treeze Ltd., Kanzleistrasse 4, CH-8610 Uster, www.treeze.ch

Life Cycle Inventories of Road and Non-Road Transport Services

Authors
Philippe Stolz, Annika Messmer, Rolf Frischknecht

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Authors	Philippe Stolz, Annika Messmer, Rolf Frischknecht treeze Ltd., fair life cycle thinking Kanzleistr. 4, CH-8610 Uster www.treeze.ch Phone +41 44 940 61 91, Fax +41 44 940 61 94 info@treeze.ch
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Abbreviations

a	year (annum)
CH	Switzerland
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalents
DB	German Railways (Deutsche Bahn)
EF	emission factor
ENTSO-E	European Network of Transmission System Operators for Electricity
GHG	greenhouse gas
GLO	global average
GVW	gross vehicle weight
GWP	global warming potential
h	hour
HBEFA	Handbook Emission Factors for Road Transport
ICE	internal combustion engine
kg	kilogram
km	kilometre
LCA	life cycle assessment
LCI	life cycle inventory analysis
MJ	mega joule
NEDC	New European Driving Cycle
NH_3	ammonia
NMVOC	non-methane volatile organic compounds
N_2O	nitrous oxide / dinitrogen monoxide
NO_x	nitrogen oxides
PAH	polycyclic aromatic hydrocarbon
pkm	passenger kilometre (transport unit)
PM	particulate matter (index gives size range in μm)
RAS	East Asia (regional code in ecoinvent)
RER	Europe (regional code in ecoinvent)
RLA	Latin America (regional code in ecoinvent)
SBB	Swiss Federal Railways (Schweizerische Bundesbahnen)
SO_2	sulphur dioxide
t	ton
tkm	ton kilometre (transport unit)

UBP	eco-points (German: Umweltbelastungspunkte)
vkm	vehicle kilometre (transport unit)
VOC	volatile organic compounds

Summary

This study is part of a project to update and extend the environmental indicator results of various transport services contained in mobitool. The environmental impacts of passenger and freight transports by road, rail, airplane, ships and further carriers such as cable cars and videoconference were calculated with KBOB life cycle inventory data v2.2:2016, which is based on ecoinvent data v2.2, and by employing the most recent impact assessment methods.

The life cycle inventories of passenger transports by electric cars, bus, trolleybus, coach and tram, the freight transports by light commercial vehicle as well as the operation of building machines and hydraulic diggers were updated in this study based on the most recent data available. New life cycle inventories were created to model passenger transports by passenger cars, hybrid and plug-in hybrid passenger cars, motorcycles and minibuses. In addition, fleet mixes of passenger transports by car and by motorcycle as well as of freight transports by lorry were compiled in order to represent the average situation in Switzerland in 2015. The life cycle inventories of freight transports by lorries with a gross vehicle weight above 32 t was disaggregated into several size classes. In addition, new life cycle inventories of the production of NCM Li-ion batteries and updated life cycle inventories of petrol and diesel supply in Switzerland and Europe are presented. All processes compiled in the present study are linked to KBOB life cycle inventory data v2.2:2016.

The environmental indicator results of the road and non-road transport processes compiled in this study are available via mobitool[1].

[1] http://mobitool.ch/, accessed on 23.11.2016.

Content

1 Introduction

This study is part of a project to update and extend the environmental indicator results of various transport services contained in mobitool[2]. The environmental impacts of passenger and freight transports by road, rail, airplane, ships and further carriers such as bicycles, cable cars, building machines and videoconference were calculated with KBOB life cycle inventory data v2.2:2016, which is based on ecoinvent data v2.2, and by employing the most recent impact assessment methods.

The life cycle inventories of some road and non-road transport services were not updated in recent years. These processes include the passenger transports by bus, trolleybus, coach and tram, the freight transports by light commercial vehicles as well as the operation of building machines and hydraulic diggers. In the mobitool project, these road transport processes were updated based on the most recent data available. The life cycle inventory of transports by electric passenger cars were updated to account for the latest information on the battery manufacturing process. Special attention was payed at the continuity and consistency of the datasets with regard to the original processes contained in ecoinvent data v2.

New life cycle inventories of additional road transport processes, namely passenger transports by passenger cars, hybrid and plug-in hybrid passenger cars, motorcycles and minibuses, were created. Another category of transport processes considered in this study are fleet mixes of different vehicles. These are very useful for analyses in which the exact specification of a vehicle, for instance its size or emission standard, is not known. The fleet mixes of passenger cars, motorcycles and lorries were updated or newly compiled.

The updated freight transport processes by lorries up to a gross vehicle weight (GVW) of 32 t that are available in ecoinvent data v3.1 were embedded in KBOB life cycle inventory data v2.2:2016. The difference in the environmental impacts of freight transports by lorries with a GVW above 32 t is substantial when comparing datasets available in ecoinvent data v3.1 to those available in ecoinvent data v2. The reason for this deviation is that this lorry size class encompasses vehicles up to a gross weight of 60 t in ecoinvent data v3.1 (compared to 40 t in the dataset available in ecoinvent data v2). The transport process by lorries with a GVW above 32 t was therefore revised in this study and disaggregated into several size classes.

The goal and scope are described in chapter 2. Some general information about the road demand and the emission factors used in various processes of road and non-road transport services is given in chapter 3. The new and updated life cycle inventories of passenger and freight transports are presented in chapters 4 and 5, respectively. Chapter 6 contains a documentation of the updated life cycle inventories of non-road vehicles.

[2] http://mobitool.ch/, accessed on 03.05.2016.

Conclusions are drawn in chapter 7. In addition, new life cycle inventories of the production of NCM Li-ion batteries, wich are used in the life cycle inventories of battery electric vehicles, were created based on literature data. The supply chain of petrol and diesel were updated in a previous study. The life cycle inventories of NCM Li-ion batteries as well as the petrol and diesel supply are presented in the appendices A and B, respectively.

2 Goal and scope

2.1 Functional unit

The functional unit of passenger transport services is 1 passenger kilometre (pkm), which corresponds to the transport of 1 person over a distance of 1 kilometre. Exceptions are the transports by passenger car and by motorcycle, which use 1 vehicle kilometre (vkm or km) as a functional unit.

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

The functional units of non-road vehicle operation are 1 MJ of diesel consumed in a building machine and 1 m^3 excavated volume by a hydraulic digger.

The functional unit of the production of vehicles and components is 1 kg.

The functional unit of crude oil and fuels is 1 kg.

2.2 System boundaries

The life cycle inventories compiled in this study encompass the whole life cycle of road transport services. This includes the following processes:

- Road manufacturing, maintenance and disposal;
- Vehicle manufacturing, maintenance and disposal;
- Fuel supply;
- Operation of the vehicle including exhaust and non-exhaust emissions;
- Supply of raw materials and energy carriers;
- Transports between individual life cycle stages.

2.3 Data sources and data quality

The life cycle inventories compiled in this study are linked to KBOB life cycle inventory data v2.2:2016, which is based on ecoinvent data v2.2 (KBOB et al. 2016), and documented in the EcoSpold v1 format. Most of the life cycle inventories of the production and disposal of vehicles and of the construction, operation and decommissioning of infrastructure were not updated due to limited resources. These life cycle inventories are described in Spielmann et al. (2007; road infrastructure, most of the vehicles), Kellenberger et al. (2007; building machine, hydraulic digger) and Leuenberger and Frischknecht (2010; two wheel vehicles). The life cycle inventories of the manufacture of passenger cars (petrol / natural gas, diesel, electric) and electric scooters, of transport services by lorries (up to a GVW of 32 t) and of non-exhaust emissions by lorries and passenger cars were updated in ecoinvent data v3.1 (ecoinvent Centre 2014) and embedded in the KBOB life cycle inventory database v2.2:2016. The life cycle inventories of petrol and diesel supply in Switzerland and Europe were updated in KBOB life cycle inventory data v2.2:2016. The data sources, assumptions and calculations are documented in Stolz and Frischknecht (2016) and the updated life cycle inventories are presented in appendix B of this report.

The Handbook Emission Factors for Road Transport (HBEFA) (INFRAS 2014) was an important source of information regarding real-life fuel consumption and air pollutant emission factors of several means of transport. Data from the Swiss non-road database[3] were used to compile the life cycle inventories of the operation of non-road vehicles. Emission factors of additional air pollutants and heavy metals were taken from the EMEP/EEA air pollutant emission inventory guidebook (Ntziachristos et al. 2014; Ntziachristos & Boulter 2014; Winther et al. 2013). A number of other reports and datasets were used in addition to these main data sources.

In general, the data quality of the road and non-road transport processes compiled in this study is classified as good and data gaps as well as assumptions are transparently documented.

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[3] Federal Office for the Environment: Non-road database, http://www.bafu.admin.ch/luft/00596/06906/offroad-daten/index.html?lang=en, accessed on 21.03.2016.

3 General information on road demand and emission factors

3.1 Overview

This chapter contains information on the common road demand and emissions of all road and non-road transport services modelled in this project. The road infrastructure demand factors are presented in subchapter 3.2 and the speciation of a fraction of the non-methane volatile organic carbon (NMVOC) emissions is described in subchapter 3.3. The emission factors of heavy metals and polycyclic aromatic hydrocarbons (PAHs), refrigerants and noise are documented in the subchapters 3.4, 3.5 and 3.6, respectively. The non-exhaust emissions encompass the abrasion of road, tyres and brakes and are described in more detail in subchapter 3.7.

3.2 Road demand

The demand of road infrastructure depends on the gross weight of the vehicle considered, which is defined as the sum of the net vehicle weight and the weight of the load (passengers and/or freight). The vehicle weight and the average load are documented for each means of road transport in the respective life cycle inventories. The weight of the driver is added to the vehicle weight for transport processes with vehicle kilometres as a functional unit such as motorcycle transports. For passengers an average weight of 75 kg was assumed based on Leuenberger and Frischknecht (2010).

The road infrastructure demand factors were taken from road transport processes in ecoinvent data v2 (Spielmann et al. 2007). It is assumed that the construction of new roads and the transport performance have grown with similar rates so that changes in these factors are insignificant. The demand for road construction and disposal is a function of the gross transport performance and amounts to $4.73 \cdot 10^{-4}$ my/(tGVW·km). The demand factor for road operation and maintenance depends on the vehicle kilometres travelled and equals $1.17 \cdot 10^{-3}$ my/km.

3.3 NMVOC speciation

Emissions of NMVOC to air encompass a very wide range of different substances with different impacts on the environment. The fraction of some important substances in the total NMVOC emissions was estimated in order to allow for the application of specific characterization factors to assess the impacts of these substances. However, it was not possible to break the total NMVOC emissions down to the level of single substances.

The NMVOC speciation depends on the vehicle considered and on the type of fuel consumed (Ntziachristos et al. 2014, Tab. 3-112). The substances distinguished were selected based on the availability of data and also on the elementary flows included in the freight transport processes by lorry in ecoinvent data v3.1 (ecoinvent Centre 2014). The NMVOC profile assumed in the life cycle inventories compiled in the present project is based on information from the EMEP/EEA air pollutant emission inventory guidebook and is shown in Tab. 3.1.

Tab. 3.1 NMVOC speciation of road and non-road transport services (Ntziachristos et al. 2014, Tab. 3-112). Light vehicles include passenger cars, motorcycles, minibuses and light commercial vehicles. Lorries, buses and coaches belong to the category of heavy vehicles.

Vehicle Category	**Light Vehicles**		**Heavy Vehicles**
Fuel Type	**Petrol**	**Diesel**	**Diesel**
NMVOC (unspecified)	45.24%	53.02%	81.23%
Ethane	3.19%	0.33%	0.03%
Propane	0.65%	0.11%	0.10%
Butane	5.24%	0.11%	0.15%
Pentane	2.15%	0.04%	0.06%
Hexane	1.61%	0.00%	0.00%
Cyclohexane	1.14%	0.65%	0.00%
Heptane	0.74%	0.20%	0.30%
Ethene	7.30%	10.97%	0.00%
Propene	3.82%	3.60%	0.00%
1-Pentene	0.11%	0.00%	0.00%
Benzene	5.61%	1.98%	0.07%
Toluene	10.98%	0.69%	0.01%
m-Xylene	5.43%	0.61%	0.98%
o-Xylene	2.26%	0.27%	0.40%
Formaldehyde	1.70%	12.00%	8.40%
Acetaldehyde	0.75%	6.47%	4.57%
Benzaldehyde	0.22%	0.86%	1.37%
Acetone	0.61%	2.94%	0.00%
Methyl ethyl ketone	0.05%	1.20%	0.00%
Acrolein	0.19%	3.58%	1.77%
Styrene	1.01%	0.37%	0.56%

3.4 Heavy metal and PAH emissions

The emissions of heavy metals, arsenic, selenium and PAHs to air are a function of the fuel consumption of the transport service considered. Furthermore, the emission factors depend on the vehicle category and on the fuel type (Ntziachristos et al. 2014; Winther et al. 2013). The emissions of the heavy metals zinc, copper, nickel, chromium, mercury, cadmium and lead are taken into account. In alignment with the road transport processes contained in ecoinvent data v3.1, chromium VI emissions were distinguished separately and calculated as a fraction of 0.2 % in the total chromium emissions to air (ecoinvent Centre 2014). The emission factor of PAH by non-road machinery (building machine and hydraulic digger) is higher than the corresponding emission factor for road vehicles by about two orders of magnitude. Additionally, emissions of benzo(a)pyrene were considered separately from the remaining PAHs in the case of non-road machinery. The emission factors used to calculate the emissions of PAHs, arsenic, selenium and heavy metals to air by road and non-road transport processes were taken from the EMEP/EEA air pollutant emission inventory guidebook and are listed in Tab. 3.2.

Tab. 3.2 Emission factors of PAHs, arsenic, selenium and heavy metals to air for road and non-road transport services (Ntziachristos et al. 2014, Tab. 3-100 and Tab. 1-103; Winther et al. 2013, Tab. 3-1).

Vehicle Category	Motorcycles, Passenger Cars	Light Commercial Vehicles		Lorries, Buses	Non-Road Machinery
Fuel Type	**Petrol**	**Petrol**	**Diesel**	**Diesel**	**Diesel**
Unit	**kg/kgfuel**	**kg/kgfuel**	**kg/kgfuel**	**kg/kgfuel**	**kg/kgfuel**
Benzo(a)pyrene	n.a.	n.a.	n.a.	n.a.	3.00E-08
PAHs	3.48E-08	2.02E-08	5.69E-08	7.82E-08	3.29E-06
Arsenic	3.00E-10	3.00E-10	1.00E-10	1.00E-10	1.00E-10
Selenium	2.00E-10	2.00E-10	1.00E-10	1.00E-10	1.00E-08
Zinc	2.16E-06	2.16E-06	1.74E-06	1.74E-06	1.00E-06
Copper	4.20E-08	4.20E-08	2.12E-08	2.12E-08	1.70E-06
Nickel	1.30E-08	1.30E-08	8.80E-09	8.80E-09	7.00E-08
Chromium	1.60E-08	1.60E-08	3.00E-08	3.00E-08	5.00E-08
Chromium VI	3.20E-11	3.20E-11	6.00E-11	6.00E-11	1.00E-10
Mercury	8.70E-09	8.70E-09	5.30E-09	5.30E-09	5.30E-09
Cadmium	1.08E-08	1.08E-08	8.70E-09	8.70E-09	1.00E-08
Lead	3.32E-08	3.30E-08	5.20E-08	5.21E-08	5.20E-08

3.5 Refrigerant emissions

A high and continuously growing share of road vehicles are equipped with air conditioners. Most of these devices use synthetic fluorinated gases, predominantly HFC-134a, as a refrigerant, which have a high impact on climate change due to their elevated global warming potential (GWP). The emissions of HFC-134a to air by air conditioning devices were taken into account for all relevant road transport services.

The refrigerant emissions were estimated based on the parameter values provided in item 2F1 of Switzerland's Greenhouse Gas Inventory (BAFU 2015) and additional information[4] (Tab. 3.3). Information on the average life time, initial charge and emission factors during the production, use, servicing and disposal of air conditioners were used to calculate the refrigerant emission factors over the life time of the device or the vehicle. In the use phase, it is further distinguished between refrigerant losses, which are refilled (usually 70 % or 100 % depending on the type of vehicle considered) and losses, which are not balanced by refilling.

The refrigerant emissions from air conditioners were considered for an average vehicle (including both vehicles with and without air conditioning devices). The share of vehicles with air conditioners was determined based on expert information[4]. It is assumed that this share is independent of the emission class of the vehicle. Furthermore, the refrigerant HFC-134a is being replaced by alternative substances such as HFO-1234yf, which have a significantly lower GWP. The share of HFO-1234yf in the total amount of refrigerants contained in mobile air conditioners is currently low and

[4] Personal communication Cornelia Stettler, Carbotech, 23.02.2016.

was estimated by an expert[4]. The total refrigerant emissions over the whole life time were scaled according to the share of vehicles equipped with air conditioners and the share of alternative refrigerants. The emissions of HFO-1234yf were neglected due to their minor importance in terms of amount and GWP compared to HFC-134a.

Tab. 3.3 Parameters used to calculate the refrigerant emissions from air conditioners in road vehicles (BAFU 2015; personal communication Cornelia Stettler, Carbotech, 23.02.2016).

		Passenger Cars	Buses, Trams	Light Commercial Vehicles, Lorries
Life time	a	15	12	12
Initial charge	kgRefrigerant	0.55	7.5	1.1
EF production	% of initial charge	0.5%	0.5%	0.5%
EF life	1/a	8.5%	15.0%	8.5%
Refilled refrigerant	1/a	6.0%	15.0%	6.0%
Not refilled refrigerant	1/a	2.6%	0.0%	2.6%
EF service over life time	% of initial charge	10.0%	10.0%	10.0%
Charge end of life	% of initial charge	57.9%	100.0%	63.3%
EF disposal	% of remaining charge	50.0%	50.0%	50.0%
Loss over life time	kgRefrigerant	0.79	18	1.4
Share of vehicles with AC	%	96.0%	91.1%	67.3%
Share of refrigerant HFC-134a	%	98.5%	98.1%	98.1%
Loss over life time, corrected	**kgHFC-134a**	**0.75**	**16**	**0.94**

3.6 Noise emissions

The assessment of noise emissions from transport processes was newly introduced by Frischknecht and Büsser Knöpfel (2013, chapter 15) in the ecological scarcity method 2013. They derived eco-factors based on the number of people highly annoyed by traffic noise and defined elementary flows for noise emissions of average passenger cars (average noise level: 72 dB(A)) and lorries (average noise level: 81 dB(A)). The unit of these elementary flows is 1 vkm. Following the recommendation of Frischknecht and Büsser Knöpfel (2013), the noise emissions were included in all relevant road and non-road transport services analysed in this project. The average noise level of each means of transport was determined based on literature information or expert judgement. The noise emissions were then modelled by the elementary flows for noise caused by passenger cars and lorries. Differences in the noise level were accounted for by correction factors presented in Tab. 3.4 (Frischknecht & Büsser Knöpfel 2013).

