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Life Cycle Inventories of Air Transport Services

Update and Completion 2021

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Abbreviations

a	year (annum)
BAK	Swiss Federal Office of Culture
CH	Switzerland
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
FOCA	Federal Office of Civil Aviation
GLO	global average
gt	gross ton
h	hour
HC	hydrocarbons
ICAO	International Civil Aviation Organization
KBOB	Koordinationskonferenz der Bau- und Liegenschaftsorgane der öffentlichen Bauherren
kg	kilogram
km	kilometre
kWh	kilowatt hour
LCA	life cycle assessment
LCI	life cycle inventory analysis
LTO	landing and take off
min	minute
NMVOC	non-methane volatile organic compounds
N_2O	nitrous oxide / dinitrogen monoxide
NOx	nitrogen oxides
p	passenger
pkm	passenger kilometre (transport unit)
PM	particulate matter (index gives size range in µm)
RER	Europe
RUMBA	Ressourcen- und Umweltmanagement der Bundesverwaltung
SO_2	sulphur dioxide
t	metric ton (tonne)
tkm	metric ton kilometre (transport unit)
UBP	eco-points (German: Umweltbelastungspunkte)
vkm	vehicle kilometre (transport unit)

Content

1 Introduction and Overview

1.1 Introduction

The environmental management system of the Swiss administration, RUMBA[1], quantifies its greenhouse gas emissions and environmental impacts using the KBOB recommendation 2009/1:2016 (KBOB et al. 2016a) and its addendum with updated data on aircraft transport services (Stolz & Frischknecht 2017). The Swiss administration needs updated and reliable life cycle assessment data to substantiate its targets and to monitor progress. Business travels is one important contributor to the environmental impacts of the Swiss administration, where appropriate data are key. In the recent past, major airlines renewed their fleet and were able to reduce the specific fuel consumption as well as the noise emissions of aircraft[2]. That is why FOCA initated a project to update the life cycle inventories of aircraft transport services.

In this report the update and extension of the life cycle inventory data of air transport services are described and presented. Data on aircraft transport are updated with current data on fuel consumption, transport performance, vehicle travel distance and load factors. The distance classes are further detailed by introducing medium-haul flights. Datasets specific for Swiss International Air Lines and Edelweiss Air ("SWISS") were established for short-, medium- and long-haul flights and the three booking classes "economy", "business" and "first" (long-haul only). Data describing the manufacture and maintenance of the aircraft as well as construction, operation and deconstruction of the airport infrastructure are not updated.

1.2 Overview

The update and completion of the life cycle inventories of aircraft transport services covers commercial passenger and freight transport with aircraft. The following updates and completions have been performed:

- Update of the datasets on "aircraft operation" and "aircraft transport", for both passengers and cargo, using current primary data from the Lufthansa Group (average datasets) and from Swiss International Air Lines including Edelweiss Air ("SWISS");
- Distinction of three distance classes defined as follows: short-haul (< 800 km), medium-haul (800 to 3'000 km) and long-haul (> 3'000 km);
- Distinction of the three main booking classes "economy", "business", "first" (long-haul flights only) within the aircraft passenger transport process.

[1] https://www.rumba.admin.ch/rumba/de/home.html, access on 9.3.2021

[2] The impacts of aircraft noise are being reassessed within the update of the eco-factors 2021 of the ecological scarcity method.

2 Goal and Scope

2.1 Functional Unit

The functional unit of passenger transport is one passenger kilometre (pkm), which corresponds to the transportation of one passenger over a distance of one kilometre.

The functional unit of freight transport is one ton kilometre (tkm), which corresponds to the transportation of one ton over a distance of one kilometre.

2.2 System Boundaries

The life cycle inventories of aircraft transport services refer to flights starting and/or landing in Europe and Switzerland.

The life cycle inventories of aircraft transport services include the following processes:

- Aircraft manufacturing and maintenance (according to LCI data described in Spielmann et al. (2007)
- Airport construction, operation and maintenance and deconstruction/disposal (according to LCI data described in Spielmann et al. (2007))
- Aircraft operation (including fuel consumption and exhaust emissions, described in Chapters 5 and 6)
- Fuel (kerosene) supply (according to LCI data described in Krebs et al. 2020).

Disposal of aircraft is not included in the life cycle inventories of air transport services. The effort of disposal is of minor importance compared to the operation and manufacture of aircraft and the operation of airports. Compiling new life cycle inventories for means of transportation and infrastructures such as manufacture and end of life treatment of aircraft and airports was not part of the project.

2.3 Data Source

Transport performance, fuel consumption, load factors and emission factors are quantified using current data provided by a leading group of European airlines (Lufthansa Group 2019, 2020), and its subsidiarySwiss International Air Lines including Edelweiss Air, complemented with data provided by FOCA[3].

[3] Pers. Communication with, FOCA, January and February 2021

2.4 Environmental impacts

2.4.1 Greenhouse gas emissions and additional climate impacts from non-greenhouse gas aircraft emissions

The climate change effect of greenhouse gases is expressed by the Global Warming Potential (GWP) with a defined 100 year timeframe (GWP_{100}) according to the 5th Assessment Report of the Intergovernmental Panel on Climate Change (expressed in kg CO_2-equivalents according to IPCC 2007). The indicator covers the emissions of the so-called "Kyoto-Substances" CO_2, CH_4, N_2O, PFC, HFC, SF_6 and NF_3. The climate-impacting ozone-depleting substances regulated by the Montreal Protocol and non-greenhouse gas emissions triggering climate impacts are not included.

Concerning aircraft operational emissions, the relevant greenhouse gas emitted from aircraft engines is CO_2. When looking at greenhouse gases alone, the CO_2-eq value from aircraft greenhouse gas emissions corresponds to the value of CO_2 emissions[4]. These fossil CO_2-emissions from aircraft operation correspond approximately to the value used for state's national greenhouse gas inventory reporting in UNFCCC and they are shown in the results tables (see Chapter 7).

However, there are additional climate effects from aircraft non-CO_2-emissions, and non-greenhouse gas emissions, respectively, directly emitted at high altitude. These additional effects are underlying high uncertainties and like for greenhouse gases, are depending on the choice of time horizon and emission metric[5]. In a simplified manner, the total impact of aviation operational emissions is expressed as a factor on the CO_2-emissions, instead of relating the additional climate effects to the actual non-CO_2 emissions. The factor illustrates the additional climate impact from aviation non-CO_2 emissions over those from CO_2 emissions alone, according to a selected metric and time horizon.

In the past the additional warming effects of the stratospheric aircraft emissions were leading to around 1 kg CO_2-eq added to each kg CO_2 emitted during aircraft operation based on the GWP_{100} metric according to Fuglestvedt et al. (2010) and Lee et al. (2010) resulting in 2.0 kg CO_2-eq/kg[6]. The latest available scientific study (Lee et al. 2021) however updated this value to 1.7 kg CO_2-eq/kg. The climate change impacts of aircraft transports based on this most recent information are also shown in the results tables (Chapter 7).

In January 2021 the Swiss Federal Council adopted Switzerland's Long-Term Climate Strategy (Schweizerischer Bundesrat 2021), where the effects of non-CO_2-emissions of the aviation sector are quantified. In the strategy paper, the Swiss Federal Council uses the factor based on the new metric (GWP*) which describes the impact on the remaining

[4] Effect from direct water vapor emissions is insignificant and only traces of other greenhouse gases are emitted (Lee et al. 2021). For greenhouse gases, this leads to a CO_2-eq value, which is just a few percent higher than the CO_2 value

[5] Lee et al. (2021), table 4a and table 5 and Neu (2020)

[6] This value is applied in mobitool 2020.

emissions budget or for emission reduction paths for the achievement of temperature targets. Switzerland's Long-term Climate Strategy follows the best estimate based on the non-CO_2 emissions increase of the last 10 years in global aviation (2007–2017) and requires the application of the GWP* of 2.5 kg CO_2-eq/kg from Neu et al. (2020) to aviation emissions. GWP* based climate change impacts are shown in the results tables (Chapter 7) because it is being used in the upcoming eco-factors 2021 of the ecological scarcity method and in the upcoming revised version of KBOB recommendation 2009/1:2021.

The software used for calculating the environmental footprints distinguishes CO_2 emissions according to where they are emitted (upper troposphere and stratosphere vs. on ground and lower troposphere). CO_2 emissions at cruising altitude account for about 70 % of total emissions for an average flight (see Subchapter 3.1). Tab. 3.2 shows the global warming potential values according to this distinction between the two altitude bands in the atmosphere.

Tab. 2.1 Global warming potential values according to the distinction between the two altitude bands in the atmosphere (assuming 70 % of the emissions occuring)

Item	**unit**	total	upper troposphere and lower stratosphere	ground and in the troposphere
Share of aircraft emissions	%	100 %	70 %	30 %
Fossil CO_2 emissions	kg CO_2-eq/kg	1.0	1.0	1.0
GWP_{100} (Lee et al. 2010)	kg CO_2-eq/kg	2.0	2.43	1.0
GWP_{100} (Lee et al. 2021)	kg CO_2-eq/kg	1.7	2.00	1.0
GWP* (Neu 2020)	kg CO_2-eq/kg	2.5	3.14	1.0

2.4.2 Swiss eco-points 2013 according to the ecological scarcity method

The overall environmental impact is assessed using the Swiss ecological scarcity method 2013 (Frischknecht & Büsser Knöpfel 2013). The method takes into account impacts from the consumption of primary energy and mineral resources, the use of land and fresh water, the emissions into air, water and soil, deposits from waste treatments and traffic noise. The eco-factor of traffic noise is established comparing the number of persons annoyed by traffic noise today with the number of persons annoyed by a noise level which is 5 dB lower than today. This eco-factor is currently being revised using the most recent data available in the SonBase database at FOEN (2015).

The indirect additional climate change effects of high tropospheric and stratospheric emissions from aircraft are taken into account (see Section 2.4.1). It converts the various environmental impacts into so-called eco-points which allows to sum them up and provide a single score indicator. The eco-points are weighted with eco-factors according to a "distance-to-target" approach. The method considers the present flow of an environmental pressure (current flow) as well as its maximum permissible level within the context of environmental policy goals (national environmental legislation and international agreements; critical flow). The squared ratio of the current divided by the critical flow

determines the weighting factor. The eco-points thus provide a tool to evaluate the overall environmental impact within the framework set by Swiss environmental policy targets.

2.4.3 Cumulative energy demand

The non-renewable cumulative energy demand includes the consumption of primary energy from fossile, nuclear and biogenic (wood from clear-cutting of primary forests) sources (Frischknecht et al. 2015). The renewable cumulative energy demand covers the energy consumption from renewable energy sources such as hydroelectric power, solar, wind and geothermal power, and generated with biogenic sources (excluding wood produced from clear-cutting of primary forests) and energy harvesting. The assessment is done on the amount of energy harvested. The total cumulative energy demand, which is the sum of renewable and non-renewable energy demands, is used as a key indicator to monitor 2000 Watt Society communities and cities.

3 Fuel consumption and emission factors

3.1 LTO and cruise fuel consumption

The share of the fuel consumption during take-off and landing (LTO) was provided for short, medium and long distance flights by FOCA (see Tab. 3.1).

Tab. 3.1 The share of the fuel consumption during take-off and landing (LTO) for short-, medium- and long-haul flights provided by FOCA[7]

Fuel consumption	short distance	medium distanc	long distance
LTO	14%	7%	3%
Cruise	86%	93%	97%
Upper troposphere / lower stratosphere	*50%*	*75%*	*80%*
Troposphere	*50%*	*25%*	*20%*
Total	*100%*	*100%*	*100%*

The altitude of the emission is important since aircraft emissions in the upper troposphere and lower stratosphere have a higher effect on climate change compared to the release of the same pollutants on the ground (see e.g. Neu 2020). During cruise, emissions occur partly in the upper troposphere/lower stratosphere and in the troposphere. According to information provided by FOCA[7] 50 %, 75 % and 80 % of cruise emissions of short-, medium and long-haul flights, respectively are emitted in the upper troposphere/lower stratosphere. The shares of cruise emissions occurring in the troposphere are 50 %, 25 % and 20 % for short-, medium and long-haul flights, respectively. 77.6 %, 69.8 % and 43 % of the total fuel is used during cruise in the upper troposphere/lower stratosphere and the emissions are accounted as stratospheric emissions.

