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Life Cycle Inventories of Rail Transport Services

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Abbreviations

a	year (annum)
AC	alternating current
CH	Switzerland
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
DB	German Railways (Deutsche Bahn)
DC	direct current
FS	Italian Railways (Ferrovie dello Stato)
GKB	Austria Railways (Graz-Köflacher Bahn und Busbetrieb)
GLO	global average
Gt	gross ton
Gtkm	gross ton kilometre
ICE	Intercity-Express train
KBOB	Koordinationskonferenz der Bau- und Liegenschaftsorgane der öffentlichen Bauherren
KEV	compensatory feed-in
kg	kilogram
km	kilometre
kWh	kilowatt-hour
LCA	life cycle assessment
LCI	life cycle inventory analysis
Mio	million
NMHC	non-methane hydrocarbons
NMVOC	non-methane volatile organic compounds
N_2O	nitrous oxide / dinitrogen monoxide
NO_x	nitrogen oxides
pkm	passenger kilometre (transport unit)
PM	particulate matter (index gives size range in µm)
RER	Europe
RFF	French Railways (Réseau ferré de France)
SBB	Swiss Federal Railways (Schweizerische Bundesbahnen)
SO_2	sulphur dioxide
t	ton
TGV	highspeed train (train à grande vitesse)
tkm	ton kilometre (transport unit)
UIC	International Union of Railways
vkm	vehicle kilometre (transport unit)
ZVV	Swiss metropolitan railway operator (Zürcher Verkehrsverbund)

Content

1 Introduction and Overview

Within the project "Update of mobitool LCA data" life cycle inventory (LCI) data on transport processes of the KBOB life cycle inventory (LCI) data v2.2:2016 (based on ecoinvent data v2.2) were updated and life cycle inventory data on further transport modes and vehicles were compiled. In this report the update and extension of the life cycle inventory data of rail transport services are described and presented.
On one hand the existing data on passenger and good transport services in Switzerland and neighbour countries are updated with current data on fuel consumption, emission factors, transport performance, vehicle travel distances and load factors. The rail transport activities are further distinguished between electricity only and diesel operated trains. Furthermore the structure of the existing datasets in KBOB LCI data v2.2:2016 was aligned with the structure of ecoinvent data v3.1 (no differentiation of operation anymore). Data describing the manufacturing and maintenance of the trains, locomotives and wagons and construction of the rail track infrastructure are not updated.

2 Goal and Scope

2.1 Functional Unit

For freight transport services the functional unit is 1 ton kilometre (tkm). This corresponds to the transport of 1 ton of goods over a distance of 1 kilometre.

For passenger transport services the functional unit is 1 passenger kilometre (pkm). This corresponds to the transport of 1 person over a distance of 1 kilometre.

2.2 Definition of regional and long distance passenger traffic

Switzerland differentiates between regional and long-distance transport services. The long-distance transport service covers the passenger transportation offered within the long distance concession. It is not ordered nor funded by the Swiss Confederation. The regional train transport service covers passenger transportation which are not part of the long distance concession. The regional train transport service is ordered and paid by the Swiss Confederation and the cantons.

The definition of long distance and regional transportation varies between countries as the factual distinction between the two is up to the individual railway companies. UIC simply prescribes the naming of the categories (suburban and regional passenger traffic, mainline and intercity passenger traffic, and high-speed passenger traffic).

2.3 System Boundaries

The processes of rail transport services cover the following activities:

- Rail equipment manufacturing and end of life treatment

- Rail infrastructure construction and operation
- Rail operation, including exhaust and non-exhaust emissions of transport and shunting activities
- Fuel and electricity supply

2.4 Data Sources and Quality

Current data of transport performance, energy consumption, load factor as well as emission factors are provided by the national rail operator SBB and DB (SBB 2014, DB 2014), the regional operator ZVV (ZVV 2014) and international statistic (UIC 2012). For the train transport in Switzerland performance data of the SBB are used. The approximation of the Swiss train transport with performance data of the SBB is considered representative for the present study even though there are other operators in Switzerland. The processes are linked to background data of the KBOB LCI data v2.2:2016 (KBOB et al. 2016).

3 Rail Transport in Switzerland

3.1 Key Figures

For Switzerland data from the SBB are considered representative for the national rail transport services. In Tab. 3.1 the key figures of passenger and freight transport are summarized.

Tab. 3.1 The traction performance of the different rail transport activities on the rail network of SBB (Data of the SBB corporate statistics (internal Access database), personal communication: Fabian Scherer, SBB, 20. October 2015)

Indicator	Unit	Value
Traction performance all trains (passenger and goods transportation)	Mio. Gtkm	72'126
Traction performance goods transportation	Mio. Gtkm	26'158
Traction performance regional trains	Mio. Gtkm	15'932
Traction performance long distance trains	Mio. Gtkm	30'037

The metropolitan transport (S-Bahn) is part of the regional transport. However in this report metropolitan transport is also presented separately. ZVV is one of the biggest metropolitan transport operators and is considered to be representative for metropolitan transport in Switzerland. The traction performance of metropolitan transport (Gtkm) is therefore calculated based on the information of ZVV (2014). The kilometric performance is multiplied by the average weight of the metropolitan train (Tab. 3.2).

Tab. 3.2 Key figures of the metropolitan train transport of ZVV (ZVV 2014)

Indicator	Unit	Value
Metropolitan train kilometric performance	Mio. vkm	22
Transport performance	Mio. pkm/a	2179
Weight of a train[1)]	t	225
Operating performance metropolitan trains [2)]	Mio. Gtkm/a	4'950
Supplied seats metropolitan trains[1)]	seats/train	378
Average load factor [2)]	%	26

[1)] Energiedatenbank Traktion-Schlussbericht (M. Tuchschmid, 2009)

[2)] own calculation

3.2 Traction Energy

In Switzerland almost all trains (passenger and goods) are operated by electricity. No separate data for diesel traction are available and therefore the simplifying assumption is made that all trains in Switzerland are operated by electricity even though a few trips are operated by diesel traction. The diesel use of these single trips is accounted to the shunting processes. Tab. 3.3 presents the specific electricity consumption provided by SBB[1] including a loss of 5.033 % due to the electricity transformation from medium voltage to the voltage level used by the locomotives and the transmission on the overhead powerline.

Tab. 3.3 Electricity consumption of passenger and goods transportation of SBB including an electricity loss of 5.033 % [1]

Indicator for Switzerland	Unit	Goods	Long distance	Regional
Energy consumption	GWh/a	437	787	519
Transport performance[1)]	Mio tkm/a resp. Mio pkm/a	8'615	12'872	3'984
Specific electricity consumption (incl. losses)	kWh/tkm resp. kWh/pkm	0.053	0.064	0.127

[1)] Transport performance only of the SBB, SBB Cargo und Cargo International in Switzerland

For metropolitan trains an average energy consumption of 33.5Wh/gtkm is published in Tuchschmid 2009). By multiplying the average energy consumption with the average weight of the train and dividing it by the number of people in the train an average energy consumption of 0.0782 kWh/pkm results inclusive the loss of 5.033%.

Data on diesel traction with and without particle filter for goods transportation were compiled even though no diesel traction is used in Switzerland. The diesel consumption is assumed to be similar to the consumption of goods transportation in Austria (10 g per

[1] Data of the SBB corporate statistics (internal Access database), personal communication, Fabian Scherer, SBB, 20. October 2015

tkm, see Chapter 4). The emissions of the diesel burned in locomotives with and without particle filter is discussed in detail in Section 3.4.2.

3.3 Airborne, Soil and Water Emissions

3.3.1 Abrasion emissions

A comprehensive study regarding the abrasion emissions of rail transport was conducted by Adolph (2016). Tab. 3.4 presents the yearly abrasion emissions to the different compartments (soil, water, air). These emissions correspond to a worst case scenario as for all emission sources the highest values have been used for the calculation.[2] For the air emissions the share of PM emission on the total abrasion was calculated and multiplied by the emission factors of the different substances. For the emissions into water it is assumed that 30% of the rail network has a drainage system therefore only 70% of the emissions are assumed to be emitted into the water. With these data and the yearly transport performance on the SBB network in 2014[3] the abrasion per pkm or tkm was calculated (Tab. 3.5).
Emissions of lubricants due to traction are not accounted for, since measures are in operation to avoid such emissions.

2 Data of the internal database ANABEL, personal communication, Gunter Adolph, SBB, 30. June 2016

3 Data of the SBB corporate statistics (internal Access database), personal communication, Stefan Weigel, SBB, 23. June 2016: Transport performances of other operators than SBB are also included.

Tab. 3.4 Total abrasion emission of passenger and freight transport on the rail network of SBB in 2014 (Adolph & Schmid 2016)[4]

	Long-distance passenger transport	Regional passenger transport	Freight transport
	[kg/a]	[kg/a]	[kg/a]
Particle Emissions into air			
Iron	442.73	170.10	324.97
Copper	12.32	11.45	3.58
Zinc	2.31	2.97	0.35
Chromium	0.78	0.28	0.57
Mangan	1.73	0.59	1.40
Lead	0.09	0.11	0.06
Antimony	2.21	0.74	0.18
Emissions into soil			
Iron	84.38	140.98	115.35
Copper	2.35	9.49	1.27
Zinc	0.44	2.46	0.13
Chromium	0.15	0.23	0.20
Mangan	0.33	0.49	0.50
Lead	0.02	0.09	0.02
Antimony	0.42	0.61	0.06
Hydrocarbon	46.75	30.73	37.79
PAH	92.06	94.47	91.21
Emissions into water			
Copper	0.36	0.36	0.36
Zinc	3.43	3.43	3.43

4 Data of the internal database ANABEL, personal communication, Gunter Adolph, SBB, 30. June 2016

Tab. 3.5 Total transport performance in 2014 on the rail network of SBB in 2014[5]

Transport performance		
Freight	11'883'825'578	tkm/a
Regional train	5'196'313'239	pkm/a
Long- distance train	12'442'797'635	pkm/a
Metropolitan[1)]	2'179'000'000	pkm/a
Gross tonkilometric performance		
Freight	26'157'869'920	btkm/a
Regional train	15'931'696'841	btkm/a
Long- distance train	30'036'917'406	btkm/a
Metropolitan[1)]	4'950'000'000	btkm/a

[1)]see Tab. 3.2 metropolitan train transport

The metropolitan transport performed in 2014 was 11 % of the total Gtkm at the SBB net. Therefore 11 % of the abrasion emission has been allocated to metropolitan trains.

3.3.2 Refrigerants

Most regional and long distance trains operated in Switzerland are air-conditioned. The air conditioning equipment use refrigerants, which are classified as greenhouse gases. According to the National Greenhouse Gas Inventory Report of Switzerland 2015 (BAFU 2015) and personal communication[6] the loss of refrigerants over the life time of a train is about 23.7 kg. Tab. 3.6 presents the refrigerant emissions per pkm covered by regional, long distance and metropolitan passenger trains. The yearly kilometric performance of the single trains is provided for representative train types of the regional, long-distance and metropolitan transport.[7] The average number of passengers in the regional and long-distance trains was calculated using the number of available seats and the load factors provided by the SBB (SBB 2014). For metropolitan transport the average number of people in the train was calculated using the transport performance (pkm) and kilometric performance (vkm) provided by ZVV (ZVV 2014).

5 Data of the SBB corporate statistics (internal Access database), personal communication, Stefan Weigel, SBB, 23. June 2016: Transport performances of other operators than SBB are also included

6 Personal communication Cornelia Stettler, Carbotech, 23. February 2016

7 Personal communication Matthias Tuchschmid, SBB, 26. November 2015

Tab. 3.6 Figures for the calculation of the refrigerant emissions of different train transportation per pkm (own calculations based on BAFU 2015)

		Regional	Long distance	Metropolitan
Loss of refrigerants over the life time of a train	kg	23.7	23.7	23.7
Average number of passenger	p	66	193	99
Average yearly kilometric performance of a single train[2)]	vkm	166'023	11'139'800	152'935
Life span[3)]	a	40	40	40
Specific refrigerant emission	kg/pkm	5.4E-08	1.1E-08	3.9E-08

[1)] National Greenhouse Gas Inventory Report of Switzerland 2015 (BAFU 2015) and personal communication, Cornelia Stettler, Carbotech, 23. February 2016

[2)] personal communication, Matthias Tuchschmid, SBB, 21. June 2016

[3)] ecoinvent report 14

3.3.3 Noise

Noise emissions were accounted for as recommended by Frischknecht and Büsser (Frischknecht & Büsser Knöpfel 2013) in paragraph 15.1.5 (page 201).

3.4 Diesel Consumption and Emissions of Shunting Processes

3.4.1 Diesel Consumption for Shunting Processes

It is assumed that the diesel consumption for traction of the SBB in 2014 is used for shunting processes of good and passenger transport as well as for the maintenance of infrastructure. 3.4 % of shunting processes can be allocated to passenger transportation and 67 % can be allocated to goods transportation (including the shunting and single trips of diesel traction). The remaining share (29.6 %) is used for construction and maintenance of infrastructure and has to be added to the maintenance and operation processes of the rail track. [8]

The diesel consumption for shunting processes, single trips of diesel traction and maintenance of the infrastructure was 10’406’000 litre in 2014. According to the information of the SBB the diesel consumption for shunting processes of goods transports is 0.66 g/tkm and for passenger transports 0.03 g/pkm (regional), 0.02 g/pkm (metropolitan) and 0.01 g/pkm (long distance)**.**

3.4.2 Emission to the Air

CO_2 and SO_2-emissions are determined based on the carbon and sulphur content of the diesel fuel.

The sulphur content of diesel used for shunting is assumed to be 0.001 mass-% (10 ppm, in line with the sulphur content of diesel used in road transportation) resulting

[8] Data of the SBB corporate statistics (internal Access database), personal communication Fabian Scherer, SBB, 14. January 2016

in an emission factor of 0.02 g SO_2/kg. The emission factor of CO_2 is 3.1375 kg/kg diesel.
For the emission of heavy metals and other substances published data of the EM/EEA Emission inventory guidebook 2013 for train and road transport are used. Emission factors of CO, NO_X, CH_4, NMHC, N_2O, PM and benzene are based on information for rail vehicles with and without particle filter from the non-road database (Notter & Schmied 2015).
The specific emission factors of rail vehicles with and without particle filter are presented in Tab. 3.7.