Tab. 3.4 Correction factors used to scale the noise emissions of road and non-road transport services to the noise level of passenger cars or lorries. The correction factors were calculated by Frischknecht and Büsser Knöpfel (2013, Tab. 113) using the formula correction factor=$10^{(\text{change in noise level}/10)}$.

Change in noise level	Correction factor
dB(A)	-
-5	0.32
-4	0.40
-3	0.50
-2	0.63
-1	0.79
0	1.00
1	1.26
2	1.58
3	2.00
4	2.51
5	3.16
6	3.98
7	5.01
8	6.31
9	7.94
10	10.00

3.7 Non-exhaust emissions

The non-exhaust emissions as defined by Simons (2013) include emissions from the abrasion of road, tyres and brakes. Unit process life cycle inventories of the three types of non-exhaust emissions are available for passenger cars and lorries in ecoinvent data v3.1 and include the emissions of particulate matter (PM), PAHs, metals and further substances to air, water and soil (ecoinvent Centre 2014). These datasets were used to model the non-exhaust emissions of the road transport services described in this report. The emission factors are a function of the GVW and are different for light vehicles (e.g., passenger cars, motorcycles) and heavy vehicles (e.g., lorries, buses) as shown in Tab. 3.5.

Tab. 3.5 Emission factors of non-exhaust emissions by road, tyre and brake wear for road transport services (ecoinvent Centre 2014). Light vehicles include passenger cars, motorcycles, minibuses and light commercial vehicles. Lorries, buses and coaches belong to the category of heavy vehicles.

Vehicle Category	Light Vehicles	Heavy Vehicles
Unit	kg/(tGVW·km)	kg/(tGVW·km)
Road wear emissions	9.77E-06	7.00E-06
Tyre wear emissions	5.72E-05	8.06E-05
Brake wear emissions	4.44E-06	8.13E-06

4 Passenger transport

4.1 Overview

New or updated life cycle inventories were compiled for transports by petrol and diesel fuelled passenger cars of different size classes and compliant with the most important emission standards (subchapter 4.2). The life cycle inventory of transports by electric car was updated and is documented in subchapter 4.3. Life cycle inventories were newly created for transport processes by hybrid and plug-in hybrid cars (subchapter 4.4) and motorcycle (subchapter 4.5). The life cycle inventories of other two wheel vehicles such as bicycle and sooter were not updated in this study. However, the battery of electric bicycles and scooters is modelled by a new life cycle inventory (subchapter 4.6). The newly created life cycle inventory of passenger transports by minibus is presented in subchapter 4.7. The life cycle inventories of bus, passenger coach as well as tram and trolleybus transports were updated and are described in subchapters 4.8, 4.9 and 4.10, respectively.

4.2 Passenger car

4.2.1 Overview

The life cycle inventories of transports by petrol and diesel fuelled passenger cars of the emission standards Euro 3 to Euro 5 were updated. New life cycle inventories were compiled for transports by passenger cars compliant with the Euro 6 emission standard, which applies to vehicles sold after 1st September 2015 (European Union 2007). The functional unit of the life cycle inventories has been changed from 1 pkm in ecoinvent data v2 to 1 vkm, which is in alignment with ecoinvent data v3.1. The life cycle inventories of passenger cars using the alternative fuels natural gas, biogas or petrol / ethanol were not updated and are described in Jungbluth et al. (2007).

The life cycle inventories of passenger car transports are representative for Europe, whereby the fuel demand and emission factors were calculated for Germany. It is assumed that Germany is representative for passenger cars in central and Western Europe. The fleet average of passenger cars is based on Swiss statistics and thus valid for Switzerland. The most recent data available were used to compile the life cycle inventories. The fuel demand and emission factors were calculated for the year 2015.

The vehicle manufacture and road demand are described in section 4.2.2. The calculation of the fuel demand and the emissions during operation is documented in section 4.2.3. The unit process life cycle inventory data of transports by passenger car are presented in section 4.2.4. Additionally, new passenger car fleet mixes were compiled for Switzerland in 2015, which are shown in section 4.2.5.

4.2.2 Vehicle manufacture and road demand

The life cycle inventories of passenger car manufacture have been updated by Althaus and Gauch (2010) and are available in ecoinvent data v3.1. These life cycle inventories were embedded in KBOB life cycle inventory data v2.2:2016 and slightly adapted in order to ensure consistency. The transport of input and waste materials was included using standard distances as recommended by Frischknecht et al. (2007). More than 80 % of the passenger cars in Switzerland are imported from European countries (EZV 2013). It is assumed that a similar situation applies to Europe. The geographical representation of the life cycle inventory of passenger car manufacture was therefore changed from global to Europe. The electricity demand is covered by the ENTSO-E (European Network of Transmission System Operators for Electricity) electricity mix.

The energy demand for car assembly was taken from the life cycle inventory of passenger car manufacture in ecoinvent data v2 (2’140 kWh electricity covered by the ENTSO-E mix, 2’220 MJ heat from natural gas burned in an industrial furnace, 63 MJ heat from light fuel oil burned in an industrial furnace; Spielmann et al. 2007) and divided by the weight of the (diesel and petrol) passenger car. It is assumed that the energy demand in assembling one car did not change in the last 15 years (higher complexity on one hand versus higher energy efficiency on the other). This energy demand was included in the life cycle inventories of passenger car manufacture. In the updated life cycle inventories contained in ecoinvent data v3.1 and transferred to KBOB life cycle inventory data v2.2:2016, the dismantling of the passenger car and the disposal of waste materials at the end of life are included in the production of the passenger car, the glider and the internal combustion engine.

It is distinguished between petrol and diesel fuelled passenger cars, which have different shares of internal combustion engine and glider. The average weight of the newly immatriculated passenger cars within the ten-year period from 2005 to 2014 was determined based on statistical data from BFE (2015). Petrol passenger cars have an average vehicle weight of 1’380 kg, which is significantly lower than the weight of the average diesel passenger cars (1’700 kg).

In alignment with ecoinvent data v3.1, different life cycle inventories were compiled for transports by small, medium and large size passenger cars (ecoinvent Centre 2014). Small passenger cars as defined in ecoinvent data v3.1 have an engine displacement of up to 1.4 L and an average weight of 1’200 kg. The engine displacement of medium size passenger cars is between 1.4 L and 2.0 L and their weight amounts to 1’600 kg. Large size passenger cars have an engine displacement above 2.0 L and an average weight of 2’000 kg. The vehicle life time performance was taken from the life cycle inventories of transports by passenger car in ecoinvent data v2 and amounts to 150’000 km (Spielmann et al. 2007). This results in a demand of passenger car manufacture of $8.00 \cdot 10^{-3}$, $1.07 \cdot 10^{-2}$, $1.33 \cdot 10^{-2}$ kg/km for small, medium and large size passenger cars, respectively.

The life cycle inventory of passenger car maintenance was not updated in ecoinvent data v3.1. This process was therefore modelled by the dataset available in ecoinvent data v2 and scaled based on the vehicle weight. The basic vehicle weight, which the original dataset relates to, is 1'240 kg according to ecoinvent data v3.1 (ecoinvent Centre 2014). The resulting demand of passenger car maintenance is $6.45 \cdot 10^{-6}$, $8.60 \cdot 10^{-6}$, $1.08 \cdot 10^{-5}$ p/km for small, medium and large size passenger cars, respectively.

The input of road construction and disposal and of operation and maintenance was calculated with the demand factors given in subchapter 3.2. The demand of road construction and disposal is modelled as a function of the GVW. As in ecoinvent data v3.1, the average load of passenger cars was estimated to 100 kg, which was added to the net vehicle weight (ecoinvent Centre 2014). The input of road construction is $6.15 \cdot 10^{-4}$, $8.04 \cdot 10^{-4}$, $9.93 \cdot 10^{-4}$ ma/km for small, medium and large size passenger cars, respectively. Road operation and maintenance is assumed to be solely a function of the travel distance and is therefore independent of the vehicle size ($1.17 \cdot 10^{-3}$ ma/km).

4.2.3 Fuel consumption and emissions during operation

Data on the real-life fuel consumption and the emissions of selected pollutants (CO_2, CO, CH_4, N_2O, NMVOC, NO_x, NH_3, SO_2, PM) were retrieved from HBEFA (INFRAS 2014). This is in alignment with other road transport processes modelled in the present study but in contrast to the life cycle inventories of passenger car transports available in ecoinvent data v3.1, which are based on data from the TREMOVE model v2.7b (ecoinvent Centre 2014; Simons 2013). The fuel consumption and emission factors reported in HBEFA for Germany in 2015 were used and applied to the European situation. Besides the engine size, it is distinguished between passenger cars compliant with different emission standards. Furthermore, different categories exist in HBEFA for Euro 3 and Euro 4 diesel passenger cars with or without particle filter.

Life cycle inventories of transports by petrol and diesel fuelled passenger cars of the emission standards Euro 3 to Euro 6 were compiled in this study. Average diesel passenger cars compliant with the emission standards Euro 3 and Euro 4 were considered, which were calculated based on the share of kilometres travelled by vehicles with and without particle filter. The fuel demand and pollutant emissions during the continuous operation of the passenger cars are included in the so-called hot emission factors available in HBEFA.

Some additional fuel is consumed and elevated emissions occur during the cold start of the vehicles, which is accounted for by excess emission factors. Another category of emissions, which is only relevant for petrol fuelled passenger cars, is fuel evaporation due to running losses, soaking and diurnal temperature changes. All categories of emissions were taken into account in the life cycle inventories of transports by passenger car. An average travel distance had to be defined to aggregate the different emission factors since the excess emissions due to cold starts and the evaporation emissions by soaking are given per event. According to detailed surveys of mobility in Switzerland the average distance travelled by passenger cars in 2010 was 32 km (BFS/ARE 2012). These data were used because information on the average travel distance of passenger cars was not available for Europe. The emission factors of petrol evaporation due to diurnal temperature changes are given per day. They were then converted to the functional unit of 1 km by assuming that two trips of 32 km are taken on average per day.

The emissions of PM, CO, NO_X and volatile organic compounds (VOC) are regulated by the European emission standards. A fraction of the total NMVOC emissions was divided into main components based on the shares reported in Tab. 3.1. The emissions of CO_2, SO_2, PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed. The corresponding emission factors for petrol and diesel fuelled vehicles (except CO_2 and SO_2, which were taken from HBEFA) are compiled in Tab. 3.2. Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The calculation of refrigerant emissions from air conditioners is described in subchapter 3.5 and summarized in Tab. 3.3. The resulting refrigerant emissions are $4.99 \cdot 10^{-6}$ kgHFC-134a/km. The non-exhaust emissions by road, tyre and brake wear were calculated using the emission factors shown in Tab. 3.5 and the GVW of 1’300, 1’700 and 2’100 kg of small, medium and large size passenger cars, respectively.

4.2.4 Unit process life cycle inventory data

Tab. 4.1 to Tab. 4.4 show the unit process life cycle inventories of transports by petrol fuelled passenger cars compliant with the emission standards Euro 3 to Euro 6. The life cycle inventories of transports by diesel fuelled passenger cars compliant with the emission standards Euro 3 to Euro 6 are presented in Tab. 4.5 to Tab. 4.8.

Tab. 4.1 Life cycle inventory of transports by small, medium and large petrol fuelled passenger cars compliant with the emission standard Euro 3.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, small size, petrol, EURO 3	transport, passenger car, medium size, petrol, EURO 3	transport, passenger car, large size, petrol, EURO 3	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER			
	InfrastructureProcess				0	0	0			
	Unit				km	km	km			
product	transport, passenger car, small size, petrol, EURO 3	RER	0	km	1	0	0			
	transport, passenger car, medium size, petrol, EURO 3	RER	0	km	0	1	0			
	transport, passenger car, large size, petrol, EURO 3	RER	0	km	0	0	1			
technosphere	passenger car, petrol/natural gas	RER	1	kg	8.00E-3			1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1200 kg; Simons 2013; Ecoinvent v3.1
	passenger car, petrol/natural gas	RER	1	kg		1.07E-2		1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1600 kg; Simons 2013; Ecoinvent v3.1
	passenger car, petrol/natural gas	RER	1	kg			1.33E-2	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 2000 kg; Simons 2013; Ecoinvent v3.1
	maintenance, passenger car	RER	1	unit	6.45E-6	8.60E-6	1.08E-5	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Basic vehicle weight: 1240 kg; Simons 2013; Ecoinvent v3.1
	road	CH	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	petrol, low-sulphur, at regional storage	RER	0	kg	5.11E-2	6.54E-2	8.74E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel demand for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	4.99E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.60E-1	2.05E-1	2.74E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.76E-3	1.57E-3	1.57E-3	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	5.51E-6	5.43E-6	5.44E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	4.02E-5	3.98E-5	3.98E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 45.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	2.83E-6	2.81E-6	2.80E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	5.77E-7	5.72E-7	5.71E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	4.65E-6	4.61E-6	4.61E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.24%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.91E-6	1.89E-6	1.89E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Hexane	-	-	kg	1.43E-6	1.42E-6	1.42E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	1.01E-6	1.00E-6	1.00E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.14%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	6.57E-7	6.51E-7	6.50E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.74%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	6.48E-6	6.42E-6	6.42E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 7.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	3.39E-6	3.36E-6	3.36E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.82%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	9.76E-8	9.67E-8	9.67E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	4.98E-6	4.93E-6	4.93E-6	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 5.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	9.75E-6	9.66E-6	9.65E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	4.82E-6	4.78E-6	4.77E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.43%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	2.01E-6	1.99E-6	1.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.26%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.51E-6	1.50E-6	1.49E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.70%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	6.66E-7	6.60E-7	6.59E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.75%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.95E-7	1.93E-7	1.93E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.22%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	5.41E-7	5.36E-7	5.36E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	4.44E-8	4.40E-8	4.39E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.05%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	1.69E-7	1.67E-7	1.67E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	8.97E-7	8.88E-7	8.88E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	6.93E-5	7.50E-5	7.50E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	4.06E-5	4.08E-5	4.09E-5	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.38E-7	4.68E-7	5.08E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	7.28E-7	9.31E-7	1.25E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	3.83E-6	3.83E-6	3.83E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.34E-9	1.71E-9	2.29E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 2.62E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	1.53E-11	1.96E-11	2.62E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	1.02E-11	1.31E-11	1.75E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	1.11E-7	1.41E-7	1.89E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.16E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	2.15E-9	2.75E-9	3.67E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 4.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	6.64E-10	8.50E-10	1.14E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.30E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	8.17E-10	1.05E-9	1.40E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.60E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.63E-12	2.09E-12	2.80E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.20E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	4.44E-10	5.69E-10	7.60E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	5.52E-10	7.06E-10	9.44E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.08E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.70E-9	2.17E-9	2.90E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.32E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	4.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1.00E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, passenger car	RER	0	kg	1.27E-5	1.66E-5	2.05E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	7.43E-5	9.72E-5	1.20E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	5.78E-6	7.55E-6	9.33E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2

Tab. 4.2 Life cycle inventory of transports by small, medium and large petrol fuelled passenger cars compliant with the emission standard Euro 4.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, small size, petrol, EURO 4	transport, passenger car, medium size, petrol, EURO 4	transport, passenger car, large size, petrol, EURO 4	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER			
	InfrastructureProcess				0	0	0			
	Unit				km	km	km			
product	transport, passenger car, small size, petrol, EURO 4	RER	0	km	1	0	0			
	transport, passenger car, medium size, petrol, EURO 4	RER	0	km	0	1	0			
	transport, passenger car, large size, petrol, EURO 4	RER	0	km	0	0	1			
technosphere	passenger car, petrol/natural gas	RER	1	kg	8.00E-3			1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1200 kg; Simons 2013; Ecoinvent v3.1
	passenger car, petrol/natural gas	RER	1	kg		1.07E-2		1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1600 kg; Simons 2013; Ecoinvent v3.1
	passenger car, petrol/natural gas	RER	1	kg			1.33E-2	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 2000 kg; Simons 2013; Ecoinvent v3.1
	maintenance, passenger car	RER	1	unit	6.45E-6	8.60E-6	1.08E-5	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Basic vehicle weight: 1240 kg; Simons 2013; Ecoinvent v3.1
	road	CH	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	petrol, low-sulphur, at regional storage	RER	0	kg	4.89E-2	6.12E-2	8.41E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel demand for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	4.99E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.53E-1	1.92E-1	2.64E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.10E-3	1.05E-3	1.05E-3	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	4.21E-6	4.20E-6	4.20E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	3.29E-5	3.28E-5	3.28E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 45.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	2.32E-6	2.31E-6	2.31E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	4.72E-7	4.71E-7	4.71E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	3.81E-6	3.80E-6	3.80E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.24%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.56E-6	1.56E-6	1.56E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Hexane	-	-	kg	1.17E-6	1.17E-6	1.17E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	8.28E-7	8.26E-7	8.26E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.14%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	5.37E-7	5.36E-7	5.36E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.74%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	5.30E-6	5.29E-6	5.29E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 7.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	2.77E-6	2.77E-6	2.77E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.82%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	7.99E-8	7.97E-8	7.97E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	4.07E-6	4.07E-6	4.06E-6	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 5.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	7.97E-6	7.96E-6	7.95E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	3.94E-6	3.94E-6	3.93E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.43%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	1.64E-6	1.64E-6	1.64E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.26%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.23E-6	1.23E-6	1.23E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.70%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	5.45E-7	5.44E-7	5.43E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.75%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.60E-7	1.59E-7	1.59E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.22%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	4.43E-7	4.42E-7	4.42E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	3.63E-8	3.62E-8	3.62E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.05%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	1.38E-7	1.38E-7	1.38E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	7.33E-7	7.32E-7	7.32E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	7.04E-5	7.50E-5	7.55E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	4.05E-5	4.06E-5	4.08E-5	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.82E-7	5.14E-7	5.64E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	6.96E-7	8.71E-7	1.20E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.95E-6	1.95E-6	1.95E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.28E-9	1.60E-9	2.20E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 2.62E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	1.47E-11	1.83E-11	2.52E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	9.77E-12	1.22E-11	1.68E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	1.06E-7	1.32E-7	1.82E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.16E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	2.05E-9	2.57E-9	3.53E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 4.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	6.35E-10	7.95E-10	1.09E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.30E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	7.82E-10	9.79E-10	1.35E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.60E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.56E-12	1.96E-12	2.69E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.20E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	4.25E-10	5.32E-10	7.32E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	5.28E-10	6.61E-10	9.08E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.08E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.62E-9	2.03E-9	2.79E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.32E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	4.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1.00E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, passenger car	RER	0	kg	1.27E-5	1.66E-5	2.05E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	7.43E-5	9.72E-5	1.20E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	5.78E-6	7.55E-6	9.33E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2