[7] Personal communication, FOCA, per Mail 29. September 2016

3.2 Aircraft Emissions

The emissions of the operation of aircraft are quantified with emission factor data provided by BAFU (2016) and FOCA[8] (see Tab. 3.2). During LTO substantially higher CO and NMVOC emission factors are reported, mainly produced in engine idle mode

Tab. 3.2 Emission factors for the main pollutants and CO_2 when burning 1 kg kerosene during aircraft LTO and cruising (BAFU 2016 and FOCA[8])

	Cruise	LTO
	(g/kg fuel)	(g/kg fuel)
CO_2	3'150.00	3'150.00
CO	1.90	13.23
SO_x	1.00	1.00
NO_x	12.93	12.44
NMVOC	0.32	1.34
H_2O	1'240.00	1'240.00
$PM_{2.5}$	0.02	0.10

No up to date information was available on the NMVOC species profile. That is why data presented in the ecoinvent report 14 (Spielmann et al. 2007, page 153) were adopted.

The emissions of LTO and cruise are accounted separately as they occur in different environments (close to the ground versus troposphere). The emissions during cruise are additionally split into a share emitted in the troposphere and the share emitted in the lower stratosphere/upper troposphere (see Section 3.1). This allows for an individual environmental impact assessment of stratospheric emissions of $PM_{2.5}$ and NO_X and of their climate change effects).

Additional to the exhaust emissions also particle emissions of the abrasion during LTO are included in the life cycle inventory. According to information of FOCA[9] the specific particle emissions $PM_{2.5}$ of the abrasion are 0.08 g/LTO for short- and medium-haul flights and 0.27 g/LTO for long-haul flights.

Noise emissions were accounted for as recommended by Frischknecht and Büsser (2013) in Section 15.1.5 (page 201). Noise impacts are assessed with the Swiss ecofactors 2013 and 2020 according to the ecological scarcity method.

[8] Personal communication, FOCA, per Mail 27. September 2016

[9] Personal communication, FOCA, per Email, 29. September 2016

4 Infrastructure

4.1 Aircraft Manufacture

The manufacture of the average intra- and intercontinental aircraft is modelled with the aircraft manufacture datasets published in KBOB life cycle inventory data DQR v2:2016 (based on ecoinvent data v2.2) for medium and long haul aircraft, respectively (KBOB et al. 2016b). Background information about aircraft manufacturing can be found in the ecoinvent report 14 (Spielmann et al. 2007).

4.2 Airport Infrastructure

4.2.1 Efforts for construction, operation and dismantling of an airport

Construction, operation and dismantling of the airport is modelled with the airport construction, operation and disposal datasets provided by KBOB life cycle inventory data DQR v2:2016 (KBOB et al. 2016b). Background information about data and modelling of the airport infrastructure can be found in the ecoinvent report 14 (Spielmann et al. 2007).

4.2.2 Demand of Airport Construction and Operation

The data on the number of passengers and on the amount of freight using the airport were taken from the yearly report of Zürich Airport (Flughafen Zürich AG 2020). To calculate the mass flow of passengers passing the Zürich Airport per year a weight of between 158 kg and 168 kg is assumed (depending on distance travelled). The annual mass flow passing the airport (including passengers) is 5’624’000 t/year. To calculate the allocation factors for freight and passengers as well as for short-, medium- and long-haul flights the mass flow is divided by the annual mass flow of Zürich Airport. The specific airport demand of a short-, medium- and long-haul flight equals two times the allocation factor divided by the respective annual transport performance (pkm or tkm) and the lifetime of the airport (100 years).

The demand of airport operation and maintenance per year equals the demand of airport per tkm and pkm multiplied by the life time of the airport (100 a).

Data about the average flight distances as well as the allocation between passenger and freight transport was determined based on data published in the annual report of the Lufthansa Group (Lufthansa Group 2019, 2020).

Tab. 4.1 Key figures of the calculation of the demand of airport construction and operation, airport lifetime: 100 years; Source: Flughafen Zürich AG 2020; Lufthansa Group 2019, 2020

Item	unit	total	short-haul	medium-haul	long-haul
passengers	#	31'507'692	20'984'123	4'915'200	5'608'369
passenger tons	t	5'145'005	3'459'659	796'225	889'120
cargo shipped	t	478'800	17'486	38'093	423'221
total weight	t	5'623'805	3'477'146	834'318	1'312'341
Airport share passengers	%	91.5	61.5	14.2	15.8
Airport share cargo	%	8.5	0.3	0.7	7.5
Distance travelled	km	2'334	750	2'800	7'800
Transport service passengers	pkm	73'526'350'051	15'738'092'154	13'762'559'866	44'025'698'031
Transport service cargo	tkm	1'117'327'680	13'114'676	106'660'650	3'322'282'310
Airport demand, passengers	#/pkm	2.55E-13	7.82E-13	2.06E-13	7.18E-14
Airport demand, cargo	#/tkm	6.75E-13	4.74E-12	1.27E-12	4.53E-13

5 Aircraft Transport Services, average

5.1 Introduction

The following chapter describes the life cycle inventories of aircraft transport services offered by average European airlines. The life cycle inventories are based on data published by the Lufthansa Group (Lufthansa Group 2019).

5.2 Key characteristics and allocation factors of the aircraft

Lufthansa Group uses different aircraft for short, medium and long distance freight and passenger transport. In Tab. 5.1 technical characteristics of the average long-, medium- and short-haul aircraft are presented.

The allocation of fuel consumption and emissions between passenger and freight transport was based on the approach used in the ICAO Carbon Emissions Calculator Methodology (ICAO 2016). This calculation method determines the weight attributable to a passenger including not only the baggage but also the facilities in the aircraft required for passenger transport. For an average weight per transported passenger (incl. baggage) it assumes 100 kg. 50 kg is added per aircraft seat to account for the on-board equipment and infrastructure associated with the passenger transport. Using the average number of passengers of short-, medium- and long-haul flights (126, 132 and 251 passengers, respectively) and the average number of available seats (163, 163 and 294 seats, respectively) the average weight per passenger is 165 kg, 162 kg and 159 kg. This results in a total weight of passengers of about 20.8, 21.3 and 40.0 tons for short-, medium- and long-haul flights. The weight of belly cargo transported on short-, medium- and long-haul flights was 844, 1'141 and 11'526 kg, respectively, which is 3.9, 5.1 and 22.5 % of the total weight. The equivalent weight of passengers and belly freight is used as allocation parameter and the percentages shown in Tab. 5.1 are the allocation factors.

Tab. 5.1 Technical characteristics and main allocation factors of the average short-, medium- and long-haul passenger aircraft of the Lufthansa Group operated in 2019 (Lufthansa Group 2019)

Item	Unit	short-haul	medium-haul	long-haul
number of seats	#	136/27	136/27	228/57/8
Occupation factor		77.1	80.7	85.4
number of passengers *	#	105/21	110/22	195/49/7
average weight of passenger	kg	165	162	159
total weight of passengers	kg	20756	21340	39772
Belly freight capacity	kg	2101	2101	18163
Belly freight factor	%	40.2	54.3	63.5
Belly freight sold	kg	844	1141	11526
share passenger weight	%	96.1	94.9	77.5
share cargo weight	%	3.9	5.1	22.5
average distance	km	750	2800	7850

*: economy/business/first class

5.3 Allocation to booking classes

The differentiation between the three booking classes “economy”, “business” and “first” requires an additional allocation step. The allocation of fuel consumption and emissions of the aircraft between these classes is based on the number of passengers per class and the area required per passenger of the respective class. In Tab. 5.2 the number of seats and the resulting allocation factors of the different classes are presented. The allocation factor applied on the fuel consumption etc. is calculated based on the area required per seat of the certain class divided by the area per average seat in the aircraft.

Tab. 5.2 Number of seats, area per seat in the different cabin classes in short haul and long haul aircraft and resulting allocation factors, see also Tab. 5.1.

Item	Unit	economy	business	first
Short-haul passenger	#	105	21	na
Area per seat	m^2	0.33-0.38	0.57-0.62	na
Allocation factor	%	75.6	24.4	
Medium-haul passenger	#	110	22	na
Area per seat	m^2	0.33-0.38	0.57-0.62	na
Allocation factor	%	75.6	24.4	
Long-haul passenger	#	195	49	7
Area per seat	m^2	0.33-0.38	0.57-0.62	1.60-1.66
Allocation factor	%	57.1	33.0	9.9

*: economy/business/first class

5.4 Aircraft Operation

The fuel consumption of an average short-, medium- and long-haul flight per km (l/km) is determined based on information of the Lufthansa Group and the allocation factors as outlined in Subchapter 5.3.

The calculation of the fuel consumption per pkm and tkm was performed according to the following four steps (see Tab. 5.3):

1) Multiplication of specific fuel consumption of passenger transport times the number of passengers;
2) Multiplication of the specific fuel consumption of freight transport times cargo transported.
3) Sum of passenger and cargo related fuel consumption of the average short-, medium and long-haul passenger aircraft (including belly freight transport) as specified in Tab. 5.1.
4) Calculation of the specific fuel consumption of passengers (per pkm) and freight (per tkm) applying the allocation factors as described in Subchapter 5.3 and division by the number of passengers and the cargo transported, respectively.

Tab. 5.3 Fuel consumption of short-, medium- and long-haul flights of the Lufthansa Group (Lufthansa Group 2019)

Item	unit	average	short-haul	medium-haul	long-haul
specific consumption passengers	l/100 pkm	3.67	5.9	3.59	3.34
number pf passengers	#	-	126	132	251
specific consumption freight	l/tkm	0.266	0.381	0.237	0.242
cargo weight sold	kg	-	844	1141	11526
aircraft fuel consumption passengers	l/km	-	7.43	4.73	8.38
aircraft fuel consumption cargo	l/km	-	0.32	0.27	2.79
aircraft fuel consumption total	l/km		7.75	5.00	11.17

5.5 Air Transport

The service life of an aircraft is more dependent on the number of so called LTO cycles (take-off/landing cycles) than on the distances travelled or the years in charge. The material of an aircraft is more stressed during take-off and landing and thus the numbers of possible LTO cycles of an aircraft is limited. In Tab. 5.4 the designed numbers of a short and long haul aircraft is 50’000 and 25’000 respectively (FAA 2010).

The life time transport distance of an aircraft is determined with the designed number of LTO cycles and the average flight distance of the short-, medium- and long-haul flight respectively. The allocation factors to attribute the appropriate share of the airplane manufacture to passengers and freight is based on the total mass shipped using a weight of 159 kg, 162 kg and 165 kg per passenger for long-, medium- and short-haul flights, respectively. Hence, 96.1 %, 94.9 % and 77.5 % of the aircraft is allocated to the passengers transported on short-, medium- and long-haul flights respectively. Dividing one airplane by the total transport performance (transport distance times average load) results in the share of aircraft manufacture attributable to each pkm provided by the aircraft.

Tab. 5.4 presents the key figures to calculate the aircraft manufacture demand for passenger and freight transport in short-, medium- and long-haul flights.

Tab. 5.4 Key figures of the aircraft demand for short-, medium- and long-haul passenger and freight transport.

Item	unit	short-haul	medium-haul	long-haul
number of LTO cycles	#	50000	50000	25000
average distance	km	750	2800	7850
lifetime performance	km	3'750'000	14'000'000	19'600'000
Average load passengers	#	126	132	251
Average load cargo	kg	844	1141	11526
Vehicle demand	#/km	2.67E-8	7.14E-9	5.1E-9
Allocation factor passenger	%	96.1	94.9	77.5
Vehicle demand passengers, allocated	#/pkm	2.04E-10	5.15E-11	1.57E-11
Vehicle demand cargo, allocated	#/tkm	1.23E-9	3.18E-10	9.93E-11

The vehicle demand per booking class are calculated with the vehicle demand, the booking class specific allocation factor and the number of passengers.

The maintenance of the aircraft is approximated by increasing the aircraft manufacture efforts by 5 %.

5.6 Average Aircraft Transport

To calculate the average of short-, medium- and long-haul flights current data of the transport performance of the Lufthansa Group (Lufthansa Group 2019) are used. The number of passengers and freight transported to short-, medium and long-haul destinations are multiplied by the average distance of short-, medium and long-haul flights. The share of each transport category is calculated by dividing the individual transport performances with the total transport performance. In Tab. 5.5 the numbers of passengers and freight transported and the shares are presented.

