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.

Category Code	Method					AD					EF				
1.A.3.a ii (i)	T1, T2, T3					NS, M					CS, D, M				
	NO_x	**NMVOC**	**SO_2**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**PB**	**Cd**	**Hg**	**Diox**	**PAH**	**HCB**
Key Category:	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-	-/-	-

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

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 during LTO-stage of domestic flights

	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Jet Kerosene	30.2	29.4	27.9	27.6	27.5	27.3	27.3	27.3	27.6	27.7	28.0	27.9	27.7	27.7	28.1	28.3	28.4	28.1	27.7
Aviation Gasoline	12.7	12.9	12.7	13.2	12.9	12.8	12.7	13.0	12.9	12.9	12.8	12.8	12.7	12.9	12.8	12.1	12.6	12.7	12.7

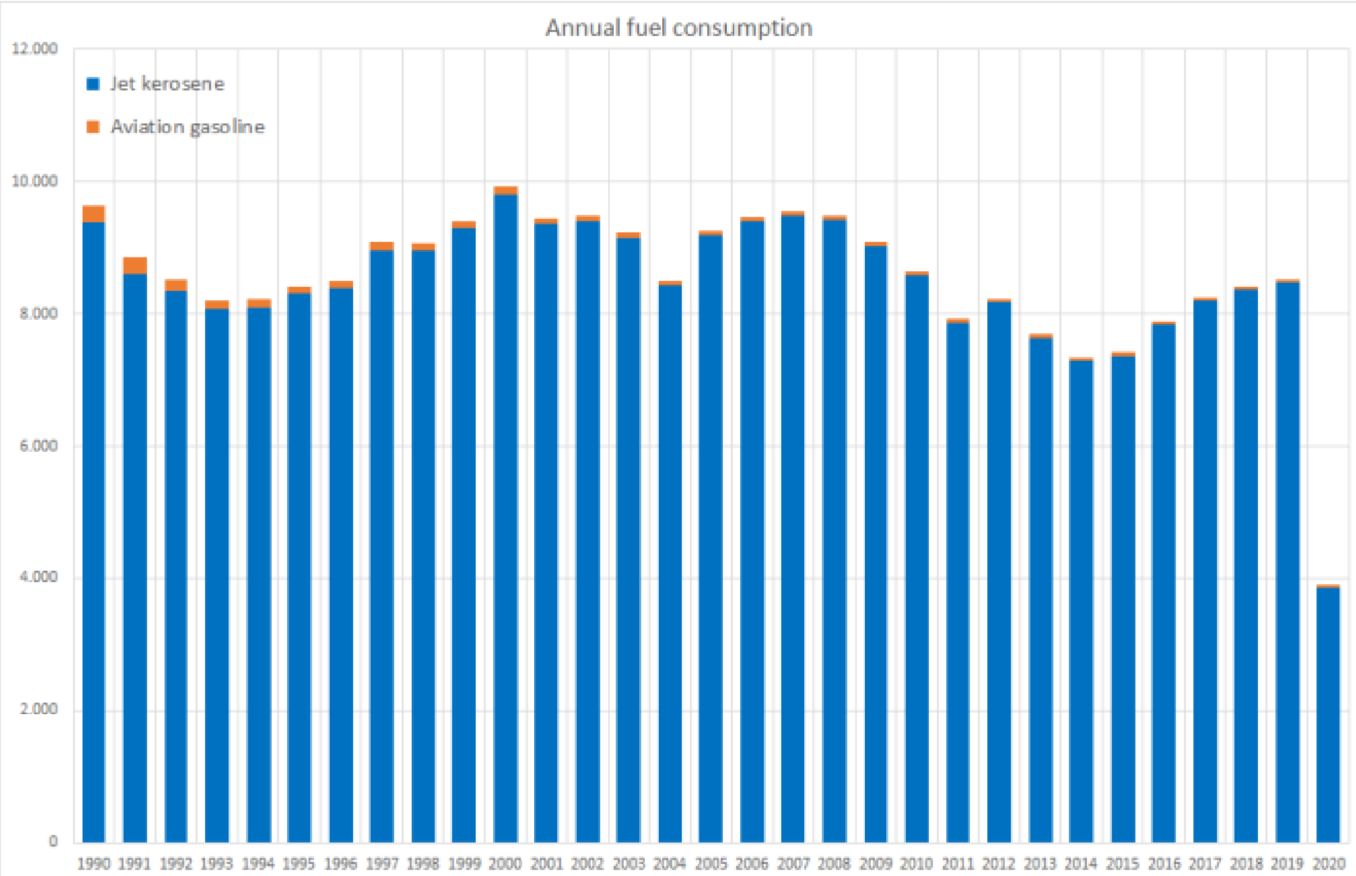
source: Knörr et al. (2021c) [1] &: Gores (2021) [2]

