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	2015	2016	2017	2018	2019	2020	2021	2022
DIESEL FUELS	1.95%	0.63%	0.87%	1.13%	1.55%	1.85%	1.80%	1.87%	2.10%	2.34%	2.74%	2.82%	2.49%
GASOLINE FUELS	68.5%	40.3%	44.9%	41.4%	35.5%	33.3%	31.6%	31.9%	35.8%	36.8%	40.3%	40.8%	40.4%

source: own estimates based on TREMOD MM

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

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
Diesel Oil	2,181	620	831	923	1,376	1,913	1,889	1,993	2,171	2,471	2,861	2,996	2,553
Gasoline	3,093	3,005	3,324	3,029	3,600	2,972	2,725	2,687	3,041	3,222	3,518	3,634	3,566
Biodiesel	0	0	0	61.4	108	106	102	109	122	140	234	210	177
Biogasoline	0	0	0	21.0	60.9	120	111	109	132	133	158	171	165
Σ 1.A.4.c ii (ii)	**5,274**	**3,624**	**4,155**	**4,035**	**5,145**	**5,111**	**4,827**	**4,897**	**5,466**	**5,966**	**6,770**	**7,011**	**6,462**

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
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

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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 (i) a revision of the underlying National Energy Balances 2003 to 2021 as well as (ii) strongly revised consumption data for agricultural mobile sources: Here, as the over-all amounts of fuels to be distributed on the different non-road mobile machinery (NRMM) is provided in NEB line 67, the strongly increased AD applied for agricultural mobile sources results in decreased amounts of diesel oil allocatd to both mobile sources in forestry and construction/demolitiion (see chapter on NFR 1.A.2.g vii).

Table 6: Revised annual shares of NEB line 67, in %

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
DIESEL FUELS												
currents submission	0.019	0.006	0.009	0.011	0.016	0.019	0.018	0.019	0.021	0.023	0.027	0.028
previous submission	0.024	0.014	0.022	0.029	0.029	0.029	0.027	0.028	0.033	0.035	0.042	0.043
absolute change	-0.005	-0.007	-0.013	-0.018	-0.014	-0.010	-0.009	-0.009	-0.012	-0.012	-0.014	-0.014
relative change	-19.0%	-53.4%	-59.4%	-60.9%	-46.8%	-35.9%	-33.9%	-32.9%	-37.2%	-33.9%	-33.9%	-33.8%
GASOLINE FUELS												
currents submission	0.685	0.403	0.449	0.414	0.355	0.333	0.316	0.319	0.358	0.368	0.403	0.408
previous submission	0.685	0.403	0.449	0.414	0.355	0.333	0.316	0.319	0.358	0.368	0.403	0.408
absolute change	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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%

Table 5: Revised activity data, in terajoules [TJ]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
DIESEL FUELS												
current submission	2,181	620	831	985	1,484	2,019	1,991	2,102	2,293	2,611	3,095	3,206
previous submission	2,694	1,331	2,048	2,516	2,777	3,088	3,013	3,182	3,586	3,834	4,744	4,836
absolute change	-513	-711	-1,217	-1,531	-1,293	-1,069	-1,021	-1,080	-1,292	-1,223	-1,648	-1,630
relative change	-19.0%	-53.4%	-59.4%	-60.9%	-46.6%	-34.6%	-33.9%	-33.9%	-36.0%	-31.9%	-34.7%	-33.7%
GASOLINE FUELS												
current submission	3,093	3,005	3,324	3,050	3,661	3,092	2,836	2,795	3,173	3,355	3,675	3,805
previous submission	3,093	3,005	3,324	3,050	1,628	1,751	1,660	1,668	1,875	1,781	2,802	2,892
absolute change	0-00	0.00	0.00	0.43	2,033	1,341	1,176	1,128	1,298	1,574	874	913
relative change	0.00%	0.00%	0.00%	0.01%	125%	76.6%	70.9%	67.6%	69.2%	88.4%	31.2%	31.6%
OVER-ALL FUEL CONSUMPTION												
current submission	5,274	3,624	4,155	4,035	5,145	5,111	4,827	4,897	5,466	5,966	6,770	7,011
previous submission	5,787	4,335	5,372	5,565	4,405	4,839	4,673	4,849	5,460	5,614	7,545	7,728
absolute change	-513	-711	-1,217	-1,531	740	272	155	47.8	5.87	352	-775	-717
relative change	-8.86%	-16.4%	-22.7%	-27.5%	16.8%	5.61%	3.31%	0.99%	0.11%	6.27%	-10.3%	-9.28%

In parallel, several **emission factors** have been unrevised within TREMOD MM. Here, the most relevant chang occurs for NMVOC emissions from both the combustion and evaporation of gasoline, where in the last submissions, emission factors for these to emission sources were confused:

NMVOC - exhaust												
current submission	5.819	5.099	5.099	5.320	5.424	2.897	2.897	2.897	2.897	2.901	2.910	2.915
previous submission	3,04	6,37	4,67	4,56	4,83	5,00	5,32	5,19	4,30	4,07	3,46	3,35
absolute change	5.816	5.093	5.095	5.315	5.419	2.892	2.891	2.891	2.892	2.897	2.906	2.911
relative change	191252%	79896%	109105%	116590%	112275%	57870%	54306%	55658%	67186%	71102%	84115%	86914%
NMVOC - evaporation												
current submission	3,04	6,37	4,67	4,56	4,83	5,00	5,32	5,19	4,30	4,03	3,46	3,35
previous submission	5.819	5.099	5.099	5.320	5.424	2.897	2.897	2.897	2.897	2.901	2.910	2.915
absolute change	-5.816	-5.093	-5.095	-5.315	-5.419	-2.892	-2.891	-2.891	-2.892	-2.897	-2.906	-2.911
relative change	-99,9%	-99,9%	-99,9%	-99,9%	-99,9%	-99,8%	-99,8%	-99,8%	-99,9%	-99,9%	-99,9%	-99,9%

For **pollutant-specific information on recalculated emission estimates for Base Year and 2021**, please see the recalculation tables following chapter 8.1 - Recalculations.

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[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.