1.A.4.c ii (b) - Off-road Vehicles and other Machinery: Forestry

Short description

Under sub-category *1.A.4.c ii (b)* fuel combustion activities and resulting emissions from off-road vehicles and mobile machinery used in forestry are reported.

~ NFR-Code	~ Source category	~ Method	~ AD	~ EF	~ Key Category	**1**
1.A.4.c ii (b)	Off-road Vehicles and Other Machinery: Agriculture	= T1, T2	= NS, M	= CS, D, M	= see 1.A.4.c ii]	

Methodology

Activity data

Primary activity data (PAD) are taken from National Energy Balances (NEBs) line 67: 'Commercial, trade, services and other consumers' (AGEB, 2018) [1].

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2018) [2], the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4. ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD MM (Knörr et al. (2019b)) [3] (cf. NFR 1.A.4 - mobile]).

Table 1: Annual contribution of forestry vehicles and mobile machinery to the primary fuel delivery

data provided in NEB line 67

1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Diesel fuels													
2,41%	1,36%	2,16%	2,88%	2,92%	2,99%	2,77%	2,76%	2,81%	2,89%	2,72%	2,79%	3,35%	3,54%
Gasoline fuels													
68,5%	40,3%	44,9%	41,4%	35,5%	35,6%	33,1%	32,9%	33,1%	33,3%	31,6%	31,9%	35,8%	36,8%

source: own estimates based on [4)]

Table 2: Annual mobile fuel consumption in forestry, in terajoules

	= **1990**	= **1995**	= **2000**	= **2005**	= **2010**	= **2011**	= **2012**	= **2013**	= **2014**	= **2015**	= **2016**	= **2017**	= **2018**
~ Diesel Oil	> 2,666	> 1,311	> 1,946	> 2,174	> 2,365	> 2,482	> 2,260	> 2,372	> 2,510	> 2,700	> 2,639	> 2,784	> 2,616
~ Gasoline	> 3,093	> 3,004	> 3,325	> 3,036	> 1,563	> 1,425	> 399	> 390	> 421	> 1,698	> 1,615	> 1,631	> 1,592
~ Biodiesel	> 0	> 0	> 0	> 48	> 153	> 163	> 148	> 137	> 152	> 146	> 139	> 148	> 143
~ Biogasoline	> 0	> 0	> 0	> 21	> 60	> 58	> 18	> 17	> 18	> 74	> 70	> 68	> 72
Σ 1.A.4.c ii (ii)	~ 5,759	~ 4,315	~ 5,271	~ 5,278	~ 4,143	~ 4,129	~ 2,824	~ 2,917	~ 3,102	~ 4,618	~ 4,463	~ 4,631	~ 4,422

source: own estimates based on [5)]

gallery size="medium" : AD_1A4cii(b).PNG : AD_1A4cii(b)_bio.PNG gallery

++ Emission factors

The emission factors used here are of rather different quality: For all **main pollutants**, **carbon monoxide** and **particulate matter**, annually changing values computed within TREMOD MM (Knörr et al. (2018b)) [6)] are used, representing the development of mitigation technologies and th effect of fuel-quality legislation.

Table 3: Annual coutry-specific emission factors from TREMOD MM ^^1^^

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gasoline fuels														
NH_3	0.089	0.092	0.093	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	
NMVOC[2]	77.8	74.8	82.3	101	106	106	106	106	106	106	106	106	106	
NMVOC[3]	678	623	571	563	561	561	561	561	561	561	561	561	561	
NO_x	54.0	68.3	75.9	76.8	76.9	76.9	77.0	77.0	77.0	77.0	77.0	77.0	77.0	
SO_x	10.1	8.3	3.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
BC[5]	0.302	0.271	0.241	0.236	0.236	0.236	0.236	0.236	0.235	0.235	0.235	0.235	0.235	
PM[4]	6.03	5.43	4.83	4.72	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71	
TSP[6]	2.35	0.82	0	0	0	0	0	0	0	0	0	0	0	

