1.A.4.c ii - Agriculture/Forestry/Fishing: Off-Road Vehicles and Other Machinery

Short description

Under sub-category *1.A.4.c ii - Agriculture/Forestry/Fishing: Off-road Vehicles and other Machinery* fuel combustion activities and resulting emissions from off-road vehicles and machinery used in agriculture and forestry are reported seperately.

image traktor.PNG size="small"

NFR-Code	Source category	Method	AD	EF	Key Category Analysis					
1.A.4.c ii	Agriculture/Forestry/Fishing: Off-Road Vehicles and Other Machinery	T1, T2	NS, M	CS, D, M	**L & T**: BC / **L**: NO,,x,,, PM,,2.5,,, PM,,10,,					
including mobile sources sub-categories										
1.A.4.c ii (a)	Off-road Vehicles and Other Machinery: Agriculture]	T1, T2	NS, M	CS, D, M	-					
1.A.4.c ii (b)	Off-road Vehicles and Other Machinery: Forestry]		= T1, T2		= NS, M		= CS, D, M		= -	

Methodology

Activity data

Sector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2019) [1].

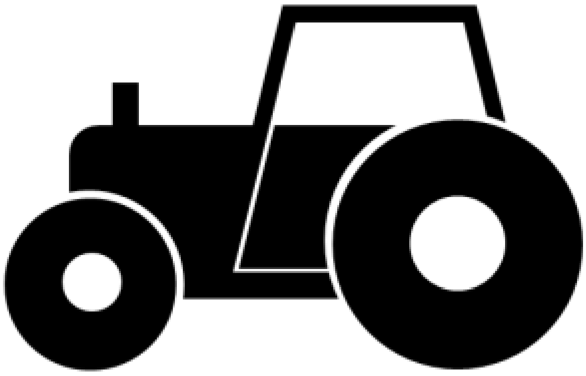

Table 1: Sources for primary fuel-delivery data

through 1994	**AGEB** - National Energy Balance, line 79: 'Haushalte und Kleinverbraucher insgesamt'
as of 1995	**AGEB** - National Energy Balance, line 67: 'Gewerbe, Handel, Dienstleistungen u. übrige Verbraucher'

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2019) [2)], the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and commercial/institutional used off-road vehicles (1.A.4.a 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]).

To provide more specific information on mobile sources in agriculture and forestry, the inventory compiler further devides NFR sector 1.A.4.c ii into **1.A.4.c ii (i) - NRMM in agriculture** in and **1.A.4.c ii (ii) - NRMM in forestry**.

Table 2: Annual percentual contribution of NFR 1.A.4.c ii 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														
1.A.4.c ii (i)														
1.A.4.c ii (ii)														
Gasoline fuels [1]														
1.A.4.c ii (ii)														

source: own estimations based on Knörr et al. (2019b) [4)] [1] no gasoline used in agriculatural vehicles and mobile machinery

Table 3: Annual mobile fuel consumption in agriculture and forestry, in terajoules

	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Diesel oil														
Biodiesel														
Gasoline														
Biogasoline														
Σ 1.A.4.b ii														

gallery size="medium" : 1A4cii_AD.png : 1A4cii_AD_bio.png gallery

Emission factors

The emission factors applied here are of rather different quality:

Basically, for all **main pollutants**, **carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM [5)] are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

> For Information on the country-specific implied emission factors applied to mobile machinery in agriculture and forestry, please refer to the respective sub-chapters linked above.
>
> 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].

[!–

Regarding heavy metal and POP emissions, with no country-specific values at hand, tier1 EF have been derived from tier1 defaults provided in the EMEP/EEA air pollutant emission inventory guidebook 2019 (EMEP/EEA, 2016) [6)].

In contrast, without country-specific information, regarding all **heavy metals** and **POPs**, tier1 values are applied. Here, EF for exhaust HMs and PAHs have been derived from the EMEP/EEA air pollutant emission inventory guidebook 2019 (EMEP/EEA, 2019) [7)] for road vehicles (chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv Passenger cars, light commercial trucks, heavy-duty vehicles including buses and motor cycles; page: 92 ff). Regarding heavy metals, separate tier1 default EFs are provided there in tables 3.77 and 3.78 for emissions from fuel combustion and engine wear as well as lubricant co-incineration. Heavy-metal emissions from lubricants (as far as not used in 2-stroke mix) are reported under NFR 2.G as emissions from product use. *(Note: Until submission 2017, the EMEP/EEA default EFs provided for NRMM were used in the German inventory. As these EFs do not differentiate between fuel combustion and lubricant co-incineration, the inventory compiler decided to apply the more specific EFs from road transport to NRMM in 1.A.2.g vii, 1.A.4.a ii, b ii and c ii as well as 1.A.5.b, too.)*

The tier1 value applied for **PCDD/F** has been derived from a study carried out by (Rentz et al., 2008) [8)] for the German Federal Environment Agency.

Table 4: Tier1 emission factors for heayv-metal and POP exhaust emissions from fuel combustion and engine wear

=	= **Pb**	= **Cd**	= **Hg**	= **As**	= **Cr**	= **Cu**	= **Ni**	= **Se**	= **Zn**	= **B[a]P**	= **B[b]F**	= **B[k]F**	= **I[...]P**	= **PAH 1-4**	= **PCDD/F**				
=									= [g/TJ]					= [mg/TJ]	= [µg/TJ]				
~ Diesel oil	> 0.012	> 0.0012	> 0.123	> 0.0023	> 0.198	> 0.133	> 0.005	> 0.002	> 0.419	> 498	> 521	> 275	> 493	> 1.788	> 1.62				
~ Biodiesel	> 0.013	> 0.0013	> 0.142	> 0.0027	> 0.228	> 0.153	> 0.005	> 0.003	> 0.483	> 575	> 601	> 317	> 569	> 2.062	> 1.62				
~ 2-stroke mix	**1**		> 0.051	> 2.0990	> 0.196	> 0.0068	> 8.961	> 357.449	> 14.699	> 2.090	> 207.527	> 919	> 919	> 90	> 204	> 2.131		> 57.50	
1																			

For **HCB** and **PCBs**, no emission factors are available at the moment.

