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 Analysis
1.A.4.c ii (b)	Off-road Vehicles and Other Machinery: Forestry	T1, T2	NS, M	CS, D, M	see superordinate chapter

Methodology

Activity data

Primary activity data (PAD) are taken from National Energy Balances (NEBs) line 67: 'Commercial, trade, services and other consumers' (AGEB, 2022) [1)].

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2022) [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. (2022b) [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	2020	2021
DIESEL FUELS	2.41%	1.36%	2.15%	2.88%	2.91%	2.99%	2.77%	2.76%	2.81%	2.89%	2.72%	2.79%	3.35%	3.54%	4.15%	4.25%
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%	40.3%	40.8%

source: own estimates based on TREMOD MM

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

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Diesel Oil	2,694	1,331	2,048	2,365	2,579	2,709	2,469	2,556	2,715	2,928	2,861	3,020	3,389	3,627	4,380	4,521
Biodiesel	3,093	3,005	3,324	3,029	1,568	1,430	414	404	432	1,678	1,591	1,600	1,794	1,707	2,679	2,761
Gasoline	0	0	0	151	198	189	174	152	167	160	152	161	197	207	364	314
Biogasoline	0	0	0	20,8	60,6	58,6	18,4	17,3	18,8	72,8	69,1	67,5	80,7	73,6	122	131
Σ 1.A.4.c ii (ii)	**5,787**	**4,335**	**5,372**	**5,565**	**4,405**	**4,386**	**3,076**	**3,129**	**3,333**	**4,839**	**4,673**	**4,849**	**5,460**	**5,614**	**7,545**	**7,728**

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. (2022b)) [4)] 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	2020	2021
DIESEL FUELS																
NH_3	0.16	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC	191	156	130	80.2	46.5	42.4	38.7	35.0	31.4	28.1	25.3	22.9	20.9	19.1	17.6	16.3
NO_x	981	1.052	1.071	834	543	495	454	422	397	375	351	326	305	285	264	239
SO_x	79.6	60.5	14.0	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[5]	84.5	60.7	41.7	27.7	21.6	21.0	20.4	19.3	17.8	16.1	14.5	13.0	11.5	10.1	8.73	7.39
PM[4]	155	111	75.8	45.3	30.4	28.8	27.3	25.3	23.1	20.8	18.6	16.5	14.6	12.8	11.1	9.51
CO	688	618	554	395	282	268	256	243	230	217	206	197	188	181	174	168
GASOLINE FUELS																
NH_3	0.075	0.083	0.083	0.086	0.087	0.088	0.091	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092
NMVOC[2]	3.04	6.37	4.67	4.56	4.83	4.74	5.23	5.22	5.11	5.00	5.32	5.19	4.30	4.07	3.46	3.35
NMVOC[3]	5,819	5,099	5,099	5,320	5,424	4,858	3,596	2,897	2,897	2,897	2,897	2,897	2,897	2,901	2,910	2,915
NO_x	42.7	49.4	49.4	76.4	86.0	78.5	63.1	55.1	55.1	55.1	55.1	55.1	55.1	55.1	55.1	55.1
SO_x	10.1	8.27	3.22	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
BC[5]	5.09	3.73	3.73	3.86	3.91	3.96	4.08	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13	4.13
PM[4]	102	74.6	74.6	77.2	78.1	79.2	81.5	82.7	82.7	82.7	82.7	82.7	82.7	82.7	82.7	82.7
TSP[6]	2.35	0.82	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
CO	16,824	14,796	14,796	15,371	15,609	15,827	16,279	16,514	16,514	16,514	16,514	16,514	16,514	16,514	16,514	16,514
Pb	1.47	0.52	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[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 [5)], 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.

Recalculations

Revisions in **activity data** result from the revision of the gasoline-consumption in military ground-vehicles as well as the implementation of the now finalised NEB 2020.

Table 5: Revised activity data, in terajoules

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
DIESEL FUELS																			
current submission	2.695	1.332	2.051	2.519	2.874	3.662	2.617	2.417	2.781	2.902	2.646	2.711	2.886	3.092	3.016	3.185	3.590	3.838	
previous submission	2.695	1.332	2.051	2.519	2.874	3.662	2.617	2.417	2.781	2.902	2.646	2.711	2.886	3.092	3.016	3.185	3.590	3.831	
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	-0,20	6,88	
relative change	0,00%	0,00%	0,00%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	-0,01%	0,18%	
GASOLINE FUELS																			
current submission	3.093	3.004	3.325	3.050	3.104	3.522	2.799	1.552	1.629	1.488	433	422	451	1.752	1.660	1.668	1.875	1.781	
previous submission	3.093	3.004	3.325	3.043	3.090	3.511	2.786	1.534	1.603	1.462	409	400	430	1.732	1.644	1.655	1.819	1.814	
absolute change	0,00	0,00	0,00	7,6	14,2	11,8	13,8	18,2	25,9	26,6	23,76	22,37	20,61	19,3	16,5	13,4	56,5	-33,4	

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
relative change	0,00%	0,00%	0,00%	0,25%	0,46%	0,34%	0,50%	1,19%	1,62%	1,82%	5,81%	5,60%	4,79%	1,11%	1,00%	0,81%	3,11%	-1,84%	
OVER-ALL FUEL CONSUMPTION																			
current submission	5.788	4.336	5.375	5.569	5.977	7.184	5.417	3.969	4.409	4.390	3.079	3.133	3.336	4.843	4.677	4.853	5.465	5.619	
previous submission	5.788	4.336	5.375	5.562	5.963	7.173	5.403	3.951	4.383	4.364	3.055	3.110	3.316	4.824	4.660	4.840	5.409	5.646	
absolute change	0,00	0,00	0,00	7,57	14,18	11,81	13,81	18,23	25,9	26,6	23,8	22,4	20,6	19,3	16,5	13,4	56,3	-26,5	
relative change	0,00%	0,00%	0,00%	0,14%	0,24%	0,16%	0,26%	0,46%	0,59%	0,61%	0,78%	0,72%	0,62%	0,40%	0,35%	0,28%	1,04%	-0,47%	

In contrast, all **emission factors** remain unrevised compared to last year's susbmission.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2020**, please see the recalculation tables following chapter 8.1 - Recalculations.

[1)] AGEB, 2022: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-1990-bis-2020/?wpv-jahresbereich-bilanz=2011-2020, (Aufruf: 23.11.2021), Köln & Berlin, 2022

[2)] BAFA, 2022: Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöldaten für die Bundesrepublik Deutschland; https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2021_12.xlsx;jsessionid=80E1FD32B36918F682608C03FDE79257.1_cid381?__blob=publicationFile&v=5, Eschborn, 2022.

[3), 4)] Knörr et al. (2022b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2022, Heidelberg, 2022.

[5)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.

[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.