Tab. 4.3 Life cycle inventory of transports by small, medium and large petrol fuelled passenger cars compliant with the emission standard Euro 5.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, small size, petrol, EURO 5	transport, passenger car, medium size, petrol, EURO 5	transport, passenger car, large size, petrol, EURO 5	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER			
	InfrastructureProcess				0	0	0			
	Unit				km	km	km			
product	transport, passenger car, small size, petrol, EURO 5	RER	0	km	1	0	0			
	transport, passenger car, medium size, petrol, EURO 5	RER	0	km	0	1	0			
	transport, passenger car, large size, petrol, EURO 5	RER	0	km	0	0	1			
technosphere	passenger car, petrol/natural gas	RER	1	kg	8.00E-3			1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1200 kg; Simons 2013; Ecoinvent v3.1
	passenger car, petrol/natural gas	RER	1	kg		1.07E-2		1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1600 kg; Simons 2013; Ecoinvent v3.1
	passenger car, petrol/natural gas	RER	1	kg			1.33E-2	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 2000 kg; Simons 2013; Ecoinvent v3.1
	maintenance, passenger car	RER	1	unit	6.45E-6	8.60E-6	1.08E-5	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Basic vehicle weight: 1240 kg; Simons 2013; Ecoinvent v3.1
	road	CH	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	petrol, low-sulphur, at regional storage	RER	0	kg	4.57E-2	5.51E-2	7.84E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel demand for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	4.99E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.43E-1	1.73E-1	2.46E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	8.99E-4	9.04E-4	9.04E-4	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	3.85E-6	3.85E-6	3.85E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	3.00E-5	3.01E-5	3.00E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 45.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	2.12E-6	2.12E-6	2.12E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	4.32E-7	4.32E-7	4.32E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	3.48E-6	3.48E-6	3.48E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.24%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.43E-6	1.43E-6	1.43E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Hexane	-	-	kg	1.07E-6	1.07E-6	1.07E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	7.57E-7	7.57E-7	7.57E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.14%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	4.91E-7	4.92E-7	4.92E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.74%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	4.85E-6	4.85E-6	4.85E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 7.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	2.54E-6	2.54E-6	2.54E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.82%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	7.31E-8	7.31E-8	7.31E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	3.73E-6	3.73E-6	3.73E-6	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 5.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	7.29E-6	7.30E-6	7.29E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	3.61E-6	3.61E-6	3.61E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.43%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	1.50E-6	1.50E-6	1.50E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.26%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.13E-6	1.13E-6	1.13E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.70%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	4.98E-7	4.98E-7	4.98E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.75%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.46E-7	1.46E-7	1.46E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.22%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	4.05E-7	4.05E-7	4.05E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	3.32E-8	3.32E-8	3.32E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.05%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	1.26E-7	1.26E-7	1.26E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	6.71E-7	6.71E-7	6.71E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	3.03E-5	3.03E-5	3.03E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	4.03E-5	4.04E-5	4.04E-5	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.36E-7	4.47E-7	4.69E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	6.50E-7	7.85E-7	1.12E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	2.07E-6	2.07E-6	2.07E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.20E-9	1.44E-9	2.05E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 2.62E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	1.37E-11	1.65E-11	2.35E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	9.13E-12	1.10E-11	1.57E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	9.87E-8	1.19E-7	1.70E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.16E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	1.92E-9	2.31E-9	3.29E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 4.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	5.93E-10	7.16E-10	1.02E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.30E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	7.30E-10	8.82E-10	1.25E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.60E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.46E-12	1.76E-12	2.51E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.20E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	3.97E-10	4.80E-10	6.82E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	4.93E-10	5.95E-10	8.47E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.08E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.52E-9	1.83E-9	2.60E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.32E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	4.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1.00E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, passenger car	RER	0	kg	1.27E-5	1.66E-5	2.05E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	7.43E-5	9.72E-5	1.20E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	5.78E-6	7.55E-6	9.33E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2

Tab. 4.4 Life cycle inventory of transports by small, medium and large petrol fuelled passenger cars compliant with the emission standard Euro 6.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, small size, petrol, EURO 6	transport, passenger car, medium size, petrol, EURO 6	transport, passenger car, large size, petrol, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER			
	InfrastructureProcess				0	0	0			
	Unit				km	km	km			
product	transport, passenger car, small size, petrol, EURO 6	RER	0	km	1	0	0			
	transport, passenger car, medium size, petrol, EURO 6	RER	0	km	0	1	0			
	transport, passenger car, large size, petrol, EURO 6	RER	0	km	0	0	1			
technosphere	passenger car, petrol/natural gas	RER	1	kg	8.00E-3			1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1200 kg; Simons 2013; Ecoinvent v3.1
	passenger car, petrol/natural gas	RER	1	kg		1.07E-2		1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1600 kg; Simons 2013; Ecoinvent v3.1
	passenger car, petrol/natural gas	RER	1	kg			1.33E-2	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 2000 kg; Simons 2013; Ecoinvent v3.1
	maintenance, passenger car	RER	1	unit	6.45E-6	8.60E-6	1.08E-5	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Basic vehicle weight: 1240 kg; Simons 2013; Ecoinvent v3.1
	road	CH	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	petrol, low-sulphur, at regional storage	RER	0	kg	4.32E-2	5.20E-2	7.47E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel demand for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	4.99E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.35E-1	1.63E-1	2.34E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	8.98E-4	9.03E-4	9.03E-4	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	3.51E-6	3.51E-6	3.51E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.73E-5	2.73E-5	2.73E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 45.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	1.93E-6	1.93E-6	1.93E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	3.93E-7	3.93E-7	3.93E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	3.17E-6	3.17E-6	3.17E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.24%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.30E-6	1.30E-6	1.30E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Hexane	-	-	kg	9.73E-7	9.73E-7	9.73E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	6.89E-7	6.89E-7	6.89E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.14%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	4.47E-7	4.47E-7	4.47E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.74%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	4.41E-6	4.41E-6	4.41E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 7.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	2.31E-6	2.31E-6	2.31E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.82%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	6.64E-8	6.65E-8	6.65E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	3.39E-6	3.39E-6	3.39E-6	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 5.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	6.63E-6	6.63E-6	6.63E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	3.28E-6	3.28E-6	3.28E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.43%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	1.37E-6	1.37E-6	1.37E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.26%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.03E-6	1.03E-6	1.03E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.70%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	4.53E-7	4.53E-7	4.53E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.75%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.33E-7	1.33E-7	1.33E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.22%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	3.68E-7	3.69E-7	3.69E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	3.02E-8	3.02E-8	3.02E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.05%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	1.15E-7	1.15E-7	1.15E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	6.10E-7	6.10E-7	6.10E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	2.91E-5	2.91E-5	2.91E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	4.02E-5	4.03E-5	4.03E-5	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.14E-7	4.18E-7	4.28E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	6.15E-7	7.41E-7	1.06E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	2.07E-6	2.07E-6	2.07E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.13E-9	1.36E-9	1.96E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 2.62E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	1.30E-11	1.56E-11	2.24E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	8.64E-12	1.04E-11	1.49E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	9.34E-8	1.12E-7	1.62E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.16E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	1.81E-9	2.18E-9	3.14E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 4.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	5.61E-10	6.76E-10	9.71E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.30E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	6.91E-10	8.32E-10	1.20E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.60E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.38E-12	1.66E-12	2.39E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.20E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	3.76E-10	4.52E-10	6.50E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	4.66E-10	5.61E-10	8.07E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.08E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.43E-9	1.73E-9	2.48E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.32E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	4.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1.00E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, passenger car	RER	0	kg	1.27E-5	1.66E-5	2.05E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	7.43E-5	9.72E-5	1.20E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	5.78E-6	7.55E-6	9.33E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2

Tab. 4.5 Life cycle inventory of transports by small, medium and large diesel fuelled passenger cars compliant with the emission standard Euro 3.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, small size, diesel, EURO 3	transport, passenger car, medium size, diesel, EURO 3	transport, passenger car, large size, diesel, EURO 3	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER			
	InfrastructureProcess				0	0	0			
	Unit				km	km	km			
product	transport, passenger car, small size, diesel, EURO 3	RER	0	km	1	0	0			
	transport, passenger car, medium size, diesel, EURO 3	RER	0	km	0	1	0			
	transport, passenger car, large size, diesel, EURO 3	RER	0	km	0	0	1			
technosphere	passenger car, diesel	RER	1	kg	8.00E-3			1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1200 kg; Simons 2013; Ecoinvent v3.1
	passenger car, diesel	RER	1	kg		1.07E-2		1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1600 kg; Simons 2013; Ecoinvent v3.1
	passenger car, diesel	RER	1	kg			1.33E-2	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 2000 kg; Simons 2013; Ecoinvent v3.1
	maintenance, passenger car	RER	1	unit	6.45E-6	8.60E-6	1.08E-5	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Basic vehicle weight: 1240 kg; Simons 2013; Ecoinvent v3.1
	road	CH	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	diesel, low-sulphur, at regional storage	RER	0	kg	3.27E-2	4.61E-2	6.26E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel demand for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	4.99E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.04E-1	1.46E-1	1.99E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	9.88E-5	9.88E-5	9.88E-5	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	6.58E-7	6.58E-7	6.58E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.42E-5	1.42E-5	1.42E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 53.0% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	8.83E-8	8.83E-8	8.83E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.33%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	2.94E-8	2.94E-8	2.94E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	2.94E-8	2.94E-8	2.94E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.07E-8	1.07E-8	1.07E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.04%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	1.74E-7	1.74E-7	1.74E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	5.35E-8	5.35E-8	5.35E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	2.93E-6	2.93E-6	2.93E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.97%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	9.63E-7	9.63E-7	9.63E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.60%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	5.30E-7	5.30E-7	5.30E-7	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 1.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	1.85E-7	1.85E-7	1.85E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.69%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	1.63E-7	1.63E-7	1.63E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	7.22E-8	7.22E-8	7.22E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.27%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	3.21E-6	3.21E-6	3.21E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 12.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	1.73E-6	1.73E-6	1.73E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 6.47%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	2.30E-7	2.30E-7	2.30E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.86%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	7.87E-7	7.87E-7	7.87E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.94%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	3.21E-7	3.21E-7	3.21E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	9.58E-7	9.58E-7	9.58E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.58%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	9.90E-8	9.90E-8	9.90E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	7.87E-4	8.02E-4	8.03E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	1.00E-6	1.00E-6	1.00E-6	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.67E-6	4.67E-6	4.67E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	5.23E-7	7.37E-7	1.00E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	3.83E-5	3.92E-5	3.80E-5	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	2.51E-9	3.54E-9	4.81E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.68E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	3.27E-12	4.61E-12	6.26E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	3.27E-12	4.61E-12	6.26E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	5.68E-8	8.01E-8	1.09E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	6.93E-10	9.77E-10	1.33E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	2.88E-10	4.05E-10	5.51E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	9.80E-10	1.38E-9	1.88E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.96E-12	2.76E-12	3.76E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	1.73E-10	2.44E-10	3.32E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	2.84E-10	4.01E-10	5.45E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.70E-9	2.40E-9	3.26E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	4.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1.00E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, passenger car	RER	0	kg	1.27E-5	1.66E-5	2.05E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	7.43E-5	9.72E-5	1.20E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	5.78E-6	7.55E-6	9.33E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2

Tab. 4.6 Life cycle inventory of transports by small, medium and large diesel fuelled passenger cars compliant with the emission standard Euro 4.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, small size, diesel, EURO 4	transport, passenger car, medium size, diesel, EURO 4	transport, passenger car, large size, diesel, EURO 4	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER			
	InfrastructureProcess				0	0	0			
	Unit				km	km	km			
product	transport, passenger car, small size, diesel, EURO 4	RER	0	km	1	0	0			
	transport, passenger car, medium size, diesel, EURO 4	RER	0	km	0	1	0			
	transport, passenger car, large size, diesel, EURO 4	RER	0	km	0	0	1			
technosphere	passenger car, diesel	RER	1	kg	8.00E-3			1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1200 kg; Simons 2013; Ecoinvent v3.1
	passenger car, diesel	RER	1	kg		1.07E-2		1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1600 kg; Simons 2013; Ecoinvent v3.1
	passenger car, diesel	RER	1	kg			1.33E-2	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 2000 kg; Simons 2013; Ecoinvent v3.1
	maintenance, passenger car	RER	1	unit	6.45E-6	8.60E-6	1.08E-5	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Basic vehicle weight: 1240 kg; Simons 2013; Ecoinvent v3.1
	road	CH	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	diesel, low-sulphur, at regional storage	RER	0	kg	3.52E-2	4.63E-2	6.27E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel demand for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	4.99E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.12E-1	1.47E-1	1.99E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	5.92E-5	5.92E-5	5.92E-5	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	3.37E-7	3.37E-7	3.37E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	7.27E-6	7.27E-6	7.27E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 53.0% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	4.52E-8	4.52E-8	4.52E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.33%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	1.51E-8	1.51E-8	1.51E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	1.51E-8	1.51E-8	1.51E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	5.48E-9	5.48E-9	5.48E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.04%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	8.91E-8	8.91E-8	8.91E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	2.74E-8	2.74E-8	2.74E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	1.50E-6	1.50E-6	1.50E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.97%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	4.93E-7	4.94E-7	4.94E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.60%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	2.71E-7	2.71E-7	2.71E-7	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 1.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	9.46E-8	9.46E-8	9.46E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.69%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	8.36E-8	8.36E-8	8.36E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	3.70E-8	3.70E-8	3.70E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.27%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.64E-6	1.65E-6	1.65E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 12.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	8.87E-7	8.87E-7	8.87E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 6.47%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.18E-7	1.18E-7	1.18E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.86%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	4.03E-7	4.03E-7	4.03E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.94%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	1.64E-7	1.65E-7	1.65E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	4.91E-7	4.91E-7	4.91E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.58%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	5.07E-8	5.07E-8	5.07E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	5.25E-4	5.34E-4	5.34E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	1.00E-6	1.00E-6	1.00E-6	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.67E-6	4.67E-6	4.67E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	5.63E-7	7.42E-7	1.00E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.26E-5	1.06E-5	9.33E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	2.70E-9	3.56E-9	4.82E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.68E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	3.52E-12	4.63E-12	6.27E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	3.52E-12	4.63E-12	6.27E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	6.12E-8	8.05E-8	1.09E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	7.47E-10	9.82E-10	1.33E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	3.10E-10	4.08E-10	5.52E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	1.06E-9	1.39E-9	1.88E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	2.11E-12	2.78E-12	3.76E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	1.87E-10	2.46E-10	3.32E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	3.06E-10	4.03E-10	5.46E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.83E-9	2.41E-9	3.26E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	4.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1.00E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, passenger car	RER	0	kg	1.27E-5	1.66E-5	2.05E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	7.43E-5	9.72E-5	1.20E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	5.78E-6	7.55E-6	9.33E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2

Tab. 4.7 Life cycle inventory of transports by small, medium and large diesel fuelled passenger cars compliant with the emission standard Euro 5.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, small size, diesel, EURO 5	transport, passenger car, medium size, diesel, EURO 5	transport, passenger car, large size, diesel, EURO 5	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER			
	InfrastructureProcess				0	0	0			
	Unit				km	km	km			
product	transport, passenger car, small size, diesel, EURO 5	RER	0	km	1	0	0			
	transport, passenger car, medium size, diesel, EURO 5	RER	0	km	0	1	0			
	transport, passenger car, large size, diesel, EURO 5	RER	0	km	0	0	1			
technosphere	passenger car, diesel	RER	1	kg	8.00E-3			1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1200 kg; Simons 2013; Ecoinvent v3.1
	passenger car, diesel	RER	1	kg		1.07E-2		1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1600 kg; Simons 2013; Ecoinvent v3.1
	passenger car, diesel	RER	1	kg			1.33E-2	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 2000 kg; Simons 2013; Ecoinvent v3.1
	maintenance, passenger car	RER	1	unit	6.45E-6	8.60E-6	1.08E-5	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Basic vehicle weight: 1240 kg; Simons 2013; Ecoinvent v3.1
	road	CH	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	diesel, low-sulphur, at regional storage	RER	0	kg	3.28E-2	4.29E-2	5.62E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel demand for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	4.99E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.04E-1	1.36E-1	1.79E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	5.24E-5	5.24E-5	5.24E-5	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	2.71E-7	2.71E-7	2.71E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.84E-6	5.84E-6	5.84E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 53.0% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	3.63E-8	3.63E-8	3.63E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.33%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	1.21E-8	1.21E-8	1.21E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	1.21E-8	1.21E-8	1.21E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	4.40E-9	4.40E-9	4.40E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.04%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	7.16E-8	7.16E-8	7.16E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	2.20E-8	2.20E-8	2.20E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	1.21E-6	1.21E-6	1.21E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.97%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	3.96E-7	3.96E-7	3.96E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.60%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	2.18E-7	2.18E-7	2.18E-7	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 1.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	7.60E-8	7.60E-8	7.60E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.69%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	6.72E-8	6.72E-8	6.72E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	2.97E-8	2.97E-8	2.97E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.27%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.32E-6	1.32E-6	1.32E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 12.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	7.12E-7	7.12E-7	7.12E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 6.47%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	9.47E-8	9.47E-8	9.47E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.86%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	3.24E-7	3.24E-7	3.24E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.94%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	1.32E-7	1.32E-7	1.32E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	3.94E-7	3.94E-7	3.94E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.58%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	4.07E-8	4.07E-8	4.07E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	6.57E-4	6.67E-4	6.67E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	1.00E-6	1.00E-6	1.00E-6	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.67E-6	4.67E-6	4.67E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	5.25E-7	6.86E-7	8.99E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	2.03E-6	2.03E-6	2.03E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	2.52E-9	3.29E-9	4.31E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.68E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	3.28E-12	4.29E-12	5.62E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	3.28E-12	4.29E-12	5.62E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	5.70E-8	7.46E-8	9.76E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	6.95E-10	9.10E-10	1.19E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	2.89E-10	3.78E-10	4.94E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	9.84E-10	1.29E-9	1.69E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.97E-12	2.57E-12	3.37E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	1.74E-10	2.27E-10	2.98E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	2.85E-10	3.73E-10	4.89E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.70E-9	2.23E-9	2.92E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	4.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1.00E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, passenger car	RER	0	kg	1.27E-5	1.66E-5	2.05E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	7.43E-5	9.72E-5	1.20E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	5.78E-6	7.55E-6	9.33E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2