Tab. 3.7 Emission factors of diesel used in diesel locomotives in Switzerland (Notter & Schmied 2015)

Emission		With particle filter	Whitout particle filter	SBB (97.7% with particle filter)
Benzene	g/kg	6.9E-03	7.1E-03	6.9E-03
Methane, fossil	g/kg	5.5E-02	5.7E-02	5.5E-02
Carbon monoxide, fossil	g/kg	2.5E+01	2.6E+01	2.5E+01
Carbon dioxide, fossil	g/kg	3.2E+03	3.2E+03	3.2E+03
Dinitrogen monoxide	g/kg	1.5E-01	1.6E-01	1.5E-01
Ammonia	g/kg	1.0E-02	1.0E-02	1.0E-02
NMVOC, non-methane volatile organic	g/kg	4.2E+00	4.3E+00	4.2E+00
Ethane	g/kg	1.5E-03	1.6E-03	1.5E-03
Propane	g/kg	5.1E-03	5.3E-03	5.1E-03
Butane	g/kg	7.7E-03	7.9E-03	7.7E-03
Pentane	g/kg	3.1E-03	3.2E-03	3.1E-03
Heptane	g/kg	1.5E-02	1.6E-02	1.5E-02
Toluene	g/kg	5.1E-04	5.3E-04	5.1E-04
m-Xylene	g/kg	5.0E-02	5.2E-02	5.0E-02
o-Xylene	g/kg	2.0E-02	2.1E-02	2.0E-02
Formaldehyde	g/kg	4.3E-01	4.4E-01	4.3E-01
Acetaldehyde	g/kg	2.3E-01	2.4E-01	2.3E-01
Benzaldehyde	g/kg	7.0E-02	7.2E-02	7.0E-02
Acrolein	g/kg	9.0E-02	9.3E-02	9.0E-02
Styrene	g/kg	2.9E-02	2.9E-02	2.9E-02
Nitrogen oxides	g/kg	4.5E+01	4.6E+01	4.5E+01
PM	g/kg	1.8E-01	1.9E+00	2.2E-01
Particulates, > 10 um	g/kg	7.1E-03	7.3E-02	8.5E-03
Particulates, > 2.5 um, and < 10um	g/kg	6.9E-03	7.1E-02	8.3E-03
Particulates, < 2.5 um	g/kg	1.7E-01	1.7E+00	2.0E-01
Sulfur dioxide	g/kg	2.0E-02	2.0E-02	2.0E-02
Benzo(a)pyrene	g/kg	3.0E-05	3.0E-05	3.0E-05
PAH, polycyclic aromatic hydrocarbons	g/kg	3.3E-03	3.3E-03	3.3E-03
Arsenic	g/kg	1.0E-07	1.0E-07	1.0E-07
Selenium	g/kg	1.0E-05	1.0E-05	1.0E-05
Zinc	g/kg	1.0E-03	1.0E-03	1.0E-03
Copper	g/kg	1.7E-03	1.7E-03	1.7E-03
Nickel	g/kg	7.0E-05	7.0E-05	7.0E-05
Chromium	g/kg	5.0E-05	5.0E-05	5.0E-05
Chromium VI	g/kg	1.0E-07	1.0E-07	1.0E-07
Mercury	g/kg	5.3E-06	5.3E-06	5.3E-06
Cadmium	g/kg	1.0E-05	1.0E-05	1.0E-05
Lead	g/kg	5.2E-05	5.2E-05	5.2E-05

The distribution of the particle size of PM emissions with and without particle filter is presented in Tab. 3.8.

Tab. 3.8 Particle size distributions (based on Spielmann et al. 2007) and exhaust emission factors [g/kg] (based on Notter & Schmied 2015) for diesel locomotives

Vehicle Category				Emission factors for different size classes		
	PM10 emission factor	Fraction of PM10 with a diameter < 2.5	Fraction of TSP with diameter < 10	Fine Particles (< 2.5)	Coarse Particles (2.5-10)	Large Particles (>10)
	[g/kg]	%	%	[g/kg]	[g/kg]	[g/kg]
Diesel locomotive without particle filter	1.879	92.3	96.2	1.735	0.073	0.071
Diesel locomotive with particle filter	0.182	92.3	96.2	0.168	0.007	0.007
Diesel locomotive SBB	0.227	92.3	96.2	0.209	0.009	0.009

3.5 Demand of Rail Transport Equipment

3.5.1 Goods Transport

The demand of locomotive and waggon per tkm is determined with data from the SBB (see Tab. 3.9). The number of goods transport locomotives (323) is divided by 40 times the total yearly goods transport performance (tkm) in 2014 (assuming a constant goods transport performance during the lifetime of the equipment). For the manufacturing of the locomotives and wagons existing processes from the KBOB LCI data v2.2:2016 are used (KBOB et al. 2016).

Tab. 3.9 Demand of locomotive and wagon per tkm

Number of locomotives SBB[1)]	unit	327
Life time[2)]	a	40
Good transport performance of SBB in (2014)[2)]	tkm	1.45E+10
Share of locomotive per performed tkm	unit/tkm	5.65E-10
Number of wagon SBB[3)]	unit	20'071
Life time[2)]	a	40
Good transport performance in Switzerland[4)]	tkm	1.23E+10
Share of wagon per performed tkm	unit/tkm	4.08E-08

1) Zahlen und Fakten, SBB, 2014

2) ecoinvent report 14

3) estimation calculated by Stefan Weigel, SBB, 27.6.2016

4) BFF 2016, Tab. 11.5.1.2., provided by Stefan Weigel, SBB, 5.7.2016

For the maintenance of the locomotives and wagons the existing processes of the KBOB LCI data v2.2:2016 are used. The process of the maintenance covers the maintenance of the whole life time of the locomotives and wagons. Therefore the demand of maintenances per tkm is equal to the demand of the locomotive and waggon per tkm.

3.5.2 Passenger Transport

The demand of a passenger train per pkm was calculated based on data of the SBB (2014) and ZVV (2014) assuming a constant transport performance over the 40 years lifetime. (see Tab. 3.10). The yearly distance covered by an average long-distance, metropolitan or regional train was multiplied by the average life span of the train (40 years) and the average number of people in the train to get the life time transport performance (expressed in pkm) of the train.

For the production process of the different trains (long distance and regional train) the existing processes in the KBOB LCI database v2.2:2016 were taken. For the metropolitan train a regional train is used.

As the weight of the different trains have changed compared to the existing processes in the KBOB LCI data v2.2:2016 the demand of train has been scaled based on the old and new weight (Tab. 3.10) (KBOB et al. 2016).

Tab. 3.10 Demand of passenger train per pkm

		Regional	Metropolitan	Long distance
Traction performance passenger trains[1)]	Mio. Gtkm	15932	4950	30037
Transport performance passenger trains[1)]	Mio. pkm	5196	2179	12443
Ratio gross tonne/carried person[2)]	Gt/p	3.07	2.27	2.41
Average number of seats in the train[3)]	#	292	378	626
Average load[3)]	%	23	26	31
Average people in the train[2)]	#	67	99	193
Calculated Weight of a train [2)]	t	205	225	467
Weight of the train in ecoinvent 2.2	t	171	220	317
Yearly performance of a single passenger train[4)]	vkm/a	166'023	11'139'800	152'935
Share of train per performed pkm[2)]	unit/pkm	2.70E-09	1.20E-09	6.84E-10

1) Data of the SBB corporate statistics (internal Access database), traction and transport performance on the rail network of SBB (including other operators) in 2014, Fabian Scherer, SBB, 20.10.2015 and Stefan Weigel, SBB, 23.6.2016

2) calculated

3) Zahlen und Fakten 2014, SBB

4) personal communication, Matthias Tuchschmid, SBB, 21.6. 2016

The process of the maintenance in the KBOB LCI database v2.2:2016 covers the maintenance of the whole life time of the trains and has the unit "one amount". Therefore the same input as for the train demands is used for the maintenance.

For the average passenger train transport in Switzerland a mix of 73 % long distance and 27 % regional train transport was calculated based on the transport performance of the SBB in 2014 (SBB 2014).

Tab. 3.11 Transport performance of regional and long distance trains of the SBB (SBB 2014)

Transport performance regional trains	Mio pkm/a	4861
Transport performance long distance trains	Mio pkm/a	12872

3.5.3 Rail Track

Both passenger and goods train use the same rail track. With the total transport performance of passenger and good transportation[9] and the ratio Gtmk/tkm and Gtkm/pkm the specific rail track demand for passenger and goods transport was determined.

According to information of the SBB the total network length is 3'027 km including single and double track. The length of double track is 1'743 km (double track) plus the single track divided by two (642 km). This results in a total double track length of 2385 km. The yearly demand of rail track construction of the different railway transport services is summarized in Tab. 3.12.

The existing construction process dataset of the rail track in the KBOB LCI data v2.2:2016 has been used to model the rail track construction (KBOB et al. 2016).

Tab. 3.12 Specific demand of rail track per pkm and tkm

Total transport performance on SBB rail network[1)]	Gtkm	7.21E+10
Length rail network SBB (calculated double track)	km	2385
Rail track per total transport performance	km/Gtkm	3.31E-08
Ratio gross tonne/carried goods	Gtkm/tkm	2.24
Ratio gross tonne/carried person regional train	Gtkm/pkm	3.07
Ratio gross tonne/carried person metropolitan train	Gtkm/pkm	2.27
Ratio gross tonne/carried person long distance train	Gtkm/pkm	2.41
Specific rail track demand per tkm	m*a/tkm	7.41E-05
Specific rail track demand per pkm regional train	m*a/pkm	1.01E-04
Specific rail track demand per pkm metropolitan train	m*a/pkm	7.51E-05
Specific rail track demand per pkm long distance train	m*a/pkm	7.98E-05

[1)] Data of the SBB corporate statistics (internal Access database): traction performance on the rail network of SBB (including other operators) in 2014, Fabian Scherer, SBB, 20.10.2015

[9] Including transport performances of other operators at the SBB network

3.6 Life Cycle Inventories

Tab. 3.13 Life cycle inventory data of freight rail transport in Switzerland

	Name	Location	InfrastructureProcess	Unit	transport, freight, rail, electricity with shunting	transport, freight, rail, diesel, with particle filter	transport, freight, rail, electricity without shunting	transport, freight, rail, diesel, without particle filter	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				tkm	tkm	tkm	tkm			
product	transport, freight, rail, electricity with shunting	CH	0	tkm	1	0	0	0			
product	transport, freight, rail, diesel, with particle filter	CH	0	tkm	0	1	0	0			
product	transport, freight, rail, electricity without shunting	CH	0	tkm	0	0	1	0			
product	transport, freight, rail, diesel, without particle filter	CH	0	tkm	0	0	0	1			
technosphere	locomotive	RER	1	unit	5.65E-10	5.65E-10	5.65E-10	5.65E-10	1	3.09	(2,1,1,1,3,5,BU:3); calculation based on the number of locomotives of SBB in 2014, an assumed constant yearly performance of 14478000000 vkm/a and a life time of 40 years; pers. correspondence SBB, June. 2015
	goods wagon	RER	1	unit	4.08E-8	4.08E-8	4.08E-8	4.08E-8	1	3.09	(2,1,1,1,3,5,BU:3); calculation based on the number of wagons of SBB in 2014, an assumed constant yearly performance of 12300000000 vkm/a and a life time of 40 years; pers.
	maintenance, goods wagon	RER	1	unit	4.08E-8	4.08E-8	4.08E-8	4.08E-8	1	3.09	(2,1,1,1,3,5,BU:3); ;
	maintenance, locomotive	RER	1	unit	5.65E-10	5.65E-10	5.65E-10	5.65E-10	1	3.09	(2,1,1,1,3,5,BU:3); ;
	disposal, locomotive	RER	1	unit	5.65E-10	5.65E-10	5.65E-10	5.65E-10	1	3.09	(2,1,1,1,3,5,BU:3); ;
	railway track	CH	1	ma	7.39E-5	7.39E-5	7.39E-5	7.39E-5	1	3.09	(2,1,1,1,3,5,BU:3); based on the gross ton kilometric performance on the SBB track in 2014: 72126484166Gtkm and the rail track length 2385 km; pers. correspondence SBB, Dec. 2015
	operation, maintenance, railway track	CH	1	ma	7.39E-5	7.39E-5	7.39E-5	7.39E-5	1	3.09	(2,1,1,1,3,5,BU:3); based on the gross ton kilometric performance on the SBB track in 2014: 72126484166Gtkm and the rail track length 2385 km; pers. correspondence SBB, Dec. 2015
	disposal, railway track	CH	1	ma	7.39E-5	7.39E-5	7.39E-5	7.39E-5	1	3.09	(2,1,1,1,3,5,BU:3); based on the gross ton kilometric performance on the SBB track in 2014: 72126484166Gtkm and the rail track length 2385 km; pers. correspondence SBB, Dec. 2015
	diesel, at regional storage	CH	0	kg	2.65E-4	1.06E-2	0	1.06E-2	1	1.21	(1,1,1,1,1,5,BU:1.05); ; pers. correspondence SBB, Dec. 2015
	electricity, medium voltage, SBB, at grid	CH	0	kWh	5.33E-2	0	5.33E-2	0	1	1.21	(1,1,1,1,1,5,BU:1.05); average electricity consumption of freight transport in CH: 5.33E-2 kWh/tkm (incl. 5.03% losses); pers. correspondence SBB, Dec. 2015
emission soil, industrial	Iron	-	-	kg	9.71E-9	9.71E-9	9.71E-9	9.71E-9	1	1.63	(2,3,2,1,3,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Iron	-	-	kg	2.73E-8	2.73E-8	2.73E-8	2.73E-8	1	5.11	(2,3,2,1,3,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Copper	-	-	kg	1.07E-10	1.07E-10	1.07E-10	1.07E-10	1	1.63	(2,3,2,1,3,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Copper	-	-	kg	3.01E-10	3.01E-10	3.01E-10	3.01E-10	1	5.11	(2,3,2,1,3,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission water, unspecified	Copper, ion	-	-	kg	3.02E-11	3.02E-11	3.02E-11	3.02E-11	1	3.10	(2,3,2,1,3,5,BU:3); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Zinc	-	-	kg	1.05E-11	1.05E-11	1.05E-11	1.05E-11	1	1.63	(2,3,2,1,3,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Zinc	-	-	kg	2.97E-11	2.97E-11	2.97E-11	2.97E-11	1	5.11	(2,3,2,1,3,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission water, unspecified	Zinc, ion	-	-	kg	2.88E-10	2.88E-10	2.88E-10	2.88E-10	1	5.11	(2,3,2,1,3,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Oils, unspecified	-	-	kg	3.18E-9	3.18E-9	3.18E-9	3.18E-9	1	1.63	(2,3,2,1,3,5,BU:1.5); hydrocarbon emission assumed as oil emission into soil; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Lead	-	-	kg	1.78E-12	1.78E-12	1.78E-12	1.78E-12	1	1.63	(2,3,2,1,3,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Lead	-	-	kg	5.02E-12	5.02E-12	5.02E-12	5.02E-12	1	5.11	(2,3,2,1,3,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Chromium	-	-	kg	1.70E-11	1.70E-11	1.70E-11	1.70E-11	1	1.63	(2,3,2,1,3,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Chromium	-	-	kg	4.78E-11	4.78E-11	4.78E-11	4.78E-11	1	5.11	(2,3,2,1,3,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Manganese	-	-	kg	4.18E-11	4.18E-11	4.18E-11	4.18E-11	1	1.63	(2,3,2,1,3,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Manganese	-	-	kg	1.18E-10	1.18E-10	1.18E-10	1.18E-10	1	5.11	(2,3,2,1,3,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Antimony	-	-	kg	5.34E-12	5.34E-12	5.34E-12	5.34E-12	1	1.63	(2,3,2,1,3,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Antimony	-	-	kg	1.51E-11	1.51E-11	1.51E-11	1.51E-11	1	5.11	(2,3,2,1,3,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Heat, waste	-	-	MJ	1.92E-1	0	1.92E-1	0	1	2.13	(3,5,2,5,5,5,BU:1.05); devault value;
	Benzene	-	-	kg	1.82E-9	7.26E-8		7.48E-8	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 6.87E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Methane, fossil	-	-	kg	1.46E-8	5.81E-7		5.98E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.50E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Carbon monoxide, fossil	-	-	kg	6.61E-6	2.63E-4		2.71E-4	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 2.49E+1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Carbon dioxide, fossil	-	-	kg	8.34E-4	3.33E-2		3.33E-2	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 3.15E+3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Dinitrogen monoxide	-	-	kg	4.01E-8	1.60E-6		1.65E-6	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.51E-1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Ammonia	-	-	kg	2.65E-9	1.06E-7		1.06E-7	1	2.13	(3,3,2,5,5,5,BU:1.2); emission factor of diesel: 1.00E-2 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.3.c, Tab. 3-3
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.10E-6	4.39E-5		4.52E-5	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.15E+0 g/kg diesel, assuming a share of 97.7% with particle filter; non road emission factor
	Ethane	-	-	kg	4.06E-10	1.62E-8		1.67E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.53E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	1.35E-9	5.40E-8		5.56E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.11E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-113
	Butane	-	-	kg	2.03E-9	8.10E-8		8.34E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.66E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-114