Tab. 5.5 Passengers and freight transported with Lufthansa Group in 2019, average distance, the calculated transport performances and the shares of intercontinental and intracontinental transports on the average transport of passengers and freight

Item	unit	total	short-haul	medium-haul	long-haul
passengers	#	106'978'000	75'500'000	11'807'000	19'671'000
Transport service passengers	1000 pkm	244'179'600	56'625'000	33'059'600	154'495'000
Share in average transport	%	100.0	23.2	13.5	63.3
Transport service cargo	tkm	8'899'000'000	325'000'000	708'000'000	7'866'000'000
Share in average transport	%	100.0	3.7	8.0	88.4

5.7 Unit process life cycle inventory data

Tab. 5.6 Life cycle inventory data of short-haul aircraft transport services

	Name	Location	InfrastructureProcess	Unit	transport, aircraft, passenger, short-haul	transport, aircraft, passenger, short-haul, economy	transport, aircraft, passenger, short-haul, business	transport, aircraft, freight, short-haul	UncertaintyType	StandardDeviation95 %	GeneralComment
	Location				RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	tkm			
product	transport, aircraft, passenger, short-haul	RER	0	pkm	1	0	0	0			
product	transport, aircraft, passenger, short-haul, economy	RER	0	pkm	0	1	0	0			
product	transport, aircraft, passenger, short-haul, business	RER	0	pkm	0	0	1	0			
product	transport, aircraft, freight, short-haul	RER	0	tkm	0	0	0	1			
technosphere	aircraft, medium haul	RER	1	unit	2.14E-10	1.94E-10	3.12E-10	1.30E-9	1	3.06	(2,4,1,3,1,5,BU:3); Calculated based on the assumed numbers of LTOs in the life time of an aircraft of 50000LTO/airplane, an average load of 126 passengers or 0 tons of freight and an average distance of a flight of 750km. For the effort of the maintenance 5% of the aircraft manufacture is added; FAA (2010) Aging Airplane Program; Lufthansa Balance 2015
	airport	RER	1	unit	7.82E-13	7.82E-13	7.82E-13	4.74E-12	1	3.06	(2,4,1,3,1,5,BU:3); assumed yearly throughput at the airport: passengers 20984123 p and freight 17486t; Airport Zürich, yearly report, 2014
	operation, maintenance, airport	RER	0	unit	7.82E-11	7.82E-11	7.82E-11	4.74E-10	1	2.06	(2,4,1,3,1,5,BU:2); same as airport multiplied by the lifetime of the airport of 100 years;
	disposal, airport	RER	1	unit	7.82E-13	7.82E-13	7.82E-13	4.74E-12	1	3.06	(2,4,1,3,1,5,BU:3); same as airport;
	kerosene, at regional storage	RER	0	kg	4.85E-2	4.40E-2	7.07E-2	2.94E-1	1	1.24	(2,4,1,3,1,5,BU:1.05); ; Lufthansa Balance 2015, BLD 2014, pers. communication Lufthasa, Mail 20.8.2015
emission air, lower stratosphere + upper troposphere	Carbon dioxide, fossil	-	-	kg	6.57E-2	5.96E-2	9.58E-2	3.98E-1	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the cruise emission take place in the upper troposphere and lower stratosphere (this corresponds to a share of of the total emissions); BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.96E-5	3.59E-5	5.77E-5	2.40E-4	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.08E-5	1.89E-5	3.04E-5	1.26E-4	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.69E-4	2.45E-4	3.93E-4	1.63E-3	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	4.24E-6	3.85E-6	6.18E-6	2.57E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.59E-2	2.35E-2	3.77E-2	1.57E-1	1	1.64	(2,5,2,5,1,5,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.26E-7	1.14E-7	1.84E-7	7.65E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	9.95E-7	9.03E-7	1.45E-6	6.04E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.19E-7	1.08E-7	1.74E-7	7.24E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.15E-6	1.05E-6	1.68E-6	7.00E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	5.00E-7	4.54E-7	7.30E-7	3.04E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	9.51E-4	8.63E-4	1.39E-3	5.77E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); ; default value
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	6.57E-2	5.96E-2	9.58E-2	3.98E-1	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the cruise emission take place in the troposphere (this corresponds to a share of of the total emissions) ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.96E-5	3.59E-5	5.77E-5	2.40E-4	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.08E-5	1.89E-5	3.04E-5	1.26E-4	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.69E-4	2.45E-4	3.93E-4	1.63E-3	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	4.24E-6	3.85E-6	6.18E-6	2.57E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.59E-2	2.35E-2	3.77E-2	1.57E-1	1	1.64	(2,5,2,5,1,5,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.26E-7	1.14E-7	1.84E-7	7.65E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	9.95E-7	9.03E-7	1.45E-6	6.04E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.19E-7	1.08E-7	1.74E-7	7.24E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.15E-6	1.05E-6	1.68E-6	7.00E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	5.00E-7	4.54E-7	7.30E-7	3.04E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	9.51E-4	8.63E-4	1.39E-3	5.77E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); default value;
emission air, low population density	Carbon dioxide, fossil	-	-	kg	2.14E-2	1.94E-2	3.12E-2	1.30E-1	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the total emission occure during the LTO; for LTO emissions different emission factors are used than for cruise; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	8.98E-5	8.15E-5	1.31E-4	5.45E-4	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	6.80E-6	6.17E-6	9.92E-6	4.12E-5	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	8.45E-5	7.67E-5	1.23E-4	5.12E-4	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.81E-6	5.28E-6	8.48E-6	3.53E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	8.42E-3	7.64E-3	1.23E-2	5.11E-2	1	1.64	(2,5,2,5,1,5,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.73E-7	1.57E-7	2.52E-7	1.05E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	1.36E-6	1.24E-6	1.99E-6	8.28E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.64E-7	1.49E-7	2.39E-7	9.93E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.58E-6	1.44E-6	2.31E-6	9.60E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	6.79E-7	6.16E-7	9.90E-7	4.12E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	3.10E-4	2.81E-4	4.52E-4	1.88E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); default value;
	Particulates, < 2.5 um	-	-	kg	8.14E-7	7.39E-7	1.19E-6	4.94E-6	1	3.11	(2,5,2,5,1,5,BU:3); PM2.5 Emission of the abrasion during LTO ; pers. correspondence BAZL, 27.9.2016
emission Non material emissions, unspecified	Noise, aircraft, freight	-	-	tkm				1.00E+0	1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
	Noise, aircraft, passenger	-	-	pkm	1.00E+0	9.08E-1	1.46E+0		1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 5.7 Life cycle inventory data of medium-haul aircraft transport services

	Name	Location	InfrastructureProcess	Unit	transport, aircraft, passenger, medium-haul	transport, aircraft, passenger, medium-haul, economy	transport, aircraft, passenger, medium-haul, business	transport, aircraft, freight, medium-haul	UncertaintyType	StandardDeviation95 %	GeneralComment
	Location				RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	tkm			
product	transport, aircraft, passenger, medium-haul	RER	0	pkm	1	0	0	0			
product	transport, aircraft, passenger, medium-haul, economy	RER	0	pkm	0	1	0	0			
product	transport, aircraft, passenger, medium-haul, business	RER	0	pkm	0	0	1	0			
product	transport, aircraft, freight, medium-haul	RER	0	tkm	0	0	0	1			
technosphere	aircraft, medium haul	RER	1	unit	5.40E-11	4.91E-11	7.88E-11	3.34E-10	1	3.06	(2,4,1,3,1,5,BU:3); Calculated based on the assumed numbers of LTOs in the life time of an aircraft of 50000LTO/airplane, an average load of 132 passengers or 0 tons of freight and an average distance of a flight of 2800km. For the effort of the maintenance 5% of the aircraft manufacture is added; FAA (2010) Aging Airplane Program; Lufthansa Balance 2015
	airport	RER	1	unit	2.06E-13	2.06E-13	2.06E-13	1.27E-12	1	3.06	(2,4,1,3,1,5,BU:3); assumed yearly throughput at the airport: passengers 4915200 p and freight 38093t; Airport Zürich, yearly report, 2014
	operation, maintenance, airport	RER	0	unit	2.06E-11	2.06E-11	2.06E-11	1.27E-10	1	2.06	(2,4,1,3,1,5,BU:2); same as airport multipied by the lifetime of the airport of 100 years;
	disposal, airport	RER	1	unit	2.06E-13	2.06E-13	2.06E-13	1.27E-12	1	3.06	(2,4,1,3,1,5,BU:3); same as airport;
	kerosene, at regional storage	RER	0	kg	2.91E-2	2.65E-2	4.25E-2	1.80E-1	1	1.24	(2,4,1,3,1,5,BU:1.05); ; Lufthansa Balance 2015, BLD 2014, pers. communication Lufthasa, Mail 20.8.2015
emission air, lower stratosphere + upper troposphere	Carbon dioxide, fossil	-	-	kg	6.40E-2	5.81E-2	9.34E-2	3.95E-1	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the cruise emission take place in the upper troposphere and lower stratosphere (this corresponds to a share of of the total emissions); BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.86E-5	3.50E-5	5.63E-5	2.38E-4	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.03E-5	1.84E-5	2.96E-5	1.25E-4	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.63E-4	2.39E-4	3.83E-4	1.62E-3	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	6.47E-6	5.87E-6	9.44E-6	3.99E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.52E-2	2.29E-2	3.68E-2	1.56E-1	1	1.64	(2,5,2,5,1,5,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.23E-7	1.12E-7	1.79E-7	7.59E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	9.70E-7	8.81E-7	1.42E-6	5.99E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.16E-7	1.06E-7	1.70E-7	7.19E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.13E-6	1.02E-6	1.64E-6	6.95E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	4.88E-7	4.43E-7	7.12E-7	3.01E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	9.27E-4	8.42E-4	1.35E-3	5.72E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); ; default value
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	2.13E-2	1.94E-2	3.11E-2	1.32E-1	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the cruise emission take place in the troposphere (this corresponds to a share of of the total emissions) ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	1.29E-5	1.17E-5	1.88E-5	7.94E-5	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	6.77E-6	6.15E-6	9.88E-6	4.18E-5	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	8.76E-5	7.95E-5	1.28E-4	5.41E-4	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.16E-6	1.96E-6	3.15E-6	1.33E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	8.40E-3	7.63E-3	1.23E-2	5.19E-2	1	1.64	(2,5,2,5,1,5,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	4.10E-8	3.72E-8	5.98E-8	2.53E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	3.23E-7	2.94E-7	4.72E-7	2.00E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	3.88E-8	3.52E-8	5.66E-8	2.40E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	3.75E-7	3.41E-7	5.47E-7	2.32E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	1.63E-7	1.48E-7	2.37E-7	1.00E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	3.09E-4	2.81E-4	4.51E-4	1.91E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); default value;
emission air, low population density	Carbon dioxide, fossil	-	-	kg	6.43E-3	5.83E-3	9.38E-3	3.97E-2	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the total emission occure during the LTO; for LTO emissions different emission factors are used than for cruise; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	2.70E-5	2.45E-5	3.94E-5	1.67E-4	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.04E-6	1.86E-6	2.98E-6	1.26E-5	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.54E-5	2.30E-5	3.70E-5	1.57E-4	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.74E-6	2.48E-6	3.99E-6	1.69E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.53E-3	2.30E-3	3.69E-3	1.56E-2	1	1.64	(2,5,2,5,1,5,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	5.20E-8	4.72E-8	7.58E-8	3.21E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	4.10E-7	3.72E-7	5.98E-7	2.53E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	4.92E-8	4.47E-8	7.18E-8	3.04E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	4.76E-7	4.32E-7	6.94E-7	2.94E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	2.04E-7	1.85E-7	2.98E-7	1.26E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	9.30E-5	8.45E-5	1.36E-4	5.74E-4	1	1.33	(2,5,2,5,1,5,BU:1.05); default value;
	Particulates, < 2.5 um	-	-	kg	2.06E-7	1.87E-7	3.00E-7	1.27E-6	1	3.11	(2,5,2,5,1,5,BU:3); PM2.5 Emission of the abrasion during LTO ; pers. correspondence BAZL, 27.9.2016
emission Non material emissions, unspecified	Noise, aircraft, freight	-	-	tkm				1.00E+0	1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
	Noise, aircraft, passenger	-	-	pkm	1.00E+0	9.08E-1	1.46E+0		1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 5.8 Life cycle inventory data of long-haul aircraft transport services

