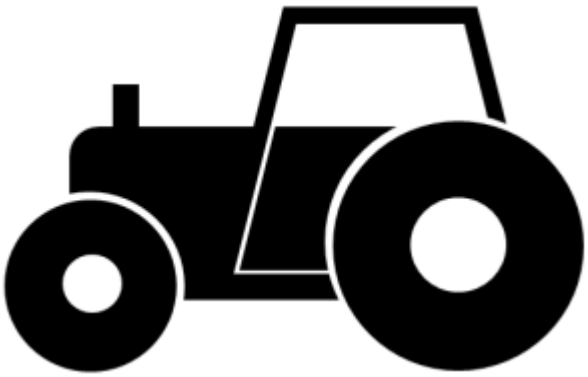
1.A.4.c ii (a) - Off-road Vehicles and other Machinery: Agriculture

Short description

Under sub-category *1.A.4.c ii (a)* fuel combustion activities and resulting emissions from agricultural off-road vehicles and mobile machinery 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

Subsector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2020) [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, 2020) [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. (2020b) [3)] (cf. NFR 1.A.4 - mobile).

Table 2: Annual contribution of agricultural vehicles and mobile machinery to the primary diesel[1] fuels delivery data provided in NEB line 67

1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
47,6%	45,6%	43,9%	46,2%	47,5%	47,2%	47,3%	48,0%	47,8%	48,3%	48,5%	48,5%	48,4%	48,4%

[1] no gasoline used in agricultural vehicles and mobile machinery

Table 3: Annual mobile fuel consumption in agriculture, 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

Σ 1.A.4.c ii (i)	**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 applied here are of rather different quality: For all **main pollutants**, **carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM [4)] are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

Table 3: Annual country-specific emission factors[1], in kg/TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
NH_3	0,153	0,156	0,159	0,162	0,163	0,164	0,164	0,164	0,164	0,164	0,164	0,164	0,165	0,165
NMVOC	258	232	205	165	124	118	112	106	100	93,8	88,6	83,8	79,1	74,8
NO_x	874	886	916	832	682	655	629	605	581	560	541	523	506	490
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
BC[3]	125,1	109,4	93,1	74,7	57,4	54,8	52,4	50,1	47,4	44,8	42,2	39,8	37,5	35,3
PM[2]	229	201	171	134	97,1	91,5	86,2	81,5	76,3	71,4	66,9	62,7	58,6	54,9
CO	882	834	779	674	555	536	518	502	484	468	453	441	428	416

[1] due to lack of better information: similar EF are applied for fossil and biofuels
[2] EF($PM_{2.5}$) also applied for PM_{10} and TSP (assumption: > 99% of TSP consists of $PM_{2.5}$)
[3] 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

> **NOTE:** With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. 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.
>
> 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 slightly adapted EBZ67 shares as well as the implementation of primary activity data from the now finalised NEB 2019.

Table 5: Revised annual contribution of 1.A.2.g vii to fuel-specific over-all fuel deliveries provided in NEB line 67

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018
Submission 2021	0,476	0,456	0,439	0,462	0,475	0,472	0,473	0,480	0,478	0,483	0,485	0,485	0,484
Submission 2020	0,484	0,467	0,468	0,501	0,509	0,506	0,506	0,505	0,503	0,507	0,510	0,511	0,512
absolute change	-0,008	-0,011	-0,030	-0,038	-0,034	-0,034	-0,033	-0,024	-0,025	-0,025	-0,025	-0,025	-0,028
relative change	-1,62%	-2,30%	-6,33%	-7,66%	-6,75%	-6,65%	-6,47%	-4,80%	-4,98%	-4,87%	-5,00%	-4,97%	-5,52%

Table 6: Resulting revised activity data, in terajoules

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018
Submission 2021	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
Submission 2020	54.142	45.674	44.513	41.905	47.980	48.928	47.989	49.482	51.634	54.190	56.531	58.245	54.553
absolute change	-878	-1.053	-2.817	-1.538	-2.734	-3.073	-2.878	-2.311	-2.533	-2.610	-2.799	-2.878	-2.695
relative change	-1,62%	-2,30%	-6,33%	-3,67%	-5,70%	-6,28%	-6,00%	-4,67%	-4,91%	-4,82%	-4,95%	-4,94%	-4,94%

In addition, several **emission factors** have been revised within TREMOD MM.

