

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 (a)	Off-road Vehicles and Other Machinery: Agriculture	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, 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	2019
Diesel Oil	53.263	44.622	41.696	37.942	42.024	42.864	42.137	44.531	46.259	48.905	51.027	52.561	49.009	49.591
Biodiesel	0	0	0	2.424	3.222	2.991	2.974	2.641	2.843	2.675	2.705	2.806	2.849	2.824
Gasoline	53.263	44.622	41.696	37.942	42.024	42.864	42.137	44.531	46.259	48.905	51.027	52.561	49.009	49.591
Biogasoline	0	0	0	2.424	3.222	2.991	2.974	2.641	2.843	2.675	2.705	2.806	2.849	2.824
Σ 1.A.4.c ii (ii)	53.263	44.622	41.696	40.366	45.246	45.855	45.111	47.172	49.102	51.580	53.732	55.367	51.858	52.415

++ 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))⁵⁾ are used, representing the development of mitigation technologies and the effect of fuel-quality legislation.

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

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gasoline fuels														
NH₃	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	
NMVO²	77.8	74.8	82.3	101	106	106	106	106	106	106	106	106	106	
NMVO³	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	
BC⁵	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	
PM⁴	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	
TSP⁶	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														
NH₃	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	
NMVO	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	
BC⁵	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	
PM⁴	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 PM₁₀ and TSP (assumption: > 99% of TSP consists of PM_{2.5})

⁵ estimated via a f-BCs as provided in ⁶⁾, 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 (NH₃, 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, SO₂)

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}, PM₁₀, 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 submission, 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](#).

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+ 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 Mineralöl-daten 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: <http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer-bibliography>

¹⁾ (bibcite 1)

²⁾ (bibcite 2)

³⁾ (bibcite 3)

⁴⁾ (bibcite 3)

⁵⁾ (bibcite 3)

⁶⁾ (bibcite 3)

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During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likelihood of condensation. So over-all condensables are very likely to occur but different to real-world conditions.