	Name	Location	InfrastructureProcess	Unit	transport, aircraft, passenger, long-haul	transport, aircraft, passenger, long-haul, economy	transport, aircraft, passenger, long-haul, business	transport, aircraft, passenger, long-haul, first	transport, aircraft, freight, long-haul	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0	0			
	Unit				pkm	pkm	pkm	pkm	tkm			
product	transport, aircraft, passenger, long-haul	RER	0	pkm	1	0	0	0		0		
product	transport, aircraft, passenger, long-haul, economy	RER	0	pkm	0	1	0	0		0		
product	transport, aircraft, passenger, long-haul, business	RER	0	pkm	0	0	1	0		0		
product	transport, aircraft, passenger, long-haul, first	RER	0	pkm	0	0	0	1		0		
product	transport, aircraft, freight, long-haul	RER	0	tkm	0	0	0	0		1		
technosphere	aircraft, long haul	RER	1	unit	1.65E-11	1.57E-11	3.60E-11	7.78E-11	1.04E-10	1	3.06	(2,4,1,3,1,5,BU:3); Calculated based on the assumed numbers of LTOs in the life time of an aircraft of 25000LTO/airplane, an average load of 251 passengers or 12 tons of freight and an average distance of a flight of 7850km; For the effort of the maintenance 5% of the production is added; FAA (2010) Aging Airplane Program; Lufthansa Balance 2015
	airport	RER	1	unit	7.18E-14	7.18E-14	7.18E-14	7.18E-14	4.53E-13	1	3.06	(2,4,1,3,1,5,BU:3); assumed yearly throughput airport: passenger 5608369 p and freight 423221t; Airport Zürich, yearly report 2019
	operation, maintenance, airport	RER	0	unit	7.18E-12	7.18E-12	7.18E-12	7.18E-12	4.53E-11	1	2.06	(2,4,1,3,1,5,BU:2); same as airport multipied by the lifetime of the airport of 100 years;
	disposal, airport	RER	1	unit	7.18E-14	7.18E-14	7.18E-14	7.18E-14	4.53E-13	1	3.06	(2,4,1,3,1,5,BU:3); same as airport;
	kerosene, at regional storage	RER	0	kg	2.82E-2	2.07E-2	4.76E-2	1.03E-1	1.78E-1	1	1.24	(2,4,1,3,1,5,BU:1.05); ; Lufthansa Balance 2015, BLD 2014, pers. communication Lufthasa, Mail 20.8.2015
emission air, lower stratosphere + upper troposphere	Carbon dioxide, fossil	-	-	kg	6.89E-2	5.06E-2	1.16E-1	2.51E-1	4.35E-1	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the cruise emission take place in the upper troposphere and lower stratosphere (this corresponds to a share of of the total emissions); BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	4.15E-5	3.05E-5	7.01E-5	1.51E-4	2.62E-4	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.19E-5	1.61E-5	3.69E-5	7.97E-5	1.38E-4	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.83E-4	2.08E-4	4.77E-4	1.03E-3	1.78E-3	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	6.96E-6	5.11E-6	1.18E-5	2.54E-5	4.39E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.71E-2	1.99E-2	4.58E-2	9.89E-2	1.71E-1	1	1.64	(2,5,2,5,1,5,BU:1.5); ; 0
	Benzene	-	-	kg	1.32E-7	9.71E-8	2.23E-7	4.82E-7	8.34E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; Ecoinvent Report 14
	Formaldehyde	-	-	kg	1.04E-6	7.66E-7	1.76E-6	3.81E-6	6.58E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.25E-7	9.20E-8	2.12E-7	4.57E-7	7.90E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.21E-6	8.89E-7	2.04E-6	4.41E-6	7.64E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	5.25E-7	3.85E-7	8.86E-7	1.91E-6	3.31E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Heat, waste	-	-	MJ	9.97E-4	7.32E-4	1.68E-3	3.64E-3	6.29E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); default value; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.72E-2	1.26E-2	2.91E-2	6.28E-2	1.09E-1	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the cruise emissione take place in the troposphere (this corresponds to a share of of the total emissions); BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	1.04E-5	7.62E-6	1.75E-5	3.78E-5	6.54E-5	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	5.47E-6	4.01E-6	9.23E-6	1.99E-5	3.45E-5	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	7.07E-5	5.19E-5	1.19E-4	2.58E-4	4.46E-4	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.74E-6	1.28E-6	2.94E-6	6.34E-6	1.10E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	6.78E-3	4.98E-3	1.14E-2	2.47E-2	4.28E-2	1	1.64	(2,5,2,5,1,5,BU:1.5); ; 0
	Benzene	-	-	kg	3.31E-8	2.43E-8	5.58E-8	1.20E-7	2.08E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; Ecoinvent Report 14
	Formaldehyde	-	-	kg	2.61E-7	1.92E-7	4.41E-7	9.51E-7	1.65E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	3.13E-8	2.30E-8	5.29E-8	1.14E-7	1.98E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	3.03E-7	2.22E-7	5.11E-7	1.10E-6	1.91E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	1.31E-7	9.63E-8	2.22E-7	4.78E-7	8.28E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Heat, waste	-	-	MJ	2.49E-4	1.83E-4	4.21E-4	9.09E-4	1.57E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); default value; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
emission air, low population density	Carbon dioxide, fossil	-	-	kg	2.66E-3	1.96E-3	4.50E-3	9.71E-3	1.68E-2	1	1.33	(2,5,2,5,1,5,BU:1.05); assumption: a share of of the total emission occure during the LTO; for LTO emissions different emission factors are used than for cruise; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	1.12E-5	8.21E-6	1.89E-5	4.08E-5	7.06E-5	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	8.47E-7	6.22E-7	1.43E-6	3.09E-6	5.34E-6	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	1.05E-5	7.72E-6	1.78E-5	3.83E-5	6.63E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.13E-6	8.32E-7	1.91E-6	4.13E-6	7.15E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	1.05E-3	7.70E-4	1.77E-3	3.82E-3	6.61E-3	1	1.64	(2,5,2,5,1,5,BU:1.5); ; 0
	Benzene	-	-	kg	2.15E-8	1.58E-8	3.64E-8	7.85E-8	1.36E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; Ecoinvent Report 14
	Formaldehyde	-	-	kg	1.70E-7	1.25E-7	2.87E-7	6.20E-7	1.07E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	2.04E-8	1.50E-8	3.45E-8	7.44E-8	1.29E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.97E-7	1.45E-7	3.33E-7	7.19E-7	1.24E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	8.45E-8	6.21E-8	1.43E-7	3.08E-7	5.33E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Heat, waste	-	-	MJ	3.86E-5	2.83E-5	6.51E-5	1.41E-4	2.43E-4	1	1.33	(2,5,2,5,1,5,BU:1.05); default value; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Particulates, < 2.5 um	-	-	kg	3.15E-8	2.31E-8	5.32E-8	1.48E-7	1.99E-7	1	3.11	(2,5,2,5,1,5,BU:3); PM2.5 Emission of the abrasion during LTO ; pers. correspondence BAZL, 27.9.2016
emission Non material emissions, unspecified	Noise, aircraft, freight	-	-	tkm					1.00E+0	1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
	Noise, aircraft, passenger	-	-	pkm	1.00E+0	7.34E-1	1.69E+0	3.65E+0		1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 5.9 Life cycle inventory data of average aircraft passenger and freight transport service

	Name	Location	InfrastructureProcess	Unit	transport, aircraft, passenger	transport, aircraft, freight	UncertaintyType	Standard Deviation 95%	GeneralComment
	Location				RER	RER			
	InfrastructureProcess				0	0			
	Unit				pkm	tkm			
product	transport, aircraft, passenger	RER	0	pkm	1	0			
product	transport, aircraft, freight	RER	0	tkm	0	1			
technosphere	aircraft, long haul	RER	1	unit	6.73E-11	1.66E-10	1	3.06	(2,4,1,3,1,5,BU:3); Passenger: share short-haul: 0.23, share medium-haul: 0.14, share long-haul: 0.63; Freight: share short-haul: 0.04, share medium-haul: 0.08, share long-haul: 0.88; Geschäftsbericht Lufthansa 2019
technosphere	airport	RER	1	unit	2.55E-13	6.75E-13	1	3.06	(2,4,1,3,1,5,BU:3); assumed yearly throughput airport: passenger 5608369 p and freight 423221t; Geschäftsbericht Lufthansa 2019
	operation, maintenance, airport	RER	0	unit	2.55E-11	6.75E-11	1	2.06	(2,4,1,3,1,5,BU:2); same as airport multipied by the lifetime of the airport of 100 years;
	disposal, airport	RER	1	unit	2.55E-13	6.75E-13	1	3.06	(2,4,1,3,1,5,BU:3); same as airport;
	kerosene, at regional storage	RER	0	kg	3.30E-2	1.82E-1	1	1.24	(2,4,1,3,1,5,BU:1.05); ;
emission air, lower stratosphere + upper troposphere	Carbon dioxide, fossil	-	-	kg	6.75E-2	4.30E-1	1	1.24	(2,4,1,3,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	4.07E-5	2.59E-4	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.14E-5	1.36E-4	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.77E-4	1.76E-3	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	6.26E-6	4.29E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.66E-2	1.69E-1	1	1.64	(2,5,2,5,1,5,BU:1.5); ; 0
	Benzene	-	-	kg	1.30E-7	8.25E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; Ecoinvent Report 14
	Formaldehyde	-	-	kg	1.02E-6	6.52E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.23E-7	7.82E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.19E-6	7.56E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	5.14E-7	3.28E-6	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Heat, waste	-	-	MJ	9.77E-4	6.23E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	2.90E-2	1.21E-1	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	1.75E-5	7.29E-5	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	9.21E-6	3.84E-5	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	1.19E-4	4.97E-4	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.38E-6	1.17E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	1.14E-2	4.77E-2	1	1.64	(2,5,2,5,1,5,BU:1.5); ; 0
	Benzene	-	-	kg	5.57E-8	2.32E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; Ecoinvent Report 14
	Formaldehyde	-	-	kg	4.40E-7	1.83E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	5.28E-8	2.20E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	5.10E-7	2.13E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	2.21E-7	9.22E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Heat, waste	-	-	MJ	4.20E-4	1.75E-3	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
emission air, low population density	Carbon dioxide, fossil	-	-	kg	7.51E-3	2.27E-2	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.16E-5	9.55E-5	1	5.12	(2,5,2,5,1,5,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.39E-6	7.23E-6	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.97E-5	8.98E-5	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.44E-6	8.95E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.96E-3	8.95E-3	1	1.64	(2,5,2,5,1,5,BU:1.5); ; 0
	Benzene	-	-	kg	6.08E-8	1.84E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; Ecoinvent Report 14
	Formaldehyde	-	-	kg	4.80E-7	1.45E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	5.76E-8	1.74E-7	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	5.56E-7	1.68E-6	1	1.64	(2,5,2,5,1,5,BU:1.5); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	2.39E-7	7.22E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; VOC Profil wie ecoinvent 2.2, ecoinvent report 14
	Heat, waste	-	-	MJ	1.09E-4	3.29E-4	1	1.33	(2,5,2,5,1,5,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Particulates, < 2.5 um	-	-	kg	2.37E-7	4.57E-7	1	3.11	(2,5,2,5,1,5,BU:3); ; pers. correspondence BAZL, 27.9.2016
emission Non material emissions, unspecified	Noise, aircraft, freight	-	-	tkm	0	1.00E+0	1	1.64	(2,5,2,5,1,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
	Noise, aircraft, passenger	-	-	pkm	1.00E+0	0	1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

6 Aircraft Transport Services, SWISS

6.1 Introduction

The following chapter includes the life cycle inventories of aircraft transport services offered by Swiss International Air Lines and Edelweiss Air, named "SWISS" in the following text. The life cycle inventories are based on confidential information and proprietary data provided by FOCA and Swiss International Air Lines[10]. Therefore only the resulting life cycle invetory data are presented. The method applied corresponds exactly to the method described in Chapter 5.