Tab. 3.13 Life cycle inventory data of freight rail transport in Switzerland (continued)

	Name	Location	InfrastructureProcess	Unit	transport, freight, rail, electricity with shunting	transport, freight, rail, diesel, with particle filter	transport, freight, rail, electricity without shunting	transport, freight, rail, diesel, without particle filter	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				tkm	tkm	tkm	tkm			
product	transport, freight, rail, electricity with shunting	CH	0	tkm	1	0	0	0			
product	transport, freight, rail, diesel, with particle filter	CH	0	tkm	0	1	0	0			
product	transport, freight, rail, electricity without shunting	CH	0	tkm	0	0	1	0			
product	transport, freight, rail, diesel, without particle filter	CH	0	tkm	0	0	0	1			
	Pentane	-	-	kg	8.12E-10	3.24E-8		3.34E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 3.07E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-115
	Heptane	-	-	kg	4.06E-9	1.62E-7		1.67E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.53E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-116
	Benzene	-	-	kg	0	0		0	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 0.00E+0 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-117
	Toluene	-	-	kg	1.35E-10	5.40E-9		5.56E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.11E-4 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-118
	m-Xylene	-	-	kg	1.33E-8	5.29E-7		5.45E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.01E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-119
	o-Xylene	-	-	kg	5.42E-9	2.16E-7		2.22E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.04E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-120
	Formaldehyde	-	-	kg	1.14E-7	4.54E-6		4.67E-6	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.29E-1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-121
	Acetaldehyde	-	-	kg	6.19E-8	2.47E-6		2.54E-6	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.33E-1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-122
	Benzaldehyde	-	-	kg	1.85E-8	7.40E-7		7.62E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.00E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-123
	Acrolein	-	-	kg	2.40E-8	9.56E-7		9.84E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 9.04E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-124
	Styrene	-	-	kg	7.58E-9	3.02E-7		3.11E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.86E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-125
	Nitrogen oxides	-	-	kg	1.19E-5	4.76E-4		4.91E-4	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.51E+1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Particulates, > 10 um	-	-	kg	2.25E-9	7.51E-8		7.74E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.10E-3 g/kg diesel, assuming a share of 97.7% with particle filter; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Particulates, > 2.5 um, and < 10um	-	-	kg	2.19E-9	7.31E-8		7.55E-7	1	2.74	(3,3,2,5,5,5,BU:2); emission factor of diesel: 6.92E-3 g/kg diesel, assuming a share of 97.7% with particle filter; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Particulates, < 2.5 um	-	-	kg	5.32E-8	1.78E-6		1.83E-5	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 1.68E-1 g/kg diesel, assuming a share of 97.7% with particle filter; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Sulfur dioxide	-	-	kg	5.30E-9	2.11E-7		2.11E-7	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 2.00E-2 g/kg diesel, assuming a share of 97.7% with particle filter; HBEFA 3.1., CH
	Benzo(a)pyrene	-	-	kg	7.94E-12	3.17E-10		3.17E-10	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	8.71E-10	3.48E-8		3.48E-8	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.29E-3 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	2.65E-14	1.06E-12		1.06E-12	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Selenium	-	-	kg	2.65E-12	1.06E-10		1.06E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	2.65E-10	1.06E-8		1.06E-8	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-3 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	4.50E-10	1.80E-8		1.80E-8	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.70E-3 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	1.85E-11	7.40E-10		7.40E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 7.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	1.32E-11	5.28E-10		5.28E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	2.65E-14	1.06E-12		1.06E-12	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	1.40E-12	5.60E-11		5.60E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.30E-6 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Cadmium	-	-	kg	2.65E-12	1.06E-10		1.06E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	1.38E-11	5.50E-10		5.50E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.20E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-12
	Heat, waste	-	-	MJ	1.13E-2	4.52E-1		4.52E-1	1	2.08	(3,3,2,5,5,5,BU:1.05); default value;
emission Non material emissions, unspecified	Noise, rail, freight train	-	-	tkm	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	2.53	(3,3,5,5,5,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 3.14 Life cycle inventory data of passenger train transport in Switzerland

	Name	Location	InfrastructureProcess	Unit	transport, long-distance train, SBB mix	transport, metropolitan train, SBB mix	transport, regional train, SBB mix	transport, average train, SBB mix	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	pkm			
product	transport, long-distance train, SBB mix	CH	0	pkm	1	0	0	0			
product	transport, metropolitan train, SBB mix	CH	0	pkm	0	1	0	0			
product	transport, regional train, SBB mix	CH	0	pkm	0	0	1	0			
product	transport, average train, SBB mix	CH	0	pkm	0	0	0	1			
technosphere	long-distance train	CH	1	unit	6.84E-10	0	0	5.01E-10	1	3.05	(2,3,1,1,1,5,BU:3); calculated lifespan transport performance 11139800 vkm, assuming a life time of 40 years and a constant transport performance; SBB Geschäftsbericht 2014, pers. communication SBB, 20.10.2015
	long-distance train	CH	1	unit		1.20E-9	0	0	1	3.05	(2,3,1,1,1,5,BU:3); calculated lifespan transport performance 6117400 vkm, assuming a life time of 40 years and a constant transport performance; ZVV 2014 Geschäftsbericht
	regional train	CH	1	unit	0	0	2.70E-9	7.21E-10	1	3.05	(2,3,1,1,1,5,BU:3); calculated lifespan transport performance 6640920 vkm, assuming a life time of 40 years and a constant transport performance; SBB Geschäftsbericht 2014, pers. communication SBB, 20.10.2015
	disposal, long-distance train	CH	1	unit	6.84E-10	1.20E-9	0	5.01E-10	1	3.05	(2,3,1,1,1,5,BU:3); ;
	disposal, regional train	CH	1	unit	0	0	2.70E-9	7.21E-10	1	3.05	(2,3,1,1,1,5,BU:3); ;
	maintenance, long-distance train	CH	1	unit	6.84E-10	1.20E-9	0	5.01E-10	1	3.05	(2,3,1,1,1,5,BU:3); ;
	maintenance, regional train	CH	1	unit	0	0	2.70E-9	7.21E-10	1	3.05	(2,3,1,1,1,5,BU:3); ;
	railway track	CH	1	ma	7.98E-5	7.51E-5	1.01E-4	8.56E-5	1	3.05	(2,3,1,1,1,5,BU:3); demand infrastructure per Gtkm 3.31E-8km/Gtkm; pers. communication SBB, 20.10.2015
	operation, maintenance, railway track	CH	1	ma	7.98E-5	7.51E-5	1.01E-4	8.56E-5	1	3.05	(2,3,1,1,1,5,BU:3); ;
	disposal, railway track	CH	1	ma	7.98E-5	7.51E-5	1.01E-4	8.56E-5	1	3.05	(2,3,1,1,1,5,BU:3); ;
	diesel, at regional storage	CH	0	kg	1.05E-5	2.05E-5	3.09E-5	1.59E-5	1	1.22	(2,3,1,1,1,5,BU:1.05); diesel consumption for shunting 2.03E-3 kg/vkm; SBB Geschäftsbericht 2014, pers. communication SBB, 14.1.2016
	electricity, medium voltage, SBB, at grid	CH	0	kWh	6.42E-2	7.99E-2	1.27E-1	8.10E-2	1	1.22	(2,3,1,1,1,5,BU:1.05); ; pers. Communication, SBB, Dez.2015
	refrigerant R134a, at plant	RER	0	kg	1.08E-8	3.91E-8	5.36E-8	2.22E-8	1	1.22	(2,3,1,1,1,5,BU:1.05); assumption of refrigerant consumption in CH 2.10E-6 kg/pkm; National Greenhouse Gas Inventory Report of Switzerland 2010 (Item 2F1, p. 156)
emission soil, industrial	Iron	-	-	kg	6.78E-9	1.32E-8	2.71E-8	1.22E-8	1	1.60	(3,3,1,5,1,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Iron	-	-	kg	3.56E-8	2.82E-8	3.27E-8	3.48E-8	1	5.08	(3,3,1,5,1,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Copper	-	-	kg	1.89E-10	5.70E-10	1.83E-9	6.26E-10	1	1.60	(3,3,1,5,1,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Copper	-	-	kg	9.90E-10	1.21E-9	2.20E-9	1.31E-9	1	5.08	(3,3,1,5,1,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission water, unspecified	Copper, ion	-	-	kg	2.89E-11	1.78E-11	6.99E-11	3.99E-11	1	3.07	(3,3,1,5,1,5,BU:3); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Zinc	-	-	kg	3.54E-11	2.07E-10	4.74E-10	1.52E-10	1	1.60	(3,3,1,5,1,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Zinc	-	-	kg	1.86E-10	4.40E-10	5.72E-10	2.89E-10	1	5.08	(3,3,1,5,1,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission water, unspecified	Zinc, ion	-	-	kg	2.75E-10	1.69E-10	6.60E-10	3.78E-10	1	5.08	(3,3,1,5,1,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Oils, unspecified	-	-	kg	3.76E-9	3.83E-9	5.91E-9	4.33E-9	1	1.60	(3,3,1,5,1,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Lead	-	-	kg	1.37E-12	4.83E-12	1.74E-11	5.64E-12	1	1.60	(3,3,1,5,1,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Lead	-	-	kg	7.18E-12	1.03E-11	2.10E-11	1.09E-11	1	5.08	(3,3,1,5,1,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Chromium	-	-	kg	1.19E-11	2.28E-11	4.51E-11	2.08E-11	1	1.60	(3,3,1,5,1,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Chromium	-	-	kg	6.25E-11	4.85E-11	5.44E-11	6.04E-11	1	5.08	(3,3,1,5,1,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Manganese	-	-	kg	2.66E-11	4.97E-11	9.47E-11	4.47E-11	1	1.60	(3,3,1,5,1,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Manganese	-	-	kg	1.39E-10	1.06E-10	1.14E-10	1.33E-10	1	5.08	(3,3,1,5,1,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Antimony	-	-	kg	3.39E-11	6.30E-11	1.18E-10	5.64E-11	1	1.60	(3,3,1,5,1,5,BU:1.5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Antimony	-	-	kg	1.78E-10	1.34E-10	1.43E-10	1.68E-10	1	5.08	(3,3,1,5,1,5,BU:5); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Heat, waste	-	-	MJ	2.31E-1	2.88E-1	4.58E-1	2.92E-1	1	1.27	(3,3,1,5,1,5,BU:1.05); ; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	1.08E-8	3.91E-8	5.36E-8	2.22E-8	1	1.57	(2,3,1,1,1,5,BU:1.5); assumption of refrigerant emission in CH 2.10E-6 kg/pkm; National Greenhouse Gas Inventory Report of Switzerland 2010 (Item 2F1, p. 156)
	Benzene	-	-	kg	7.22E-11	1.41E-10	2.13E-10	1.10E-10	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 6.88E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Methane, fossil	-	-	kg	5.77E-10	1.13E-9	1.70E-9	8.77E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.50E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Carbon monoxide, fossil	-	-	kg	2.62E-7	5.12E-7	7.71E-7	3.98E-7	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 2.50E+1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Carbon dioxide, fossil	-	-	kg	3.31E-5	6.46E-5	9.74E-5	5.02E-5	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 3.15E+3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Dinitrogen monoxide	-	-	kg	1.59E-9	3.10E-9	4.68E-9	2.41E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.51E-1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Ammonia	-	-	kg	1.05E-10	2.05E-10	3.09E-10	1.59E-10	1	2.13	(3,3,2,5,5,5,BU:1.2); emission factor of diesel: 1.00E-2 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.3.c, Tab. 3-3
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	4.36E-8	8.51E-8	1.28E-7	6.62E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.15E+0 g/kg diesel, assuming a share of 97.7% with particle filter; non road emission factor
	Ethane	-	-	kg	1.61E-11	3.14E-11	4.74E-11	2.45E-11	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.53E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	5.37E-11	1.05E-10	1.58E-10	8.15E-11	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.11E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Butane	-	-	kg	8.05E-11	1.57E-10	2.37E-10	1.22E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.67E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	3.22E-11	6.29E-11	9.48E-11	4.89E-11	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 3.07E-3 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	1.61E-10	3.14E-10	4.74E-10	2.45E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.53E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzene	-	-	kg	0	0	0	0	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 0.00E+0 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	5.37E-12	1.05E-11	1.58E-11	8.15E-12	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.11E-4 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	5.26E-10	1.03E-9	1.55E-9	7.99E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.01E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	2.15E-10	4.19E-10	6.32E-10	3.26E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.05E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	4.51E-9	8.81E-9	1.33E-8	6.85E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.29E-1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	2.45E-9	4.79E-9	7.22E-9	3.73E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.34E-1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	7.35E-10	1.44E-9	2.16E-9	1.12E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.00E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acrolein	-	-	kg	9.50E-10	1.86E-9	2.80E-9	1.44E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 9.05E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	3.01E-10	5.87E-10	8.85E-10	4.57E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.86E-2 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112

Tab. 3.14 Life cycle inventory data of passenger train transport in Switzerland (continued)