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	2020
Jet Kerosene	9,380	8,303	9,811	9,187	9,402	9,493	9,422	9,021	8,589	7,869	8,171	7,633	7,297	7,358	7,844	8,210	8,362	8,476	3,867
Aviation Gasoline	245	119	113	71.7	64.7	60.0	63.0	60.2	56.9	65.1	58.3	52.1	49.8	58.0	47.0	44.2	44.7	37.4	24.8
Σ 1.A.3.a ii (i)	**9,625**	**8,422**	**9,924**	**9,259**	**9,467**	**9,553**	**9,485**	**9,081**	**8,646**	**7,934**	**8,229**	**7,686**	**7,347**	**7,416**	**7,891**	**8,254**	**8,407**	**8,513**	**3,891**

source: Knörr et al. (2020c) &: Gores (2020)



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)) [3] and have since then been compiled, revised and maintained in TREMOD AV.

Furthermore, the **newly implemented EF(BC)** have been estimated via f-BCs as provided in the 2019 EMEP/EEA Guidebook [4], Chapter 1.A.3.a, 1.A.5.b Aviation, page 49: "Conclusion".

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

Table 3: 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	28,4	28,92	30,52	32,44	33,91	34,40	34,66	33,19	32,27	31,94	32,02	34,86	37,00	36,91	36,45	38,32	39,11	40,60	57,98
NO_x	295	324	287	277	276	281	290	300	304	309	312	311	310	312	321	322	316	312	291

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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]	1,43	1,57	1,54	1,61	1,62	1,59	1,47	1,48	1,51	1,50	1,52	1,53	1,50	1,52	1,44	1,44	1,56	1,46	1,68
PM[2]	2,99	3,28	3,21	3,36	3,38	3,32	3,06	3,07	3,14	3,13	3,17	3,18	3,12	3,17	3,01	2,99	3,25	3,05	3,50
CO	212	211	275	291	292	286	280	266	260	254	252	260	265	265	252	255	262	268	349
AVIATION GASOLINE																			
NH_3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
NMVOC	628	635	625	642	636	633	627	633	631	631	628	632	628	632	627	620	648	660	660
NO_x	87,6	87,4	87,5	85,9	86,2	85,8	87,4	85,8	85,3	87,1	87,2	87,1	87,3	85,9	87,9	88,9	88,6	92,0	92,7
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[1]	5,91	5,92	5,97	6,21	6,14	6,20	5,95	6,2	6,3	5,9	5,9	5,9	5,9	6,1	5,8	5,6	5,7	5,1	5,0
PM[2]	39,4	39,4	39,8	41,4	41,0	41,3	39,7	41,4	42,0	39,6	39,4	39,5	39,2	41,0	38,6	37,3	38,1	34,2	33,4
TSP[3]	54,6	54,6	55,0	56,6	56,1	56,5	54,8	56,6	57,2	54,8	54,6	54,7	54,4	56,1	53,8	52,5	53,2	49,4	48,6
CO	17,603	17,600	17,623	17,217	17,482	17,633	17,637	17,659	17,804	17,797	17,932	17,770	17,951	17,878	17,977	18,210	17,408	17,046	17,009