6.2 Key characteristics and allocation factors of the aircraft (confidential)

6.3 Allocation to booking classes (confidential)

6.4 Aircraft Operation (confidential)

6.5 Air Transport (confidential)

6.6 Average Aircraft Transport (confidential)

[10] personal communications, , FOCA, February and March 2021

6.7 Unit process life cycle inventory data

Tab. 6.6 Life cycle inventory data of short-haul aircraft transport services of SWISS

	Name	Location	InfrastructureProcess	Unit	transport, aircraft, passenger, Swiss, short-haul	transport, aircraft, passenger, Swiss, short-haul, economy	transport, aircraft, passenger, Swiss, short-haul, business	transport, aircraft, freight, Swiss, short-haul	UncertaintyType	StandardDeviation95 %	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	tkm			
product	transport, aircraft, passenger, Swiss, short-haul	CH	0	pkm	1	0	0	0			
product	transport, aircraft, passenger, Swiss, short-haul, economy	CH	0	pkm	0	1	0	0			
product	transport, aircraft, passenger, Swiss, short-haul, business	CH	0	pkm	0	0	1	0			
product	transport, aircraft, freight, Swiss, short-haul	CH	0	tkm	0	0	0	1			
technosphere	aircraft, medium haul	RER	1	unit	3.04E-10	2.79E-10	4.40E-10	1.81E-9	1	3.02	
	airport	RER	1	unit	1.06E-12	1.06E-12	1.06E-12	6.46E-12	1	3.02	(2,4,1,3,1,1,BU:3); assumed yearly throughput at the airport: passengers 20984123 p and freight 17486t; Airport Zürich, yearly report 2019
	operation, maintenance, airport	RER	0	unit	1.06E-10	1.06E-10	1.06E-10	6.46E-10	1	2.02	(2,4,1,3,1,1,BU:2); same as airport multiplied by the lifetime of the airport of 100 years; Airport Zürich, yearly report 2019
	disposal, airport	RER	1	unit	1.06E-12	1.06E-12	1.06E-12	6.46E-12	1	3.02	(2,4,1,3,1,1,BU:3); same as airport; Airport Zürich, yearly report 2019
	kerosene, at regional storage	RER	0	kg	4.205E-2	3.86E-2	6.09E-2	2.51E-1	1	1.13	(2,4,1,3,1,1,BU:1.05); ; pers. communication Alice Suri, Mail 10.2.2021
emission air, lower stratosphere + upper troposphere	Carbon dioxide, fossil	-	-	kg	5.70E-2	5.23E-2	8.25E-2	3.40E-1	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the cruise emission take place in the upper troposphere and lower stratosphere (this corresponds to a share of of the total emissions); BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.43E-5	3.15E-5	4.97E-5	2.05E-4	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	1.81E-5	1.66E-5	2.62E-5	1.08E-4	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.34E-4	2.14E-4	3.39E-4	1.39E-3	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.75E-6	5.28E-6	8.34E-6	3.43E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.24E-2	2.06E-2	3.25E-2	1.34E-1	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.09E-7	1.00E-7	1.58E-7	6.52E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	8.63E-7	7.92E-7	1.25E-6	5.15E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.04E-7	9.50E-8	1.50E-7	6.18E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.00E-6	9.19E-7	1.45E-6	5.97E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	4.34E-7	3.98E-7	6.29E-7	2.59E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	8.24E-4	7.57E-4	1.19E-3	4.92E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); ; default value
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	5.70E-2	5.23E-2	8.25E-2	3.40E-1	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the cruise emission take place in the troposphere (this corresponds to a share of of the total emissions) ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.43E-5	3.15E-5	4.97E-5	2.05E-4	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	1.81E-5	1.66E-5	2.62E-5	1.08E-4	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.34E-4	2.14E-4	3.39E-4	1.39E-3	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.75E-6	5.28E-6	8.34E-6	3.43E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.24E-2	2.06E-2	3.25E-2	1.34E-1	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.09E-7	1.00E-7	1.58E-7	6.52E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	8.63E-7	7.92E-7	1.25E-6	5.15E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.04E-7	9.50E-8	1.50E-7	6.18E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.00E-6	9.19E-7	1.45E-6	5.97E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	4.34E-7	3.98E-7	6.29E-7	2.59E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	8.24E-4	7.57E-4	1.19E-3	4.92E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); default value;
emission air, low population density	Carbon dioxide, fossil	-	-	kg	1.85E-2	1.70E-2	2.69E-2	1.11E-1	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the total emission occure during the LTO; for LTO emissions different emission factors are used than for cruise; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	7.79E-5	7.15E-5	1.13E-4	4.65E-4	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	5.90E-6	5.41E-6	8.54E-6	3.52E-5	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	7.32E-5	6.72E-5	1.06E-4	4.37E-4	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	7.89E-6	7.24E-6	1.14E-5	4.71E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	7.30E-3	6.70E-3	1.06E-2	4.36E-2	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.50E-7	1.38E-7	2.17E-7	8.95E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	1.18E-6	1.09E-6	1.71E-6	7.06E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.42E-7	1.30E-7	2.06E-7	8.48E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.37E-6	1.26E-6	1.99E-6	8.19E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	5.89E-7	5.40E-7	8.53E-7	3.51E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	2.68E-4	2.46E-4	3.89E-4	1.60E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); default value;
	Particulates, < 2.5 um	-	-	kg	1.16E-6	1.06E-6	1.68E-6	6.90E-6	1	3.00	(1,1,2,1,1,2,BU:3); PM2.5 Emission of the abrasion during LTO ; pers. correspondence BAZL, 27.9.2016
emission Non material emissions, unspecified	Noise, aircraft, freight	-	-	tkm				1.00E+0	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
	Noise, aircraft, passenger	-	-	pkm	1.00E+0	9.18E-1	1.45E+0		1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 6.7 Life cycle inventory data of medium-haul aircraft transport services, SWISS

	Name	Location	InfrastructureProcess	Unit	transport, aircraft, passenger, Swiss, medium-haul	transport, aircraft, passenger, Swiss, medium-haul, economy	transport, aircraft, passenger, Swiss, medium-haul, business	transport, aircraft, freight, Swiss, medium-haul	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	tkm			
product	transport, aircraft, passenger, Swiss, medium-haul	CH	0	pkm	1	0	0	0			
product	transport, aircraft, passenger, Swiss, medium-haul, economy	CH	0	pkm	0	1	0	0			
product	transport, aircraft, passenger, Swiss, medium-haul, business	CH	0	pkm	0	0	1	0			
product	transport, aircraft, freight, Swiss, medium-haul	CH	0	tkm	0	0	0	1			
technosphere	aircraft, medium haul	RER	1	unit	1.04E-10	9.54E-11	1.51E-10	6.44E-10	1	3.02	
	airport	RER	1	unit	4.02E-13	4.02E-13	4.02E-13	2.48E-12	1	3.02	(2,4,1,3,1,1,BU:3); assumed yearly throughput at the airport: passengers 4915200 p and freight 38093t; Airport Zürich, yearly report 2019
	operation, maintenance, airport	RER	0	unit	4.02E-11	4.02E-11	4.02E-11	2.48E-10	1	2.02	(2,4,1,3,1,1,BU:2); same as airport multiplied by the lifetime of the airport of 100 years; Airport Zürich, yearly report 2019
	disposal, airport	RER	1	unit	4.02E-13	4.02E-13	4.02E-13	2.48E-12	1	3.02	(2,4,1,3,1,1,BU:3); same as airport; Airport Zürich, yearly report 2019
	kerosene, at regional storage	RER	0	kg	2.79E-2	2.56E-2	4.04E-2	1.73E-1	1	1.13	(2,4,1,3,1,1,BU:1.05); ; pers. communication Alice Suri, Mail 10.2.2021
emission air, lower stratosphere + upper troposphere	Carbon dioxide, fossil	-	-	kg	6.13E-2	5.63E-2	8.89E-2	3.80E-1	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the cruise emission take place in the upper troposphere and lower stratosphere (this corresponds to a share of of the total emissions); BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.69E-5	3.39E-5	5.35E-5	2.29E-4	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	1.95E-5	1.79E-5	2.82E-5	1.21E-4	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.52E-4	2.31E-4	3.65E-4	1.56E-3	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	6.20E-6	5.69E-6	8.98E-6	3.84E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.41E-2	2.22E-2	3.50E-2	1.50E-1	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.18E-7	1.08E-7	1.71E-7	7.29E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	9.29E-7	8.53E-7	1.35E-6	5.76E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.12E-7	1.02E-7	1.62E-7	6.91E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.08E-6	9.89E-7	1.56E-6	6.68E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	4.67E-7	4.29E-7	6.77E-7	2.90E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	8.88E-4	8.15E-4	1.29E-3	5.50E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); ; default value
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	2.04E-2	1.88E-2	2.96E-2	1.27E-1	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the cruise emission take place in the troposphere (this corresponds to a share of of the total emissions) ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	1.23E-5	1.13E-5	1.78E-5	7.63E-5	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	6.49E-6	5.96E-6	9.40E-6	4.02E-5	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	8.39E-5	7.70E-5	1.22E-4	5.20E-4	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.07E-6	1.90E-6	2.99E-6	1.28E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	8.05E-3	7.39E-3	1.17E-2	4.99E-2	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	3.92E-8	3.60E-8	5.69E-8	2.43E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	3.10E-7	2.84E-7	4.49E-7	1.92E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	3.72E-8	3.41E-8	5.39E-8	2.30E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	3.59E-7	3.30E-7	5.21E-7	2.23E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	1.56E-7	1.43E-7	2.26E-7	9.65E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	2.96E-4	2.72E-4	4.29E-4	1.83E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); default value;
emission air, low population density	Carbon dioxide, fossil	-	-	kg	6.16E-3	5.65E-3	8.92E-3	3.81E-2	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the total emission occure during the LTO; for LTO emissions different emission factors are used than for cruise; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	2.59E-5	2.37E-5	3.75E-5	1.60E-4	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	1.96E-6	1.80E-6	2.84E-6	1.21E-5	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.43E-5	2.23E-5	3.52E-5	1.51E-4	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.62E-6	2.40E-6	3.80E-6	1.62E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.42E-3	2.22E-3	3.51E-3	1.50E-2	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	4.98E-8	4.57E-8	7.21E-8	3.08E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	3.93E-7	3.61E-7	5.69E-7	2.43E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	4.72E-8	4.33E-8	6.83E-8	2.92E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	4.56E-7	4.18E-7	6.60E-7	2.82E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	1.95E-7	1.79E-7	2.83E-7	1.21E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	8.91E-5	8.18E-5	1.29E-4	5.52E-4	1	1.06	(1,1,2,1,1,2,BU:1.05); default value;
	Particulates, < 2.5 um	-	-	kg	3.96E-7	3.64E-7	5.74E-7	2.45E-6	1	3.00	(1,1,2,1,1,2,BU:3); PM2.5 Emission of the abrasion during LTO ; pers. correspondence BAZL, 27.9.2016
emission Non material emissions, unspecified	Noise, aircraft, freight	-	-	tkm				1.00E+0	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
	Noise, aircraft, passenger	-	-	pkm	1.00E+0	9.18E-1	1.45E+0		1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 6.8 Life cycle inventory data of long-haul aircraft transport services, SWISS