Tab. 4.8 Life cycle inventory of transports by small, medium and large diesel fuelled passenger cars compliant with the emission standard Euro 6.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, small size, diesel, EURO 6	transport, passenger car, medium size, diesel, EURO 6	transport, passenger car, large size, diesel, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER			
	InfrastructureProcess				0	0	0			
	Unit				km	km	km			
product	transport, passenger car, small size, diesel, EURO 6	RER	0	km	1	0	0			
	transport, passenger car, medium size, diesel, EURO 6	RER	0	km	0	1	0			
	transport, passenger car, large size, diesel, EURO 6	RER	0	km	0	0	1			
technosphere	passenger car, diesel	RER	1	kg	8.00E-3			1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1200 kg; Simons 2013; Ecoinvent v3.1
	passenger car, diesel	RER	1	kg		1.07E-2		1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1600 kg; Simons 2013; Ecoinvent v3.1
	passenger car, diesel	RER	1	kg			1.33E-2	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 2000 kg; Simons 2013; Ecoinvent v3.1
	maintenance, passenger car	RER	1	unit	6.45E-6	8.60E-6	1.08E-5	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 150000 vkm; Basic vehicle weight: 1240 kg; Simons 2013; Ecoinvent v3.1
	road	CH	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	diesel, low-sulphur, at regional storage	RER	0	kg	3.10E-2	4.07E-2	5.30E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel demand for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	4.99E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	9.87E-2	1.29E-1	1.68E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	5.24E-5	5.24E-5	5.24E-5	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	2.71E-7	2.71E-7	2.71E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.84E-6	5.84E-6	5.84E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 53.0% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	3.63E-8	3.63E-8	3.63E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.33%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	1.21E-8	1.21E-8	1.21E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	1.21E-8	1.21E-8	1.21E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	4.40E-9	4.40E-9	4.40E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.04%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	7.16E-8	7.16E-8	7.16E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	2.20E-8	2.20E-8	2.20E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	1.21E-6	1.21E-6	1.21E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.97%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	3.96E-7	3.96E-7	3.96E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.60%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	2.18E-7	2.18E-7	2.18E-7	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 1.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	7.60E-8	7.60E-8	7.60E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.69%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	6.72E-8	6.72E-8	6.72E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	2.97E-8	2.97E-8	2.97E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.27%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.32E-6	1.32E-6	1.32E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 12.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	7.12E-7	7.12E-7	7.12E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 6.47%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	9.47E-8	9.47E-8	9.47E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.86%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	3.24E-7	3.24E-7	3.24E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.94%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	1.32E-7	1.32E-7	1.32E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	3.94E-7	3.94E-7	3.94E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.58%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	4.07E-8	4.07E-8	4.07E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	2.56E-4	2.59E-4	2.59E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	1.00E-6	1.00E-6	1.00E-6	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.67E-6	4.67E-6	4.67E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	4.97E-7	6.51E-7	8.47E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	2.03E-6	2.03E-6	2.03E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	2.38E-9	3.12E-9	4.07E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.68E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	3.10E-12	4.07E-12	5.30E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	3.10E-12	4.07E-12	5.30E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	5.39E-8	7.07E-8	9.20E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	6.58E-10	8.62E-10	1.12E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	2.73E-10	3.58E-10	4.66E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	9.31E-10	1.22E-9	1.59E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.86E-12	2.44E-12	3.18E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	1.64E-10	2.16E-10	2.81E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	2.70E-10	3.54E-10	4.61E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.61E-9	2.12E-9	2.75E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	4.99E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1.00E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, passenger car	RER	0	kg	1.27E-5	1.66E-5	2.05E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	7.43E-5	9.72E-5	1.20E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	5.78E-6	7.55E-6	9.33E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	6.15E-4	8.04E-4	9.93E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2

4.2.5 Fleet mixes

Fleet mixes of transports by passenger car were compiled based on ecoinvent processes of different size and emission classes. It is distinguished between a petrol car fleet, a diesel car fleet and an overall fleet with petrol and diesel passenger cars.

The average fleet of passenger cars in Switzerland in the year 2015 was modelled based on the share of each size and emission class in the total vehicle kilometres travelled as reported in HBEFA (INFRAS 2014). The size classes small, medium and large and the emission classes Euro 3, Euro 4, Euro 5 and Euro 6 were included in the fleet mixes. The shares of cars, which do not comply with one of these emission classes, were not considered due to missing life cycle inventory data.

The life cycle inventories of the petrol and diesel car fleet mixes are shown in Tab. 4.9 and Tab. 4.10, respectively. The life cycle inventory of the passenger car fleet mix including both petrol and diesel cars is presented in Tab. 4.11.

Tab. 4.9 Life cycle inventory of the average petrol car fleet in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, petrol, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, passenger car, petrol, fleet average	CH	0	km	1			
technosphere	transport, passenger car, small size, petrol, EURO 3	RER	0	km	2.39E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, petrol, EURO 4	RER	0	km	9.72E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, petrol, EURO 5	RER	0	km	1.41E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, petrol, EURO 6	RER	0	km	1.72E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, medium size, petrol, EURO 3	RER	0	km	6.94E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, petrol, EURO 4	RER	0	km	2.13E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, petrol, EURO 5	RER	0	km	1.88E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, petrol, EURO 6	RER	0	km	2.35E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, large size, petrol, EURO 3	RER	0	km	4.19E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, petrol, EURO 4	RER	0	km	1.17E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, petrol, EURO 5	RER	0	km	6.13E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, petrol, EURO 6	RER	0	km	7.51E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2

Tab. 4.10 Life cycle inventory of the average diesel car fleet in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, diesel, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, passenger car, diesel, fleet average	CH	0	km	1			
technosphere	transport, passenger car, small size, diesel, EURO 3	RER	0	km	1.99E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, diesel, EURO 4	RER	0	km	8.81E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, diesel, EURO 5	RER	0	km	9.69E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, diesel, EURO 6	RER	0	km	1.39E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, medium size, diesel, EURO 3	RER	0	km	5.01E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, diesel, EURO 4	RER	0	km	1.98E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, diesel, EURO 5	RER	0	km	3.22E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, diesel, EURO 6	RER	0	km	4.09E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, large size, diesel, EURO 3	RER	0	km	3.71E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, diesel, EURO 4	RER	0	km	1.31E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, diesel, EURO 5	RER	0	km	1.76E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, diesel, EURO 6	RER	0	km	2.23E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2

Tab. 4.11 Life cycle inventory of the average petrol and diesel car fleet in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, passenger car, fleet average	CH	0	km	1			
technosphere	transport, passenger car, small size, petrol, EURO 3	RER	0	km	1.45E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, petrol, EURO 4	RER	0	km	5.91E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, petrol, EURO 5	RER	0	km	8.57E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, petrol, EURO 6	RER	0	km	1.04E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, medium size, petrol, EURO 3	RER	0	km	4.22E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, petrol, EURO 4	RER	0	km	1.29E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, petrol, EURO 5	RER	0	km	1.14E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, petrol, EURO 6	RER	0	km	1.43E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, large size, petrol, EURO 3	RER	0	km	2.54E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, petrol, EURO 4	RER	0	km	7.08E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, petrol, EURO 5	RER	0	km	3.72E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, petrol, EURO 6	RER	0	km	4.57E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, small size, diesel, EURO 3	RER	0	km	7.81E-4	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, diesel, EURO 4	RER	0	km	3.46E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, diesel, EURO 5	RER	0	km	3.80E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, small size, diesel, EURO 6	RER	0	km	5.46E-4	1	2.06	(2,2,1,1,3,3,BU:2); Size class <1.4L; HBEFA v3.2
	transport, passenger car, medium size, diesel, EURO 3	RER	0	km	1.97E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, diesel, EURO 4	RER	0	km	7.79E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, diesel, EURO 5	RER	0	km	1.27E-1	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, medium size, diesel, EURO 6	RER	0	km	1.61E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class 1.4-2.0L; HBEFA v3.2
	transport, passenger car, large size, diesel, EURO 3	RER	0	km	1.46E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, diesel, EURO 4	RER	0	km	5.14E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, diesel, EURO 5	RER	0	km	6.90E-2	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2
	transport, passenger car, large size, diesel, EURO 6	RER	0	km	8.73E-3	1	2.06	(2,2,1,1,3,3,BU:2); Size class >2.0L; HBEFA v3.2

4.3 Electric car

4.3.1 Overview

The dataset representing transport by electric car has been adapted from the dataset published in ecoinvent data v3.1. The weight of the car as well as the geographic representation of the dataset were changed. The process of vehicle manufacture and the demand of road infrastructure are described in section 4.3.2. The electricity consumption as well as the emissions during the operation of the electric car are documented in sections 4.3.3 and 4.3.4, respectively. The unit process life cycle inventory data are presented in section 4.3.5.

4.3.2 Vehicle manufacture and road demand

The vehicle demand depends on the life time performance and the weight of the electric car. In the original dataset the weight of the electric car was assumed to be 1’253 kg including the battery of 262 kg. This has been adjusted to 1’585 kg including a battery of 318 kg according to the technical datasheet of the e-Golf. The life time performance of the electric car and the battery has not been changed and still remains at 150’000 km and 100’000 km, respectively. No further usage of the battery is assumed at the end of its service life in the car. The spent battery is assumed to undergo a mix of hydrometallurgical and pyrometallurgical treatment. The maintenance demand was adjusted to $9.20 \cdot 10^{-6}$ p/km according to the corrected weight of the electric car.

The manufacture of the Li-ion battery is one of the key drivers of environmental impacts of electric car driving. Different types of Li-ion battery are used in electric cars. However, information on Li-ion battery manufacture is hardly available. The life cycle inventory data of battery manufacture were updated using recent data from a battery manufacturer of NCM[5] Li-ion batteries (Ager-Wick Ellingsen et al. 2014). The battery cell is manufactured in East Asia and the assembly of the battery takes place in Norway. The authors describe a scenario in which the observed energy consumption in the battery production was reduced to cope with efficiency improvements by increasing the capacity utilisation of the factory analysed. The data assuming full capacity utilisation are used in the life cycle inventory of battery production. The detailed life cycle inventory data of the battery manufacture are presented in Appendix A.

The road demand depends on the GVW and is $7.97 \cdot 10^{-4}$ my/km driven with an electric car ($4.73 \cdot 10^{-4}$ my/(t GVW·km)). The demand of road operation and maintenance is $1.17 \cdot 10^{-4}$ my/km.

4.3.3 Electricity consumption

The New European Driving Cycle (NEDC) consumption of a VW e-Golf provided by VW is 12.1 kWh/100 km. For electric cars, a real world surcharge (including electricity used for heating, electronics, etc.) of 65 % was added to the NEDC consumption. The resulting real electricity consumption of 20 kWh/100 km corresponds well with the value published by Althaus and Gauch (2010). The electricity consumption is covered with the Swiss supply mix (low voltage).

4.3.4 Emissions during operation

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). According to VCS (2015a) electric cars emit noise of between 66 and 75 dB(A). The VW e-Golf emits 69 dB(A) and thus the amount of noise kilometres is reduced by 50 % compared to the average car fleet in Switzerland (see Tab. 3.4).

The non-exhaust emissions by road, tyre and brake wear are a function of the GVW and were calculated using the emission factors shown in Tab. 3.5. To account for the recuperation the brake wear emissions were reduced to 10 % of the initial value (Althaus & Gauch 2010). Refrigerant emissions from air conditioning were added to the datasets according to the information provided in subchapter 3.5.

4.3.5 Unit process life cycle inventory data

Tab. 4.12 shows the unit process life cycle inventory data of electric car transport in Switzerland.

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[5] NCM: Nickel-Cobalt-Manganese, the metals included in the cathode of the battery.

Tab. 4.12 Life cycle inventory of electric car transport in Switzerland.

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, electric, LiNCM	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, passenger car, electric, LiNCM	CH	0	km	1			
technosphere	battery, rechargeable, prismatic, LiNCM, at plant	NO	0	kg	3.18E-03	1	1.24	(1,4,1,3,1,5,BU:1.05); Battery life time performacne 100'000km, battery weight: 318kg; technical data of e-Golf, 2015
	road	CH	1	ma	7.97E-04	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-03	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	disposal, road	RER	1	ma	7.97E-04	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	passenger car, electric, without battery	RER	1	kg	8.45E-03	1	3.06	(1,4,1,3,1,5,BU:3); vehicle life time performance: 150'000km, Vehicle weight : 1585kg (incl. battery); technical data of e-Golf, 2015
	maintenance, electric vehicle, without battery	RER	1	unit	9.20E-06	1	4.06	(4,5,5,5,5,5,BU:3); vehicle life time performance: 150'000km, Vehicle weight : 1267kg (without battery);
	electricity, low voltage, at grid	CH	0	kWh	1.99E-01	1	1.32	(1,5,2,5,1,5,BU:1.05); electricity consumption 0.199kWh/km; Vergleichende Ökobilanz individueller Mobilität: elektro vs. Konventioneller Mobilität, H. Althaus, M. Gauch, 2010
	refrigerant R134a, at plant	RER	0	kg	4.99E-06	1	1.22	(2,2,2,2,1,5,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-06	1	1.57	(2,2,2,2,1,5,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
	road wear emissions, passenger car	RER	0	kg	1.65E-05	1	2.08	(2,1,3,5,1,5,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	9.64E-05	1	2.08	(2,1,3,5,1,5,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	brake wear emissions, passenger car	RER	0	kg	7.49E-07	1	2.08	(2,1,3,5,1,5,BU:2); Only 10% of brake ware emission assumed for electic vehicles, Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; ; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2; Vergleichende Ökobilanz individueller Mobilität: elektro vs. Konventioneller Mobilität, H. Althaus,
	disposal, Li-ions batteries, mixed technology	GLO	0	kg	3.18E-03	1	1.27	(2,1,3,5,1,5,BU:1.05); Battery life time performacne 100'000km, battery weight: 318kg; technical data of e-Golf, 2015
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	5.00E-01	1	1.94	(4,5,5,5,1,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

4.4 Hybrid and plug-in hybrid car

4.4.1 Overview

The dataset representing transports by hybrid and plug-in hybrid cars have been adapted from the dataset published in Althaus and Gauch (2010). The process of vehicle manufacture and the demand of road infrastructure are described in section 4.4.2. The petrol and electricity consumption as well as the emissions during the operation of the hybrid and plug-in hybrid car are documented in sections 4.4.3 and 4.4.4, respectively. The unit process life cycle inventory data are presented in section 4.4.5.

4.4.2 Vehicle manufacture and road demand

The vehicle demand depends on the life time performance and the weight of the hybrid and plug-in hybrid car. According to the technical information the weight of the Toyota Prius III hybrid is 1'460 kg and of the Toyota Prius Plug-In 1'500 kg. The Toyota Prius plug-in hybrid is similar to the Toyota Prius hybrid except the battery size which is

41 kg for the hybrid and 80 kg for the plug-in hybrid car[6]. The Toyota Prius III is equipped with an electric motor, a range extender (including an internal combustion engine (ICE) and a generator) and a battery. The manufacture of the range extender is modelled with data published by Althaus and Gauch (2010). The electric powertrain and the glider are modelled with the corresponding datasets of ecoinvent data v3.1, embedded in KBOB life cycle inventory data v2.2:2016. The weight of the electric powertrain was adjusted to 77.6 kg according to the lower engine power of the hybrid car (60 kW) compared to the electric car.

The life time performance of the hybrid car and the battery are 150'000 km and 100'000 km, respectively. The maintenance demand was adjusted to $1.03 \cdot 10^{-5}$ p/km according to the adjusted weight of the hybrid car (excluding battery). The manufacture of the NCM[5] Li-ion battery is modelled using recent data from a battery manufacturer (Ager-Wick Ellingsen et al. 2014, see Appendix A).

The demand of road construction, maintenance and disposal of the road were calculated using the demand factors described in subchapter 3.2 and the GVW of the hybrid car (1.56 t including a payload of 100 kg) or plug-in hybrid car (1.60 t including a payload of 100 kg).

4.4.3 Fuel and electricity consumption

The fuel consumption of the Toyota Prius III hybrid (Euro 5) in the NEDC cycle is 3.9 l/100 km (Althaus & Gauch 2010). For hybrid and plug-in hybrid cars, ICCT (2015) reports a real world surcharge of 42 %, resulting in 5.5 l/100 km. The fuel consumption of the Toyota Prius III hybrid (Euro 6) was adjusted according to the ratio of the fuel consumption of a medium size petrol passenger car Euro 5 and Euro 6 (see Tab. 4.3 and Tab. 4.4).

According to Althaus and Gauch (2010) the range of plug-in hybrids is 50 km and thus a split of 80 % electricity and 20 % petrol can be assumed. The electricity consumption is covered with the Swiss supply mix (low voltage).

4.4.4 Emissions during operation

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). According to VCS (2015a) hybrid cars have noise emissions of between 71 and 73 dB(A). The Toyota Prius III emits 72 dB(A) which is identical with the noise emissions of the fleet average.

The non-exhaust emissions by road, tyre and brake wear are a function of the GVW and were calculated using the emission factors shown in Tab. 3.5. To account for the recuperation the brake wear emissions were reduced to 10 % of the initial value (Althaus &

[6] www.priuswiki.de, accessed on 15.06.2016.

Gauch 2010). Refrigerant emissions from air conditioning were added to the datasets according to the information provided in subchapter 3.5.

For the exhaust emissions from burning petrol the emission profiles of Euro 5 and Euro 6 medium size petrol passenger cars are used.

4.4.5 Unit process life cycle inventory data

Tab. 4.13 and Tab. 4.14 show the unit process life cycle inventory data of hybrid car (Euro 5 and Euro 6, respectively) transport in Switzerland. Tab. 4.15 and Tab. 4.16 present the unit process life cycle inventory data of plug-in hybrid car (Euro 5 and Euro 6, respectively) transport in Switzerland.