[1] estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in [5)]
[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

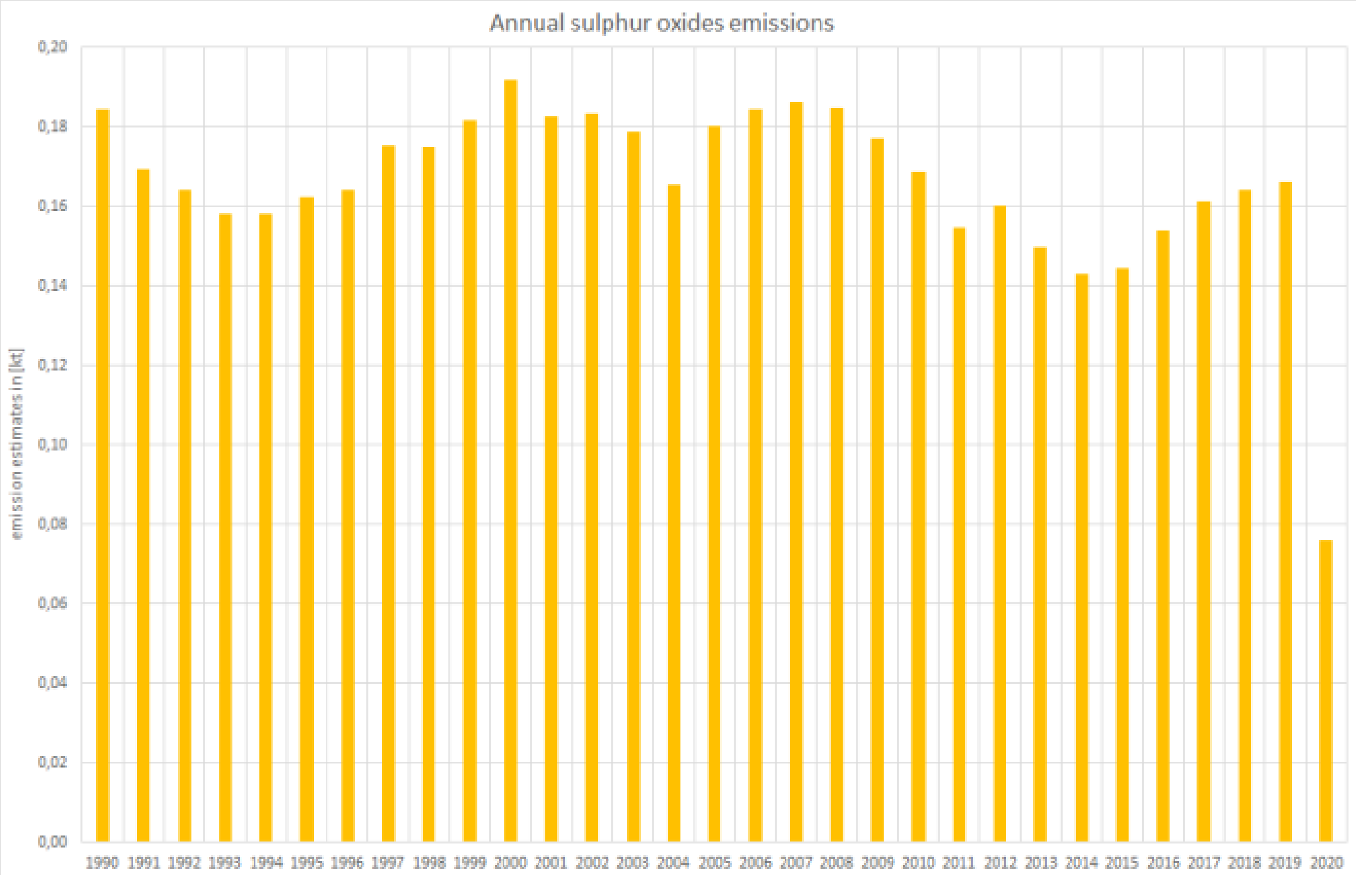
For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