	Name	Location	InfrastructureProcess	Unit	transport, aircraft, passenger, Swiss, long-haul	transport, aircraft, passenger, Swiss, long-haul, economy	transport, aircraft, passenger, Swiss, long-haul, business	transport, aircraft, passenger, Swiss, long-haul, first	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	pkm			
product	transport, aircraft, passenger, Swiss, long-haul	CH	0	pkm	1	0	0	0			
product	transport, aircraft, passenger, Swiss, long-haul, economy	CH	0	pkm	0	1	0	0			
product	transport, aircraft, passenger, Swiss, long-haul, business	CH	0	pkm	0	0	1	0			
product	transport, aircraft, passenger, Swiss, long-haul, first	CH	0	pkm	0	0	0	1			
product	transport, aircraft, freight, Swiss, long-haul	CH	0	tkm	0	0	0	0			
technosphere	aircraft, long haul	RER	1	unit	1.85E-11	1.76E-11	3.96E-11	8.38E-11	1	3.02	
	airport	RER	1	unit	7.31E-14	7.31E-14	7.31E-14	7.31E-14	1	3.02	(2,4,1,3,1,1,BU:3); assumed yearly throughput airport: passenger 5608369 p and freight 4232211t; Airport Zürich, yearly report 2019
	operation, maintenance, airport	RER	0	unit	7.31E-12	7.31E-12	7.31E-12	7.31E-12	1	2.02	(2,4,1,3,1,1,BU:2); same as airport multipied by the lifetime of the airport of 100 years; Airport Zürich, yearly report 2019
	disposal, airport	RER	1	unit	7.31E-14	7.31E-14	7.31E-14	7.31E-14	1	3.02	(2,4,1,3,1,1,BU:3); same as airport; Airport Zürich, yearly report
	kerosene, at regional storage	RER	0	kg	2.65E-2	1.96E-2	4.40E-2	9.31E-2	1	1.13	(2,4,1,3,1,1,BU:1.05); ; pers. communication Alice Suri, Mail
emission air, lower stratosphere + upper troposphere	Carbon dioxide, fossil	-	-	kg	6.47E-2	4.79E-2	1.07E-1	2.28E-1	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the crusie emission take place in the upper troposphere and lower stratosphere (this corresponds to a share of of the total emissions); BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.90E-5	2.88E-5	6.47E-5	1.37E-4	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.05E-5	1.52E-5	3.41E-5	7.22E-5	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.65E-4	1.96E-4	4.41E-4	9.34E-4	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	6.53E-6	4.84E-6	1.09E-5	2.30E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.55E-2	1.88E-2	4.23E-2	8.96E-2	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.24E-7	9.19E-8	2.06E-7	4.37E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	9.80E-7	7.26E-7	1.63E-6	3.45E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.18E-7	8.71E-8	1.95E-7	4.14E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.14E-6	8.42E-7	1.89E-6	4.00E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	4.93E-7	3.65E-7	8.19E-7	1.73E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative
	Heat, waste	-	-	MJ	9.36E-4	6.93E-4	1.56E-3	3.29E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); default value;
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.62E-2	1.20E-2	2.69E-2	5.69E-2	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the cruise emissione take place in the troposphere (this corresponds to a share of of the total emissions); BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	9.74E-6	7.21E-6	1.62E-5	3.43E-5	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	5.13E-6	3.80E-6	8.52E-6	1.81E-5	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	6.63E-5	4.91E-5	1.10E-4	2.33E-4	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.63E-6	1.21E-6	2.71E-6	5.75E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	6.36E-3	4.71E-3	1.06E-2	2.24E-2	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	3.10E-8	2.30E-8	5.15E-8	1.09E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	2.45E-7	1.81E-7	4.07E-7	8.62E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	2.94E-8	2.18E-8	4.88E-8	1.03E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	2.84E-7	2.10E-7	4.72E-7	1.00E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	1.23E-7	9.12E-8	2.05E-7	4.33E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	2.34E-4	1.73E-4	3.89E-4	8.24E-4	1	1.06	(1,1,2,1,1,2,BU:1.05); default value;
emission air, low population density	Carbon dioxide, fossil	-	-	kg	2.50E-3	1.85E-3	4.15E-3	8.80E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); assumption: a share of of the total emission occure during the LTO; for LTO emissions different emission factors are used than for cruise; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	1.05E-5	7.77E-6	1.74E-5	3.69E-5	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	7.95E-7	5.89E-7	1.32E-6	2.80E-6	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	9.87E-6	7.31E-6	1.64E-5	3.47E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.06E-6	7.88E-7	1.77E-6	3.74E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	9.84E-4	7.29E-4	1.63E-3	3.46E-3	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	2.02E-8	1.50E-8	3.36E-8	7.11E-8	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	1.60E-7	1.18E-7	2.65E-7	5.62E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	1.91E-8	1.42E-8	3.18E-8	6.74E-8	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	1.85E-7	1.37E-7	3.08E-7	6.51E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	7.94E-8	5.88E-8	1.32E-7	2.79E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	3.62E-5	2.68E-5	6.01E-5	1.27E-4	1	1.06	(1,1,2,1,1,2,BU:1.05); default value;
	Particulates, < 2.5 um	-	-	kg	3.53E-8	2.61E-8	5.86E-8	1.60E-7	1	3.00	(1,1,2,1,1,2,BU:3); PM2.5 Emission of the abrasion during LTO ; pers. correspondence BAZL, 27.9.2016
emission Non material emissions, unspecified	Noise, aircraft, freight	-	-	tkm					1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
	Noise, aircraft, passenger	-	-	pkm	1.00E+0	7.40E-1	1.66E+0	3.52E+0	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 6.9 Life cycle inventory data of average aircraft passenger and freight transport service, SWISS

	Name	Location	InfrastructureProcess	Unit	transport, aircraft, passenger, Swiss	transport, aircraft, freight, Swiss	UncertaintyType	Standard Deviation 95%	GeneralComment
	Location				CH	CH			
	InfrastructureProcess				0	0			
	Unit				pkm	tkm			
product	transport, aircraft, passenger, Swiss	CH	0	pkm	1	0			
product	transport, aircraft, freight, Swiss	CH	0	tkm	0	1			
technosphere	aircraft, long haul	RER	1	unit	5.58E-11	6.54E-10	1	3.02	(2,4,1,3,1,1,BU:3); Passenger: share short-haul: 0.08, share medium-haul: 0.19, share long-haul: 0.73; FAA (2010) Aging Airplane Program; Swiss Fleet 2019
technosphere	airport	RER	1	unit	2.16E-13	2.58E-12	1	3.02	(2,4,1,3,1,1,BU:3); Freight: share short-haul: 0.03, share medium-haul: 0.97, share long-haul: 0.01; Airport Zürich, yearly report 2019
	operation, maintenance, airport	RER	0	unit	2.16E-11	2.58E-10	1	2.02	(2,4,1,3,1,1,BU:2); Freight: share short-haul: 0.97, share medium-haul: 0.01, share long-haul: 0.00; Airport Zürich, yearly report 2019
	disposal, airport	RER	1	unit	2.16E-13	2.58E-12	1	3.02	(2,4,1,3,1,1,BU:3); Freight: share short-haul: 0.01, share medium-haul: 0.00, share long-haul: 0.00; Airport Zürich, yearly report 2019
	kerosene, at regional storage	RER	0	kg	2.85E-2	1.78E-1	1	1.13	(2,4,1,3,1,1,BU:1.05); Freight: share short-haul: 0.00, share medium-haul: 0.00, share long-haul: 0.00; pers. communication Alice Suri, Mail 10.2.2021
emission air, lower stratosphere + upper troposphere	Carbon dioxide, fossil	-	-	kg	6.44E-2	3.84E-1	1	1.13	(2,4,1,3,1,1,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	3.88E-5	2.31E-4	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	2.04E-5	1.22E-4	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	2.64E-4	1.58E-3	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	6.51E-6	3.88E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	2.54E-2	1.51E-1	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	1.04E-5	1.70E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	8.19E-5	1.34E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	9.83E-6	1.61E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	9.50E-5	1.56E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	4.91E-7	2.93E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	9.33E-4	5.56E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); ; 0
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	2.07E-2	1.34E-1	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	1.24E-5	8.10E-5	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	6.56E-6	4.27E-5	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	8.48E-5	5.52E-4	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.09E-6	1.36E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	8.14E-3	5.29E-2	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	2.61E-6	5.41E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	2.06E-5	4.27E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	2.47E-6	5.12E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	2.39E-5	4.95E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	1.57E-7	1.02E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	2.99E-4	1.95E-3	1	1.06	(1,1,2,1,1,2,BU:1.05); ; 0
emission air, low population density	Carbon dioxide, fossil	-	-	kg	4.59E-3	4.06E-2	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Carbon monoxide, fossil	-	-	kg	1.93E-5	1.71E-4	1	5.00	(1,1,2,1,1,2,BU:5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Sulfur dioxide	-	-	kg	1.46E-6	1.29E-5	1	1.06	(1,1,2,1,1,2,BU:1.05); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Nitrogen oxides	-	-	kg	1.81E-5	1.60E-4	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.95E-6	1.73E-5	1	1.50	(1,1,2,1,1,2,BU:1.5); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Water	-	-	kg	1.81E-3	1.60E-2	1	1.50	(1,1,2,1,1,2,BU:1.5); ; Ecoinvent Report 14
	Benzene	-	-	kg	4.19E-7	5.33E-7	1	3.00	(1,1,2,1,1,2,BU:3); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Formaldehyde	-	-	kg	3.31E-6	4.21E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Butadiene	-	-	kg	3.97E-7	5.05E-7	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Ethene	-	-	kg	3.84E-6	4.89E-6	1	1.50	(1,1,2,1,1,2,BU:1.5); ; VOC profile according to ecoinvent 2.2, ecoinvent report 14
	Particulates, < 2.5 um	-	-	kg	1.46E-7	1.29E-6	1	3.00	(1,1,2,1,1,2,BU:3); ; BAFU (2016) Switzerland's Informative Inventory Report 2014 (IIR); pers. correspondence BAZL, 27.9.2016
	Heat, waste	-	-	MJ	6.64E-5	5.88E-4	1	1.06	(1,1,2,1,1,2,BU:1.05); default value;
	Particulates, < 2.5 um	-	-	kg	1.88E-7	2.49E-6	1	3.10	(2,5,2,1,1,5,BU:3); ; pers. correspondence BAZL, 27.9.2016
emission Non material emissions, unspecified	Noise, aircraft, freight	-	-	tkm	0	1.00E+0	1	1.62	(2,5,2,1,1,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
	Noise, aircraft, passenger	-	-	pkm	1.00E+0	0	1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

7 Results

7.1 Overview

This chapter contains a description and discussion of the life cycle based environmental impacts of aircraft passenger transport services (Subchapter 7.2) and of aircraft cargo transport services (Subchapter 7.3) operated by Lufthansa Group (used to represent the performance of the average of European airlines) and by SWISS (used to represent the performance of an average Swiss network carrier). Greenhouse gas emissions and environmental impacts of aircraft transport services are compared to those of mobitool 2016 and mobitool 2020 in Subchapter 7.4. Data quality issues are described in Subchapter 7.5).

7.2 Aircraft passenger transport services

Based on the data sources and methodology as specified in this report, an average passenger transport service causes specific greenhouse gas emissions and additional climate impacts from non-greenhouse gas aircraft emissions in the order of 214 g, 213 g and 303 g CO_2-eq/pkm (CO_2 –Equivalents per Passenger and km, when applying a factor 2 for CO_2 emitted by aircraft), in the order of 263, 259 and 350 g CO_2-eq/pkm (when applying a factor 2.5) and in the order of 158, 156 and 219 g CO_2-eq/pkm (when applying a factor 1.7) on a long-, medium- and short-haul flight, respectively. The fossil CO_2-emissions from flight operations only are in the order of 89 g, 92 g and 153 g CO_2/pkm on a long-, medium- and short-haul flight, respectively. The allocated life cycle emissions per passenger of an average medium- and long-haul flight are very similar due to a slightly higher specific fuel consumption of medium-haul flights but at the same a higher share of freight transport of the long-haul flights.

Passenger transport services booked in business class are attributed 60 % more greenhouse gas emissions and additional effects from aircraft non-CO_2-emissions compared to flights in economy class (short- and medium haul) and more than twice as much on long-haul flights. One person flying first class is attributed five times more emissions than one person flying in economy class.

The cumulative greenhouse gas emissions are mainly caused by burning kerosine during the operation of the aircraft. The emissions caused by the fuel supply contribute a share of about 12 to 14 %. The contributions from the aircraft manufacture and the airport construction and operation are very small.

The environmental impacts expressed in ecopoints 2013 according to the ecological scarcity method vary between 112 UBP/pkm (long-haul, economy) and 555 UBP/pkm (long-haul, first). The share of fuel supply on total impacts is about one fourth.

The greenhouse gas emissions and the environmental impacts caused by aircraft transport services offered by SWISS are slightly lower (medium-haul) and between 6 % and 10 % lower (long- and short-haul flights) compared to those of an average of European airlines.