Tab. 4.13 Life cycle inventory of hybrid car transport in Switzerland (Euro 5).

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, hybrid, petrol, EURO 5	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, passenger car, hybrid, petrol, EURO 5	CH	0	km	1			
technosphere	road	CH	1	ma	7.38E-4	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	disposal, road	RER	1	ma	7.38E-4	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	passenger car, hybrid, without battery	RER	1	kg	9.46E-3	1	3.06	(1,4,1,3,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1460 kg; Technical data Toyota PriusIII ,H.J. Althaus und M.Gauch
	battery, rechargeable, prismatic, LiNCM, at plant	NO	0	kg	4.10E-4	1	1.24	(1,4,1,3,1,5,BU:1.05); battery life time performance: 100000km, battery weight: 41kg; Technical data Toyota PriusIII ,H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	maintenance, electric vehicle, without battery	RER	1	unit	1.03E-5	1	4.06	(4,5,5,5,5,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1439 kg (without battery); H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	petrol, low-sulphur, at regional storage	CH	0	kg	4.15E-2	1	1.24	(1,4,1,3,1,5,BU:1.05); assumed real consumption 5.5l/100km; H.J. Althaus und M.Gauch (2010)
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	1	1.22	(2,2,2,2,1,5,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, un	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	1	1.57	(2,2,2,2,1,5,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, un	Carbon dioxide, fossil	-	-	kg	1.30E-1	1	1.24	(1,4,1,3,1,5,BU:1.05); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	6.81E-4	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Methane, fossil	-	-	kg	2.90E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.27E-5	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	5.71E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	1.60E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	3.25E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	2.62E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.08E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	3.71E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	2.81E-6	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	5.50E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	2.72E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	1.13E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	8.51E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	3.76E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.10E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	9.51E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	2.50E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	3.05E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	5.06E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	2.28E-5	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Ammonia	-	-	kg	3.04E-5	1	1.32	(1,4,1,3,1,5,BU:1.2); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	3.37E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	5.92E-7	1	1.24	(1,4,1,3,1,5,BU:1.05); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.56E-6	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.09E-9	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Selenium	-	-	kg	8.31E-12	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103

Tab. 4.13 Life cycle inventory of hybrid car transport in Switzerland (Euro 5). (continued)

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, hybrid, petrol, EURO 5	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, passenger car, hybrid, petrol, EURO 5	CH	0	km	1			
	Zinc	-	-	kg	8.98E-8	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	1.74E-9	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	5.40E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	6.65E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.33E-12	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	3.61E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	4.49E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.38E-9	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Hexane	-	-	kg	8.06E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	1.91E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Arsenic	-	-	kg	1.25E-11	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethene	-	-	kg	3.66E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	5.51E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
technosphere	road wear emissions, passenger car	RER	0	kg	1.52E-5	1	2.06	(1,4,1,3,1,5,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	8.92E-5	1	2.06	(1,4,1,3,1,5,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	brake wear emissions, passenger car	RER	0	kg	6.93E-7	1	2.06	(1,4,1,3,1,5,BU:2); 90% reduction due to recuperation; Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	disposal, Li-ions batteries, mixed technology	GLO	0	kg	4.10E-4	1	1.24	(1,4,1,3,1,5,BU:1.05); battery life time performance: 100000km, battery weight: 41kg;
emission Non m	Noise, road, passenger car, average	-	-	km	1.00E+0	1	1.94	(4,5,5,5,1,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht &

Tab. 4.14 Life cycle inventory of hybrid car transport in Switzerland (Euro 6).

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, hybrid, petrol, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, passenger car, hybrid, petrol, EURO 6	CH	0	km	1			
technosphere	road	CH	1	ma	7.38E-4	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	disposal, road	RER	1	ma	7.38E-4	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	passenger car, hybrid, without battery	RER	1	kg	9.46E-3	1	3.06	(1,4,1,3,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1460 kg; Technical data Toyota PriusIII ,H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	battery, rechargeable, prismatic, LiNCM, at plant	NO	0	kg	4.10E-4	1	1.24	(1,4,1,3,1,5,BU:1.05); battery life time performance: 100000km, battery weight: 41kg; Technical data Toyota PriusIII ,H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	maintenance, electric vehicle, without battery	RER	1	unit	1.03E-5	1	4.06	(4,5,5,5,5,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1439 kg (without battery); H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	petrol, low-sulphur, at regional storage	CH	0	kg	3.92E-2	1	1.24	(1,4,1,3,1,5,BU:1.05); assumed real consumption 5.7l/100km; H.J. Althaus und M.Gauch (2010)
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	1	1.22	(2,2,2,2,1,5,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	1	1.57	(2,2,2,2,1,5,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.23E-1	1	1.24	(1,4,1,3,1,5,BU:1.05); Same emission factor used as for passenger car, petrol, Euro 6; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	6.80E-4	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 6; HBEFA database v3.2
	Methane, fossil	-	-	kg	2.64E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 6; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.06E-5	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 6; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	5.19E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 6; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	1.45E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	2.96E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	2.39E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	9.79E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	3.37E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	2.55E-6	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	5.00E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	2.47E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	1.03E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	7.74E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	3.41E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.00E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	8.65E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	2.28E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	2.78E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	4.60E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	2.19E-5	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Ammonia	-	-	kg	3.03E-5	1	1.32	(1,4,1,3,1,5,BU:1.2); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	3.15E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	5.58E-7	1	1.24	(1,4,1,3,1,5,BU:1.05); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.56E-6	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.03E-9	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9

Tab. 4.14 Life cycle inventory of hybrid car transport in Switzerland (Euro 6). (continued)

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, hybrid, petrol, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, passenger car, hybrid, petrol, EURO 6	CH	0	km	1			
	Selenium	-	-	kg	7.84E-12	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	8.47E-8	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	1.65E-9	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	5.09E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	6.27E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.25E-12	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	3.41E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	4.23E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.30E-9	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Hexane	-	-	kg	7.33E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	1.74E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Arsenic	-	-	kg	1.18E-11	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethene	-	-	kg	3.32E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	5.01E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
technosphere	road wear emissions, passenger car	RER	0	kg	1.52E-5	1	2.06	(1,4,1,3,1,5,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	8.92E-5	1	2.06	(1,4,1,3,1,5,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	brake wear emissions, passenger car	RER	0	kg	6.93E-7	1	2.06	(1,4,1,3,1,5,BU:2); 90% reduction due to recuperation; Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	disposal, Li-ions batteries, mixed technology	GLO	0	kg	4.10E-4	1	1.24	(1,4,1,3,1,5,BU:1.05); battery life time performance: 100000km, battery weight: 41kg;
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1	1.94	(4,5,5,5,1,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 4.15 Life cycle inventory of plug-in hybrid car transport in Switzerland (Euro 5).

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, plug-in hybrid, petrol, EURO 5	transport, passenger car, plug-in hybrid, petrol, certified electricity, EURO 5	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH			
	InfrastructureProcess				0	0			
	Unit				km	km			
product	transport, passenger car, plug-in hybrid, petrol, EURO 5	CH	0	km	1	0			
product	transport, passenger car, plug-in hybrid, petrol, certified electricity, EURO 5	CH	0	km	0	1			
technosphere	road	CH	1	ma	7.56E-4	7.56E-4	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1	3.06	(1,4,1,3,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	disposal, road	RER	1	ma	7.56E-4	7.56E-4	1	3.06	(1,4,1,3,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	passenger car, hybrid, without battery	RER	1	kg	9.46E-3	9.46E-3	1	3.06	(1,4,1,3,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1500kg (incl. Battery); Technical data Toyota PriusIII ,H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	battery, rechargeable, prismatic, LiNCM, at plant	NO	0	kg	8.00E-4	8.00E-4	1	1.24	(1,4,1,3,1,5,BU:1.05); battery life time performance: 100000km, battery weight: 80kg; Technical data Toyota PriusIII ,H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	maintenance, electric vehicle, without battery	RER	1	unit	1.03E-5	1.03E-5	1	4.06	(4,5,5,5,5,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1420 kg (without battery); H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	petrol, low-sulphur, at regional storage	CH	0	kg	8.31E-3	8.31E-3	1	1.24	(1,4,1,3,1,5,BU:1.05); assumed operation with petrol: 20%, real consumption 5.5l/100km; H.J. Althaus und M.Gauch (2010)
	electricity, low voltage, at grid	CH	0	kWh	1.60E-1		1	1.22	(2,2,2,2,1,5,BU:1.05); assumed operation with electricity: 80%, real consumption 20kWh/100km; H.J. Althaus und M.Gauch (2010)
	electricity, low voltage, certified electricity, at grid	CH	0	kWh		1.60E-1	1	1.22	(2,2,2,2,1,5,BU:1.05); assumed operation with electricity: 80%, real consumption 20kWh/100km; H.J. Althaus und M.Gauch (2010)
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	1	1.22	(2,2,2,2,1,5,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, un	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	1	1.57	(2,2,2,2,1,5,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, un	Carbon dioxide, fossil	-	-	kg	2.60E-2	2.60E-2	1	1.24	(1,4,1,3,1,5,BU:1.05); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.36E-4	1.36E-4	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Methane, fossil	-	-	kg	5.81E-7	5.81E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	4.53E-6	4.53E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	1.14E-7	1.14E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	3.19E-7	3.19E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	6.51E-8	6.51E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	5.25E-7	5.25E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	2.15E-7	2.15E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	7.41E-8	7.41E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	5.62E-7	5.62E-7	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	1.10E-6	1.10E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	5.44E-7	5.44E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	2.26E-7	2.26E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.70E-7	1.70E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	7.51E-8	7.51E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	2.20E-8	2.20E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	1.90E-8	1.90E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	5.01E-9	5.01E-9	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	6.11E-8	6.11E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	1.01E-7	1.01E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	4.56E-6	4.56E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Ammonia	-	-	kg	6.08E-6	6.08E-6	1	1.32	(1,4,1,3,1,5,BU:1.2); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	6.74E-8	6.74E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	1.18E-7	1.18E-7	1	1.24	(1,4,1,3,1,5,BU:1.05); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	3.12E-7	3.12E-7	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	2.18E-10	2.18E-10	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Selenium	-	-	kg	1.66E-12	1.66E-12	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	1.80E-8	1.80E-8	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	3.49E-10	3.49E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	1.08E-10	1.08E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	1.33E-10	1.33E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	2.66E-13	2.66E-13	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	7.23E-11	7.23E-11	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103

Tab. 4.15 Life cycle inventory of plug-in hybrid car transport in Switzerland (Euro 5). (continued)

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, plug-in hybrid, petrol, EURO 5	transport, passenger car, plug-in hybrid, petrol, certified electricity, EURO 5	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH			
	InfrastructureProcess				0	0			
	Unit				km	km			
product	transport, passenger car, plug-in hybrid, petrol, EURO 5	CH	0	km	1	0			
product	transport, passenger car, plug-in hybrid, petrol, certified electricity, EURO 5	CH	0	km	0	1			
	Cadmium	-	-	kg	8.97E-11	8.97E-11	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	2.76E-10	2.76E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Hexane	-	-	kg	1.61E-7	1.61E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	3.83E-7	3.83E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Arsenic	-	-	kg	2.49E-12	2.49E-12	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethene	-	-	kg	7.31E-7	7.31E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	1.10E-8	1.10E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
technosphere	road wear emissions, passenger car	RER	0	kg	1.56E-5	1.56E-5	1	2.06	(1,4,1,3,1,5,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	9.15E-5	9.15E-5	1	2.06	(1,4,1,3,1,5,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	brake wear emissions, passenger car	RER	0	kg	7.10E-7	7.10E-7	1	2.06	(1,4,1,3,1,5,BU:2); 90% reduction due to recuperation; Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	disposal, Li-ions batteries, mixed technology	GLO	0	kg	8.00E-4	8.00E-4	1	1.24	(1,4,1,3,1,5,BU:1.05); battery life time performance: 100000km, battery weight: 80kg;
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1	1.94	(4,5,5,5,1,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

Tab. 4.16 Life cycle inventory of plug-in hybrid car transport in Switzerland (Euro 6).

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, plug-in hybrid, petrol, EURO 6	transport, passenger car, plug-in hybrid, petrol, certified electricity, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH			
	InfrastructureProcess				0	0			
	Unit				km	km			
product	transport, passenger car, plug-in hybrid, petrol, EURO 6	CH	0	km	1	0			
product	transport, passenger car, plug-in hybrid, petrol, certified electricity, EURO 6	CH	0	km	0	1			
technosphere	road	CH	1	ma	7.56E-4	7.56E-4	1	3.07	(2,4,1,5,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1	3.06	(1,4,1,3,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	disposal, road	RER	1	ma	7.56E-4	7.56E-4	1	3.06	(1,4,1,3,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load: 100 kg; Ecoinvent v2
	passenger car, hybrid, without battery	RER	1	kg	9.46E-3	9.46E-3	1	3.06	(1,4,1,3,1,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1500kg (incl. Battery); Technical data Toyota PriusIII ,H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	battery, rechargeable, prismatic, LiNCM, at plant	NO	0	kg	8.00E-4	8.00E-4	1	1.24	(1,4,1,3,1,5,BU:1.05); battery life time performance: 100000km, battery weight: 80kg; Technical data Toyota PriusIII ,H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	maintenance, electric vehicle, without battery	RER	1	unit	1.03E-5	1.03E-5	1	4.06	(4,5,5,5,5,5,BU:3); Vehicle life time performance: 150000 vkm; Vehicle weight: 1420 kg (without battery); H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1
	petrol, low-sulphur, at regional storage	CH	0	kg	7.84E-3	7.84E-3	1	1.24	(1,4,1,3,1,5,BU:1.05); assumed operation with petrol: 20%, real consumption 5.7l/100km; H.J. Althaus und M.Gauch (2010)
	electricity, low voltage, at grid	CH	0	kWh	1.60E-1		1	1.22	(2,2,2,2,1,5,BU:1.05); assumed operation with electricity: 80%, real consumption 20kWh/100km; H.J. Althaus und M.Gauch (2010)
	electricity, low voltage, certified electricity, at grid	CH	0	kWh		1.60E-1	1	1.22	(2,2,2,2,1,5,BU:1.05); assumed operation with electricity: 80%, real consumption 20kWh/100km; H.J. Althaus und M.Gauch (2010)
	refrigerant R134a, at plant	RER	0	kg	4.99E-6	4.99E-6	1	1.22	(2,2,2,2,1,5,BU:1.05); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.99E-6	4.99E-6	1	1.57	(2,2,2,2,1,5,BU:1.5); Refrigerant emissions: 4.99E-06 kg/vkm; Vehicle life time performance: 1.50E+05 vkm; National Greenhouse Gas Inventory Report of Switzerland 2010, Item 2F1, Tab. 4-12; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	2.46E-2	2.46E-2	1	1.24	(1,4,1,3,1,5,BU:1.05); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.36E-4	1.36E-4	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Methane, fossil	-	-	kg	5.29E-7	5.29E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	4.12E-6	4.12E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	1.04E-7	1.04E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	2.90E-7	2.90E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	5.92E-8	5.92E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	4.77E-7	4.77E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.96E-7	1.96E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	6.74E-8	6.74E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	5.11E-7	5.11E-7	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	1.00E-6	1.00E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	4.94E-7	4.94E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	2.06E-7	2.06E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.55E-7	1.55E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	6.83E-8	6.83E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	2.00E-8	2.00E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	1.73E-8	1.73E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	4.55E-9	4.55E-9	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	5.55E-8	5.55E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	9.20E-8	9.20E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	4.39E-6	4.39E-6	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Ammonia	-	-	kg	6.07E-6	6.07E-6	1	1.32	(1,4,1,3,1,5,BU:1.2); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	6.30E-8	6.30E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	1.12E-7	1.12E-7	1	1.24	(1,4,1,3,1,5,BU:1.05); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	3.12E-7	3.12E-7	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	2.05E-10	2.05E-10	1	3.06	(1,4,1,3,1,5,BU:3); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Selenium	-	-	kg	1.57E-12	1.57E-12	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	1.69E-8	1.69E-8	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	3.29E-10	3.29E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	1.02E-10	1.02E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	1.25E-10	1.25E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	2.51E-13	2.51E-13	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103; Spielmann et al. 2007
	Mercury	-	-	kg	6.82E-11	6.82E-11	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103

Tab. 4.16 Life cycle inventory of plug-in hybrid car transport in Switzerland (Euro 6). (continued)

	Name	Location	InfrastructureProcess	Unit	transport, passenger car, plug-in hybrid, petrol, EURO 6	transport, passenger car, plug-in hybrid, petrol, certified electricity, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH			
	InfrastructureProcess				0	0			
	Unit				km	km			
product	transport, passenger car, plug-in hybrid, petrol, EURO 6	CH	0	km	1	0			
product	transport, passenger car, plug-in hybrid, petrol, certified electricity, EURO 6	CH	0	km	0	1			
	Cadmium	-	-	kg	8.46E-11	8.46E-11	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	2.60E-10	2.60E-10	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Hexane	-	-	kg	1.47E-7	1.47E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	3.48E-7	3.48E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Arsenic	-	-	kg	2.35E-12	2.35E-12	1	5.07	(1,4,1,3,1,5,BU:5); Same emission factor used as for passenger car, petrol, Euro 5; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethene	-	-	kg	6.65E-7	6.65E-7	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	1.00E-8	1.00E-8	1	1.58	(1,4,1,3,1,5,BU:1.5); Same emission factor used as for passenger car, petrol, Euro 5; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
technosphere	road wear emissions, passenger car	RER	0	kg	1.56E-5	1.56E-5	1	2.06	(1,4,1,3,1,5,BU:2); Emission factor: 9.77E-06 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	9.15E-5	9.15E-5	1	2.06	(1,4,1,3,1,5,BU:2); Emission factor: 5.72E-05 kg/(tGVW*km); Average load: 100 kg; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	brake wear emissions, passenger car	RER	0	kg	7.10E-7	7.10E-7	1	2.06	(1,4,1,3,1,5,BU:2); 90% reduction due to recuperation; Emission factor: 4.44E-06 kg/(tGVW*km); Average load: 100 kg; H.J. Althaus und M.Gauch (2010), Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	disposal, Li-ions batteries, mixed technology	GLO	0	kg	8.00E-4	8.00E-4	1	1.24	(1,4,1,3,1,5,BU:1.05); battery life time performance: 100000km, battery weight: 80kg;
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.00E+0	1.00E+0	1	1.94	(4,5,5,5,1,5,BU:1.5); ; Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013

4.5 Motorcycle

4.5.1 Overview

Apart from scooters with an engine size of approximately 50 cm^3, ecoinvent data v2 do not contain datasets on transport processes by motorcycles. The life cycle inventories of transports by motorcycles, grouped into the two size classes of 250-750 cm^3 and >750 cm^3, were therefore newly created within this project. In addition, fleet mixes of motorcycle transports for Switzerland were compiled. Data on transport performance, fuel consumption and emission factors represent the situation in Europe, in line with other passenger transport datasets.