	Name	Location	InfrastructureProcess	Unit	transport, long-distance train, SBB mix	transport, metropolitan train, SBB mix	transport, regional train, SBB mix	transport, average train, SBB mix	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH	CH	CH			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	pkm			
product	transport, long-distance train, SBB mix	CH	0	pkm	1	0	0	0			
product	transport, metropolitan train, SBB mix	CH	0	pkm	0	1	0	0			
product	transport, regional train, SBB mix	CH	0	pkm	0	0	1	0			
product	transport, average train, SBB mix	CH	0	pkm	0	0	0	1			
	Nitrogen oxides	-	-	kg	4.74E-7	9.25E-7	1.39E-6	7.19E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.51E+1 g/kg diesel, assuming a share of 97.7% with particle filter; BAFU 2015: non road emission factor database
	Particulates, > 10 um	-	-	kg	8.91E-11	1.74E-10	2.62E-10	1.35E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 8.49E-3 g/kg diesel, assuming a share of 97.7% with particle filter; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Particulates, > 2.5 um, and < 10um	-	-	kg	8.69E-11	1.70E-10	2.56E-10	1.32E-10	1	2.74	(3,3,2,5,5,5,BU:2); emission factor of diesel: 8.27E-3 g/kg diesel, assuming a share of 97.7% with particle filter; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Particulates, < 2.5 um	-	-	kg	2.11E-9	4.12E-9	6.21E-9	3.20E-9	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 8.27E-3 g/kg diesel, assuming a share of 97.7% with particle filter; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Sulfur dioxide	-	-	kg	2.10E-10	4.10E-10	6.18E-10	3.19E-10	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 2.01E-1 g/kg diesel, assuming a share of 97.7% with particle filter; HBEFA 3.1., CH
	Benzo(a)pyrene	-	-	kg	3.15E-13	6.15E-13	9.27E-13	4.78E-13	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 2.00E-2 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	3.45E-11	6.75E-11	1.02E-10	5.25E-11	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	1.05E-15	2.05E-15	3.09E-15	1.59E-15	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 3.29E-3 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Selenium	-	-	kg	1.05E-13	2.05E-13	3.09E-13	1.59E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	1.05E-11	2.05E-11	3.09E-11	1.59E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	1.78E-11	3.49E-11	5.25E-11	2.71E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-3 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	7.35E-13	1.44E-12	2.16E-12	1.12E-12	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.70E-3 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	5.25E-13	1.03E-12	1.55E-12	7.97E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 7.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	1.05E-15	2.05E-15	3.09E-15	1.59E-15	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	5.56E-14	1.09E-13	1.64E-13	8.45E-14	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Cadmium	-	-	kg	1.05E-13	2.05E-13	3.09E-13	1.59E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.30E-6 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	5.46E-13	1.07E-12	1.61E-12	8.29E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, assuming a share of 97.7% with particle filter; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Heat, waste	-	-	MJ	2.32E-4	2.89E-4	4.59E-4	2.92E-4	1	2.08	(3,3,2,5,5,5,BU:1.05); default value;
emission Non material emissions, unspecified	Noise, rail, passenger train, average	-	-	pkm	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

4 Rail Transport in Neighbour Countries

4.1 Key Figures

Data on the rail transport and rail system in neighbour countries are limited. Some data of rail transport operators covering the year 2011/2012 are published in the current UIC Statistic (2012) (Tab. 4.1). However, UIC Statistic (2012) covers only data of some rail transport operators of the different countries. For Austria data of the ÖBB and GKB, for Germany data of the DB, for France data of the RFF and for Italy data of the FS are included in the statistic. As the availability of the data is limited the data covered in the UIC Statistic (2012) are assumed to be representative for the rail transport service in the different countries. For the freight transport an average process of Europe was compiled using the sum of the transport performance, kilometric performance, energy consumption of the freight transport in Switzerland and the neighbour countries assuming that these countries are representative for the European train transport.

Tab. 4.1 Key figures of the train transport performance in neighbour countries approximated by data of the UIC statistic (UIC 2012)

	Unit	Austria	Germany	France	Italy
Gross transport performance passenger transport	Mio Gtkm/a	27'611	166'945	150'499	75'327
Gross transport performance freight transport	Mio Gtkm/a	36'301	218'268	48'165	39'674
Passenger transport performance	Mio pkm/a	10'346	80'210	85'634	37'489
Freight transport performance	Mio tkm/a	17'753	105'894	24'985	12'757
Average number passengers[1)]	p	107	125	208	166
Average load[1)]	t	522	521	577	380

[1)]own calculation

4.2 Traction Energy

In the neighbour countries Austria, Germany, France and Italy both traction by electricity and by diesel locomotives is used for passenger and goods transportation.

In Tab. 4.2 and Tab. 4.3 the share of diesel and electricity transportation as well as the consumption per pkm and tkm is summarized. The electricity loss of the rail transport in France, Austria and Germany is assumed to be similar to Switzerland with about 5.0 % whereas for Italy a higher loss of 7 % is assumed[10]. The Italian railway uses direct current (DC) electricity, which leads to higher losses (additional transformation) compared to alternate current (AC) electricity.

The share of diesel traction varies between 0 % (goods, France) and 13 % (passenger, Germany). Generally, the share of electric traction is higher with goods compared to passengers.

Tab. 4.2 Passenger transport: the diesel and electricity consumption of the traction in Austria, Germany, France, Italy (UIC 2012)

Country	Electric traction including losses	Diesel traction	Share of electric traction	Share of diesel traction
	kWh/pkm	kg/pkm	%	%
Austria	0.0915	0.0020	91.6%	8.4%
Germany	0.0828	0.0028	87.8%	12.2%
France	0.0713	0.0014	92.5%	7.5%
Italy	0.0910	0.0014	93.8%	6.2%

10 Personal communication Matthias Tuchschmid, SBB, 28.1.2016

Tab. 4.3 Goods transport: The diesel and electricity consumption of rail traction in Austria, Germany, France, Italy (UIC 2012)

Country	Electric traction including losses	Diesel traction	Share of electric traction	Share of diesel traction
	kWh/tkm	kg/tkm	%	%
Austria	0.0394	0.0007	92.8%	7.2%
Germany	0.0275	0.0010	86.9%	13.1%
France	0.0785	0.0000	100.0%	0.0%
Italy	0.0446	0.0002	97.8%	2.2%

For freight transport also transport processes using only electricity are compiled. The electricity demand for these transport processes was calculated by dividing the electricity consumption by the share of the transport performance of the electricity traction.

4.3 Airborne Emissions

4.3.1 Emission from Diesel

Emission factors of Swiss diesel locomotives are used to model emissions of Austrian, German, French and Italian diesel locomotives (see Section 3.4.2). Diesel locomotives operated in the neighbour countries are assumed not to be equipped with a particle filter. No additional inquiries on this aspect were performed since the last update of these data. Thus this assumption may not be fully representative for the current situation in Austria, Germany, France and Italy.

4.3.2 Abrasion Emissions and Refrigerants Emissions

No country-specific data on abrasion emissions and refrigerants emissions of railway transports are available. Therefore the abrasion emission factors per gross transport performance (Gkm) of Switzerland are applied (see subchapter 3.3) and multiplied by the ratio Gtkm/pkm or Gtkm/tkm transported in the different trains. For passenger transport a long distance train is assumed.

The determination of the specific refrigerant emission for each country is based on the emission factor per kilometric performance of a long distance train in Switzerland and divided by the number of people in the train of each country (see Tab. 4.1).

Tab. 4.4 Specific refrigerant emission of passenger transport in neighbour countries

Emission per kilometric performance of a long distance train (CH)	kg/vkm	2.0976E-06
Passenger transport Austria	kg/pkm	1.96244E-08
Passenger transport Germany	kg/pkm	1.67693E-08
Passenger transport France	kg/pkm	1.00976E-08
Passenger transport Italy	kg/pkm	1.2636E-08

4.4 Diesel Consumption and Emissions of Shunting Processes

The diesel consumption for shunting processes of passenger and goods transport in the neighbour countries is calculated based on the diesel consumption for shunting processes in Switzerland per kilometric performance and divided by the number of people or the transported tonnage, see subchapter 3.4.

4.5 Demand of Rail Transport Equipment

4.5.1 Goods Transport

The demand of rail transport equipment is calculated based on the demand of locomotives and wagons per kilometric performance in Switzerland and divided by the transported tonnage of each train.

Tab. 4.5 Demand of locomotive and wagon per vkm

Number of locomotives SBB[1)]	unit	327
Life time[2)]	a	40
Good kilometric transport performance of SBB in (2014)[2)]	vkm	3.36E+07
Share of locomotive per performed vkm	unit/vkm	2.43E-07
Number of wagon SBB[3)]	unit	20'071
Life time[2)]	a	40
Good kilometric transport performance in Switzerland[4)]	vkm	2.41E+08
Share of wagon per performed vkm	unit/vkm	2.08E-06

1) Zahlen und Fakten, SBB, 2014

2) ecoinvent report 14

3) estimation calculated by Stefan Weigel, SBB, 27.6.2016

4) Data of the SBB corporate statistics (internal Access database), provided by Stefan Weigel, SBB, 27.6.2016

4.5.2 Passenger Transport

The passenger transport in neighbour countries is assumed to be provided by a long distance train. The demand of trains per pkm for the different countries is summarized in Tab. 4.6.

Tab. 4.6 The demand of passenger train per pkm for passenger transport on Austria, Germany, France and Italy

		Austria	Germany	France	Italy
Transport performance	Mio. pkm	10'346	80'210	85'634	37'489
Train performance	1000 vkm	96'794	641'245	412'233	225'836
People in the train	#	107	125	208	166
Yearly performance of a long distance passenger train (CH)	Mio. vkm	11.14	11.14	11.14	11.14
Share of train per performed pkm	unit/pkm	7.56E-10	5.89E-10	4.98E-10	4.52E-10

4.5.3 Rail Track

The specific demand of rail track per Gtkm of the Swiss railway system is used (see Section 3.5.3) because no country specific data are available. Specific ratios of “gross tonne/carried goods" and "gross tonne/carried passenger" representative of the national railway companies were applied, based on data of traffic (gtkm) and transport (tkm) performance published by UIC (UIC 2012). The specific demand of railway track per tkm and pkm representative for the railway transportation in the four European countries are presented in Tab. 4.7.

Tab. 4.7 The specific demand of rail track for passenger and freight transport in Austria, Germany, France and Italy

		Austria	Germany	France	Italy
Rail track per total transport performance (CH)	km/Gtkm	3.3E-08	3.3E-08	3.3E-08	3.3E-08
ratio gross tonne/carried goods	Gtkm/tkm	2.04	2.06	1.93	3.11
ratio gross tonne/carried person regional train	Gtkm/p	2.67	2.08	1.76	2.01
specific rail track demand per tkm	m*a/tkm	6.8E-08	6.8E-08	6.4E-08	1.0E-07
specific rail track demand per pkm regional train	m*a/pkm	8.8E-05	6.9E-05	5.8E-05	6.6E-05

4.6 Life Cycle Inventories

Tab. 4.8 Life cycle inventory data of freight rail transport in the neighbour countries Austria, Germany, France and Italy

	Name	Location	InfrastructureProcess	Unit	transport, freight, rail	transport, freight, rail	transport, freight, rail	transport, freight, rail	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				AT	IT	FR	DE			
	InfrastructureProcess				0	0	0	0			
	Unit				tkm	tkm	tkm	tkm			
product	transport, freight, rail	AT	0	tkm	1	0	0	0			
product	transport, freight, rail	IT	0	tkm	0	1	0	0			
product	transport, freight, rail	FR	0	tkm	0	0	1	0			
product	transport, freight, rail	DE	0	tkm	0	0	0	1			
product	transport, freight, rail	RER	0	tkm	0	0	0	0			
technosphere	locomotive	RER	1	unit	4.66E-10	6.40E-10	4.37E-10	4.67E-10	1	3.29	(2,4,1,3,4,5,BU:3); estimation based on the demand per vkm from CH (2.43E-7unit/vkm)) and the average load; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	goods wagon	RER	1	unit	3.99E-9	5.49E-9	3.75E-9	4.00E-9	1	3.29	(2,4,1,3,4,5,BU:3); estimation based on the demand per vkm from CH (2.08E-6unit/vkm)) and the average load; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	maintenance, goods wagon	RER	1	unit	3.99E-9	5.49E-9	3.75E-9	4.00E-9	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for goods wagon; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	maintenance, locomotive	RER	1	unit	4.66E-10	6.40E-10	4.37E-10	4.67E-10	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for locomotive; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	disposal, locomotive	RER	1	unit	4.66E-10	6.40E-10	4.37E-10	4.67E-10	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for locomotive; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	railway track	CH	1	ma	6.76E-5	1.03E-4	6.37E-5	6.82E-5	1	3.29	(2,4,1,3,4,5,BU:3); estimation based on track demand per Gtkm for CH (3.31E-8km/Gtkm) and the specific gross transport performance per tkm (Gtkm/tkm)); SBB Zahlen und Fakten 2014, UIC Statistic 2012
	operation, maintenance, railway track	CH	1	ma	6.76E-5	1.03E-4	6.37E-5	6.82E-5	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for rail track; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	disposal, railway track	CH	1	ma	6.76E-5	1.03E-4	6.37E-5	6.82E-5	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for rail track; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	diesel, at regional storage	RER	0	kg	1.28E-3	9.71E-4	5.03E-4	1.54E-3	1	1.58	(2,4,1,3,4,5,BU:1.05); specific diesel consumption of the country; UIC Statistic 2012
	electricity, medium voltage, ÖBB, at grid	AT	0	kWh	3.94E-2				1	1.21	(1,1,1,1,1,5,BU:1.05); electricity consumption 0.04kWh/tkm, assumed losses 5.03%; UIC Statistic 2012
	electricity, medium voltage, railway, at grid	IT	0	kWh		4.46E-2			1	1.21	(1,1,1,1,1,5,BU:1.05); electricity consumption 0.04kWh/tkm, assumed losses 7%; UIC Statistic 2012
	electricity, medium voltage, railway, at grid	FR	0	kWh			7.85E-2		1	1.21	(1,1,1,1,1,5,BU:1.05); electricity consumption 0.08kWh/tkm, assumed losses 7%; UIC Statistic 2012
	electricity, medium voltage, DB, at grid	DE	0	kWh				2.75E-2	1	1.21	(1,1,1,1,1,5,BU:1.05); electricity consumption 0.03kWh/tkm, assumed losses 7%; UIC Statistic 2012
	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh					1	1.21	(1,1,1,1,1,5,BU:1.05); electricity consumption 0.04kWh/tkm, assumed losses 7%; UIC Statistic 2012
emission soil, industrial	Iron	-	-	kg	9.02E-9	1.37E-8	8.50E-9	9.09E-9	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission per Gkm from CH (4.41E-9unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission air, unspecified	Iron	-	-	kg	2.54E-8	3.86E-8	2.39E-8	2.56E-8	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission soil, industrial	Copper	-	-	kg	9.93E-11	1.51E-10	9.37E-11	9.87E-12	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission air, unspecified	Copper	-	-	kg	2.80E-10	4.26E-10	2.64E-10	2.78E-11	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission water, unspecified	Copper, ion	-	-	kg	2.81E-11	4.27E-11	2.65E-11	2.70E-10	1	3.02	(3,3,1,3,1,1,BU:3); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission soil, industrial	Zinc	-	-	kg	9.79E-12	1.49E-11	9.23E-12	9.87E-12	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission air, unspecified	Zinc	-	-	kg	2.76E-11	4.19E-11	2.60E-11	2.78E-11	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission water, unspecified	Zinc, ion	-	-	kg	2.68E-10	4.08E-10	2.53E-10	2.70E-10	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission soil, industrial	Oils, unspecified	-	-	kg	2.95E-9	4.49E-9	2.79E-9	2.98E-9	1	1.52	(3,3,1,3,1,1,BU:1.5); hydro carbon emissions assumed as oil emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
	Lead	-	-	kg	1.66E-12	2.52E-12	1.56E-12	1.67E-12	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission air, unspecified	Lead	-	-	kg	4.67E-12	7.10E-12	4.40E-12	4.70E-12	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission soil, industrial	Chromium	-	-	kg	1.58E-11	2.40E-11	1.49E-11	1.59E-11	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission air, unspecified	Chromium	-	-	kg	4.44E-11	6.76E-11	4.19E-11	4.48E-11	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission soil, industrial	Manganese	-	-	kg	3.88E-11	5.90E-11	3.66E-11	3.91E-11	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission air, unspecified	Manganese	-	-	kg	1.09E-10	1.66E-10	1.03E-10	1.10E-10	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission soil, industrial	Antimony	-	-	kg	4.96E-12	7.55E-12	4.68E-12	5.00E-12	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
emission air, unspecified	Antimony	-	-	kg	1.40E-11	2.13E-11	1.32E-11	1.41E-11	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC Statistic 2012
	Heat, waste	-	-	MJ	1.42E-1	1.61E-1	2.83E-1	9.89E-2	1	1.09	(2,3,1,3,1,1,BU:1.05); default value;
	Benzene	-	-	kg	9.03E-9	6.87E-9	3.56E-9	1.09E-8	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 7.08E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Methane, fossil	-	-	kg	7.23E-8	5.50E-8	2.85E-8	8.71E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.66E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Carbon monoxide, fossil	-	-	kg	3.28E-5	2.49E-5	1.29E-5	3.95E-5	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 2.57E+1 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Carbon dioxide, fossil	-	-	kg	4.02E-3	3.06E-3	1.58E-3	4.84E-3	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 3.15E+3 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Dinitrogen monoxide	-	-	kg	1.99E-7	1.51E-7	7.83E-8	2.39E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.56E-1 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Ammonia	-	-	kg	1.28E-8	9.71E-9	5.03E-9	1.54E-8	1	2.13	(3,3,2,5,5,5,BU:1.2); emission factor of diesel: 1.00E-2 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.3.c, Tab. 3-3
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.46E-6	4.15E-6	2.15E-6	6.57E-6	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.27E+0 g/kg diesel, assuming no use of particle filters; non road emission factor