Tab. 7.1 Environmental impacts of aircraft passenger transport services, average of European airlines

Kategorie	Bereich	Bezugsgrösse	Primärenergiefaktor total [MJ oil-eq]	Primärenergiefaktor fossil [MJ oil-eq]	Primärenergiefaktor nuklear [MJ oil-eq]	Primärenergiefaktor total erneuerbar [MJ oil-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=2; [kg CO_2-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=2.5; [kg CO_2-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=1.7; [kg CO_2-eq]	Kohlendioxid, fossil [kg]	Umweltbelastungspunkte [UBP13]
Flugzeug, Durchschnitt[1]	Total	pkm	1.94	1.88	0.04	0.01	0.234	0.283	0.205	0.128	171.4
	Betrieb	pkm					0.201	0.249	0.172	0.104	125.7
	Brennstoffbereitstellung	pkm	1.85	1.82	0.02	0.01	0.029	0.029	0.029	0.019	41.1
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.4
	Infrastruktur	pkm	0.08	0.06	0.02	0.01	0.004	0.004	0.004	0.004	4.1
Flugzeug, Kurzstrecke[1]	Total	pkm	2.97	2.85	0.09	0.03	0.303	0.350	0.275	0.193	230.1
	Betrieb	pkm					0.247	0.294	0.219	0.153	156.6
	Brennstoffbereitstellung	pkm	2.72	2.67	0.04	0.01	0.043	0.043	0.043	0.029	60.3
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.01	0.00	0.00	0.000	0.000	0.000	0.000	0.4
	Infrastruktur	pkm	0.24	0.17	0.05	0.02	0.013	0.013	0.013	0.012	12.7
Flugzeug, Kurzstrecke, economy[1]	Total	pkm	2.72	2.60	0.09	0.03	0.276	0.319	0.251	0.177	210.0
	Betrieb	pkm					0.224	0.267	0.198	0.139	142.1
	Brennstoffbereitstellung	pkm	2.47	2.42	0.03	0.01	0.039	0.039	0.039	0.026	54.8
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.4
	Infrastruktur	pkm	0.24	0.17	0.05	0.02	0.013	0.013	0.013	0.012	12.7
Flugzeug, Kurzstrecke, business[1]	Total	pkm	4.22	4.07	0.11	0.04	0.436	0.505	0.395	0.277	329.8
	Betrieb	pkm					0.360	0.429	0.319	0.223	228.4
	Brennstoffbereitstellung	pkm	3.96	3.89	0.05	0.02	0.063	0.063	0.063	0.042	88.0
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.01	0.00	0.00	0.001	0.001	0.001	0.001	0.6
	Infrastruktur	pkm	0.24	0.17	0.05	0.02	0.013	0.013	0.013	0.012	12.7
Flugzeug, Mittelstrecke[1]	Total	pkm	1.70	1.65	0.04	0.01	0.213	0.259	0.185	0.112	154.6
	Betrieb	pkm					0.184	0.229	0.156	0.092	114.9
	Brennstoffbereitstellung	pkm	1.63	1.60	0.02	0.01	0.026	0.026	0.026	0.017	36.3
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.1
	Infrastruktur	pkm	0.06	0.05	0.01	0.00	0.003	0.003	0.003	0.003	3.3
Flugzeug, Mittelstrecke, economy[1]	Total	pkm	1.55	1.50	0.03	0.01	0.194	0.235	0.169	0.102	140.6
	Betrieb	pkm					0.167	0.208	0.142	0.083	104.3
	Brennstoffbereitstellung	pkm	1.48	1.46	0.02	0.01	0.023	0.023	0.023	0.016	32.9
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.1
	Infrastruktur	pkm	0.06	0.05	0.01	0.00	0.003	0.003	0.003	0.003	3.3
Flugzeug, Mittelstrecke, business[1]	Total	pkm	2.45	2.39	0.05	0.02	0.309	0.376	0.269	0.162	224.0
	Betrieb	pkm					0.268	0.335	0.228	0.134	167.5
	Brennstoffbereitstellung	pkm	2.38	2.34	0.03	0.01	0.038	0.038	0.038	0.025	52.9
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.2
	Infrastruktur	pkm	0.06	0.05	0.01	0.00	0.003	0.003	0.003	0.003	3.3
Flugzeug, Langstrecke[1]	Total	pkm	1.60	1.57	0.03	0.01	0.214	0.263	0.184	0.107	153.1
	Betrieb	pkm					0.187	0.237	0.158	0.089	116.7
	Brennstoffbereitstellung	pkm	1.58	1.55	0.02	0.01	0.025	0.025	0.025	0.017	35.1
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.1
	Infrastruktur	pkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.2
Flugzeug, Langstrecke, economy[1]	Total	pkm	1.18	1.16	0.02	0.01	0.157	0.193	0.135	0.079	112.7
	Betrieb	pkm					0.138	0.174	0.116	0.065	85.7
	Brennstoffbereitstellung	pkm	1.16	1.14	0.02	0.01	0.018	0.018	0.018	0.012	25.8
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.1
	Infrastruktur	pkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.2
Flugzeug, Langstrecke, business[1]	Total	pkm	2.69	2.64	0.04	0.01	0.360	0.443	0.310	0.179	257.8
	Betrieb	pkm					0.316	0.400	0.266	0.150	197.2
	Brennstoffbereitstellung	pkm	2.67	2.62	0.04	0.01	0.042	0.042	0.042	0.028	59.2
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.2
	Infrastruktur	pkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.2
Flugzeug, Langstrecke, first[1]	Total	pkm	5.79	5.67	0.08	0.03	0.776	0.956	0.668	0.386	555.1
	Betrieb	pkm					0.683	0.863	0.575	0.324	425.6
	Brennstoffbereitstellung	pkm	5.76	5.65	0.08	0.03	0.091	0.091	0.091	0.061	127.9
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.01	0.00	0.00	0.000	0.000	0.000	0.000	0.5
	Infrastruktur	pkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.2

Tab. 7.2 Environmental impacts of aircraft passenger transport services, SWISS

Kategorie	Bereich	Bezugsgrösse	Primärenergiefaktor total [MJ oil-eq]	Primärenergiefaktor fossil [MJ oil-eq]	Primärenergiefaktor nuklear [MJ oil-eq]	Primärenergiefaktor total erneuerbar [MJ oil-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=2; [kg CO_2-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=2.5; [kg CO_2-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=1.7; [kg CO_2-eq]	Kohlendioxid, fossil [kg]	Umweltbelastungspunkte [UBP13]
Flugzeug, Durchschnitt[1]	Total	pkm	1.64	1.59	0.04	0.01	0.208	0.253	0.180	0.108	150.6
	Betrieb	pkm					0.179	0.224	0.152	0.088	111.9
	Brennstoffbereitstellung	pkm	1.57	1.54	0.02	0.01	0.025	0.025	0.025	0.016	34.8
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.3
	Infrastruktur	pkm	0.07	0.05	0.01	0.00	0.004	0.004	0.004	0.003	3.5
Flugzeug, Kurzstrecke[1]	Total	pkm	2.70	2.56	0.11	0.03	0.269	0.310	0.245	0.174	206.4
	Betrieb	pkm					0.214	0.255	0.190	0.132	136.1
	Brennstoffbereitstellung	pkm	2.36	2.31	0.03	0.01	0.037	0.037	0.037	0.025	52.3
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.01	0.00	0.00	0.001	0.001	0.001	0.001	0.6
	Infrastruktur	pkm	0.33	0.24	0.07	0.02	0.017	0.017	0.017	0.016	17.3
Flugzeug, Kurzstrecke, economy[1]	Total	pkm	2.50	2.37	0.10	0.03	0.249	0.286	0.226	0.161	190.9
	Betrieb	pkm					0.197	0.234	0.174	0.122	124.9
	Brennstoffbereitstellung	pkm	2.16	2.12	0.03	0.01	0.034	0.034	0.034	0.023	48.0
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.01	0.00	0.00	0.001	0.001	0.001	0.001	0.6
	Infrastruktur	pkm	0.33	0.24	0.07	0.02	0.017	0.017	0.017	0.016	17.3
Flugzeug, Kurzstrecke, business[1]	Total	pkm	3.76	3.60	0.12	0.04	0.382	0.442	0.347	0.244	291.3
	Betrieb	pkm					0.310	0.369	0.275	0.192	197.3
	Brennstoffbereitstellung	pkm	3.41	3.35	0.05	0.02	0.054	0.054	0.054	0.036	75.8
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.02	0.01	0.00	0.00	0.001	0.001	0.001	0.001	0.9
	Infrastruktur	pkm	0.33	0.24	0.07	0.02	0.017	0.017	0.017	0.016	17.3
Flugzeug, Mittelstrecke[1]	Total	pkm	1.69	1.63	0.05	0.02	0.207	0.251	0.181	0.111	151.6
	Betrieb	pkm					0.176	0.220	0.149	0.088	110.1
	Brennstoffbereitstellung	pkm	1.56	1.54	0.02	0.01	0.025	0.025	0.025	0.016	34.7
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.2
	Infrastruktur	pkm	0.13	0.09	0.03	0.01	0.007	0.007	0.007	0.006	6.5
Flugzeug, Mittelstrecke, economy[1]	Total	pkm	1.56	1.50	0.05	0.02	0.191	0.231	0.167	0.102	139.7
	Betrieb	pkm					0.161	0.202	0.137	0.081	101.0
	Brennstoffbereitstellung	pkm	1.44	1.41	0.02	0.01	0.023	0.023	0.023	0.015	31.9
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.2
	Infrastruktur	pkm	0.13	0.09	0.03	0.01	0.007	0.007	0.007	0.006	6.5
Flugzeug, Mittelstrecke, business[1]	Total	pkm	2.40	2.32	0.06	0.02	0.297	0.361	0.259	0.157	216.7
	Betrieb	pkm					0.255	0.318	0.216	0.127	159.5
	Brennstoffbereitstellung	pkm	2.27	2.23	0.03	0.01	0.036	0.036	0.036	0.024	50.3
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.3
	Infrastruktur	pkm	0.13	0.09	0.03	0.01	0.007	0.007	0.007	0.006	6.5
Flugzeug, Langstrecke[1]	Total	pkm	1.51	1.47	0.03	0.01	0.201	0.247	0.173	0.100	143.9
	Betrieb	pkm					0.176	0.222	0.148	0.083	109.7
	Brennstoffbereitstellung	pkm	1.48	1.46	0.02	0.01	0.023	0.023	0.023	0.016	32.9
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.1
	Infrastruktur	pkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.2
Flugzeug, Langstrecke, economy[1]	Total	pkm	1.12	1.10	0.02	0.01	0.149	0.183	0.128	0.074	106.9
	Betrieb	pkm					0.130	0.165	0.110	0.062	81.2
	Brennstoffbereitstellung	pkm	1.10	1.08	0.01	0.00	0.017	0.017	0.017	0.012	24.4
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.1
	Infrastruktur	pkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.2
Flugzeug, Langstrecke, business[1]	Total	pkm	2.49	2.44	0.04	0.01	0.333	0.410	0.287	0.166	238.3
	Betrieb	pkm					0.292	0.369	0.246	0.138	182.2
	Brennstoffbereitstellung	pkm	2.46	2.42	0.03	0.01	0.039	0.039	0.039	0.026	54.7
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.2
	Infrastruktur	pkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.2
Flugzeug, Langstrecke, first[1]	Total	pkm	5.25	5.14	0.08	0.03	0.703	0.866	0.606	0.350	503.5
	Betrieb	pkm					0.619	0.782	0.521	0.293	385.9
	Brennstoffbereitstellung	pkm	5.21	5.12	0.07	0.02	0.083	0.083	0.083	0.055	115.9
	Unterhalt Fahrzeug	pkm									
	Fahrzeug	pkm	0.01	0.01	0.00	0.00	0.000	0.000	0.000	0.000	0.5
	Infrastruktur	pkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.2

7.3 Aircraft cargo transport services

Based on the data sources and methodology as specified in this report, the cargo transport service performed by an average European airline causes between 1.3 and 1.85 kg CO_2-eq per tkm (applying a factor 2 for CO_2 from aircraft), between 1.6 and 2.1 kg CO_2-eq per tkm (applying a factor 2.5), and between 1.0 and 1.3 kg CO_2-eq per tkm (applying a factor 1.7). When performed by SWISS the emissions caused are between 1.25 and 1.6 kg CO_2-eq per tkm (factor 2.0), between 1.55 and 1.85 kg CO_2-eq per tkm (factor 2.5) and between 0.94 and 1.1 kg CO_2-eq per tkm (applying a factor 1.7). The fossil CO_2-emissions from flight operations only cause between 0.56 and 0.93 kg CO_2/tkm and between 0.54 and 0.82 kg CO_2/tkm when offered by SWISS. The share of impacts caused by fuel supply is similar to that of passenger transport services.

The environmental impact caused by a cargo transport service offered by an average carrier varies between 960 and 1'400 UBP/tkm and between 915 and 1'240 UBP/tkm when offered by SWISS.

