2]	27.9 [2]	698 [5]	1,164 [5]	801 [6]	184 [6]	2,847 [4]	0.885 [2]	1.86 [2]	93.0 [7]
Heavy fuel oil	4.46 [3]	0.496 [3]	0.496 [3]	16.9 [3]	17.8 [3]	31.0 [3]	793 [3]	5.20 [3]	29.7 [3]	741 [5]	1,235 [5]	849 [6]	195 [6]	3,020 [4]	14.1 [3]	3.46 [3]	98.7 [7]

[2] tier1 defaults from [10)], Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-2
[3] tier1 defaults from [11)], 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 [12)], Chapter: 1.A.3.c Railways: Diesel, Table 3-1
[6] tier1 defaults from [13)], 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 [14)]

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7), 8), 10), 11), 12), 13) EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.
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