Tab. 4.8 Life cycle inventory data of freight rail transport in the neighbour countries Austria, Germany, France and Italy (continued)

	Name	Location	InfrastructureProcess	Unit	transport, freight, rail	transport, freight, rail	transport, freight, rail	transport, freight, rail	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				AT	IT	FR	DE			
	InfrastructureProcess				0	0	0	0			
	Unit				tkm	tkm	tkm	tkm			
product	transport, freight, rail	AT	0	tkm	1	0	0	0			
product	transport, freight, rail	IT	0	tkm	0	1	0	0			
product	transport, freight, rail	FR	0	tkm	0	0	1	0			
product	transport, freight, rail	DE	0	tkm	0	0	0	1			
product	transport, freight, rail	RER	0	tkm	0	0	0	0			
	Ethane	-	-	kg	2.01E-9	1.53E-9	7.93E-10	2.43E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.58E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	6.72E-9	5.11E-9	2.64E-9	8.09E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.26E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-113
	Butane	-	-	kg	1.01E-8	7.67E-9	3.97E-9	1.21E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.89E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-114
	Pentane	-	-	kg	4.03E-9	3.07E-9	1.59E-9	4.85E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 3.16E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-115
	Heptane	-	-	kg	2.01E-8	1.53E-8	7.93E-9	2.43E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.58E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-116
	Benzene	-	-	kg	0	0	0	0	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 0.00E+0 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-117
	Toluene	-	-	kg	6.72E-10	5.11E-10	2.64E-10	8.09E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.26E-4 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-118
	m-Xylene	-	-	kg	6.58E-8	5.01E-8	2.59E-8	7.93E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.16E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-119
	o-Xylene	-	-	kg	2.69E-8	2.04E-8	1.06E-8	3.24E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.11E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-120
	Formaldehyde	-	-	kg	5.64E-7	4.29E-7	2.22E-7	6.80E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.42E-1 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-121
	Acetaldehyde	-	-	kg	3.07E-7	2.34E-7	1.21E-7	3.70E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.41E-1 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-122
	Benzaldehyde	-	-	kg	9.20E-8	7.00E-8	3.62E-8	1.11E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.21E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-123
	Acrolein	-	-	kg	1.19E-7	9.05E-8	4.68E-8	1.43E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 9.31E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-124
	Styrene	-	-	kg	3.76E-8	2.86E-8	1.48E-8	4.53E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.95E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-125
	Nitrogen oxides	-	-	kg	5.93E-5	4.51E-5	2.33E-5	7.14E-5	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.64E+1 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Particulates, > 10 um	-	-	kg	9.35E-8	7.12E-8	3.68E-8	1.13E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.33E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Particulates, > 2.5 um, and < 10um	-	-	kg	9.11E-8	6.94E-8	3.59E-8	1.10E-7	1	2.74	(3,3,2,5,5,5,BU:2); emission factor of diesel: 7.14E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Particulates, < 2.5 um	-	-	kg	2.21E-6	1.68E-6	8.72E-7	2.67E-6	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 1.73E+0 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Sulfur dioxide	-	-	kg	2.55E-8	1.94E-8	1.01E-8	3.08E-8	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 2.00E-2 g/kg diesel, assuming no use of particle filters; HBEFA 3.1., CH
	Benzo(a)pyrene	-	-	kg	3.83E-11	2.91E-11	1.51E-11	4.61E-11	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	4.20E-9	3.20E-9	1.65E-9	5.06E-9	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.29E-3 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	1.28E-13	9.71E-14	5.03E-14	1.54E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Selenium	-	-	kg	1.28E-11	9.71E-12	5.03E-12	1.54E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	1.28E-9	9.71E-10	5.03E-10	1.54E-9	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-3 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	2.17E-9	1.65E-9	8.54E-10	2.61E-9	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.70E-3 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	8.93E-11	6.80E-11	3.52E-11	1.08E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 7.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	6.38E-11	4.86E-11	2.51E-11	7.69E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	1.28E-13	9.71E-14	5.03E-14	1.54E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	6.76E-12	5.15E-12	2.66E-12	8.15E-12	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.30E-6 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Cadmium	-	-	kg	1.28E-11	9.71E-12	5.03E-12	1.54E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	6.64E-11	5.05E-11	2.61E-11	8.00E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.20E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-12
	Heat, waste	-	-	MJ	5.46E-2	4.16E-2	2.15E-2	6.58E-2	1	1.09	(2,3,1,3,1,1,BU:1.05); default value;
emission Non material emissions,	Noise, rail, freight train	-	-	tkm	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	2.53	(3,3,5,5,5,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 4.9 Life cycle inventory data of freight rail transport only with electricity in the neighbour countries Austria, Germany, France and Italy

	Name	Location	InfrastructureProcess	Unit	transport, freight, rail, electricity only	transport, freight, rail, electricity only	transport, freight, rail, electricity only	transport, freight, rail, electricity only	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				AT	IT	FR	DE			
	InfrastructureProcess				0	0	0	0			
	Unit				tkm	tkm	tkm	tkm			
product	transport, freight, rail, electricity only	AT	0	tkm	1	0	0	0			
product	transport, freight, rail, electricity only	IT	0	tkm	0	1	0	0			
product	transport, freight, rail, electricity only	FR	0	tkm	0	0	1	0			
product	transport, freight, rail, electricity only	DE	0	tkm	0	0	0	1			
product	transport, freight, rail, electricity only	RER	0	tkm	0	0	0	0			
technosphere	locomotive	RER	1	unit	4.66E-10	6.40E-10	4.37E-10	4.67E-10	1	3.29	(2,4,1,3,4,5,BU:3); estimation based on the demand per vkm from CH (2.43E-7unit/vkm)) and the average load; SBB, Zahlen und Fakten 2014
	goods wagon	RER	1	unit	3.99E-9	5.49E-9	3.75E-9	4.00E-9	1	3.29	(2,4,1,3,4,5,BU:3); estimation based on the demand per vkm from CH (2.08E-6unit/vkm)) and the average load; SBB, Zahlen und Fakten 2014
	maintenance, goods wagon	RER	1	unit	3.99E-9	5.49E-9	3.75E-9	4.00E-9	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for goods wagon; SBB, Zahlen und Fakten 2014
	maintenance, locomotive	RER	1	unit	4.66E-10	6.40E-10	4.37E-10	4.67E-10	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for locomotive; SBB, Zahlen und Fakten 2014
	disposal, locomotive	RER	1	unit	4.66E-10	6.40E-10	4.37E-10	4.67E-10	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for locomotive; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	railway track	CH	1	ma	6.76E-5	1.03E-4	6.37E-5	6.82E-5	1	3.29	(2,4,1,3,4,5,BU:3); estimation based on track demand per Gtkm for CH (3.31E-8km/Gtkm) and the specific gross transport performance per tkm (Gtkm/tkm)); SBB Zahlen und Fakten 2014, UIC Statistic 2012
	operation, maintenance, railway track	CH	1	ma	6.76E-5	1.03E-4	6.37E-5	6.82E-5	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for rail track; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	disposal, railway track	CH	1	ma	6.76E-5	1.03E-4	6.37E-5	6.82E-5	1	3.29	(2,4,1,3,4,5,BU:3); same demand as for rail track; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	electricity, medium voltage, ÖBB, at grid	AT	0	kWh	4.25E-2				1	1.58	(2,4,1,3,4,5,BU:1.05); electricity consumption 0.04kWh/tkm, assumed losses 5.03%; UIC, statistic 2012
	electricity, medium voltage, railway, at grid	IT	0	kWh		4.56E-2			1	1.58	(2,4,1,3,4,5,BU:1.05); electricity consumption 0.04kWh/tkm, assumed losses 7%; UIC, statistic 2012
	electricity, medium voltage, railway, at grid	FR	0	kWh			7.85E-2		1	1.58	(2,4,1,3,4,5,BU:1.05); electricity consumption 0.07kWh/tkm, assumed losses 5.03%; UIC, statistic 2012
	electricity, medium voltage, DB, at grid	DE	0	kWh				3.16E-2	1	1.58	(2,4,1,3,4,5,BU:1.05); electricity consumption 0.03kWh/tkm, assumed losses 5.03%; UIC, statistic 2012
	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh					1	1.58	(2,4,1,3,4,5,BU:1.05); electricity consumption 0.04kWh/tkm; average of AT, DE, IT and FR
emission soil, industrial	Iron	-	-	kg	9.02E-9	1.37E-8	8.50E-9	9.09E-9	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission air, unspecified	Iron	-	-	kg	2.54E-8	3.86E-8	2.39E-8	2.56E-8	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission soil, industrial	Copper	-	-	kg	9.93E-11	1.51E-10	9.37E-11	1.00E-10	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission air, unspecified	Copper	-	-	kg	2.80E-10	4.26E-10	2.64E-10	2.82E-10	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission water, unspecified	Copper, ion	-	-	kg	2.81E-11	4.27E-11	2.65E-11	2.83E-11	1	3.02	(3,3,1,3,1,1,BU:3); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission soil, industrial	Zinc	-	-	kg	9.79E-12	1.49E-11	9.23E-12	9.87E-12	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission air, unspecified	Zinc	-	-	kg	2.76E-11	4.19E-11	2.60E-11	2.78E-11	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission water, unspecified	Zinc, ion	-	-	kg	2.68E-10	4.08E-10	2.53E-10	2.70E-10	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission soil, industrial	Oils, unspecified	-	-	kg	2.95E-9	4.49E-9	2.79E-9	2.98E-9	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission soil, industrial	Lead	-	-	kg	1.66E-12	2.52E-12	1.56E-12	1.67E-12	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission air, unspecified	Lead	-	-	kg	4.67E-12	7.10E-12	4.40E-12	4.70E-12	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission soil, industrial	Chromium	-	-	kg	1.58E-11	2.40E-11	1.49E-11	1.59E-11	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission air, unspecified	Chromium	-	-	kg	4.44E-11	6.76E-11	4.19E-11	4.48E-11	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission soil, industrial	Manganese	-	-	kg	3.88E-11	5.90E-11	3.66E-11	3.91E-11	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission air, unspecified	Manganese	-	-	kg	1.09E-10	1.66E-10	1.03E-10	1.10E-10	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission soil, industrial	Antimony	-	-	kg	4.96E-12	7.55E-12	4.68E-12	5.00E-12	1	1.52	(3,3,1,3,1,1,BU:1.5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission air, unspecified	Antimony	-	-	kg	1.40E-11	2.13E-11	1.32E-11	1.41E-11	1	5.02	(3,3,1,3,1,1,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016, UIC statistic 2012
emission air, unspecified	Heat, waste	-	-	MJ	1.53E-1	1.64E-1	2.83E-1	1.14E-1	1	1.09	(2,3,1,3,1,1,BU:1.05); default value;
emission Non material emissions, unspecified	Noise, rail, freight train	-	-	tkm	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	2.53	(3,3,5,5,5,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 4.10 Life cycle inventory of freight rail transport (with diesel and electricity) and only with electricity in Europe