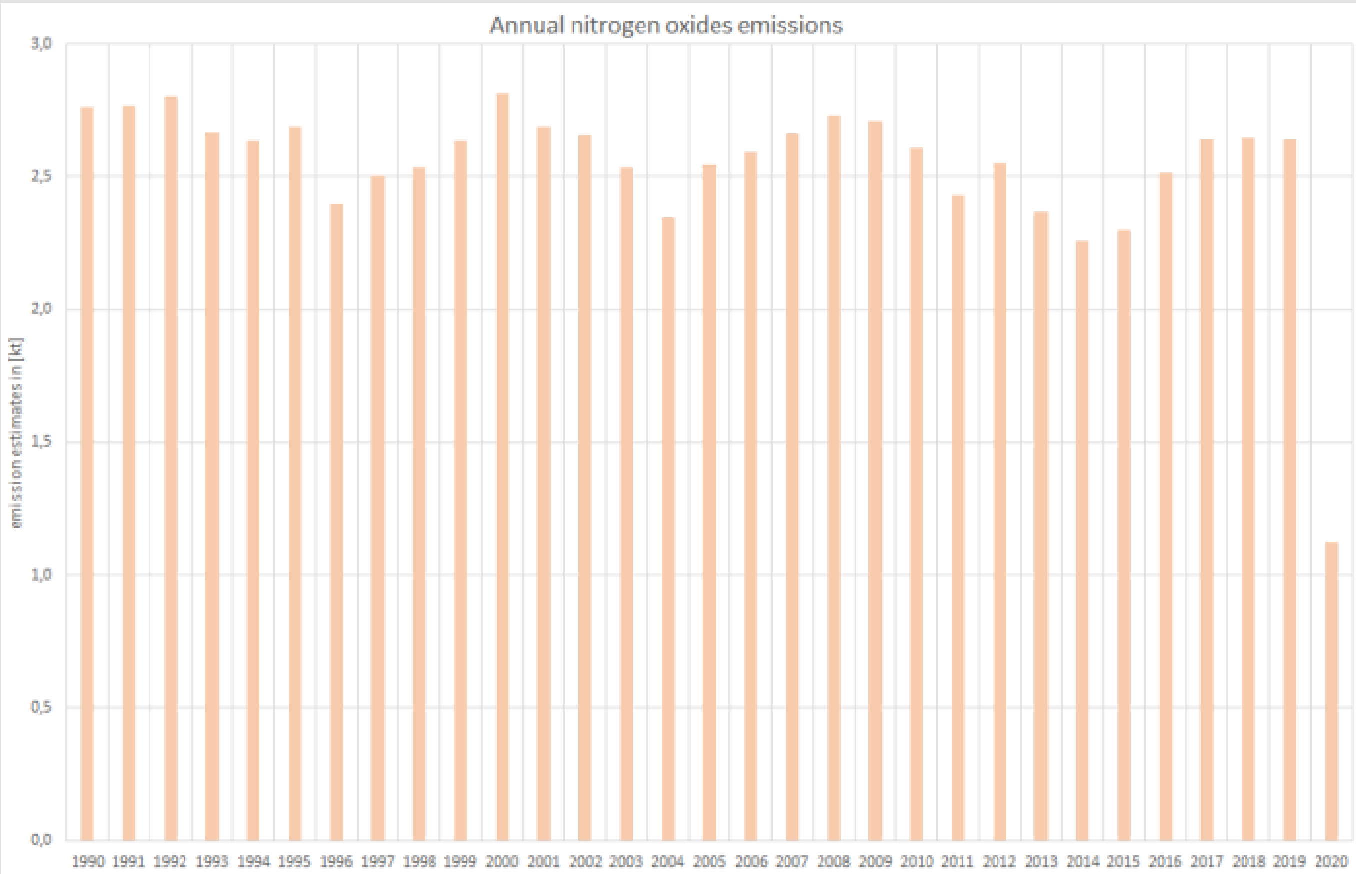
For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Trend discussion for Key Sources