Due to the separate reporting of mobile fuel combustion in agriculture and forestry as well as the differentiation into 2- and 4-stroke gasoline engines, a broad set of emission factors is applied here. For further information on the tier1 default EF as well as annual IEF modelled in TREMOD-MM please refer to the sub-chapters linked above. Here, as no such specific EF are available for biofuels, the values used for diesel oil and gasoline are applied to biodiesel and bio-ethanol, too.

–]

Discussion of emission trends

> **NFR 1.A.4.c ii** is key source for emissions of **NO,,x,,**, **BC**, **PM,,2.5,,** and **PM,,10,,**.

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

gallery size="medium" : 1A4cii_EM_NH3.PNG gallery

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

++ Regulated pollutants

+++ Nitrogen oxides (NO,,x,,), Sulphur dioxide (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" : 1A4cii_EM_NOx.PNG : 1A4cii_EM_SOx.PNG gallery

+++ Particulate matter (Black Carbon, 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" : 1A4cii_EM_PM.PNG gallery

+++ Heavy-matel emissions: Cadmium

gallery size="medium" : 1A4cii_EM_Cd.PNG gallery

As all other heavy-metal and POP emissions, emissions of cadmium for this NFR category are calculated based on default EF from [9].

Here, the extreme steps in emission estimates result from two effects:

(i) the annual amounts of gasoline fuels allocated to NFR 1.A.4.c ii depend on the amounts delivered to the military also covered in NEB line 67. (see superordinate chapter] for further information). This approach results in strong declines in gasoline consumption after 2007 and 2011 followed by an increase after 2014.

gallery size="medium" : 1A4cii_AD_OK.png gallery

Table: Development of gasoline consumption in NFR 1.A.4.c ii, in terajoules

	= **2010**	= **2011**	= **2012**	= **2013**	= **2014**	= **2015**	= **2016**	= **2017**	= **2018**
~ Gasoline	> 1,563	> 1,425	> 399	> 391	> 421	> 1,698	> 1,615	> 1,631	> 1,592
~ Biogasoline	> 60	> 58	> 18	> 17	> 18	> 74	> 70	> 68	> 72

(ii) All gasoline fuels allocated to NFR 1.A.4.c ii are used in 2-stroke-engines in forestry equipment. As the 2-stroke fuel also includes lubricant oil, the fuel's heavy metal content is significantly higher than that of 4-stroke gasoline (or diesel fuels). (see Appendix 2.3] for more information on the reporting of HM emissions.)

Table: Tier1 default emission factors applied to NRMM, in g/TJ

=	= **Pb**	= **Cd**	= **Hg**	= **As**	= **Cr**	= **Cu**	= **Ni**	= **Se**	= **Zn**		
~ Diesel oil	> 0.012	> 0.001	> 0.123	> 0.002	> 0.198	> 0.133	> 0.005	> 0.002	> 0.419		
~ Biodiesel	**1**		> 0.013	> 0.001	> 0.142	> 0.003	> 0.228	> 0.153	> 0.005	> 0.003	> 0.483
~ Gasoline fuels - 4-stroke	> 0.037	> 0.005	> 0.200	> 0.007	> 0.145	> 0.103	> 0.053	> 0.005	> 0.758		
~ Gasoline fuels - 2-stroke	**2**		> 0.051	> 2.10	> 0.196	> 0.007	> **8.96**	> 357	> 14.7	> 2.09	> 208
~ LPG (1.A.4.a ii only)	= NE	= NE	= NE	= NE	= NE	= NE	= NE	= NE	= NE		
1											
2											

Hence, emission estimates reported for cadmium are significantly higher for years with higher gasoline use (in 2-stroke enignes).

Recalculations

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

Table 6: Revised activity data 2015-2017, in terajoules

	= **2015**	= **2016**	= **2017**
= **diesel fuels**			
~ Submission 2020	> 57,036	> 59,309	> 61,176
~ Submission 2019	> 57,034	> 59,306	> 60,819
~ absolute change	> 1.97	> 2.31	> 357
~ 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	> 58.808	> 60,994	> 62,876
~ Submission 2019	> 58.806	> 60,992	> 62,790
~ absolute change	> 1.94	> 2.28	> 86.3
~ relative change	> 0.003%	> 0.004%	> 0.14%

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 pollutant-specific information on recalculated emission estimates for Base Year and 2018, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations.

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by (Knörr et al. (2009)) [10].

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

Planned improvements

Besides a **routine revision of TREMOD MM**, no specific improvements are planned.

FAQs

Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?

The EF provided in [11] represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

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: 29.11.2019), 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_2018_dezember.html, Eschborn, 2019. : 3 : Knörr et al. (2019b): 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) 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 : 6 : Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf, FKZ 360 16 023, Heidelberg & Zürich, 2009. bibliography

[1] (bibcite 1)
[2] (bibcite 2)
[3] (bibcite 3)
[4] (bibcite 3)
[5] (bibcite 3)
[6] (bibcite 4)
[7] (bibcite 4)
[8] (bibcite 5)
[9] (bibcite 4)
[10] (bibcite 6)
[11] (bibcite 4)