	Name	Location	InfrastructureProcess	Unit	transport, freight, rail, electricity only	transport, freight, rail	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER			
	InfrastructureProcess				0	0			
	Unit				tkm	tkm			
product	transport, freight, rail, electricity only	RER	0	tkm	1	0			
product	transport, freight, rail	RER	0	tkm	0	1			
technosphere	locomotive	RER	1	unit	4.81E-10	4.81E-10	1	3.33	(4,4,1,3,4,5,BU:3); average of the freight transport in AT (10%), IT (7%), FR (15%), DE (62%) and CH (5%); SBB Zahlen und Fakten 2014, UIC Statistic 2012
	goods wagon	RER	1	unit	4.12E-9	4.12E-9	1	3.33	(4,4,1,3,4,5,BU:3); average of the freight transport in AT (10%), IT (7%), FR (15%), DE (62%) and CH (5%); SBB Zahlen und Fakten 2014, UIC Statistic 2012
	maintenance, goods wagon	RER	1	unit	4.12E-9	4.12E-9	1	3.33	(4,4,1,3,4,5,BU:3); same demand as for goods wagon; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	maintenance, locomotive	RER	1	unit	4.81E-10	4.81E-10	1	3.33	(4,4,1,3,4,5,BU:3); same demand as for locomotive; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	disposal, locomotive	RER	1	unit	4.81E-10	4.81E-10	1	3.33	(4,4,1,3,4,5,BU:3); same demand as for locomotive; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	railway track	CH	1	ma	7.03E-5	7.03E-5	1	3.33	(4,4,1,3,4,5,BU:3); estimation based on track demand per Gtkm for CH (3.31E-8km/Gtkm) and the specific gross transport performance per tkm (Gtkm/tkm)); SBB Zahlen und Fakten 2014, UIC Statistic 2012
	operation, maintenance, railway track	CH	1	ma	7.03E-5	7.03E-5	1	3.33	(4,4,1,3,4,5,BU:3); same demand as for rail track; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	disposal, railway track	CH	1	ma	7.03E-5	7.03E-5	1	3.33	(4,4,1,3,4,5,BU:3); same demand as for rail track; SBB Zahlen und Fakten 2014, UIC Statistic 2012
	diesel, at regional storage	RER	0	kg		1.27E-3	1	1.64	(4,4,1,3,4,5,BU:1.05); diesel consumption in AT, DE, IT for freight transport; UIC Statistic 2012
	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	3.71E-2	3.60E-2	1	1.64	(4,4,1,3,4,5,BU:1.05); electricity consumption 0.04kWh/tkm, assumed losses 5.03%; UIC Statistic 2012
emission soil, industrial	Iron	-	-	kg	9.38E-9	9.38E-9	1	1.89	(4,4,1,3,4,5,BU:1.5); estimation based on the emission per Gkm from CH (4.41E-9unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission air, unspecified	Iron	-	-	kg	2.64E-8	2.64E-8	1	5.38	(4,4,1,3,4,5,BU:5); estimation based on the emission factors per Gkm of freight transport in Switzerland and specific gross ton kilometric performance per tkm (Gtkm/tkm); Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission soil, industrial	Copper	-	-	kg	1.03E-10	1.03E-10	1	1.89	(4,4,1,3,4,5,BU:1.5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission air, unspecified	Copper	-	-	kg	2.91E-10	2.91E-10	1	5.38	(4,4,1,3,4,5,BU:5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission water, unspecified	Copper, ion	-	-	kg	2.92E-11	2.92E-11	1	3.33	(4,4,1,3,4,5,BU:3); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission soil, industrial	Zinc	-	-	kg	1.02E-11	1.02E-11	1	1.89	(4,4,1,3,4,5,BU:1.5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission air, unspecified	Zinc	-	-	kg	2.87E-11	2.87E-11	1	5.38	(4,4,1,3,4,5,BU:5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission water, unspecified	Zinc, ion	-	-	kg	2.79E-10	2.79E-10	1	5.38	(4,4,1,3,4,5,BU:5); estimation based on the emission per Gkm from CH (0.00E+0unit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission soil, industrial	Oils, unspecified	-	-	kg	3.07E-9	3.07E-9	1	1.89	(4,4,1,3,4,5,BU:1.5); hydro carbon emissions assumed as oil emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
	Lead	-	-	kg	1.72E-12	1.72E-12	1	1.89	(4,4,1,3,4,5,BU:1.5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission air, unspecified	Lead	-	-	kg	4.85E-12	4.85E-12	1	5.38	(4,4,1,3,4,5,BU:5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission soil, industrial	Chromium	-	-	kg	1.64E-11	1.64E-11	1	1.89	(4,4,1,3,4,5,BU:1.5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission air, unspecified	Chromium	-	-	kg	4.62E-11	4.62E-11	1	5.38	(4,4,1,3,4,5,BU:5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission soil, industrial	Manganese	-	-	kg	4.04E-11	4.04E-11	1	1.89	(4,4,1,3,4,5,BU:1.5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission air, unspecified	Manganese	-	-	kg	1.14E-10	1.14E-10	1	5.38	(4,4,1,3,4,5,BU:5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission soil, industrial	Antimony	-	-	kg	5.17E-12	5.17E-12	1	1.89	(4,4,1,3,4,5,BU:1.5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
emission air, unspecified	Antimony	-	-	kg	1.46E-11	1.46E-11	1	5.38	(4,4,1,3,4,5,BU:5); estimation based on the emission per Gkm from CH (kg/pkmunit/vkm)) and the average load; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016; UIC Statistic 2012
	Heat, waste	-	-	MJ	1.34E-1	1.30E-1	1	2.12	(4,3,2,5,5,5,BU:1.05); default value;
	Benzene	-	-	kg		9.00E-9	1	3.78	(4,3,2,5,5,5,BU:3); emission factor of diesel: 7.08E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Methane, fossil	-	-	kg		7.20E-8	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.66E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Carbon monoxide, fossil	-	-	kg		3.26E-5	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 2.57E+1 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Carbon dioxide, fossil	-	-	kg		4.00E-3	1	2.12	(4,3,2,5,5,5,BU:1.05); emission factor of diesel: 3.15E+3 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database

Tab. 4.10 Life cycle inventory of freight rail transport (with diesel and electricity) and only with electricity in Europe (continued)

	Name	Location	InfrastructureProcess	Unit	transport, freight, rail, electricity only	transport, freight, rail	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER			
	InfrastructureProcess				0	0			
	Unit				tkm	tkm			
product	transport, freight, rail, electricity only	RER	0	tkm	1	0			
product	transport, freight, rail	RER	0	tkm	0	1			
	Dinitrogen monoxide	-	-	kg		1.98E-7	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.56E-1 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Ammonia	-	-	kg		1.27E-8	1	2.16	(4,3,2,5,5,5,BU:1.2); emission factor of diesel: 1.00E-2 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.3.c, Tab. 3-3
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg		5.43E-6	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.27E+0 g/kg diesel, assuming no use of particle filters; non road emission factor
	Ethane	-	-	kg		2.01E-9	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.58E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg		6.69E-9	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.26E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-113
	Butane	-	-	kg		1.00E-8	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.89E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-114
	Pentane	-	-	kg		4.01E-9	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 3.16E-3 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-115
	Heptane	-	-	kg		2.01E-8	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.58E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-116
	Benzene	-	-	kg		0	1	3.78	(4,3,2,5,5,5,BU:3); emission factor of diesel: 0.00E+0 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-117
	Toluene	-	-	kg		6.69E-10	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.26E-4 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-118
	m-Xylene	-	-	kg		6.56E-8	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.16E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-119
	o-Xylene	-	-	kg		2.68E-8	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.11E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-120
	Formaldehyde	-	-	kg		5.62E-7	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.42E-1 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-121
	Acetaldehyde	-	-	kg		3.06E-7	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.41E-1 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-122
	Benzaldehyde	-	-	kg		9.16E-8	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.21E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-123
	Acrolein	-	-	kg		1.18E-7	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 9.31E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-124
	Styrene	-	-	kg		3.75E-8	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.95E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-125
	Nitrogen oxides	-	-	kg		5.90E-5	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.64E+1 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Particulates, > 10 um	-	-	kg		9.32E-8	1	2.34	(4,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.33E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Particulates, > 2.5 um, and < 10um	-	-	kg		9.08E-8	1	2.77	(4,3,2,5,5,5,BU:2); emission factor of diesel: 7.14E-2 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Particulates, < 2.5 um	-	-	kg		2.20E-6	1	3.78	(4,3,2,5,5,5,BU:3); emission factor of diesel: 1.73E+0 g/kg diesel, assuming no use of particle filters; BAFU 2015: non road emission factor database
	Sulfur dioxide	-	-	kg		2.54E-8	1	2.12	(4,3,2,5,5,5,BU:1.05); emission factor of diesel: 2.00E-2 g/kg diesel, assuming no use of particle filters; HBEFA 3.1., CH
	Benzo(a)pyrene	-	-	kg		3.81E-11	1	3.78	(4,3,2,5,5,5,BU:3); emission factor of diesel: 3.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg		4.18E-9	1	3.78	(4,3,2,5,5,5,BU:3); emission factor of diesel: 3.29E-3 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg		1.27E-13	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Selenium	-	-	kg		1.27E-11	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg		1.27E-9	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-3 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg		2.16E-9	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 1.70E-3 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg		8.90E-11	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 7.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg		6.36E-11	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 5.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg		1.27E-13	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg		6.74E-12	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 5.30E-6 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Cadmium	-	-	kg		1.27E-11	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg		6.61E-11	1	5.90	(4,3,2,5,5,5,BU:5); emission factor of diesel: 5.20E-5 g/kg diesel, assuming no use of particle filters; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-12
	Heat, waste	-	-	MJ		5.44E-2	1	2.12	(4,3,2,5,5,5,BU:1.05); default value;
emission Non material emissions,	Noise, rail, freight train	-	-	tkm	1.00E+0	1.00E+0	1	2.32	(3,3,3,5,5,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 4.11 Life cycle inventory of passenger train transport in the neighbour countries Austria, Germany, France and Italy

	Name	Location	InfrastructureProcess	Unit	transport, average train	transport, average train	transport, average train	transport, average train	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				AT	IT	FR	DE			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	pkm			
product	transport, average train	AT	0	pkm	1	0	0	0			
product	transport, average train	IT	0	pkm	0	1	0	0			
product	transport, average train	FR	0	pkm	0	0	1	0			
product	transport, average train	DE	0	pkm	0	0	0	1			
technosphere	long-distance train	CH	1	unit	7.56E-10	4.52E-10	4.98E-10	5.89E-10	1	3.09	(2,1,1,1,3,5,BU:3); estimated with the yearly transport performance; UIC Statistik 2014
	maintenance, long-distance train	CH	1	unit	7.56E-10	4.52E-10	4.98E-10	5.89E-10	1	3.09	(2,1,1,1,3,5,BU:3); ; UIC Statistik 2014
	disposal, long-distance train	CH	1	unit	7.56E-10	4.52E-10	4.98E-10	5.89E-10	1	3.09	(2,1,1,1,3,5,BU:3); ;
	railway track	CH	1	ma	8.82E-5	6.64E-5	5.81E-5	6.88E-5	1	3.09	(2,1,1,1,3,5,BU:3); allocated based on gross ton kilometric performance per pkm (Gtkm/pkm) and the rail track demand per gross ton kilometric performance in Switzerland (km/Gtkm); UIC Statistik 2014
	operation, maintenance, railway track	CH	1	ma	8.82E-5	6.64E-5	5.81E-5	6.88E-5	1	3.09	(2,1,1,1,3,5,BU:3); ;
	disposal, railway track	CH	1	ma	8.82E-5	6.64E-5	5.81E-5	6.88E-5	1	3.09	(2,1,1,1,3,5,BU:3); ;
	diesel, at regional storage	RER	0	kg	2.05E-3	1.45E-3	1.41E-3	2.81E-3	1	1.31	(2,1,1,1,3,5,BU:1.05); ; UIC Statistik 2014
	electricity, medium voltage, ÖBB, at grid	AT	0	kWh	9.15E-2				1	1.31	(2,1,1,1,3,5,BU:1.05); electricity consumption 0.09kWh/pkm, assumed losses 5.03%; UIC Statistik 2014, SBB pers. Correspondence, Dez. 2015
	electricity, medium voltage, railway, at grid	IT	0	kWh		9.10E-2			1	1.31	(2,1,1,1,3,5,BU:1.05); electricity consumption 0.09kWh/pkm assumed losses 7%; UIC Statistik 2014, SBB pers. Correspondence, Dez. 2015
	electricity, medium voltage, railway, at grid	FR	0	kWh			7.13E-2		1	1.31	(2,1,1,1,3,5,BU:1.05); electricity consumption 0.07kWh/pkm assumed losse 5.03%; UIC Statistik 2014, SBB pers. Correspondence, Dez. 2015
	electricity, medium voltage, DB, at grid	DE	0	kWh				8.28E-2	1	1.31	(2,1,1,1,3,5,BU:1.05); electricity consumption 0.08kWh/pkm; UIC Statistik 2014, SBB pers. Correspondence, Dez. 2015
	refrigerant R134a, at plant	RER	0	kg	1.96E-8	1.26E-8	1.01E-8	1.68E-8	1	1.31	(2,3,2,1,3,5,BU:1.05); assumption of refrigerant consumption 2.10E-6 kg/pkm; National Greenhouse Gas Inventory Report of Switzerland 2010 (Item 2F1, p. 156)
emission soil, industrial	Iron	-	-	kg	7.50E-9	5.64E-9	4.94E-9	5.85E-9	1	1.63	(2,3,2,1,3,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Iron	-	-	kg	3.93E-8	2.96E-8	2.59E-8	3.07E-8	1	5.11	(2,3,2,1,3,5,BU:5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Copper	-	-	kg	2.09E-10	1.57E-10	1.37E-10	1.63E-10	1	1.63	(2,3,2,1,3,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Copper	-	-	kg	1.09E-9	8.24E-10	7.21E-10	8.54E-10	1	5.11	(2,3,2,1,3,5,BU:5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission water, unspecified	Copper, ion	-	-	kg	3.20E-11	2.41E-11	2.11E-11	2.49E-11	1	3.10	(2,3,2,1,3,5,BU:3); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Zinc	-	-	kg	3.92E-11	2.95E-11	2.58E-11	3.05E-11	1	1.63	(2,3,2,1,3,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Zinc	-	-	kg	2.06E-10	1.55E-10	1.35E-10	1.60E-10	1	5.11	(2,3,2,1,3,5,BU:5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission water, unspecified	Zinc, ion	-	-	kg	3.05E-10	2.29E-10	2.01E-10	2.38E-10	1	5.11	(2,3,2,1,3,5,BU:5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Oils, unspecified	-	-	kg	4.15E-9	3.13E-9	2.74E-9	3.24E-9	1	1.63	(2,3,2,1,3,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Lead	-	-	kg	1.51E-12	1.14E-12	9.96E-13	1.18E-12	1	1.63	(2,3,2,1,3,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Lead	-	-	kg	7.94E-12	5.98E-12	5.23E-12	6.19E-12	1	5.11	(2,3,2,1,3,5,BU:5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Chromium	-	-	kg	1.32E-11	9.92E-12	8.67E-12	1.03E-11	1	1.63	(2,3,2,1,3,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Chromium	-	-	kg	6.91E-11	5.20E-11	4.55E-11	5.39E-11	1	5.11	(2,3,2,1,3,5,BU:5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Manganese	-	-	kg	2.94E-11	2.21E-11	1.93E-11	2.29E-11	1	1.63	(2,3,2,1,3,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Manganese	-	-	kg	1.54E-10	1.16E-10	1.01E-10	1.20E-10	1	5.11	(2,3,2,1,3,5,BU:5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission soil, industrial	Antimony	-	-	kg	3.75E-11	2.82E-11	2.47E-11	2.92E-11	1	1.63	(2,3,2,1,3,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
emission air, unspecified	Antimony	-	-	kg	1.97E-10	1.48E-10	1.29E-10	1.53E-10	1	5.11	(2,3,2,1,3,5,BU:5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	1.96E-8	1.26E-8	1.01E-8	1.68E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); abrasion emission; Data from ANABEL; Personal correspondence Gunter Adolf, SBB, June 2016
	Heat, waste	-	-	MJ	3.29E-1	3.28E-1	2.57E-1	2.98E-1	1	2.08	(3,3,2,5,5,5,BU:1.05); default value;
	Benzene	-	-	kg	1.45E-8	1.03E-8	9.99E-9	1.99E-8	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 7.08E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Methane, fossil	-	-	kg	1.16E-7	8.23E-8	7.99E-8	1.59E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.66E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Carbon monoxide, fossil	-	-	kg	5.26E-5	3.73E-5	3.63E-5	7.21E-5	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 2.57E+1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Carbon dioxide, fossil	-	-	kg	6.45E-3	4.58E-3	4.45E-3	8.85E-3	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 3.15E+3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Dinitrogen monoxide	-	-	kg	3.19E-7	2.26E-7	2.20E-7	4.37E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.56E-1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Ammonia	-	-	kg	2.05E-8	1.45E-8	1.41E-8	2.81E-8	1	2.13	(3,3,2,5,5,5,BU:1.2); emission factor of diesel: 1.00E-2 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.3.c, Tab. 3-3
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	8.76E-6	6.21E-6	6.04E-6	1.20E-5	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.27E+0 g/kg diesel, no use of particle filter is assumed; non road emission factor
	Ethane	-	-	kg	3.23E-9	2.29E-9	2.23E-9	4.43E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.58E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	1.08E-8	7.64E-9	7.43E-9	1.48E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.26E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Butane	-	-	kg	1.62E-8	1.15E-8	1.11E-8	2.22E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.89E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	6.47E-9	4.59E-9	4.46E-9	8.87E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 3.16E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	3.23E-8	2.29E-8	2.23E-8	4.43E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.58E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	1.08E-9	7.64E-10	7.43E-10	1.48E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.26E-4 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	1.06E-7	7.49E-8	7.28E-8	1.45E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.16E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	4.31E-8	3.06E-8	2.97E-8	5.91E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.11E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	9.06E-7	6.42E-7	6.24E-7	1.24E-6	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.42E-1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	4.93E-7	3.49E-7	3.40E-7	6.76E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.41E-1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	1.48E-7	1.05E-7	1.02E-7	2.03E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.21E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112