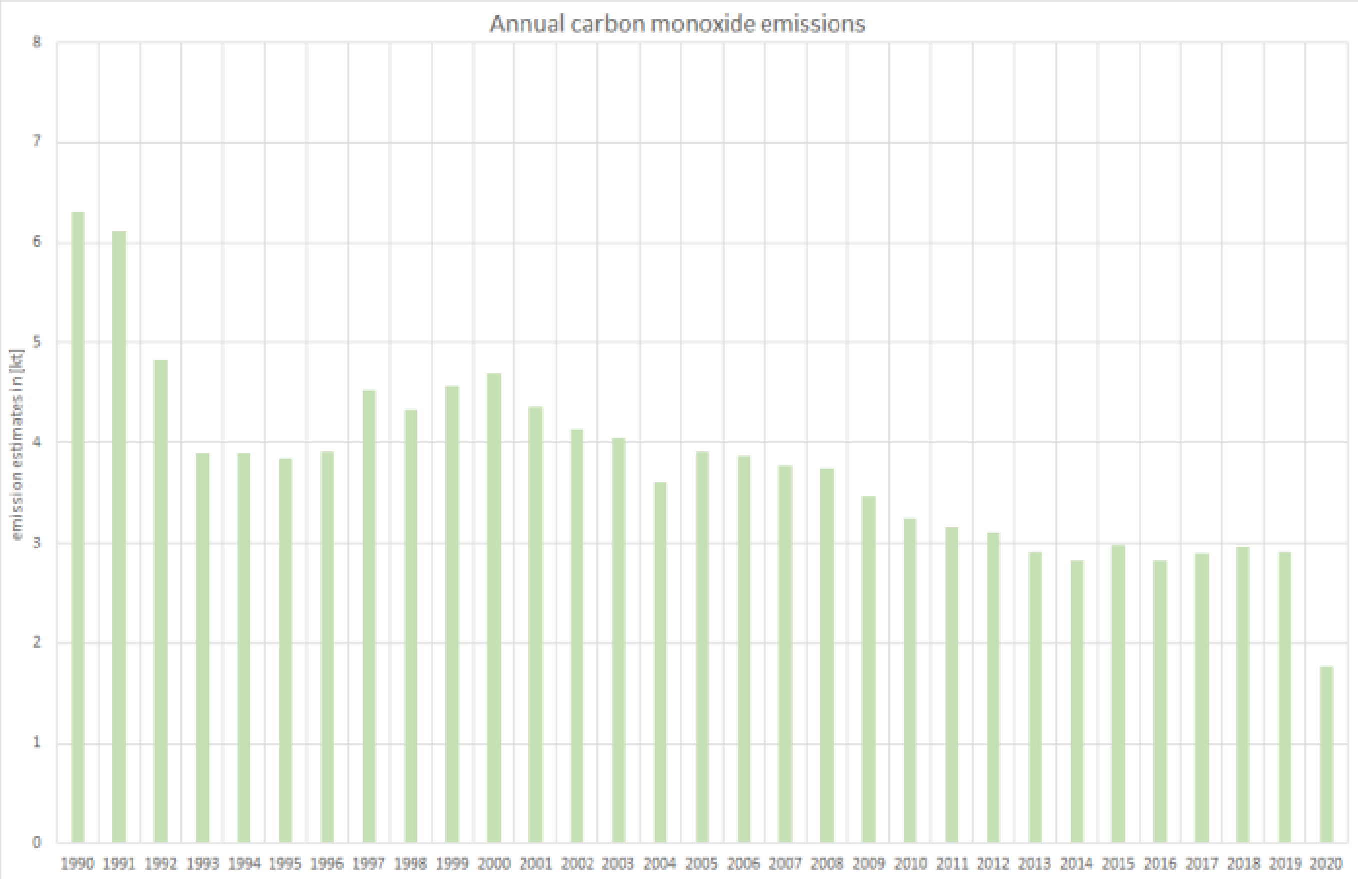
NFR sub-category 1.A.3.a ii (i) is no key source for emissions.