CO	38,459	35,290	32,423	32,108	34,681	35,250	35,791	36,289	36,661	36,840	36,918	36,973	37,010	
Pb	1.471	0.516	0	0	0	0	0	0	0	0	0	0	0	
Diesel fuels														
NH_3	0.161	0.164	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	
NMVOC	185	157	134	90	59	55	52	48	44	41	38	35	32	
NO_x	1,047	1,012	970	757	523	484	449	417	386	357	325	292	263	
SO_x	79.6	60.5	14.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
BC[5]	78.5	64.1	51.1	36.4	27.6	26.5	25.3	23.8	22.1	20.5	18.8	17.2	15.7	
PM[4]	149	121	94	60	39	36	34	32	29	27	25	22	20	
CO	585	579	552	421	324	313	304	296	289	283	278	272	267	

[1] due to lack of better information: similar EF are applied for fossil and biofuels
[2] from fuel combustion
[3] from gasoline evaporation
[4] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
[5] estimated via a f-BCs as provided in [7)], Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery
[6] from leaded gasoline (until 1997)

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. [1)]

> 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

++ Unregulated pollutants (NH,,3,,, HMs, POPs)

For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

gallery size="medium" : EM_1A2gvii_NH3.PNG : EM_1A2gvii_Cd.PNG gallery

++ Regulated pollutants (NO,,x,,, SO,,2,,)

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation.

gallery size="medium" : EM_1A2gvii_NOx.PNG : EM_1A2gvii_SOx.PNG gallery

++ Particulate matter (PM,,2.5,,, PM,,10,,, and TSP)

Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.

Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

gallery size="medium" : EM_1A2gvii_PM.PNG : EM_1A2gvii_TSP(Pb).PNG gallery

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+ Recalculations

Revisions in **activity data** result from slightly adapted NCVs (2015-2017) as well as the implementation of primary activity data from the now finalised NEB 2017.

Table 5: Revised annual mobile fuel consumption in forestry, in terajoules

	= **2015**	= **2016**	= **2017**	
= **diesel fuels**				
~ Submission 2020	> 2,846	> 2,778	> 2,931	
~ Submission 2019	> 2,846	> 2,778	> 2,914	
~ absolute change	> 0.10	> 0.11	> 17.09	
~ relative change	> 0.003%	> 0.004%	> 0.59%	
= **gasoline fuels**				
~ Submission 2020	> 1,772	> 1,685	> 1,700	
~ Submission 2019	> 1,772	> 1,686	> 1,970	
~ absolute change	> -0.03	> -0.02	> -270	
~ relative change	> -0.002%	> -0.001%	> -13.72%	
= **over-all fuel consumption**				
~ Submission 2020	> 4,618	> 4,463	> 4,631	
~ Submission 2019	> 4,618	> 4,463	> 4,884	
~ absolute change	> 0.07	> 0.08	> -253	
~ relative change	> 0.002%	> 0.002%	> -5.19%	

As in contrast, all **emission factors** remain unrevised compared to last year's susbmission, emission estimates for the years as of 2015 change in accordance with the underlying activity data.

> For more **information on the impacts on emission estimates for Base Year and 2017**, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations].

[!–

+ Planned improvements

+ FAQs

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bibliography : 1 : AGEB, 2019: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; URL:

https://ag-energiebilanzen.de/7-0-Bilanzen-1990-2017.html, (Aufruf: 30.11.2019), Köln & Berlin, 2019. : 2 : BAFA, 2019: Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; URL: https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2017_dezember.html, Eschborn, 2019. : 3 : Knörr et al. (2019b): Knörr, W., Heidt, C., Gores, S., & Bergk, F. (2019b): ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2019, Heidelberg, 2019. : 4 : EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019. : 5 : Rentz et al., 2008: Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, January 2008 - URL:
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[1] (bibcite 1)
[2] (bibcite 2)
[3] (bibcite 3)
[4] (bibcite 3)
[5] (bibcite 3)
[6] (bibcite 3)
[7] (bibcite 3)
[1]

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.