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

Short description

In NFR category *1.A.3.a ii (i) - Domestic Civil Aviation: LTO* emissions from domestic flights between German airports occuring during LTO stage (Landing/Take-off: 0-3,000 feet) are reported.

Method AD EF Key C	Category
T1, T2, T3 NS, M CS, D, M <i>no key</i>	/ category
T = key source by Trend L = key	y source by Level
Methods	
D	Default
RA	Reference Approach
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
Т3	Tier 3 / Detailed Methodology *
С	CORINAIR
CS	Country Specific
Μ	Model
	INAIR 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 organ	
Q specific questionnaires, surv	/eys
EF - Emission Factors	
D Default (EMEP Guidebook)	
C Confidential	
CS Country Specific	
PS Plant Specific data	

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

Methodology

Actitvity Data

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

Table 1: Percentual annual fuel consumption	on during LTO-stage of domestic flights	_
•		

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Jet Kerosene																		
Aviation Gasoline																		

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

As explained above, the use of aviation gasoline is - due to a lack of further information - assumed to entirely take place within the LTO-range.

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

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Jet Kerosene																		
Aviation Gasoline																		

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

gallery size="medium" : 1A3aii(i)_AD.png gallery

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 $^{6)}$.

Furthermore, the **newly implemented EF(BC)** have been estimated via f-BCs as provided in the 2019 EMEP/EEA Guidebook ⁷⁾, Chapter 1.A.3.a, 1.A.5.b Aviation, page 49: "Conclusion".

For more details, please see superordinate chapter on civil aviation.

Table 3: Country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
JET KER	OSEN	E												
NH ₃														
ΝΜΥΟΟ														
NO _x														
SO _x														
BC ¹														
PM ²														
СО														
Ανιατια	N GA	SOLIN	İE											

NH₃ NMVOC							
NMVOC							
NO _x							
SO _x							
BC ¹							
PM ²							
NO _x SO _x BC ¹ PM ² TSP ³ CO							
CO							

¹ estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in ⁸⁾

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: $EF(TSP) = 1.6 \times EF(Pb)$ - see road transport



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

	= 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/٦					= [mg/TJ]	=		
~ Kerosene	= NE	= NE	= NE	= NE = NE	= NE												
~ Aviation gasoline	> 9,48	1		> 0.005	> 0.200	> 0.007	> 0.145	> 0.103	> 0.053	> 0.005	> 0.758	> 126	> 182	> 90	> 205	> 602	= NE
1																	

Table 4: Tier1 emission factors for heavy-metal and POP exhaust emissions

NFR 1.A.3.a ii (i) - Domestic Civil Aviation - LTO is no key source.

Where **sulphur oxides** emissions are dominated by jet kerosene due to the amount of fuel used, the majority of **carbon monoxide** stems from the consumption of avgas given the much higher emission factor applied to this fuel.

gallery size="medium" : 1A3aii(i)_SOx.png : 1A3aii(i)_CO.png gallery

Lead emissions on the other hand, with no emission factor available for jet kerosene, are only calculated for avgas.

gallery size="medium" : 1A3aii(i)_Pb.png gallery

Recalculations

Activity data

In order to keep in line with the EMEP/EEA Guidebook 2019 and the regularly updated data sets provided to the EEA by Eurocontrol, the average fuel use per LTO cycle has been updated again within TREMOD Aviation but with much smaller impact as in last year's submission.

Resulting from this revision, the percentual shares of kerosene consumed during LTO within TREMOD AV have been recalculated as shown in Table 4.

Table 4: Revised percentual share of kerosene consumed during L/TO for domestic 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																	

Hence, the amount of kerosene allocated to sub-category 1.A.3.a ii (i) had to be revised accordingly:

Table 5: Revised fuel consumption data, in terajoule

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
JET KEROSENE																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
AVIATION GASOLINE																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
TOTAL FUEL CONSUMPTION																	
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.

Furthermore, all EF applied for aviation gasoline have been revised widely based on better knowlegde but with no significant impact on the emission inventory.

Table 6: Revised country-specific emission factors for jet kerosene, in [kg/T]]

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018					
Non-methane volatile organic compounds - NMVOC																						
Submission 2021																						
Submission 2020																						
absolute change																						
relative change																						
Nitrogen oxides - NO,,x,,																						
Submission 2021																						
Submission 2020																						
absolute change																						
relative change																						
Sulphur oxides - SO,,x,,																						
Submission 2021																						
Submission 2020																						
absolute change																						
relative change																						
Particulate Ma	atter	- PM (PM,,2.	5,, = F	PM,,10	,, = TS	5P)					^ S	ubmis	sion 2	2021					Ι		II
Particulate Ma ^ Submission Black C	2020 Carbon	 - BC absolu	 te ch	 ange		^ ab 	osolut ^ 	e cha Subm 	nge lissiol ^ re	 n 202: lative	 1 chan	 ge		^ rela 	tive (^ S 	chang Submi Ca	e ssion 2 arbon r	 20 no	 20 no	 xio	 de	 -
Submission 2021																						
Submission 2020																						
absolute change																						
relative change																						

The TSP emissions calculated depend directly on the reported lead emissions: The emission factor for TSP is 1.6 times the emission factor used for lead: $EF(TSP) = 1.6 \times EF(Pb)$. The applied procedure is similar to the one used for calculating TSP emissions from leaded gasoline used in road transport.

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) 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, 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 bibliography

- ¹⁾ (bibcite 2)
- ²⁾ (bibcite 3)
- ³⁾ (bibcite 2)
- ⁴⁾ (bibcite 3)
- ⁵⁾ (bibcite 1)
- ⁶⁾ (bibcite 2)
- ⁷⁾ (bibcite 4)
- ⁸⁾ (bibcite 4)
- ⁹⁾ (bibcite 4)
- ¹⁰⁾ (bibcite 5)