The life cycle inventory of the production of the motorcycle is documented in section 4.5.2. The transports by motorcycles with an engine size of 250-750 cm^3 and >750 cm^3 are described in section 4.5.3. The motorcycle fleet mixes are presented in section 4.5.4.

4.5.2 Vehicle manufacture

Only little information is available on the production of motorcycles or their average material composition. The vehicle production was therefore modelled analogously to the production of passenger cars represented in ecoinvent data v3.1 and the processes of engine and glider production were extrapolated to motorcycles (ecoinvent Centre 2014). A motorcycle with a 1’000 cm^3 engine was considered to determine the shares of engine and glider in the total vehicle weight. The BMW S 1000 XR has an unladen mass of approximately 210 kg[7]. Its four cylinder inline engine weighs 59.8 kg and the gearbox is approximately 13 kg[8]. Based on these components, the weight of the glider was estimated to 137 kg. Data on the energy consumption of the manufacturing of motorcycles were not available. In the passenger car manufacturing process contained in ecoinvent data v3.1, the consumption of electricity, natural gas and light fuel oil for the assembling was taken from the original dataset in ecoinvent data v2 and modelled as a function of the vehicle weight. A different approach was chosen in this study where the energy demand for the assembling was assumed to be comparable for different vehicles such as passenger cars and motorcycles (see section 4.2.2). The energy consumption was therefore taken from the passenger car manufacturing process in ecoinvent data v2 and divided by the weight of the BMW S 1000 XR (210 kg). It was thereby assumed that the energy demand of assembling a vehicle is mainly determined by the number of components rather than by their weight.

The dismantling of the used motorcycle at its end of life was assumed to be comparable to the corresponding dataset for passenger cars as represented in ecoinvent data v3.1. The amounts of waste rubber and waste glass were taken from the dismantling dataset of passenger cars in ecoinvent data v3.1 and scaled based on the weight of the glider. The same procedure was applied to the amount of waste mineral oil but this output was scaled according to the weight of the engine. The life cycle inventory of the production of motorcycles is presented in Tab. 4.17.

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7 http://www.bmw-motorrad.ch/de/de/index.html?content=http://www.bmw-motorrad.ch/de/de/bike/adventure/s1000xr/s1000xr_overview.html&notrack=1, accessed on 28.04.2016.

8 http://www.bmw-motorrad.ch/de/de/index.html?content=http://www.bmw-motorrad.ch/de/de/technology_detail/engine_drive/item_four_cylinder_inline_engine.html&notrack=1, accessed on 28.04.2016.

Tab. 4.17 Life cycle inventory of the production (and dismantling) of motorcycles.

	Name	Location	InfrastructureProcess	Unit	motorcycle	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
product	motorcycle	RER	0	kg	1			
technosphere	internal combustion engine, for passenger car	RER	1	kg	3.47E-1	1	3.05	(2,3,2,3,1,5,BU:3); Estimation based on BMW S 1000 XR; BMW
	glider, for passenger car	RER	1	kg	6.53E-1	1	3.05	(2,3,2,3,1,5,BU:3); Estimation based on BMW S 1000 XR; BMW
	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	1.02E+1	1	1.25	(2,3,3,3,1,5,BU:1.05); Energy demand for vehicle assembling: 2140 kWh/vehicle; Vehicle weight: 210 kg; Spielmann et al.
	heat, natural gas, at industrial furnace >100kW	RER	0	MJ	1.06E+1	1	1.25	(2,3,3,3,1,5,BU:1.05); Energy demand for vehicle assembling: 2220 MJ/vehicle; Vehicle weight: 210 kg; Spielmann et al. 2007;
	heat, light fuel oil, at industrial furnace 1MW	RER	0	MJ	3.00E-1	1	1.25	(2,3,3,3,1,5,BU:1.05); Energy demand for vehicle assembling: 63 MJ/vehicle; Vehicle weight: 210 kg; Spielmann et al. 2007;
	transport, lorry >16t, fleet average	RER	0	tkm	6.34E-4	1	2.06	(2,3,2,3,1,5,BU:2); Transport of waste materials; Standard distance: 10 km; Ecoinvent v2
	dismantling, manual dismantling of motor vehicles, mechanically, at plant	RER	1	kg	1.00E+0	1	3.05	(2,3,2,3,1,5,BU:3); Approximation; Ecoinvent v3.1
	disposal, rubber, unspecified, 0% water, to municipal incineration	CH	0	kg	3.54E-2	1	1.23	(2,3,2,3,1,5,BU:1.05); Rubber from the tyres; Amount taken from passenger car production and scaled based on share of glider; Ecoinvent v3.1; BMW Motorrad Deutschland 2015
	disposal, glass, 0% water, to municipal incineration	CH	0	kg	2.51E-2	1	1.23	(2,3,2,3,1,5,BU:1.05); Waste glass from the manual dismantling of the vehicle; Amount taken from passenger car production and scaled based on share of glider; Ecoinvent v3.1; BMW Motorrad
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	2.87E-3	1	1.23	(2,3,2,3,1,5,BU:1.05); Various lubricants used in the vehicle; Amount taken from passenger car production and scaled based on share of internal combustion engine; Ecoinvent v3.1; BMW

4.5.3 Transport

The vehicle demand depends on the life time performance and the weight of the motorcycle. The average life time was determined from TRACCS data on the number of immatriculated motorcycles (21.1 millions) and the new immatriculations (1.10 millions) for the EU28 in 2010 (Papadimitriou et al. 2013). Assuming steady state conditions, these figures yield an average life time of 19.2 years. The average yearly travel distance of motorcycles in the EU28 in 2010 was 5'170 vkm (Papadimitriou et al. 2013), which results in a life time performance of approximately 100'000 vkm. The typical unladen weight of motorcycles with an engine size of 250-750 cm^3 is estimated to 180 kg[9]. Motorcycles with an engine size of >750 cm^3 have a weight of approximately 220 kg[10].

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9 See for instance:
BMW G 650 GS, http://www.bmw-motorrad.ch/de/de/index.html?content=http://www.bmw-motorrad.ch/de/de/bike/enduro/g650gs/g650gs_overview.html&notrack=1, accessed on 28 April 2016.
Kawasaki Ninja ZX-6R, http://www.kawasaki.eu/en/products/supersport/2016/ninja_zx-6r/specifications?Uid=081AC11YX11YDV9YXlFZXFxYUQleW1FQXgpRC1EOWFENDl8, accessed on 28.04.2016.

10 See for instance:
BMW S 1000 XR, http://www.bmw-motorrad.ch/de/de/index.html?content=http://www.bmw-motorrad.ch/de/de/bike/adventure/s1000xr/s1000xr_overview.html&notrack=1, accessed on 28.04.2016.
Kawasaki Ninja H2, http://www.kawasaki.ch/de/products/supersport/2015/ninja_h2/specifications?Uid=0918DAlYWwlaDloOClxRXFtQCgkKXApQWV5RXQ4OWFpeCQw, accessed on 28.04.2016.

The motorcycle maintenance was modelled by the ecoinvent v2 dataset representing the maintenance of passenger cars due to lacking data on the consumption of tyres, lubricating oil, batteries and other materials during the life time of motorcycles. The specific demand of maintenance was calculated to $8.06 \cdot 10^{-4}$ p/kg for passenger cars and then applied to motorcycles. The road construction demand depends on the GVW (see subchapter 3.2). The weight of the passenger (75 kg according to Leuenberger and Frischknecht (2010)) was added to the vehicle weight, which leads to a road demand of $1.21 \cdot 10^{-4}$ my/km and $1.40 \cdot 10^{-4}$ my/km for motorcycles with a 250-750 cm^3 and a >750 cm^3 engine, respectively. The demand of road operation and maintenance is modelled as a function of the travel distance and amounts to $1.17 \cdot 10^{-3}$ my/vkm (Spielmann et al. 2007).

Data on the fuel consumption and the emissions of selected pollutants (CO_2, CO, CH_4, N_2O, NMVOC, NO_x, NH_3, SO_2) were retrieved from HBEFA (INFRAS 2014). In alignment with other transport processes in ecoinvent data v3.1, the emission factors reported for Germany in 2015 were used and extrapolated to the European situation. Besides the engine size, it is distinguished between motorcycles, which have been put into operation before emission regulations were introduced (preEuro), and motorcycles, which comply with one of the emission standards Euro 1 to Euro 4. Since the emission standard Euro 4 for motorcycles was introduced on 1st January 2016 (European Union 2013), the corresponding fuel demand and emission factors were calculated based on HBEFA data for the year 2020. Only the fuel demand and pollutant emissions during the continuous operation of the motorcycles (hot emissions) were taken into account since emission factors for cold starts and evaporation are either not available in HBEFA or equal to zero. A fraction of the total NMVOC emissions was further divided into main components based on the shares reported in Tab. 3.1. The emissions of PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed. The corresponding emission factors are compiled in Tab. 3.2. The emission factor of PM to air was taken from the EMEP/EEA air pollutant emission inventory guidebook (Ntziachristos et al. 2014, Tab. 3-25). The emission factors of PM by motorcycles are a only function of the distance travelled and amount to 0.014 g/km for the emission classes preEuro and Euro 1 and 0.0035 g/km for the emission classes Euro 2 and Euro 3. For motorcycles compliant with the Euro 4 emission standard, the emission factor of PM was assumed to be the same as for the classes Euro 2 and Euro 3 since specific data were not available.

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The legal threshold value for noise emissions from motorcycles is 80 dB(A), which corresponds to the noise level of lorries (ASTRA 2013; Frischknecht & Büsser Knöpfel 2013). The noise emissions were modelled by the elementary flow for noise emissions by passenger cars (average noise level: 72 dB(A)) and scaled by the factor 6.31 to account for the real noise level (see Tab. 3.4). The non-exhaust emissions by road, tyre and brake wear are a function of the GVW and were calculated using the emission factors for passenger cars (Tab. 3.5).

The life cycle inventories of transports by motorcycles with an engine size of 250-750 cm^3 and for the emission classes preEuro to Euro 3 are listed in Tab. 4.18. The life cycle inventories of transports by motorcycles with an engine size of >750 cm^3 are presented in Tab. 4.19.

Tab. 4.18 Life cycle inventory of transports by a 250-750 cm³ motorcycle compliant with the emission standard Euro 0 (preEuro) to Euro 4.

	Name	Location	InfrastructureProcess	Unit	transport, motor cycle, 250-750 ccm engine, preEURO	transport, motor cycle, 250-750 ccm engine, EURO1	transport, motor cycle, 250-750 ccm engine, EURO2	transport, motor cycle, 250-750 ccm engine, EURO3	transport, motor cycle, 250-750 ccm engine, EURO4	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0	0			
	Unit				km	km	km	km	km			
product	transport, motor cycle, 250-750 ccm engine, preEURO	RER	0	km	1	0	0	0	0			
product	transport, motor cycle, 250-750 ccm engine, EURO1	RER	0	km	0	1	0	0	0			
product	transport, motor cycle, 250-750 ccm engine, EURO2	RER	0	km	0	0	1	0	0			
product	transport, motor cycle, 250-750 ccm engine, EURO3	RER	0	km	0	0	0	1	0			
product	transport, motor cycle, 250-750 ccm engine, EURO4	RER	0	km	0	0	0	0	1			
technosphere	motorcycle	RER	0	kg	1.80E-3	1.80E-3	1.80E-3	1.80E-3	1.80E-3	1	2.07	(3,1,3,2,1,5,BU:2); Vehicle weight: 180 kg; Vehicle life time performance: 100'000 vkm; BMW 2016; Kawasaki 2016; TRACCS 2013
	maintenance, passenger car	RER	1	unit	1.45E-6	1.45E-6	1.45E-6	1.45E-6	1.45E-6	1	3.07	(3,1,3,2,1,5,BU:3); Modelled by passenger car maintenance with demand factor: 8.06E-04 p/kg; Vehicle weight: 180 kg; Vehicle life time performance: 100'000 vkm; BMW 2016; Kawasaki 2016; TRACCS 2013; Ecoinvent v3.1
	road	CH	1	ma	1.21E-4	1.21E-4	1.21E-4	1.21E-4	1.21E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Vehicle weight: 180 kg; Passenger weight: 75 kg; BMW 2016; Kawasaki 2016; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	petrol, low-sulphur, at regional storage	RER	0	kg	3.86E-2	3.64E-2	3.19E-2	3.72E-2	3.68E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; HBEFA database v3.2
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.21E-1	1.14E-1	1.00E-1	1.17E-1	1.15E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	2.03E-2	1.53E-2	3.77E-3	1.60E-3	1.33E-3	1	5.01	(2,2,2,3,1,2,BU:5); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	4.53E-5	5.60E-5	3.47E-5	1.28E-5	1.11E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.87E-4	2.76E-4	1.71E-4	6.30E-5	5.48E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 45.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	4.14E-5	1.95E-5	1.21E-5	4.44E-6	3.87E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	8.44E-6	3.97E-6	2.46E-6	9.06E-7	7.88E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	6.80E-5	3.20E-5	1.98E-5	7.30E-6	6.35E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.24%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	2.79E-5	1.31E-5	8.14E-6	3.00E-6	2.61E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Hexane	-	-	kg	2.09E-5	9.83E-6	6.10E-6	2.24E-6	1.95E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	1.48E-5	6.96E-6	4.32E-6	1.59E-6	1.38E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.14%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	9.60E-6	4.52E-6	2.80E-6	1.03E-6	8.97E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.74%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	9.48E-5	4.46E-5	2.76E-5	1.02E-5	8.85E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 7.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	4.96E-5	2.33E-5	1.45E-5	5.32E-6	4.63E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.82%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	1.43E-6	6.72E-7	4.17E-7	1.53E-7	1.33E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	7.28E-5	3.43E-5	2.12E-5	7.82E-6	6.80E-6	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 5.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	1.43E-4	6.71E-5	4.16E-5	1.53E-5	1.33E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	7.05E-5	3.32E-5	2.06E-5	7.57E-6	6.58E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.43%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	2.93E-5	1.38E-5	8.56E-6	3.15E-6	2.74E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.26%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	2.21E-5	1.04E-5	6.44E-6	2.37E-6	2.06E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.70%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	9.73E-6	4.58E-6	2.84E-6	1.04E-6	9.09E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.75%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	2.86E-6	1.34E-6	8.33E-7	3.07E-7	2.67E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.22%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	7.92E-6	3.73E-6	2.31E-6	8.50E-7	7.39E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	6.49E-7	3.05E-7	1.89E-7	6.97E-8	6.06E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.05%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	2.47E-6	1.16E-6	7.20E-7	2.65E-7	2.30E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	1.31E-5	6.17E-6	3.82E-6	1.41E-6	1.22E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	3.12E-4	3.08E-4	3.04E-4	1.39E-4	1.13E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	1.21	(2,2,2,3,1,2,BU:1.2); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	5.51E-7	5.19E-7	4.55E-7	5.30E-7	4.98E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.40E-5	1.40E-5	3.50E-6	3.50E-6	3.50E-6	1	3.01	(2,2,2,3,1,2,BU:3); Average for motorcycles with a 250-750 ccm engine in Germany in 2015; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-25
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.34E-9	1.27E-9	1.11E-9	1.29E-9	1.28E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.48E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9

Tab. 4.18 Life cycle inventory of transports by a 250-750 cm3 motorcycle compliant with the emission standard Euro 0 (preEuro) to Euro 4. (continued)

	Name	Location	InfrastructureProcess	Unit	transport, motor cycle, 250-750 ccm engine, preEURO	transport, motor cycle, 250-750 ccm engine, EURO1	transport, motor cycle, 250-750 ccm engine, EURO2	transport, motor cycle, 250-750 ccm engine, EURO3	transport, motor cycle, 250-750 ccm engine, EURO4	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0	0			
	Unit				km	km	km	km	km			
	Arsenic	-	-	kg	1.16E-11	1.09E-11	9.58E-12	1.12E-11	1.10E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	7.73E-12	7.28E-12	6.39E-12	7.44E-12	7.36E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	8.36E-8	7.88E-8	6.91E-8	8.05E-8	7.95E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.16E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	1.62E-9	1.53E-9	1.34E-9	1.56E-9	1.54E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 4.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	5.02E-10	4.73E-10	4.15E-10	4.84E-10	4.78E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.30E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	6.18E-10	5.83E-10	5.11E-10	5.95E-10	5.88E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.60E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.24E-12	1.17E-12	1.02E-12	1.19E-12	1.18E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.20E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	3.36E-10	3.17E-10	2.78E-10	3.24E-10	3.20E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	4.17E-10	3.93E-10	3.45E-10	4.02E-10	3.97E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.08E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.28E-9	1.21E-9	1.06E-9	1.23E-9	1.22E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.32E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	6.31E+0	6.31E+0	6.31E+0	6.31E+0	6.31E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Legal noise threshold of motorcycles is 80 dB(A); Average noise of passenger cars (72 dB(A)) scaled; Frischknecht & Büsser Knöpfel 2013; ASTRA 2013
technosphere	road wear emissions, passenger car	RER	0	kg	2.49E-6	2.49E-6	2.49E-6	2.49E-6	2.49E-6	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 9.77E-06 kg/(tGVW*km); Vehicle weight: 180 kg; Passenger weight: 75 kg; Ecoinvent v3.1; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	1.46E-5	1.46E-5	1.46E-5	1.46E-5	1.46E-5	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 5.72E-05 kg/(tGVW*km); Vehicle weight: 180 kg; Passenger weight: 75 kg; Ecoinvent v3.1; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	1.13E-6	1.13E-6	1.13E-6	1.13E-6	1.13E-6	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 4.44E-06 kg/(tGVW*km); Vehicle weight: 180 kg; Passenger weight: 75 kg; Ecoinvent v3.1; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	1.21E-4	1.21E-4	1.21E-4	1.21E-4	1.21E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Vehicle weight: 180 kg; Passenger weight: 75 kg; BMW 2016; Kawasaki 2016; Ecoinvent v2

Tab. 4.19 Life cycle inventory of transports by a >750 cm^3 motorcycle compliant with the emission standard Euro 0 (preEuro) to Euro 4.