Tab. 4.11 Life cycle inventory of passenger train transport in the neighbour countries Austria, Germany, France and Italy (continued)

	Name	Location	InfrastructureProcess	Unit	transport, average train	transport, average train	transport, average train	transport, average train	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				AT	IT	FR	DE			
	InfrastructureProcess				0	0	0	0			
	Unit				pkm	pkm	pkm	pkm			
product	transport, average train	AT	0	pkm	1	0	0	0			
product	transport, average train	IT	0	pkm	0	1	0	0			
product	transport, average train	FR	0	pkm	0	0	1	0			
product	transport, average train	DE	0	pkm	0	0	0	1			
	Acrolein	-	-	kg	1.91E-7	1.35E-7	1.32E-7	2.62E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 9.31E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	6.04E-8	4.28E-8	4.16E-8	8.28E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.95E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Nitrogen oxides	-	-	kg	9.51E-5	6.74E-5	6.56E-5	1.30E-4	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.64E+1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Particulates, > 10 um	-	-	kg	1.50E-7	1.06E-7	1.03E-7	2.06E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.33E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Particulates, > 2.5 um, and < 10um	-	-	kg	1.46E-7	1.04E-7	1.01E-7	2.01E-7	1	2.74	(3,3,2,5,5,5,BU:2); emission factor of diesel: 7.14E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Particulates, < 2.5 um	-	-	kg	3.55E-6	2.52E-6	2.45E-6	4.87E-6	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 1.73E+0 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Sulfur dioxide	-	-	kg	4.10E-8	2.91E-8	2.82E-8	5.62E-8	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 2.00E-2 g/kg diesel, no use of particle filter is assumed; HBEFA 3.1., CH
	Benzo(a)pyrene	-	-	kg	6.15E-11	4.36E-11	4.24E-11	8.43E-11	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	6.74E-9	4.78E-9	4.64E-9	9.24E-9	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.29E-3 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	2.05E-13	1.45E-13	1.41E-13	2.81E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Selenium	-	-	kg	2.05E-11	1.45E-11	1.41E-11	2.81E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	2.05E-9	1.45E-9	1.41E-9	2.81E-9	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-3 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	3.48E-9	2.47E-9	2.40E-9	4.78E-9	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.70E-3 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	1.43E-10	1.02E-10	9.88E-11	1.97E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 7.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	1.02E-10	7.26E-11	7.06E-11	1.40E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	2.05E-13	1.45E-13	1.41E-13	2.81E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	1.09E-11	7.70E-12	7.48E-12	1.49E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.30E-6 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Cadmium	-	-	kg	2.05E-11	1.45E-11	1.41E-11	2.81E-11	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	1.07E-10	7.55E-11	7.34E-11	1.46E-10	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.20E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Heat, waste	-	-	MJ	4.17E-4	3.90E-4	3.17E-4	4.18E-4	1	2.08	(3,3,2,5,5,5,BU:1.05); default value;
emission Non material emissions, unspecified	Noise, rail, passenger train, average	-	-	pkm	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	1.50	(1,1,1,1,1,1,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

5 Transportation with High Speed Trains in Europe

5.1 Introduction

The life cycle inventories of German, French and Italian high speed trains (ICE, TGV, and FrecceRossa) are described in this chapter. The inventories are based on information from UIC statistic and the Deutsche Bahn (DB). As the availability of data of High speed train transport is limited for abrasion emission and refrigerant emissions for an approximation some information is adopted from long-distance trains provided by Swiss Railways. For Germany the specific electricity mix of DB is applied and for Italy and France national electricity mixes are applied to cover the electricity demand of high speed trains.

5.2 Key Figures

In Tab. 5.1 the key figures of the ICE high speed train in Germany are presented. Due to limited resources and the lack of information for other high speed trains these data are used also for the French and Italian high speed trains.

Tab. 5.1 Key figures of the ICE high speed train in Germany (UIC 2012, DB 2014)

Average weight of ICE train	469	t
Number of passengers	235.5	#
Kilometric performance of ICE	105'126'000	vkm
Transport performance ICE	24'753'000'000	pkm

5.3 Traction Energy

High speed trains have a generally higher electricity demand per pkm compared to long-distance trains. Network-Rail 2009) published an electricity consumption of 0.04 kWh/seatkm resulting in an electricity consumption of 0.074 kWh/pkm using the specific load factor of high speed trains in Europe. No specific electricity consumptions for the different countries (Germany, Italy and France) are available for high speed trains therefore the same energy consumption has been used for all three countries. Electricity losses are added according to the electricity losses of average electric rail transport in the different countries. No specific information about the diesel consumption for shunting processes is available. Therefore the diesel consumption for the shunting processes are calculated based on half of the diesel consumption per vkm (2.0g/vkm) for the average long distance train in Switzerland (due to the long distance only 50% of the shunting processes are assumed for high speed trains) and divided by the number of people in the train (see Tab. 5.1). The diesel consumption per pkm of the German, French and Italian high speed train transportation is 0.0043g.

5.4 Airborne Emissions

5.4.1 Emission from Diesel

Emission factors of Swiss diesel locomotives are used to model emissions of German, French and Italian diesel locomotives (see section 3.4.2). For the use of diesel locomotives in the neighbour countries locomotives equipped with no particle filter are assumed.

5.4.2 Refrigerant Emissions

No specific emission data are available for high speed trains. Therefore the emission factors per kilometric performance (vkm) of Swiss long distance trains are applied (see Subchapter 3.3) and divided by the number of people transported in the high speed train.

5.5 Abrasion Emissions

No specific emission data are available for high speed trains. Therefore the emission factors per gross transport performance (Gtkm) of Swiss long distance trains are applied (see Subchapter 3.3) and divided by the ratio gross weight per passenger (Gt/p) of the high speed train.

5.6 Demand of Rail Transport Equipment

5.6.1 High Speed Transport

With data of the high speed train transport provided from UIC 2012 and DB 2014 the demand of high speed trains per pkm is calculated (see Tab. 5.2). This amount is used to quantify the demand of the French (TGV) and Italian (FrecceRossa) high speed trains too. For the production of the high speed train no update of the life cycle inventory was performed and the life cycle inventory data of the KBOB LCI data v2.2:2016 were used for the high speed train (KBOB et al. 2016).

Tab. 5.2 The demand of high speed train per pkm (UIC 2012, DB 2014)

Number of ICE trains of DB	253	unit
Transport performance	24'753'000'000	pkm
Life span	40	a
demand of ICE per pkm	2.56E-10	unit/pkm

5.6.2 Rail Track

The demand of track per Gtkm was calculated based on data of DB 2014. The weight the weight of the ICE train is multiplied by the kilometric performance (Tab. 5.1) The specific ratios of “gross tonne/carried passenger” are determined based on data about the traffic (Gtkm) and the transport performance (pkm) of ICE trains from the UIC Statistic and DB (see Tab. 5.3).

Tab. 5.3 Calculated traction performance and the gross weight per passenger

Traction performance ICE	4.929E+10	Gtkm
Transport performance ICE	2.475E+10	pkm
Average weight of train per passenger	1.99	Gt/p

Tab. 5.4 The specific demand of rail track for passenger transport with high speed trains (DB 2014)

Traction performance of all trains in Germany	4.65E+11	Gtkm
Length network DB	33281	km
Demand of infrastructure per pkm	1.42E-07	km/pkm

5.6.3 Life Cycle Inventory Input Data

Tab. 5.5 Life cycle inventory data of high speed passenger train transport in DE, FR, IT

	Name	Location	InfrastructureProcess	Unit	transport, high speed train	transport, high speed train	transport, high speed train	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				DE	FR	IT			
	InfrastructureProcess				0	0	0			
	Unit				pkm	pkm	pkm			
product	transport, high speed train	DE	0	pkm	1	0	0			
product	transport, high speed train	FR	0	pkm	0	1	0			
product	transport, high speed train	IT	0	pkm	0	0	1			
technosphere	ICE	DE	1	unit	2.56E-10	2.56E-10	2.56E-10	1	3.29	(2,4,1,3,4,5,BU:3); assuming a constant transport performance of 97837945 pkm per year and an average life time of 40 years; Data of German ICE in UIC statistic, 2014
	disposal, ICE	DE	1	unit	2.56E-10	2.56E-10	2.56E-10	1	3.29	(2,4,1,3,4,5,BU:3); ;
	maintenance, ICE	DE	1	unit	2.56E-10	2.56E-10	2.56E-10	1	3.29	(2,4,1,3,4,5,BU:3); assuming a constant year transport performance of 97837945 pkm per year and an average life time of 40 years; Data of German ICE in UIC statistic, 2014
	railway track, ICE	DE	1	ma	1.42E-4	1.42E-4	1.42E-4	1	3.29	(2,4,1,3,4,5,BU:3); assuming the length of 33281km of the German rail track and a yearly gross transport performanc of 465248000000Gtkm/a; DB business report, 2015
	operation, maintenance, railway track, ICE	DE	1	ma	1.42E-4	1.42E-4	1.42E-4	1	3.29	(2,4,1,3,4,5,BU:3); ;
	disposal, railway track	CH	1	ma	1.42E-4	1.42E-4	1.42E-4	1	3.29	(2,4,1,3,4,5,BU:3); ;
	electricity, medium voltage, DB, at grid	DE	0	kWh	7.77E-2			1	1.58	(2,4,1,3,4,5,BU:1.05); assumed energy demand: 0.074kWh/pkm and a loss of 5.033%; Velaro, ATOC (2009) and pers. Corrspondence SBB, Matthias Tuchschmied, 2016
	electricity, medium voltage, railway, at grid	FR	0	kWh		7.77E-2		1	1.58	(2,4,1,3,4,5,BU:1.05); assumed energy demand: 0.074kWh/pkm and a loss of 5.033%; Velaro, ATOC (2009) and pers. Corrspondence SBB, Matthias Tuchschmied, 2016
	electricity, medium voltage, railway, at grid	IT	0	kWh			7.92E-2	1	1.58	(2,4,1,3,4,5,BU:1.05); assumed energy demand: 0.074kWh/pkm and a loss of 7%; Velaro, ATOC (2009) and pers. Corrspondence SBB, Matthias Tuchschmied, 2016
	diesel, at regional storage	RER	0	kg	4.31E-6	4.31E-6	4.31E-6	1	1.58	(2,4,1,3,4,5,BU:1.05); assuming 50% of the diesel consumption for shunting processes in Switzerland (2.0E-3kg/vkm) and an average
	refrigerant R134a, at plant	RER	0	kg	8.91E-9	8.91E-9	8.91E-9	1	1.58	(2,4,1,3,4,5,BU:1.05); extrapolated from refrigerant consumption in CH 2.10E-6 kg/vkm;
emission soil, industrial	Iron	-	-	kg	5.59E-9	5.59E-9	5.59E-9	1	1.84	(2,4,1,3,4,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
emission air, unspecified	Iron	-	-	kg	2.94E-8	2.94E-8	2.94E-8	1	5.33	(2,4,1,3,4,5,BU:5); extrapolated from abrasion emission of long-distance train in CH;
emission soil, industrial	Copper	-	-	kg	1.56E-10	1.56E-10	1.56E-10	1	1.84	(2,4,1,3,4,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
emission air, unspecified	Copper	-	-	kg	8.17E-10	8.17E-10	8.17E-10	1	5.33	(2,4,1,3,4,5,BU:5); extrapolated from abrasion emission of long-distance train in CH;
emission water, unspecified	Copper, ion	-	-	kg	2.39E-11	2.39E-11	2.39E-11	1	3.29	(2,4,1,3,4,5,BU:3); extrapolated from abrasion emission of long-distance train in CH;
emission soil, industrial	Zinc	-	-	kg	2.92E-11	2.92E-11	2.92E-11	1	1.84	(2,4,1,3,4,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
emission air, unspecified	Zinc	-	-	kg	1.53E-10	1.53E-10	1.53E-10	1	5.33	(2,4,1,3,4,5,BU:5); extrapolated from abrasion emission of long-distance train in CH;
emission water, unspecified	Zinc, ion	-	-	kg	2.27E-10	2.27E-10	2.27E-10	1	5.33	(2,4,1,3,4,5,BU:5); extrapolated from abrasion emission of long-distance train in CH;
emission soil, industrial	Oils, unspecified	-	-	kg	3.10E-9	3.10E-9	3.10E-9	1	1.84	(2,4,1,3,4,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
	Lead	-	-	kg	1.13E-12	1.13E-12	1.13E-12	1	1.84	(2,4,1,3,4,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
emission air, unspecified	Lead	-	-	kg	5.92E-12	5.92E-12	5.92E-12	1	5.33	(2,4,1,3,4,5,BU:5); extrapolated from abrasion emission of long-distance train in CH;
emission soil, industrial	Chromium	-	-	kg	9.83E-12	9.83E-12	9.83E-12	1	1.84	(2,4,1,3,4,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
emission air, unspecified	Chromium	-	-	kg	5.16E-11	5.16E-11	5.16E-11	1	5.33	(2,4,1,3,4,5,BU:5); extrapolated from abrasion emission of long-distance train in CH;
emission soil, industrial	Manganese	-	-	kg	2.19E-11	2.19E-11	2.19E-11	1	1.84	(2,4,1,3,4,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
emission air, unspecified	Manganese	-	-	kg	1.15E-10	1.15E-10	1.15E-10	1	5.33	(2,4,1,3,4,5,BU:5); extrapolated from abrasion emission of long-distance train in CH;
emission soil, industrial	Antimony	-	-	kg	2.79E-11	2.79E-11	2.79E-11	1	1.84	(2,4,1,3,4,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
emission air, unspecified	Antimony	-	-	kg	1.47E-10	1.47E-10	1.47E-10	1	5.33	(2,4,1,3,4,5,BU:5); extrapolated from abrasion emission of long-distance train in CH;
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	8.91E-9	8.91E-9	8.91E-9	1	2.34	(2,5,1,5,5,5,BU:1.5); extrapolated from abrasion emission of long-distance train in CH;
	Heat, waste	-	-	MJ	2.80E-1	2.80E-1	2.85E-1	1	1.09	(2,3,1,3,1,1,BU:1.05); default value;
	Benzene	-	-	kg	3.05E-11	3.05E-11	3.05E-11	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 7.08E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Methane, fossil	-	-	kg	2.44E-10	2.44E-10	2.44E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.66E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Carbon monoxide, fossil	-	-	kg	1.11E-7	1.11E-7	1.11E-7	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 2.57E+1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Carbon dioxide, fossil	-	-	kg	1.36E-5	1.36E-5	1.36E-5	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 3.15E+3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Dinitrogen monoxide	-	-	kg	6.71E-10	6.71E-10	6.71E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.56E-1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Ammonia	-	-	kg	4.31E-11	4.31E-11	4.31E-11	1	2.13	(3,3,2,5,5,5,BU:1.2); emission factor of diesel: 1.00E-2 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.3.c, Tab. 3-3
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.84E-8	1.84E-8	1.84E-8	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.27E+0 g/kg diesel, no use of particle filter is assumed; non road emission factor
	Ethane	-	-	kg	6.81E-12	6.81E-12	6.81E-12	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.58E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	2.27E-11	2.27E-11	2.27E-11	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.26E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112

