1.A.3.a ii (ii) - Domestic Civil Aviation: Cruise

Short description

Category Code	Method					AD					EF				
1.A.3.a ii (ii)	T1, T2, T3					NS, M					CS, D, M				
Key Category	**SO_2**	**NO_x**	**NH_3**	**NMVOC**	**CO**	**BC**	**Pb**	**Hg**	**Cd**	**Diox**	**PAH**	**HCB**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
1.A.3.a ii (ii)	*not included in key category analysis*														

In NFR category *1.A.3.a ii (ii) - Domestic Civil Aviation: Cruise* emissions from domestic flights between German airports during cruise stage (above 3,000 feet of altitude) are reported.

In the following, information on sub-category specific activity data, (implied) emission factors and emission estimates are provided.

Methodology

Actitvity Data

Specific fuel consumption during LTO-stage is calculated within TREMOD AV as described in the superordinate chapter.

Table 1: annual jet kerosene & avgas consumption during cruise-stage, in terajoules

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Kerosene	21,690	19,937	25,301	24,071	24,736	25,337	25,111	24,048	22,503	20,552	21,026	19,762	19,038	19,195	20,067	20,793	21,067	21,672	10,114
Avgas	1,681	805	779	472	437	408	432	404	382	440	398	354	343	393	322	320	310	256	170

source: Knörr et al. (2020c) [1)] & Gores (2020) [2)]

Emission factors

All country specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 [3)] and have since then been compiled, revised and maintained in TREMOD AV [4)].

For more information, please see the superordinate chapter on civil aviation.

Table 2: Annual country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JET KEROSENE																			
NH_3	3.98	3.95	3.95	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
NMVOC	14.4	16.00	16.60	18.92	19.93	20.39	20.59	20.33	19.87	19.90	20.23	21.67	22.75	22.03	17.67	18.05	17.67	19.39	26.13
NO_x	337	375	348	340	341	347	358	368	374	376	381	383	381	386	397	400	396	396	370
SO_x	19.7	19.5	19.5	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
BC	1.82	2.15	2.00	2.20	2.28	2.23	1.98	1.97	2.02	2.00	2.02	2.02	1.95	2.05	1.95	1.99	2.18	2.13	2.66
PM	3.80	4.48	4.16	4.58	4.75	4.65	4.13	4.11	4.22	4.17	4.20	4.21	4.07	4.27	4.06	4.15	4.54	4.45	5.55
CO	147	149	186	203	203	203	204	202	197	197	201	212	219	214	154	151	152	159	241
AVGAS																			
NH_3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	549	559	545	551	550	548	549	551	548	558	557	557	556	555	557	552	561	579	580
NO_x	132	134	130	132	131	130	131	131	130	134	133	134	133	132	133.2	130.4	134.7	142.5	143.5
SO_x	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
BC	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.43	0.42	0.42	0.42
PM	2.78	2.81	2.78	2.80	2.80	2.81	2.80	2.81	2.81	2.82	2.83	2.82	2.83	2.83	2.82	2.85	2.83	2.80	2.79
TSP	17.9	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
CO	21,184	21,581	21,324	21,543	21,663	21,780	21,630	21,761	21,850	21,864	21,979	21,921	22,002	22,097	21,979	22,459	21,962	21,040	20,928

[1] EF(TSP) also applied for PM_{10} and $PM_{2.5}$ (assumption: > 99% of TSP consists of $PM_{2.5}$)

[2] estimated via a f-BC of 0.48 as provided in [5)], Chapter: 1.A.3.a, 1.A.5.b Aviation, page 49: “Conclusion”.

For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

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.

Trend discussion for Key Sources

NFR 1.A.3.a ii (ii) - Domestic Civil Aviation - Cruise is **not included in the national emission totals** and hence **not included in the key category analysis**.

Recalculations

Activity data have been revised for all years within TREMOD AV to keep in line with information available from Eurocontrol's AEM model [6)].

Furthermore, for the first time, the use of aviation gasoline (avgas) for international flights has been estimated. These amounts have been re-allocated from NFR 1.A.3.a ii (i), where 100% of avgas consumption has been allocated so far.

Table 3: Revised annual fuel consumption in 1.A.3.a ii (ii), in terajoules

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
JET KEROSENE																	
Submission 2021	21.690	19.937	25.301	24.071	24.736	25.337	25.111	24.048	22.503	20.552	21.026	19.762	19.038	19.195	20.067	20.793	21.067
Submission 2020	20.024	20.875	22.967	21.565	22.122	22.904	23.145	21.771	21.579	21.776	20.673	18.717	19.614	19.730	19.746	19.074	19.178
absolute change	1.667	-938	2.334	2.505	2.615	2.433	1.966	2.277	923	-1.224	354	1.045	-576	-535	321	1.719	1.888
relative change	8,32%	-4,49%	10,16%	11,62%	11,82%	10,62%	8,49%	10,46%	4,28%	-5,62%	1,71%	5,58%	-2,94%	-2,71%	1,63%	9,01%	9,85%
AVGAS																	
Submission 2021	1.580	614	614	291	260	228	259	244	237	283	246	199	180	233	145	142	116
Submission 2020	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
absolute change	1.580	614	614	291	260	228	259	244	237	283	246	199	180	233	145	142	116

In parallel, the majority of **country-specific emission factors** has been revised within TREMOD AV based on information available from Eurocontrol's AEM model [7)].

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

Uncertainties

For uncertainties information, please see the main chapter on civil aviation.

Planned improvements

For information on planned improvements, please see the main chapter on civil aviation.

[1), 4)] Knörr et al. (2020c): Knörr, W., Schacht, A., & Gores, S.: TREMOD Aviation (TREMOD AV) 2018 - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Heidelberg, Berlin: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., Berlin & Heidelberg, 2020.
[2)] Gores (2020): Inventartool zum deutschen Flugverkehrsinventar 1990-2018, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2020.
[3)] Knörr, W., Schacht, A., & Gores, S. (2010): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV) : Endbericht. Endbericht zum F+E-Vorhaben 360 16 029, URL: https://www.umweltbundesamt.de/publikationen/entwicklung-eines-modells-zur-berechnung; Berlin & Heidelberg, 2012.
[5)] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019, https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation/view; Copenhagen, 2019.
[6), 7)] Eurocontrol (2020): Advanced emission model (AEM); https://www.eurocontrol.int/model/advanced-emission-model; 2020.