1.A.3.a i (i) - Internatinal Civil Aviation: LTO

Short description

In NFR category *1.A.3.a i (i) - Internatinal Civil Aviation: LTO* emissions during LTO stage (Landing/Take-off: 0-3,000 feet) are reported. In the following, information on sub-category specific AD, (implied) emission factors and emission estimates are provided.

Category Code	Method					AD					EF				
1.A.3.a.i.(i)	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.i.(i)	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-	-/-	-	-/-	-/-	-/-

T = key source by Trend **L** = key source by Level

Methods	
D	Default
RA	Reference Approach
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model
* as described in the EMEP/CORINAIR Emission Inventory Guidebook - 2007, in the group specific chapters.	

AD - Data Source for Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific data
AS	Associations, business organisations
Q	specific questionnaires, surveys

EF - Emission Factors	
D	Default (EMEP Guidebook)
C	Confidential
CS	Country Specific
PS	Plant Specific data

Methodology

Actitvity Data

Specific jet kerosene consumption during LTO-stage is calculated within TREMOD AV as described in the main chapter on civil aviation.

Table 1: Percentual annual fuel consumption during LTO-stage of international flights

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Jet Kerosene	8,17	7,80	8,19	8,00	7,97	7,95	7,91	7,86	7,90	7,81	7,92	7,98	7,98	8,09	8,11	8,13	8,18	8,15
Aviation Gasoline	5,24	11,8	11,1	19,1	20,5	23,2	20,4	20,2	19,8	17,3	19,1	22,2	26,3	20,8	42,2	43,7	51,4	61,6

source: Knörr et al. (2019c) [1)] &: Gores (2019) [2)]

Table 2: annual LTO fuel consumption for international flights, in terajoule

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Jet Kerosene	13.252	16.012	21.465	24.860	26.063	26.992	27.184	26.249	26.115	24.796	27.036	27.726	26.778	27.115	29.304	32.205	33.340	32.948
Aviation Gasoline	25,7	21,6	21,5	21,7	22,5	23,2	21,1	19,2	19,0	14,3	14,3	13,9	14,2	15,3	11,8	12,5	12,8	10,5

source: Knörr et al. (2019c) [3)] &: Gores (2019) [4)]

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Emission factors

All country specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 (Knörr, W., Schacht, A., & Gores, S. (2010)) [5)] and have since then been compiled, revised and maintained in TREMOD AV [6)].

For more information, please see 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
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
NMVOC	59,7	36,11	25,68	22,88	22,86	22,46	22,02	21,16	21,23	20,77	20,46	20,30	19,88	20,48	20,25	20,77	21,43	20,69
NO_x	297	306	303	324	325	330	331	338	342	345	346	349	353	352	357	358	355	357
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
BC[1]	1,78	1,63	1,45	1,37	1,33	1,28	1,25	1,23	1,21	1,20	1,18	1,17	1,15	1,14	1,13	1,12	1,12	1,10
PM[2]	3,71	3,40	3,02	2,86	2,76	2,66	2,60	2,56	2,52	2,49	2,46	2,44	2,40	2,38	2,35	2,33	2,33	2,30
CO	249	227	236	219	217	211	209	203	203	199	199	197	194	196	192	192	195	192
AVIATION GASOLINE																		
NH_3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	459	484	466	469	455	456	460	475	470	521	514	515	521	514	495	494	528	548
NO_x	73,1	68,7	71,7	71,7	73,6	71,5	70,6	66,4	66,1	56,0	55,9	57,6	60,1	55,9	53,7	53,3	52,5	56,0
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
BC[1]	9,05	9,59	9,33	9,59	9,21	9,48	9,44	10,2	10,3	11,0	11,0	10,9	10,4	11,3	11,3	11,0	11,9	11,2
PM[2]	60,3	64,0	62,2	64,0	61,4	63,2	63,0	67,8	68,6	73,5	73,4	72,7	69,2	75,5	75,6	73,4	79,1	74,5
TSP[3]	75,5	79,1	77,4	79,1	76,6	78,4	78,1	83,0	83,8	88,7	88,5	87,9	84,3	90,7	90,8	88,5	94,3	89,6
CO	20.188	20.764	20.440	20.152	20.057	20.400	20.612	21.105	21.199	22.662	22.769	22.422	22.168	22.650	23.205	23.427	23.210	22.827

[1] estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in [7)]
[2] EF(PM,,2.5,,) also applied for PM,,10,, and TSP (assumption: > 99% of TSP from diesel oil combustion consists of PM,,2.5,,)
[3] also including TSP from lead: EF(TSP) = 1.6 x EF(Pb) - see road transport

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

Discussion of emission trends

> NFR 1.A.3.a i (i) - International Civil Aviation - LTO is **no key category**.

Recalculations

As mentioned in the superordinate chapter on 1.A.3.a, the LTO fuel consumptions applied in TREMOD AV have been adapted to the the EMERP/EEA Guidebook 2019. [8)]

Hence, the percentual annual shares of kerosene consumed during L/TO for international flights have been re-estimated...

Table 3: Revised percentual share of kerosene consumed during L/TO for international flights, in %

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	

... and the amounts of kerosene allocated to sub-category 1.A.3.a i (i) were revised accordingly:

Table 4: Revised kerosene usage in 1.A.3.a i (i), in terajoules

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	

In parallel, the majority of **country-specific emission factors** has been revised within TREMOD AV based on information available from the 2019 EMEP/EEA Guidebook [9)] and Eurocontrol's AEM model [10)].

Here, among others, the EF for SO,,2,, from jet kerosene has been replaced by new and more reliable data showing no sulphur reduction since 1990.

Table 5: Revised country-specific emission factors applied for jet kerosene

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NON-METHANE VOLATILE ORGANIC COMPUNDS - NMVOC																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
NITROGEN OXIDES																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
SULPHUR OXIDES																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
BLACK CARBON - BC																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
PARTICULATE MATTER - PM																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
CARBON MONOXIDE - CO																	
Submission 2021																	
Submission 2020																	

absolute change																	
relative change																	

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 main chapter on civil aviation.

Planned improvements

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

FAQs

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bibliography : 1 : 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. : 2 : Knörr et al. (2019c): Knörr, W., Schacht, A., & Gores, S.: TREMOD Aviation (TREMOD AV) 2019 - 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, 2019. : 3 : Gores (2019): Inventartool zum deutschen Flugverkehrsinventar 1990-2018, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2019. : 4 : 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. : 5 : Eurocontrol (2019): Advanced emission model (AEM); https://www.eurocontrol.int/model/advanced-emission-model; 2019
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[1)] (bibcite 2)
[2)] (bibcite 3)
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[4)] (bibcite 3)
[5)] (bibcite 1)
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[7)] (bibcite 4)
[8)] (bibcite 4)
[9)] (bibcite 4)
[10)] (bibcite 5)