Tab. 7.3 Environmental impacts of aircraft cargo transport services, average of European airlines

Kategorie	Bereich	Bezugsgrösse	Primärenergiefaktor total [MJ oil-eq]	Primärenergiefaktor fossil [MJ oil-eq]	Primärenergiefaktor nuklear [MJ oil-eq]	Primärenergiefaktor total erneuerbar [MJ oil-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=2; [kg CO_2-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=2.5; [kg CO_2-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=1.7; [kg CO_2-eq]	Kohlendioxid, fossil [kg]	Umweltbelastungspunkte [UBP'13]
Flugzeug, Durchschnitt[1]	Total	tkm	10.43	10.19	0.19	0.06	1.363	1.671	1.178	0.692	985.9
	Betrieb	tkm					1.190	1.497	1.005	0.574	747.2
	Brennstoffbereitstellung	tkm	10.21	10.02	0.14	0.05	0.162	0.162	0.162	0.107	226.7
	Unterhalt Fahrzeug	tkm									
	Fahrzeug	tkm	0.02	0.01	0.00	0.00	0.001	0.001	0.001	0.001	1.0
	Infrastruktur	tkm	0.21	0.15	0.05	0.01	0.011	0.011	0.011	0.010	11.0
Flugzeug, Kurzstrecke[1]	Total	tkm	18.00	17.27	0.55	0.18	1.838	2.124	1.667	1.173	1401.2
	Betrieb	tkm					1.498	1.783	1.326	0.926	955.3
	Brennstoffbereitstellung	tkm	16.47	16.18	0.22	0.07	0.261	0.261	0.261	0.173	366.0
	Unterhalt Fahrzeug	tkm									
	Fahrzeug	tkm	0.05	0.03	0.01	0.00	0.003	0.003	0.003	0.002	2.7
	Infrastruktur	tkm	1.48	1.06	0.32	0.10	0.077	0.077	0.077	0.071	77.1
Flugzeug, Mittelstrecke[1]	Total	tkm	10.49	10.19	0.22	0.07	1.314	1.597	1.144	0.692	959.6
	Betrieb	tkm					1.133	1.416	0.963	0.567	714.4
	Brennstoffbereitstellung	tkm	10.08	9.90	0.13	0.04	0.160	0.160	0.160	0.106	223.9
	Unterhalt Fahrzeug	tkm									
	Fahrzeug	tkm	0.01	0.01	0.00	0.00	0.001	0.001	0.001	0.001	0.7
	Infrastruktur	tkm	0.40	0.28	0.09	0.03	0.021	0.021	0.021	0.019	20.7
Flugzeug, Langstrecke[1]	Total	tkm	10.11	9.89	0.17	0.05	1.348	1.659	1.161	0.672	970.7
	Betrieb	tkm					1.182	1.493	0.995	0.560	741.5
	Brennstoffbereitstellung	tkm	9.96	9.78	0.13	0.04	0.158	0.158	0.158	0.105	221.2
	Unterhalt Fahrzeug	tkm									
	Fahrzeug	tkm	0.01	0.01	0.00	0.00	0.001	0.001	0.001	0.001	0.6
	Infrastruktur	tkm	0.14	0.10	0.03	0.01	0.007	0.007	0.007	0.007	7.4

[1] Allokation auf Passagiere und Fracht basierend auf der Tonnage (1 Person = 159 bis 165 kg)

Tab. 7.4 Environmental impacts of aircraft cargo transport services, SWISS

Kategorie	Bereich	Bezugsgrösse	Primärenergiefaktor total [MJ oil-eq]	Primärenergiefaktor fossil [MJ oil-eq]	Primärenergiefaktor nuklear [MJ oil-eq]	Primärenergiefaktor total erneuerbar [MJ oil-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=2; [kg CO_2-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=2.5; [kg CO_2-eq]	Treibhausgasemissionen und Klimaeffekte Flugzeugemissionen, RFI=1.7; [kg CO_2-eq]	Kohlendioxid, fossil [kg]	Umweltbelastungspunkte [UBP13]
Flugzeug, Durchschnitt[1]	Total	tkm	9.59	9.37	0.17	0.05	1.271	1.562	1.096	0.637	917.3
	Betrieb	tkm					1.112	1.403	0.937	0.529	698.6
	Brennstoffbereitstellung	tkm	9.40	9.23	0.12	0.04	0.149	0.149	0.149	0.099	208.9
	Unterhalt Fahrzeug	tkm									
	Fahrzeug	tkm	0.01	0.01	0.00	0.00	0.001	0.001	0.001	0.001	0.8
	Infrastruktur	tkm	0.17	0.12	0.04	0.01	0.009	0.009	0.009	0.008	9.0
Flugzeug, Kurzstrecke[1]	Total	tkm	16.14	15.29	0.64	0.21	1.609	1.853	1.463	1.038	1239.1
	Betrieb	tkm					1.278	1.522	1.132	0.790	818.1
	Brennstoffbereitstellung	tkm	14.06	13.81	0.19	0.06	0.223	0.223	0.223	0.148	312.3
	Unterhalt Fahrzeug	tkm									
	Fahrzeug	tkm	0.06	0.04	0.01	0.01	0.004	0.004	0.004	0.003	3.7
	Infrastruktur	tkm	2.02	1.44	0.44	0.14	0.105	0.105	0.105	0.096	105.0
Flugzeug, Mittelstrecke[1]	Total	tkm	10.49	10.09	0.30	0.10	1.284	1.556	1.121	0.685	944.2
	Betrieb	tkm					1.089	1.361	0.926	0.545	687.3
	Brennstoffbereitstellung	tkm	9.69	9.52	0.13	0.04	0.154	0.154	0.154	0.102	215.3
	Unterhalt Fahrzeug	tkm									
	Fahrzeug	tkm	0.02	0.02	0.00	0.00	0.001	0.001	0.001	0.001	1.3
	Infrastruktur	tkm	0.78	0.55	0.17	0.05	0.040	0.040	0.040	0.037	40.3
Flugzeug, Langstrecke[1]	Total	tkm	9.52	9.31	0.16	0.05	1.268	1.560	1.092	0.632	914.3
	Betrieb	tkm					1.111	1.404	0.936	0.527	698.1
	Brennstoffbereitstellung	tkm	9.36	9.20	0.12	0.04	0.148	0.148	0.148	0.098	208.0
	Unterhalt Fahrzeug	tkm									
	Fahrzeug	tkm	0.01	0.01	0.00	0.00	0.001	0.001	0.001	0.001	0.7
	Infrastruktur	tkm	0.14	0.10	0.03	0.01	0.007	0.007	0.007	0.007	7.5

[1] Allokation auf Passagiere und Fracht basierend auf der Tonnage (1 Person = 158 bis 168 kg)

7.4 Comparison with mobitool 2016 and 2020

7.4.1 Passenger transport

The specific greenhouse gas emissions published in this update are between about 45 % and more than 130 % higher when compared to those reported in mobitool 2016 (and in the addendum to the KBOB recommendation 2009/1:2016). For an average aircraft transport service the specific greenhouse gas emissions are about 53 % higher.

The RFI factor changed from 1.35 to 2.5 for CO_2 emissions of kerosene used in aircraft. The greenhouse gas emissions of the fuel supply chain increased as well. On the other hand, an increase in fuel efficiency counteracts the two effects mentioned before. A change in allocation factors between economy, business and first of long-haul flights (based on seats offered in the long-haul fleet of the Lufthansa Group) leads to lower specific emissions of passengers travelling in economy class and higher specific emissions of passengers travelling in first class.

The differences are smaller but still positive when comparing the specific greenhouse gas emissions published in this update to those published in mobitool 2020. While mobitool 2020 is based on the RFI factor 2.0, this update uses a factor of 2.5, following the

Longterm Climate Strategy for Switzerland. Both datasets rely on the same fuel supply chain data. The difference in allocation factors in long-haul transport services leads to lower specific emissions of economy class passengers and higher specific emissions of first class passengers[11]. Because the average transport service includes a significantly smaller share of short-haul flights compared to data used in mobitool 2020, the increase of the specific greenhouse gas emissions of the average flight (7.5 %) is smaller than the increase in specific greenhouse gas emissions of the average short- and long-haul flights (10.1 % and 10.4 %, respectively).

Tab. 7.5 Greenhouse gas emissions of aircraft passenger transport services, average of European airlines; "this study" values are based using the factor 2.5 for CO_2 emitted by aircraft.

g CO_2-eq/pkm	short-haul			long-haul				average
	average	economy	business	average	economy	business	first	
mobitool 2016	241	220	337	159	127	263	404	185
mobitool 2020	318	291	447	238	190	393	606	263
this study, RFI = 2.5	350	319	505	263	193	443	956	283
difference to mobitool 2016	45.4%	44.7%	49.8%	65.0%	51.7%	68.8%	136.4%	53.2%
difference to mobitool 2020	10.1%	9.8%	13.0%	10.4%	1.7%	12.8%	57.8%	7.5%

The differences in specific environmental impacts are less pronounced and mainly driven by the new RFI factor 2.5, gains in fuel efficiency and the change in allocation factors (long-haul flights). The change in fuel supply leads to lower specific environmental impacts. On average, the specific environmental impacts are about 23 % higher than those published in the addendum of the KBOB recommendation 2009/1:2016 and in mobitool 2016.

Tab. 7.6 Environmental impacts of aircraft passenger transport services, average of European airlines

UBP/pkm	short-haul			long-haul				average
	average	economy	business	average	economy	business	first	
mobitool 2016	195	179	272	117	94	193	296	140
mobitool 2020	191	175	265	115	92	188	290	136
this study, RFI 2.5	230	210	330	153	113	258	555	171
difference to mobitool 2016	17.9%	17.3%	21.3%	30.8%	20.2%	33.8%	87.4%	22.7%
difference to mobitool 2020	20.8%	20.2%	24.3%	33.6%	22.8%	36.8%	91.6%	25.6%

7.4.2 Cargo transport

The specific greenhouse gas emissions of cargo transports increased by half to two thirds when compared to the values published in mobitool 2016. Compared to the recently updated data in mobitool 2020, a increase of 10 % to 12 % can be observed. Because the average transport service includes a significantly smaller share of short-haul flights compared to data used in mobitool 2020, the increase of the specific greenhouse gas emissions of the average flight (11.6 %) is closer to the increase in specific greenhouse gas emissions of long-haul flights (12.1 %).

[11] Please note that the grouping of distance classes changed from short- and long-haul (the latter including medium-haul) in mobitool 2016 and 2020 to short-, medium and long-haul flights in this study.

Tab. 7.7 Greenhouse gas emissions of aircraft passenger transport services, average of European airlines; "this study" values are based using the factor 2.5 for CO_2 emitted by aircraft.

g CO_2-eq/tkm	short-haul	long-haul	average
mobitool 2016	1'454	990	1'009
mobitool 2020	1'920	1'479	1'498
this study, RFI = 2.5	2'124	1'659	1'671
difference to mobitool 2016	46.1%	67.6%	65.6%
difference to mobitool 2020	10.6%	12.1%	11.6%

The specific environmental impacts of cargo transports increased by between 18 and 37 % compared to mobitool 2016 and 2020, respectively, mainly driven by the new RFI factor 2.5.

Tab. 7.8 Environmental impacts of aircraft passenger transport services, average of European airlines

UBP/tkm	short-haul	long-haul	average
mobitool 2016	1'184	732	736
mobitool 2020	1'156	717	720
this study, RFI 2.5	1'401	971	986
difference to mobitool 2016	18.4%	32.6%	33.9%
difference to mobitool 2020	21.2%	35.5%	36.9%

7.5 Data quality

Aircraft transport services offered by the average of European airlines are represented with most recent and complete data on fuel consumption, passenger and cargo load factors published by the Lufthansa Group. The load factors are assumed to be identical for the three different booking classes.

Allocation between passenger and freight is based on gross metric tons, using passenger weight factors according to the ICAO Carbon Emissions Calculator methodology. Allocation between the different booking classes is based on the specific area occupied.

Aircraft transport services offered by SWISS International Air Lines and Edelweiss Air are represented with most recent and complete and partially confidential data on fuel consumption, passenger and cargo load factors provided by SWISS International Air Lines.

Data on aircraft manufacture and maintenance as well as on airport construction, operation and deconstruction were not updated and are rather aged.

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