Table 7: Revised annual implied emission factors (IEF), in [kg/T]

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ammonia													
Submission 2021	0,153	0,156	0,159	0,162	0,163	0,164	0,164	0,164	0,164	0,164	0,164	0,164	0,165
Submission 2020	0,152	0,155	0,158	0,160	0,163	0,163	0,163	0,163	0,164	0,164	0,164	0,164	0,164
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
relative change	0,35%	0,62%	0,88%	1,05%	0,56%	0,50%	0,43%	0,34%	0,29%	0,24%	0,19%	0,17%	0,13%
NMVOC													
Submission 2021	258	232	205	165	124	118	112	106	100	94	89	84	79
Submission 2020	261	237	216	182	139	132	126	119	112	105	99	93	88
absolute change	-3,31	-5,53	-10,80	-16,58	-14,89	-14,78	-14,31	-12,68	-11,94	-11,11	-10,10	-9,52	-8,94
relative change	-1,27%	-2,33%	-5,01%	-9,13%	-10,72%	-11,16%	-11,37%	-10,69%	-10,70%	-10,58%	-10,23%	-10,20%	-10,15%
Nitrogen oxides													
Submission 2021	874	886	916	832	682	655	629	605	581	560	541	523	506
Submission 2020	869	887	917	846	713	686	660	632	604	575	544	514	487
absolute change	4,90	-1,57	-1,06	-14,27	-31,05	-31,00	-30,70	-26,64	-22,57	-14,33	-2,54	8,58	18,80
relative change	0,56%	-0,18%	-0,12%	-1,69%	-4,35%	-4,52%	-4,65%	-4,21%	-3,74%	-2,49%	-0,47%	1,67%	3,86%
Black Carbon													
Submission 2021	125,1	109,4	93,1	74,7	57,4	54,8	52,4	50,1	47,4	44,8	42,2	39,8	37,5
Submission 2020	129,7	114,9	100,5	84,6	63,9	61,3	58,6	55,6	52,4	49,3	46,3	43,8	41,2
absolute change	-4,68	-5,54	-7,40	-9,84	-6,50	-6,57	-6,28	-5,50	-5,01	-4,52	-4,10	-3,93	-3,73
relative change	-3,61%	-4,82%	-7,36%	-11,63%	-10,17%	-10,71%	-10,71%	-9,89%	-9,55%	-9,17%	-8,86%	-8,99%	-9,06%
Particulate Matter (PM)													
Submission 2021	229	201	171	134	97,1	91,5	86,2	81,5	76,3	71,4	66,9	62,7	58,6
Submission 2020	238	211	184	152	110	105,0	99,4	93,4	87,5	81,8	76,5	72,0	67,5
absolute change	-8,46	-9,99	-13,49	-18,45	-13,39	-13,58	-13,21	-11,92	-11,17	-10,40	-9,64	-9,31	-8,90
relative change	-3,56%	-4,74%	-7,32%	-12,14%	-12,12%	-12,93%	-13,29%	-12,76%	-12,77%	-12,70%	-12,59%	-12,94%	-13,18%
Carbon monoxide													
Submission 2021	882	834	779	674	555	536	518	502	484	468	453	441	428
Submission 2020	896	853	813	723	603	584	564	543	522	504	486	471	457
absolute change	-14,42	-19,03	-33,83	-48,66	-48,03	-47,51	-46,06	-40,75	-38,52	-36,09	-32,91	-30,70	-28,62
relative change	-1,61%	-2,23%	-4,16%	-6,73%	-7,96%	-8,14%	-8,16%	-7,51%	-7,37%	-7,17%	-6,77%	-6,51%	-6,27%

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

Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

[1)] AGEB, 2020: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; URL: http://www.ag-energiebilanzen.de/7-0-Bilanzen-1990-2018.html, (Aufruf: 29.11.2020), Köln & Berlin, 2020.
[2)] BAFA, 2020: 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, 2020.
[3), 4)] Knörr et al. (2020b): 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) 2020, Heidelberg, 2020.
[5)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.