Where, for example, **nitrogen oxides** and **sulphur oxides** emissions are dominated by jet kerosene due to the amount of fuel used,—

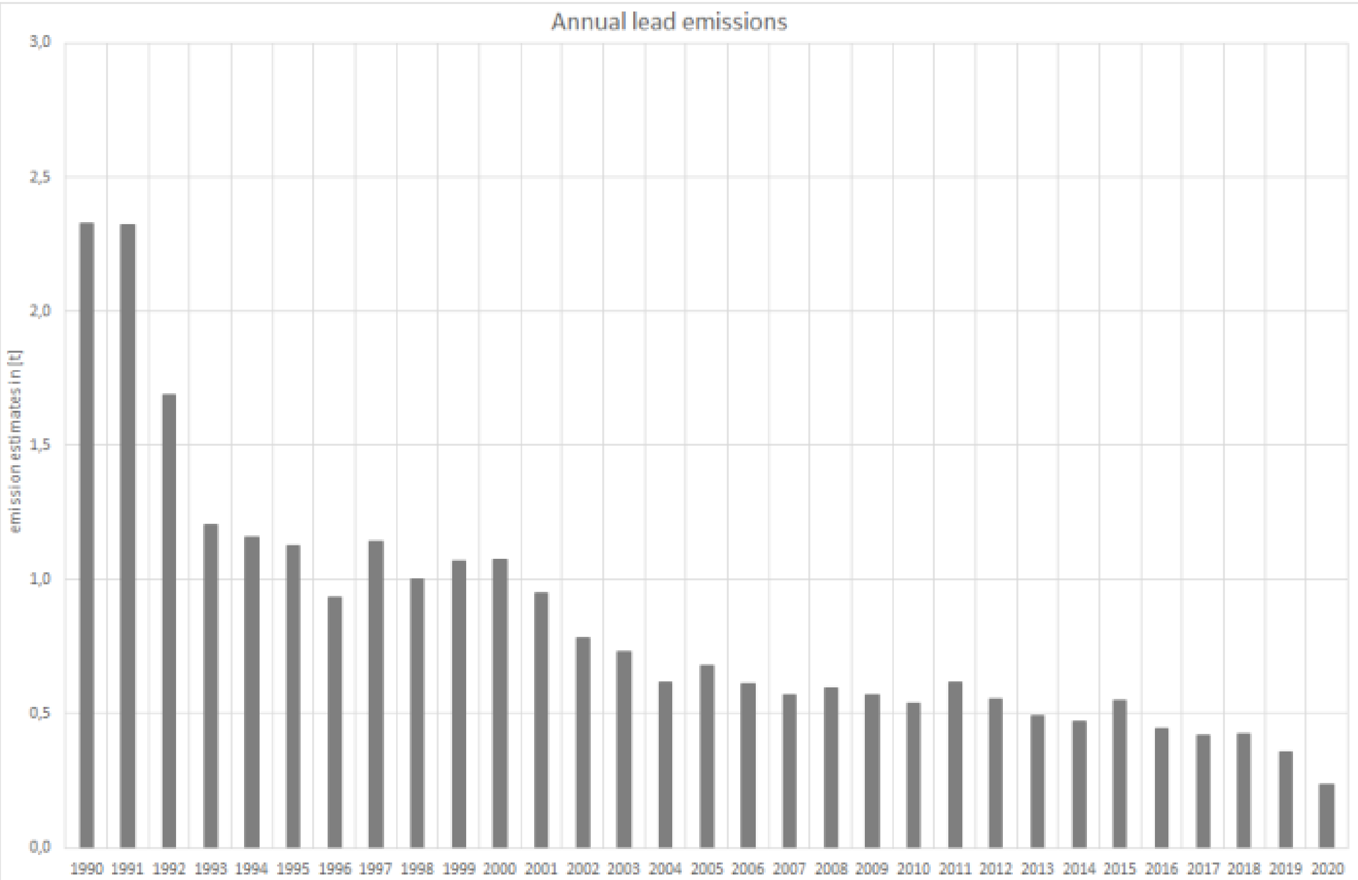




… the majority of **carbon monoxide** stems from the consumption of avgas given the much higher emission factor applied to this fuel.