	Name	Location	InfrastructureProcess	Unit	transport, motor cycle, >750 ccm engine, preEURO	transport, motor cycle, >750 ccm engine, EURO1	transport, motor cycle, >750 ccm engine, EURO2	transport, motor cycle, >750 ccm engine, EURO3	transport, motor cycle, >750 ccm engine, EURO4	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0	0			
	Unit				km	km	km	km	km			
product	transport, motor cycle, >750 ccm engine, preEURO	RER	0	km	1	0	0	0	0			
product	transport, motor cycle, >750 ccm engine, EURO1	RER	0	km	0	1	0	0	0			
product	transport, motor cycle, >750 ccm engine, EURO2	RER	0	km	0	0	1	0	0			
product	transport, motor cycle, >750 ccm engine, EURO3	RER	0	km	0	0	0	1	0			
product	transport, motor cycle, >750 ccm engine, EURO4	RER	0	km	0	0	0	0	1			
technosphere	motorcycle	RER	0	kg	2.20E-3	2.20E-3	2.20E-3	2.20E-3	2.20E-3	1	2.07	(3,1,3,2,1,5,BU:2); Vehicle weight: 220 kg; Vehicle life time performance: 100'000 vkm; BMW 2016; Kawasaki 2016; TRACCS 2013
	maintenance, passenger car	RER	1	unit	1.77E-6	1.77E-6	1.77E-6	1.77E-6	1.77E-6	1	3.07	(3,1,3,2,1,5,BU:3); Modelled by passenger car maintenance with demand factor: 8.06E-04 p/kg; Vehicle weight: 220 kg; Vehicle life time performance: 100'000 vkm; BMW 2016; Kawasaki 2016; TRACCS 2013; Ecoinvent v3.1
	road	CH	1	ma	1.40E-4	1.40E-4	1.40E-4	1.40E-4	1.40E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Vehicle weight: 220 kg; Passenger weight: 75 kg; BMW 2016; Kawasaki 2016; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1.17E-3	1.17E-3	1	3.01	(2,2,2,3,1,2,BU:3); Road demand: 1.17E-03 my/km; Ecoinvent v2
	petrol, low-sulphur, at regional storage	RER	0	kg	4.12E-2	3.95E-2	4.11E-2	3.97E-2	3.93E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for motorcycles with a >750 ccm engine in Germany in 2015; HBEFA database v3.2
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.29E-1	1.24E-1	1.29E-1	1.25E-1	1.23E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for motorcycles with a >750 ccm engine in Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	2.03E-2	1.05E-2	3.77E-3	1.60E-3	1.33E-3	1	5.01	(2,2,2,3,1,2,BU:5); Average for motorcycles with a >750 ccm engine in Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	4.53E-5	5.60E-5	3.47E-5	1.28E-5	1.11E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for motorcycles with a >750 ccm engine in Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.87E-4	2.76E-4	1.71E-4	6.30E-5	5.48E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 45.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	4.14E-5	1.95E-5	1.21E-5	4.44E-6	3.87E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	8.44E-6	3.97E-6	2.46E-6	9.06E-7	7.88E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	6.80E-5	3.20E-5	1.98E-5	7.30E-6	6.35E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.24%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	2.79E-5	1.31E-5	8.14E-6	3.00E-6	2.61E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Hexane	-	-	kg	2.09E-5	9.83E-6	6.10E-6	2.24E-6	1.95E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	1.48E-5	6.96E-6	4.32E-6	1.59E-6	1.38E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.14%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	9.60E-6	4.52E-6	2.80E-6	1.03E-6	8.97E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.74%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	9.48E-5	4.46E-5	2.76E-5	1.02E-5	8.85E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 7.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	4.96E-5	2.33E-5	1.45E-5	5.32E-6	4.63E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 3.82%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	1.43E-6	6.72E-7	4.17E-7	1.53E-7	1.33E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	7.28E-5	3.43E-5	2.12E-5	7.82E-6	6.80E-6	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 5.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	1.43E-4	6.71E-5	4.16E-5	1.53E-5	1.33E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 10.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	7.05E-5	3.32E-5	2.06E-5	7.57E-6	6.58E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 5.43%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	2.93E-5	1.38E-5	8.56E-6	3.15E-6	2.74E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 2.26%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	2.21E-5	1.04E-5	6.44E-6	2.37E-6	2.06E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.70%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	9.73E-6	4.58E-6	2.84E-6	1.04E-6	9.09E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.75%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	2.86E-6	1.34E-6	8.33E-7	3.07E-7	2.67E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.22%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	7.92E-6	3.73E-6	2.31E-6	8.50E-7	7.39E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	6.49E-7	3.05E-7	1.89E-7	6.97E-8	6.06E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.05%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	2.47E-6	1.16E-6	7.20E-7	2.65E-7	2.30E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.19%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	1.31E-5	6.17E-6	3.82E-6	1.41E-6	1.22E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	2.89E-4	2.73E-4	2.34E-4	1.39E-4	1.13E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for motorcycles with a >750 ccm engine in Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	1.21	(2,2,2,3,1,2,BU:1.2); Average for motorcycles with a >750 ccm engine in Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for motorcycles with a >750 ccm engine in Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	5.88E-7	5.63E-7	5.86E-7	5.66E-7	5.32E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for motorcycles with a >750 ccm engine in Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.40E-5	1.40E-5	3.50E-6	3.50E-6	3.50E-6	1	3.01	(2,2,2,3,1,2,BU:3); Average for motorcycles with a >750 ccm engine in Germany in 2015; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-25
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.44E-9	1.37E-9	1.43E-9	1.38E-9	1.37E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.48E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A3.b.i-iv, Tab. 3-8 and 3-9

Tab. 4.19 Life cycle inventory of transports by a >750 cm^3 motorcycle compliant with the emission standard Euro 0 (preEuro) to Euro 4. (continued)

	Name	Location	InfrastructureProcess	Unit	transport, motor cycle, >750 ccm engine, preEURO	transport, motor cycle, >750 ccm engine, EURO1	transport, motor cycle, >750 ccm engine, EURO2	transport, motor cycle, >750 ccm engine, EURO3	transport, motor cycle, >750 ccm engine, EURO4	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0	0			
	Unit				km	km	km	km	km			
	Arsenic	-	-	kg	1.24E-11	1.18E-11	1.23E-11	1.19E-11	1.18E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	8.25E-12	7.90E-12	8.23E-12	7.95E-12	7.86E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	8.92E-8	8.54E-8	8.90E-8	8.59E-8	8.50E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.16E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	1.73E-9	1.66E-9	1.73E-9	1.67E-9	1.65E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 4.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	5.36E-10	5.13E-10	5.35E-10	5.17E-10	5.11E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.30E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	6.60E-10	6.32E-10	6.58E-10	6.36E-10	6.29E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.60E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.32E-12	1.26E-12	1.32E-12	1.27E-12	1.26E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.20E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	3.59E-10	3.43E-10	3.58E-10	3.46E-10	3.42E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	4.45E-10	4.26E-10	4.44E-10	4.29E-10	4.24E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.08E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.37E-9	1.31E-9	1.37E-9	1.32E-9	1.30E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.32E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	6.31E+0	6.31E+0	6.31E+0	6.31E+0	6.31E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Legal noise threshold of motorcycles is 80 dB(A); Average noise of passenger cars (72 dB(A)) scaled; Frischknecht & Büsser Knöpfel 2013; ASTRA 2013
technosphere	road wear emissions, passenger car	RER	0	kg	2.88E-6	2.88E-6	2.88E-6	2.88E-6	2.88E-6	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 9.77E-06 kg/(tGVW*km); Vehicle weight: 220 kg; Passenger weight: 75 kg; Ecoinvent v3.1; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, passenger car	RER	0	kg	1.69E-5	1.69E-5	1.69E-5	1.69E-5	1.69E-5	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 5.72E-05 kg/(tGVW*km); Vehicle weight: 220 kg; Passenger weight: 75 kg; Ecoinvent v3.1; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, passenger car	RER	0	kg	1.31E-6	1.31E-6	1.31E-6	1.31E-6	1.31E-6	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 4.44E-06 kg/(tGVW*km); Vehicle weight: 220 kg; Passenger weight: 75 kg; Ecoinvent v3.1; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, road	RER	1	ma	1.40E-4	1.40E-4	1.40E-4	1.40E-4	1.40E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Vehicle weight: 220 kg; Passenger weight: 75 kg; BMW 2016; Kawasaki 2016; Ecoinvent v2

4.5.4 Fleet mixes

Fleet mixes were compiled based on the transport processes by motorcycles of different size and emission classes. It is distinguished between a motorcycle fleet with an engine size of 250-750 cm^3 and a fleet of larger motorcycles with an engine size of >750 cm^3. In addition, an overall motorcycle fleet of both size classes and the emission classes preEuro to Euro 3 is considered.

The average fleet of motorcycles in Switzerland in the year 2015 was modelled based on the share of each size and emission class in the total vehicle kilometres travelled as reported in HBEFA (INFRAS 2014). The relatively small shares of motorcycles with an engine size <250 cm^3 were not considered in the fleet mix due to missing life cycle inventory data.

The life cycle inventories of the motorcycle fleet mixes with an engine size of 250-750 cm^3 and >750 cm^3 are shown in Tab. 4.9 and Tab. 4.10, respectively. The life cycle inventory of the motorcycle fleet mix including all vehicles with an engine size of >250 cm^3 and compliant with different emission standards is presented in Tab. 4.11. More than 60 % of all motorcycles comply with Euro 3 standard irrespective of the engine size. Euro 4 motorcycles are not in the fleet mixes for the year 2015 because this emission standard was introduced on 1st January 2016 (European Union 2013).

Tab. 4.20 Life cycle inventory of the average motorcycle fleet with an engine size of 250-750 cm^3 in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, motor cycle, 250-750 ccm engine, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, motor cycle, 250-750 ccm engine, fleet average	CH	0	km	1			
technosphere	transport, motor cycle, 250-750 ccm engine, preEURO	RER	0	km	2.36E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, 250-750 ccm engine, EURO1	RER	0	km	2.44E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, 250-750 ccm engine, EURO2	RER	0	km	1.02E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, 250-750 ccm engine, EURO3	RER	0	km	6.31E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2

Tab. 4.21 Life cycle inventory of the average motorcycle fleet with an engine size of >750 cm^3 in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, motor cycle, >750 ccm engine, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, motor cycle, >750 ccm engine, fleet average	CH	0	km	1			
technosphere	transport, motor cycle, >750 ccm engine, preEURO	RER	0	km	1.67E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, >750 ccm engine, EURO1	RER	0	km	2.18E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, >750 ccm engine, EURO2	RER	0	km	1.24E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, >750 ccm engine, EURO3	RER	0	km	6.42E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2

Tab. 4.22 Life cycle inventory of the average motorcycle fleet with an engine size of >250 cm^3 in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, motor cycle, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				km			
product	transport, motor cycle, fleet average	CH	0	km	1			
technosphere	transport, motor cycle, 250-750 ccm engine, preEURO	RER	0	km	8.61E-3	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, 250-750 ccm engine, EURO1	RER	0	km	8.90E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, 250-750 ccm engine, EURO2	RER	0	km	3.71E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, 250-750 ccm engine, EURO3	RER	0	km	2.30E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, >750 ccm engine, preEURO	RER	0	km	1.06E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, >750 ccm engine, EURO1	RER	0	km	1.38E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, >750 ccm engine, EURO2	RER	0	km	7.88E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, motor cycle, >750 ccm engine, EURO3	RER	0	km	4.08E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2

4.6 Other two wheel vehicles

4.6.1 Overview

The ecoinvent database v2.2 contains life cycle inventories of other two wheel vehicles than motorcycles. Included are the life cycle inventories of transports by bicycle (section 4.6.2), electric bicycle (section 4.6.3), scooter (section 4.6.4) and electric scooter (section 4.6.5).

4.6.2 Bicycle

The life cycle inventory of bicycle transport was compiled by Leuenberger and Frischknecht (2010) and remains unchanged in the KBOB life cycle inventory database v2.2:2016 (KBOB et al. 2016).

4.6.3 Electric bicycle

The life cycle inventory of electric bicycle transport was compiled by Leuenberger and Frischknecht (2010). The life time performance of the battery of electric bicycles increased in the past years. According to the information from an expert[11] between zero and one battery replacements in the life time of electric bicycles are usual. In analogy to the electric passenger car an average of 0.5 changes of battery is assumed for the electric bicycle. The battery production is modelled based on the new life cycle inventory of NCM Li-ion batteries compiled by Ager-Wick Ellingsen et al. (2014). Detailed information about the life cycle inventory of the NCM Li-ion battery can be found in the Appendix A.

4.6.4 Scooter

The life cycle inventory of scooter transport was compiled by Leuenberger and Frischknecht (2010) and remains unchanged in the KBOB life cycle inventory database v2.2:2016 (KBOB et al. 2016).

4.6.5 Electric scooter

The life cycle inventory of electric scooter transport was compiled by Leuenberger and Frischknecht (2010). The battery production is modelled by the new life cycle inventory of NCM Li-ion batteries compiled by Ager-Wick Ellingsen et al. (2014). Detailed information about the life cycle inventory of the NCM Li-ion battery can be found in the Appendix A.

4.7 Minibus

A minibus is similar to a light commercial vehicle (see subchapter 5.2) but its main purpose is the transport of passengers instead of goods. An average minibus operated in Switzerland is considered. According to HBEFA (INFRAS 2014), 85 % of the minibuses in Switzerland are diesel fuelled and 15 % use petrol. The minibus has a capacity of 15 persons. The average occupancy rate is determined by the following use pattern described by Tuchschmid and Halder (2010): 30 % of the trips are shuttles with ten occupied seats for one way and an empty return, 55 % of the rides are journeys with ten pas-

[11] Personal communication, branch manager of a big retailer of electric bicycles in Switzerland, 4 October 2016.

sengers and the remaining 15 % are empty transports to pick up the vehicle or bring it back. This results in an average occupancy rate of 7 persons.

The minibus has an unladen weight of 2’150 kg (and 2’680 kg including the average occupancy, using an average passenger weight of 75 kg (Leuenberger & Frischknecht 2010)) and a vehicle life time performance of 220’000 vkm (VCS 2015b; Spielmann et al. 2007). Its manufacture was approximated with the manufacture of a light commercial vehicle (see section 5.2.2). The life cycle inventory of the maintenance of minibuses was taken from ecoinvent data v2, whereby the demand of maintenance was scaled according to the vehicle weight (van in ecoinvent v2: 2’500 kg; Spielmann et al. 2007). The road demand depends on the GVW and is $1.81 \cdot 10^{-4}$ my/pkm for minibuses. The demand for road operation and maintenance is $1.67 \cdot 10^{-4}$ my/pkm.

Data on the fuel consumption (0.073 kg/vkm) and the emissions of selected pollutants (CO_2, CO, CH_4, N_2O, NMVOC, NO_x, NH_3, SO_2, PM) were retrieved from HBEFA (INFRAS 2014). The emission factors were calculated for Switzerland in 2015 and are identical to those of light commercial vehicles (see section 5.2.4). In addition to the fuel demand and the pollutant emissions during the hot operation of the minibuses, cold start emissions and fuel evaporation emissions due to running losses, soaking and diurnal temperature changes were taken into account as done for transports by passenger car (see section 4.2.3). Specific information on the average travel distance of minibuses was not available. The excess emission factors for cold starts and evaporation by soaking were therefore converted to the functional unit of 1 pkm by assuming an average travel distance of 32 km, which is valid for passenger cars (BFS/ARE 2012). For the evaporation emissions due to diurnal temperature changes, an average of two trips per day was estimated. A fraction of the total NMVOC emissions was further divided into main components based on the speciation shown in Tab. 3.1. The emissions of PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed and were calculated using the emission factors compiled in Tab. 3.2.

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The typical noise level of minibuses is 70-75 dB(A), which similar to passenger cars (VCS 2015b; Frischknecht & Büsser Knöpfel 2013). The noise emissions were therefore modelled by the corresponding elementary flow for passenger cars. The refrigerant emissions from air conditioners were extrapolated from the parameter values for lorries (see Tab. 3.3). The resulting HFC-134a emissions of minibuses are $6.07 \cdot 10^{-7}$ kg/pkm. The non-exhaust emissions by road, tyre and brake wear are a function of the GVW and were calculated using the emission factors presented in Tab. 3.5.

The life cycle inventory of transports by an average minibus in Switzerland is presented in Tab. 4.23.

Tab. 4.23 Life cycle inventory of passenger transports by an average minibus.