Tab. 5.5 Life cycle inventory data of high speed passenger train transport in DE, FR, IT (continued)

	Name	Location	InfrastructureProcess	Unit	transport, high speed train	transport, high speed train	transport, high speed train	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				DE	FR	IT			
	InfrastructureProcess				0	0	0			
	Unit				pkm	pkm	pkm			
product	transport, high speed train	DE	0	pkm	1	0	0			
product	transport, high speed train	FR	0	pkm	0	1	0			
product	transport, high speed train	IT	0	pkm	0	0	1			
	Butane	-	-	kg	3.40E-11	3.40E-11	3.40E-11	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.89E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	1.36E-11	1.36E-11	1.36E-11	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 3.16E-3 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	6.81E-11	6.81E-11	6.81E-11	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 1.58E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	2.27E-12	2.27E-12	2.27E-12	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.26E-4 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	2.22E-10	2.22E-10	2.22E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 5.16E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	9.08E-11	9.08E-11	9.08E-11	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.11E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	1.91E-9	1.91E-9	1.91E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.42E-1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	1.04E-9	1.04E-9	1.04E-9	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.41E-1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	3.11E-10	3.11E-10	3.11E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.21E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acrolein	-	-	kg	4.02E-10	4.02E-10	4.02E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 9.31E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	1.27E-10	1.27E-10	1.27E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 2.95E-2 g/kg diesel, no use of particle filter is assumed; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Nitrogen oxides	-	-	kg	2.00E-7	2.00E-7	2.00E-7	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 4.64E+1 g/kg diesel, no use of particle filter is assumed; BAFU 2015: non road emission factor database
	Particulates, > 10 um	-	-	kg	3.16E-10	3.16E-10	3.16E-10	1	2.31	(3,3,2,5,5,5,BU:1.5); emission factor of diesel: 7.33E-2 g/kg diesel, no use of particle filter is assumed; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Particulates, > 2.5 um, and < 10um	-	-	kg	3.08E-10	3.08E-10	3.08E-10	1	2.74	(3,3,2,5,5,5,BU:2); emission factor of diesel: 7.14E-2 g/kg diesel, no use of particle filter is assumed; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Particulates, < 2.5 um	-	-	kg	7.48E-9	7.48E-9	7.48E-9	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 1.73E+0 g/kg diesel, no use of particle filter is assumed; own calculation with SBB tractions data and non road emission factor (BAFU 2015)
	Sulfur dioxide	-	-	kg	8.62E-11	8.62E-11	8.62E-11	1	2.08	(3,3,2,5,5,5,BU:1.05); emission factor of diesel: 2.00E-2 g/kg diesel, no use of particle filter is assumed; HBEFA 3.1., CH
	Benzo(a)pyrene	-	-	kg	1.29E-13	1.29E-13	1.29E-13	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.42E-11	1.42E-11	1.42E-11	1	3.74	(3,3,2,5,5,5,BU:3); emission factor of diesel: 3.29E-3 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	4.31E-16	4.31E-16	4.31E-16	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Selenium	-	-	kg	4.31E-14	4.31E-14	4.31E-14	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	4.31E-12	4.31E-12	4.31E-12	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-3 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	7.33E-12	7.33E-12	7.33E-12	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.70E-3 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	3.02E-13	3.02E-13	3.02E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 7.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	2.16E-13	2.16E-13	2.16E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	4.31E-16	4.31E-16	4.31E-16	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-7 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	2.29E-14	2.29E-14	2.29E-14	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.30E-6 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Cadmium	-	-	kg	4.31E-14	4.31E-14	4.31E-14	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 1.00E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	2.24E-13	2.24E-13	2.24E-13	1	5.86	(3,3,2,5,5,5,BU:5); emission factor of diesel: 5.20E-5 g/kg diesel, no use of particle filter is assumed; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Heat, waste	-	-	MJ	1.85E-4	1.85E-4	1.85E-4	1	2.08	(3,3,2,5,5,5,BU:1.05); ;
emission Non material emissions, unspecified	Noise, rail, passenger train, average	-	-	pkm	1.00E+0	1.00E+0	1.00E+0	1	2.53	(3,3,5,5,5,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

6 Electricity Mixes of the Railway Operators

6.1 Introduction

The railway operators SBB, DB and ÖBB use specific electricity mixes on their railway networks. In the following Subchapters 6.2, 6.3 and 6.4 the electricity mix used by SBB in Switzerland, by DB in Germany and by ÖBB in Austria are described in more detail.

6.2 Railway Mix of SBB

The electricity mix used by the Swiss Railways in the year 2014 consists of 96.4 % hydropower, 2.9 % nuclear power and 0.7 % new renewables funded by KEV[11]. The electricity generated with owned hydroelectric power plants is divided in electricity produced from Swiss run-of-river power plants, Swiss reservoir power plants and French run-of-river power plants. The reservoir hydropower is modelled using the data set describing net production with reservoir hydroelectric power plants because the electricity demand of the pumps is accounted for separately in the statistics provided by the Swiss Railways. The supply pumps of reservoir power plants as well as the pumps of the pumped storage power plants of the SBB use electricity from nuclear power plants, which adds 1.3 % to the amount of electricity used by SBB.

73 % of the nuclear electricity purchased is produced by French nuclear power plants, 27 % by Swiss nuclear power plants.

0.7 % of the total electricity used by the Swiss Railways stems from the production funded by the foundation KEV. This share is split in the different technologies according to the annual report of the foundation KEV (2014). The production volumes and the shares of the different technologies contributing to the electricity mix consumed by the Swiss Railways are shown in Tab. 6.1.

Tab. 6.1 Electricity funded by the foundation KEV in the year 2014 according to KEV (2014)

Founded electricity KEV	Production in 2014 (GWh)	Share
Hydropow er	766.2	46%
Photovoltaics	214.4	13%
Wind	52.6	3%
Biomass	635.9	38%

Tab. 6.2 shows the mix of the electricity production of the Swiss railways for the year 2014.

[11] Personal communication, Fabian Scherer, SBB, per Mail, 2. November 2015

Tab. 6.2 Electricity mix used by the Swiss railways in 2014 based on data provided by the Swiss Railways[12].

Production Mix SBB	**GWh (2014)**	**Shares (2014)**
Hydropower total	2294.95	96.40%
Run-off-River CH	321.67	13.51%
Reservoir CH	1'486.17	62.43%
Run-off-River FR	487.11	20.46%
Renewables (KEV funded)	16.66	0.70%
Hydropower mix CH	7.65	0.32%
Photovoltaics	2.13	0.09%
Wind	0.53	0.02%
Biomass	6.35	0.27%
Nuclear Power	69.04	2.90%
Nuclear power CH	18.71	0.79%
Nuclear power FR	50.33	2.11%
Net production	**2380.65**	**100.00%**
Pumping energy	31.84	1.34%
Gross production	**2412.50**	**101.34%**

6.3 Railway Mix of ÖBB

The electricity mix used by the Austrian Railways for the year 2013 consists of 88.7% hydropower, 7.5% natural gas power and 3.8% new renewables (UIC 2013). The electricity generated from hydropower is divided in electricity produced from run-of-river power plants and storage type power plants according to the share of the different technologies in Austria. For the electricity production using natural gas power, a conventional power plant is assumed. The power produced with new renewables can be divided into 1.2% wind, 0.8% biomass, 0.1% photovoltaics and other renewables (1.78 %). The other renewables were modelled as electricity from municipal waste. In Tab. 6.3 the production mix of the Austrian Railway is presented.

Tab. 6.3 Electricity mix used by the Austrian railways in 2013 based on data provided by the railway statistic (UIC 2013)

	Production Mix 2013
Hydropower	88.67%
Natural gas	7.50%
Renewables	
Wind	1.18%
Photovoltaics	0.10%
Biomass	0.77%
Other renewables	1.78%

[12] Personal communication with Fabian Scherer, SBB, 9.11.2015

6.4 Railway Mix of DB

The electricity mix used by the German Railways for the year 2014 consists of 27.4% hard coal, 9.9% lignite, 16.2% nuclear power, 5.9% natural gas, 5% hydropower and 34.6% new renewables (DB 2014). The electricity generated from hydropower is divided in electricity produced from run-of-river power plants and storage type power plants according to the share of the different technologies in the country (PRIS 2011). For the electricity production using natural gas power, a conventional power plant is assumed.

For the electricity production using nuclear power, the production using German boiling water and pressure-water power plants is distinguished according to the shares of the different technologies in the country (PRIS 2011). The power produced with new renewables can be divided into 13% wind, 12% biomass, 9% photovoltaics and 1 % other renewables (modelled as electricity from municipal waste). In Tab. 6.4 the production mix of the German Railway is presented.

Tab. 6.4 Electricity mix used by the Austrian railways in 2013 based on data provided by the German Railways

	Production mix 2014
Lignit	9.90%
Hard coal	27.40%
Nuclear pow er	16.20%
Natural gas	5.90%
Wind	13%
Hydropow er	5%
Photovoltaics	9%
Biomass	12%
Others	1%

6.5 Life cycle Inventories of the Electricity Mixes

Tab. 6.5 Unit process raw data of the electricity production mixes of SBB (2014), ÖBB (2013) and DB (2014)

	Name	Location	InfrastructureProcess	Unit	electricity mix, SBB	electricity mix, ÖBB	electricity mix, DB	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	AT	DE			
	InfrastructureProcess				0	0	0			
	Unit				kWh	kWh	kWh			
product	electricity mix, SBB	CH	0	kWh	1	0	0			
product	electricity mix, SBB, 2014	CH	0	kWh	0	0	0			
product	electricity mix, ÖBB	AT	0	kWh	0	1	0			
product	electricity mix, DB	DE	0	kWh	0	0	1			
technosphere	electricity, hard coal, at power plant	DE	0	kWh			2.74E-1	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity, lignite, at power plant	DE	0	kWh			9.90E-2	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity, natural gas, at power plant	DE	0	kWh			5.90E-2	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity, nuclear, at power plant	DE	0	kWh			1.62E-1	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity, at wind power plant	RER	0	kWh			1.32E-1	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity, hydropower, at power plant	DE	0	kWh			5.22E-2	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity, at cogen with biogas engine, allocation exergy	CH	0	kWh			1.23E-1	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity, production mix photovoltaic, at plant	DE	0	kWh			8.90E-2	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity from waste, at municipal waste incineration plant	CH	0	kWh			1.00E-2	1	1.05	(1,1,1,1,1,1,BU:1.05); ; yearly report DB (2014)
	electricity, natural gas, at power plant	AT	0	kWh		7.50E-2		1	1.05	(1,1,1,1,1,1,BU:1.05); ; UIC statistic 2013
technosphere	electricity, at wind power plant	RER	0	kWh		1.18E-2		1	1.05	(1,1,1,1,1,1,BU:1.05); ; UIC statistic 2013
	electricity, hydropower, at power plant	AT	0	kWh		8.87E-1		1	1.05	(1,1,1,1,1,1,BU:1.05); ; UIC statistic 2013
	electricity, at cogen with biogas engine, allocation exergy	CH	0	kWh		7.70E-3		1	1.05	(1,1,1,1,1,1,BU:1.05); ; UIC statistic 2013
	electricity, production mix photovoltaic, at plant	AT	0	kWh		1.00E-3		1	1.05	(1,1,1,1,1,1,BU:1.05); ; UIC statistic 2013
	electricity from waste, at municipal waste incineration plant	CH	0	kWh		1.78E-2		1	1.05	(1,1,1,1,1,1,BU:1.05); ; UIC statistic 2013
	electricity, nuclear, at power plant	CH	0	kWh	1.15E-02			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)
	electricity, nuclear, at power plant pressure water reactor	FR	0	kWh	3.09E-02			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)
	electricity, at wind power plant	RER	0	kWh	2.24E-04			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)
	electricity, hydropower, at run-of-river power plant	CH	0	kWh	1.35E-01			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)
	electricity, hydropower, net, at reservoir power plant	CH	0	kWh	6.24E-01			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)
	electricity, hydropower, at power plant	CH	0	kWh	3.21E-03			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)
	electricity, hydropower, at run-of-river power plant	RER	0	kWh	2.05E-01			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)
	electricity, production mix photovoltaic, at plant	CH	0	kWh	8.96E-04			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)
	electricity, at cogen with biogas engine, allocation exergy	CH	0	kWh	2.67E-03			1	1.05	(1,1,1,1,1,1,BU:1.05); ; personal communication SBB (2015)

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