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



Recalculations

Activity data

In order to keep in line with 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.

Furthermore, as explained in the superordinate chapter, avgas consumption for international flights and outside the L/TO range has been estimated for the first time for this submission, with the respective amounts of avgas re-allocated accordingly.

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 and avgas 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	2019
JET KEROSENE																		
Submission 2022	30.2	29.4	27.9	27.6	27.5	27.3	27.3	27.3	27.6	27.7	28.0	27.9	27.7	27.7	28.1	28.3	28.4	28.1
Submission 2021	30.2	29.4	27.9	27.6	27.5	27.3	27.3	27.3	27.6	27.7	28.0	27.9	27.7	27.7	28.1	28.3	28.4	28.1
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	0.00	0.00	0.00	0.00	0.05
relative 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%	0.00%	0.00%	0.00%	0.00%	0.17%
AVGAS																		
Submission 2022	12.7	12.9	12.7	13.2	12.9	12.8	12.7	13.0	12.9	12.9	12.8	12.8	12.7	12.9	12.8	12.1	12.6	12.7
Submission 2021	18.9	36.0	33.6	50.2	52.1	55.4	51.6	51.2	49.9	46.7	49.1	54.0	56.8	51.4	61.8	62.0	68.0	76.0
absolute change	-6.16	-23.2	-21.0	-37.0	-39.2	-42.6	-38.9	-38.2	-36.9	-33.8	-36.3	-41.2	-44.2	-38.5	-49.0	-49.8	-55.4	-63.3
relative change	-32.6%	-64.3%	-62.3%	-73.7%	-75.2%	-76.9%	-75.4%	-74.7%	-74.0%	-72.3%	-74.0%	-76.2%	-77.7%	-75.0%	-79.3%	-80.4%	-81.5%	-83.2%

Hence, the amounts of kerosene and avgas 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	2019
JET KEROSENE																		
Submission 2022	9,380	8,303	9,811	9,187	9,402	9,493	9,422	9,021	8,589	7,869	8,171	7,633	7,297	7,358	7,844	8,210	8,362	8,476
Submission 2021	9,380	8,303	9,811	9,187	9,402	9,493	9,422	9,021	8,589	7,869	8,171	7,633	7,297	7,358	7,844	8,210	8,362	8,417
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	0.00	0.00	0.00	0.00	58.4
relative 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%	0.00%	0.00%	0.00%	0.00%	0.69%
AVGAS																		
Submission 2022	245	119	113	71.7	64.7	60.0	63.0	60.2	56.9	65.1	58.3	52.1	49.8	58.0	47.0	44.2	44.7	37.4
Submission 2021	368	346	311	293	283	283	276	255	236	248	237	234	237	246	234	232	248	229
absolute change	-123	-227	-198	-222	-218	-223	-213	-195	-179	-183	-179	-182	-188	-188	-187	-188	-203	-192
relative change	-33.3%	-65.7%	-63.7%	-75.6%	-77.2%	-78.8%	-77.2%	-76.4%	-75.8%	-73.8%	-75.4%	-77.7%	-79.0%	-76.5%	-79.9%	-81.0%	-81.9%	-83.7%

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 [6] and Eurocontrol's AEM model [7] but cannot be displayed here in a proper way.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2019**, 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.

---

[1] Knörr et al. (2021c): Knörr, W., Schacht, A., & Gores, S.: TREMOD Aviation (TREMOD AV) 2021 - 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, 2021.
[2] Gores (2021): Inventartool zum deutschen Flugverkehrsinventar 1990-2020, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2021.
[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.
[4], [5], [6] 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.