	Name	Location	InfrastructureProcess	Unit	transport, minibus	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
product	transport, minibus	CH	0	pkm	1			
technosphere	light commercial vehicle	RER	0	kg	1.40E-3	1	2.07	(3,1,3,2,1,5,BU:2); Vehicle weight: 2.15 t; Vehicle life time performance: 2.20E+05 vkm; Average occupancy rate: 7.0 passengers; ASTRA: MOFIS 2015; Ecoinvent v2.2; Own assumption
	maintenance, van < 3.5t	RER	1	unit	5.58E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 2.20E+05 vkm; Input scaled by vehicle weight: 2.15 t (light commercial vehicle in ecoinvent: 2.5 t); Average occupancy rate: 7.0 passengers; ASTRA: MOFIS 2015; Ecoinvent v2; Own assumption
	road	CH	1	ma	1.81E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average occupancy rate: 7.0 passengers; Passenger weight: 75 kg; Vehicle weight: 2.15 t; Ecoinvent v2; Own assumption
	operation, maintenance, road	CH	1	ma	1.67E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road operation demand: 1.17E-03 my/km; Average occupancy rate: 7.0 passengers; Ecoinvent v2; Own assumption
	diesel, low-sulphur, at regional storage	CH	0	kg	9.08E-3	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel consumption of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	petrol, low-sulphur, at regional storage	CH	0	kg	1.52E-3	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel consumption of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	6.07E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 4.25E-06 kg/vkm; Average occupancy rate: 7.0 passengers; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	3.34E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.18E-4	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	3.92E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	3.77E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; Petrol: 45.2% of total NMVOC emissions; Diesel: 53.0% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	1.87E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 3.19%; Diesel: 0.33%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	3.92E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.65%; Diesel: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	2.98E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 5.24%; Diesel: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.22E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 2.15%; Diesel: 0.04%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Hexane	-	-	kg	9.07E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 1.61%; Diesel: 0.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	7.93E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 1.14%; Diesel: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	4.63E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.74%; Diesel: 0.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	6.65E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 7.30%; Diesel: 10.97%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	2.98E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 3.82%; Diesel: 3.60%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	6.20E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.11%; Diesel: 0.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	3.62E-7	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: Petrol: 5.61%; Diesel: 1.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	6.35E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 10.98%; Diesel: 0.69%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	3.20E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 5.43%; Diesel: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	1.34E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 2.26%; Diesel: 0.27%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	3.73E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 1.70%; Diesel: 12.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	1.92E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.75%; Diesel: 6.47%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	3.23E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.22%; Diesel: 0.86%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	1.02E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.61%; Diesel: 2.94%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	3.05E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.05%; Diesel: 1.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	9.34E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.19%; Diesel: 3.58%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	6.55E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 1.01%; Diesel: 0.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112

Tab. 4.23 Life cycle inventory of passenger transports by an average minibus. (continued)

	Name	Location	InfrastructureProcess	Unit	transport, minibus	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
	Nitrogen oxides	-	-	kg	1.35E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	1.35E-6	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	7.21E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	2.06E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	5.19E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	5.47E-10	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: Petrol: 2.02E-08 kg/kgfuel; Diesel: 5.69E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	1.36E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 3.00E-10 kg/kgfuel; Diesel: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	1.21E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 2.00E-10 kg/kgfuel; Diesel: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	1.91E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 2.16E-06 kg/kgfuel; Diesel: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	2.56E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 4.20E-08 kg/kgfuel; Diesel: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	9.97E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 1.30E-08 kg/kgfuel; Diesel: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	2.97E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 1.60E-08 kg/kgfuel; Diesel: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	5.93E-13	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 3.20E-11 kg/kgfuel; Diesel: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	6.14E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 8.70E-09 kg/kgfuel; Diesel: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	9.54E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 1.08E-08 kg/kgfuel; Diesel: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	5.22E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 3.30E-08 kg/kgfuel; Diesel: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	6.07E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 4.25E-06 kg/vkm; Average occupancy rate: 7.0 passengers; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	1.43E-1	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Noise level of light commercial vehicles is comparable to passenger cars: 70-75 dB(A); Frischknecht & Büsser Knöpfel 2013; VCS 2016
technosphere	road wear emissions, passenger car	RER	0	kg	3.73E-6	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 9.77E-06 kg/(tGVW*km); Average occupancy rate: 7.0 passengers; Passenger weight: 75 kg; Vehicle weight: 2.15 t; Ecoinvent v3.1; Own assumption
	tyre wear emissions, passenger car	RER	0	kg	2.18E-5	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 5.72E-05 kg/(tGVW*km); Average occupancy rate: 7.0 passengers; Passenger weight: 75 kg; Vehicle weight: 2.15 t; Ecoinvent v3.1; Own assumption
	brake wear emissions, passenger car	RER	0	kg	1.70E-6	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 4.44E-06 kg/(tGVW*km); Average occupancy rate: 7.0 passengers; Passenger weight: 75 kg; Vehicle weight: 2.15 t; Ecoinvent v3.1; Own assumption
	disposal, road	RER	1	ma	1.81E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average occupancy rate: 7.0 passengers; Passenger weight: 75 kg; Vehicle weight: 2.15 t; Ecoinvent v2; Own assumption

4.8 Bus

The life cycle inventory of passenger transports by regular bus was updated considering the average fleet of buses with a diesel engine operated in Switzerland in 2015. Natural gas fuelled buses, which have a share of 4.3 % in the total vehicle kilometres travelled by regular buses, were disregarded because the emission factors for these vehicles provided by HBEFA are intended for indicative purposes and do not cover all substances (INFRAS 2014). The average occupancy rate is 10.0 persons according to the data from the Swiss passenger transport statistics on the vehicle kilometres (0.267 billion vkm) and passenger kilometres (2.68 billion pkm) travelled in 2014 (BFS 2015a; BFS 2015b).

Standard (also named rigid or non-articulated) buses were considered in this study because they account for 57 % of the vehicle kilometres driven by regular buses in Switzerland in 2015 (INFRAS 2014). The processes of bus manufacturing and maintenance are modelled by the corresponding datasets in ecoinvent data v2. The vehicle weight of modern standard buses with a capacity of 65 persons is comparable to the weight declared in the life cycle inventory in ecoinvent (11.0 t) (Görgler 2014b; Görgler 2015). The demand of bus manufacturing and maintenance were calculated with the average occupancy rate and an assumed life time performance of 1’000’000 vkm, which was adopted from Spielmann et al. (2007). The demand of road construction is a function of the GVW and the demand of road operation and maintenance depends on the vehicle kilometric performance. These inputs were calculated with the demand factor reported in subchapter 3.2, a GVW of 11.8 t and an average occupancy of 10.0 persons.

Data on the fuel consumption (0.357 kg/vkm) and the emissions of selected pollutants (CO_2, CO, CH_4, N_2O, NMVOC, NO_x, NH_3, SO_2, PM) were retrieved from HBEFA (INFRAS 2014). The emission factors are valid for an average diesel-fuelled regular bus in Switzerland in 2015. A share of the NMVOC emissions was further divided into main components based on the shares reported in the EMEP/EEA air pollutant emission inventory guidebook (see Tab. 3.1). The emissions of PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed. The corresponding emission factors are compiled in Tab. 3.2.

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The noise emissions caused by regular buses were assumed to be similar to those of lorries because their engine is of similar power size and because more specific information was not available. The calculation of refrigerant emissions from air conditioners is described in subchapter 3.5 and summarized in Tab. 3.3. The resulting refrigerant emissions are $1.61 \cdot 10^{-6}$ kgHFC-134a/pkm. The non-exhaust emissions by road, tyre and brake wear were calculated using the emission factors shown in Tab. 3.5 and the GVW of 11.8 t.

The life cycle inventory of passenger transports by regular bus is shown in Tab. 4.24.

Tab. 4.24 Life cycle inventory of passenger transports by an average diesel-fuelled regular bus.

	Name	Location	InfrastructureProcess	Unit	transport, regular bus	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
product	transport, regular bus	CH	0	pkm	1			
technosphere	bus	RER	1	unit	9.96E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Average occupancy rate: 10.0 passengers; BFS 2015; Ecoinvent v2
	maintenance, bus	CH	1	unit	9.96E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Average occupancy rate: 10.0 passengers; BFS 2015; Ecoinvent v2
	road	CH	1	ma	5.54E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average occupancy rate: 10.0 passengers; Passenger weight: 75 kg; Vehicle weight: 11.0 t; BFS 2015; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	1.17E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Average occupancy rate: 10.0 passengers; BFS 2015; Ecoinvent v2
	diesel, low-sulphur, at regional storage	CH	0	kg	3.56E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel consumption of average diesel buses in Switzerland in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	1.61E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.61E-05 kg/vkm; Average occupancy rate: 10.0 passengers; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.12E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average diesel buses Switzerland in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.02E-4	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor of average diesel buses Switzerland in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	3.35E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average diesel buses Switzerland in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.11E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	4.09E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.03%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	1.36E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.10%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	2.04E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	8.17E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.06%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	4.09E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	9.53E-9	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 0.07%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	1.36E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	1.33E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	5.45E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.14E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 8.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	6.22E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 4.57%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.87E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	2.41E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.77%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	7.63E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.56%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	7.36E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average diesel buses Switzerland in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	2.99E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor of average diesel buses Switzerland in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	7.62E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average diesel buses Switzerland in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	7.11E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average diesel buses Switzerland in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	5.24E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor of average diesel buses Switzerland in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	2.78E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.82E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	3.56E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	3.56E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	6.18E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	7.54E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	3.13E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	1.07E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	2.13E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	1.88E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	3.09E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.85E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.21E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	1.61E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.61E-05 kg/vkm; Average occupancy rate: 10.0 passengers; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech

Tab. 4.24 Life cycle inventory of passenger transports by an average diesel-fuelled regular bus. (continued)

	Name	Location	InfrastructureProcess	Unit	transport, regular bus	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
emission Non material	Noise, road, lorry, average	-	-	km	9.96E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Noise emissions similar to lorries; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, lorry	RER	0	kg	8.20E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 7.00E-06 kg/(tGVW*km); Average occupancy rate: 10.0 passengers; Passenger weight: 75 kg; Vehicle weight: 11.0 t; Ecoinvent v3.1; BFS 2015; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab.
	tyre wear emissions, lorry	RER	0	kg	9.43E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.06E-05 kg/(tGVW*km); Average occupancy rate: 10.0 passengers; Passenger weight: 75 kg; Vehicle weight: 11.0 t; Ecoinvent v3.1; BFS 2015; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab.
	brake wear emissions, lorry	RER	0	kg	9.52E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.13E-06 kg/(tGVW*km); Average occupancy rate: 10.0 passengers; Passenger weight: 75 kg; Vehicle weight: 11.0 t; Ecoinvent v3.1; BFS 2015; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab.
	disposal, bus	CH	1	unit	9.96E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Average
	disposal, road	RER	1	ma	5.54E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average occupancy rate: 10.0 passengers; Passenger weight: 75 kg; Vehicle weight: 11.0 t; BFS 2015; Ecoinvent v2

4.9 Coach

The life cycle inventory of passenger transports by coach was updated considering the average passenger coach fleet in Switzerland in 2015. The average occupancy rate is 21.1 persons according to the data from the Swiss passenger transport statistics on the vehicle kilometres (0.128 billion vkm) and passenger kilometres (2.70 billion pkm) travelled in 2014 (BFS 2015a; BFS 2015b).

The processes of vehicle manufacturing and maintenance were modelled by the corresponding datasets of a regular bus published in ecoinvent data v2 and scaled by the weight ratio of a passenger coach and the bus. The vehicle weight of passenger coaches varies depending on the model considered and ranges from approximately 12.5 t to 16.5 t. The coach analysed in the present study is assumed to have a vehicle weight of 13.0 t and a capacity of about 50 persons (Görgler 2012; Görgler 2013). The weight of the bus represented in the ecoinvent dataset is 11.0 t. The demand of the bus manufacturing and maintenance was calculated with the average occupancy rate and an assumed life time performance of 1’000’000 vkm, which was taken from Spielmann et al. (2007). The road input is a function of the GVW and was calculated with the demand factor given in subchapter 3.2 and a GVW of 14.6 t. The weight of an average passenger was thereby assumed to be 75 kg (Leuenberger & Frischknecht 2010). The demand of road operation and maintenance depends on the vehicle kilometric performance and was calculated using the demand factor from subchapter 3.2 and the average occupancy of 21.1 persons.

Data on the fuel consumption (0.279 kg/vkm) and the emissions of selected pollutants (CO_2, CO, CH_4, N_2O, NMVOC, NO_x, NH_3, SO_2, PM) were retrieved from HBEFA (INFRAS 2014). The emission factors are valid for an average diesel-fuelled passenger coach in Switzerland in 2015. A share of the NMVOC emissions was further divided into main components based on the shares reported in the EMEP/EEA air pollutant emission inventory guidebook (see Tab. 3.1). The emissions of PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed. The corresponding emission factors are compiled in Tab. 3.2.

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The noise emissions caused by passenger coaches were assumed to be similar to those of lorries because their engine is of similar power size and because more specific information was not available. The calculation of refrigerant emissions from air conditioners is described in subchapter 3.5 and summarized in Tab. 3.3. The resulting refrigerant emissions are $7.64 \cdot 10^{-7}$ kgHFC-134a/pkm. The non-exhaust emissions by road, tyre and brake wear were calculated using the emission factors shown in Tab. 3.5 and the GVW of 14.6 t.

The life cycle inventory of passenger transports by coach is shown in Tab. 4.25.

Tab. 4.25 Life cycle inventory of passenger transports by an average coach.

	Name	Location	InfrastructureProcess	Unit	transport, passenger coach	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
product	transport, passenger coach	CH	0	pkm	1			
technosphere	bus	RER	1	unit	5.60E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Input scaled by vehicle weight: 13.0 t (bus in ecoinvent: 11.0 t); Average occupancy rate: 21.1 passengers; BFS 2015; Görgler 2012, 2013; Ecoinvent v2
	maintenance, bus	CH	1	unit	5.60E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Input scaled by vehicle weight: 13.0 t (bus in ecoinvent: 11.0 t); Average occupancy rate: 21.1 passengers; BFS 2015; Görgler 2012, 2013; Ecoinvent v2
	road	CH	1	ma	3.27E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average occupancy rate: 21.1 passengers; Passenger weight: 75 kg; Vehicle weight: 13.0 t; BFS 2015; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	5.55E-5	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Average occupancy rate: 21.1 passengers; BFS 2015; Ecoinvent v2
	diesel, low-sulphur, at regional storage	CH	0	kg	1.32E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel consumption of average coaches in Switzerland in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	7.64E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.61E-05 kg/vkm; Average occupancy rate: 21.1 passengers; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	4.16E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average coaches in Switzerland in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	8.06E-5	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor of average coaches in Switzerland in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	2.19E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	7.25E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	2.68E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.03%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	8.92E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.10%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	1.34E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	5.35E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.06%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	2.68E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	6.25E-9	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 0.07%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	8.92E-10	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	8.74E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	3.57E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	7.50E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 8.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	4.08E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 4.57%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	1.22E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	1.58E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.77%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	5.00E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.56%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	2.84E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	1.42E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor of average coaches in Switzerland in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	1.06E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	2.64E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average coaches in Switzerland in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	4.61E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor of average coaches in Switzerland in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.03E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.82E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	1.32E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	1.32E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	2.30E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	2.80E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	1.16E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	3.97E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	7.93E-13	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	7.01E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	1.15E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	6.89E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.21E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103

Tab. 4.25 Life cycle inventory of passenger transports by an average coach. (continued)

	Name	Location	InfrastructureProcess	Unit	transport, passenger coach	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	7.64E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.61E-05 kg/vkm; Average occupancy rate: 21.1 passengers; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission Non material	Noise, road, lorry, average	-	-	km	4.73E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Noise emissions similar to lorries; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, lorry	RER	0	kg	4.83E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 7.00E-06 kg/(tGVW*km); Average occupancy rate: 21.1 passengers; Passenger weight: 75 kg; Vehicle weight: 13.0 t; BFS 2015; Görgler 2012, 2013; Ecoinvent v3.1
	tyre wear emissions, lorry	RER	0	kg	5.56E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.06E-05 kg/(tGVW*km); Average occupancy rate: 21.1 passengers; Passenger weight: 75 kg; Vehicle weight: 13.0 t; BFS 2015; Görgler 2012, 2013; Ecoinvent v3.1
	brake wear emissions, lorry	RER	0	kg	5.61E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.13E-06 kg/(tGVW*km); Average occupancy rate: 21.1 passengers; Passenger weight: 75 kg; Vehicle weight: 13.0 t; BFS 2015; Görgler 2012, 2013; Ecoinvent v3.1
	disposal, bus	CH	1	unit	5.60E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Input scaled by vehicle weight: 13.0 t (bus in ecoinvent: 11.0 t); Average occupancy rate: 21.1 passengers; BFS 2015; Görgler 2012, 2013; Ecoinvent v2
	disposal, road	RER	1	ma	3.27E-4	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Input scaled by vehicle weight: 13.0 t (bus in ecoinvent: 11.0 t); Average occupancy rate: 21.1 passengers; BFS 2015; Görgler 2012, 2013; Ecoinvent v2

A specific dataset was created for transport services by long-distance passenger coaches ("Fernbus") operated by the Swiss Federal Railways (Schweizerische Bundesbahnen; SBB) and by the German Railways (Deutsche Bahn; DB) between Zurich and Munich. Larger passenger coaches with a capacity of 74 persons are used for this route[12,13]. The vehicle weight was estimated to 19.0 t and the demand of vehicle manufacturing and maintenance was scaled accordingly (Görgler 2014a). The average occupancy rate of long-distance passenger coaches travelling between Zurich and Munich is 32.5 persons and the diesel consumption amounts to 0.323 kg/vkm[12]. The emission factors of average Swiss passenger coaches in 2015 were used and scaled based on the specific fuel demand.

The life cycle inventory of passenger transports by long-distance passenger coach is shown in Tab. 4.26.

[12] Personal communication Fabian Scherer, SBB, 20.11.2015.

[13] http://www.bahn.de/p/view/angebot/fernverkehrsmittel/ic-bus.shtml, accessed on 07.01.2016.

Tab. 4.26 Life cycle inventory of passenger transports by long-distance passenger coach. The vehicle size, fuel demand and occupancy rate are specific for the route Zurich - Munich.

	Name	Location	InfrastructureProcess	Unit	transport, passenger coach, InterCity-Bus	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
product	transport, passenger coach, InterCity-Bus	CH	0	pkm	1			
technosphere	bus	RER	1	unit	5.32E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Input scaled by vehicle weight: 19.0 t (bus in ecoinvent: 11.0 t); Average occupancy rate: 32.5 passengers; Personal communication Fabian Scherer, SBB, 23.11.2015; Görgler 2014; Ecoinvent v2
	maintenance, bus	CH	1	unit	5.32E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Input scaled by vehicle weight: 19.0 t (bus in ecoinvent: 11.0 t); Average occupancy rate: 32.5 passengers; Personal communication Fabian Scherer, SBB, 23.11.2015; Görgler 2014; Ecoinvent v2
	road	CH	1	ma	3.12E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average occupancy rate: 32.5 passengers; Passenger weight: 75 kg; Vehicle weight: 19.0 t; Personal communication Fabian Scherer, SBB, 23.11.2015; Ecoinvent v2
	operation, maintenance, road	CH	1	ma	3.61E-5	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 1.17E-03 my/km; Average occupancy rate: 32.5 passengers; Personal communication Fabian Scherer, SBB, 23.11.2015; Ecoinvent v2
	diesel, low-sulphur, at regional storage	CH	0	kg	9.96E-3	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel consumption of long-distance coaches on the route Zurich-Munich; Personal communication Fabian Scherer, SBB, 23.11.2015
	refrigerant R134a, at plant	RER	0	kg	4.97E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.61E-05 kg/vkm; Average occupancy rate: 32.5 passengers; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler,
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	3.14E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	6.07E-5	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; HBEFA database v3.2
	Methane, fossil	-	-	kg	1.65E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.46E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	2.02E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.03%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	6.72E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.10%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	1.01E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	4.03E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.06%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	2.02E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	4.71E-9	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.07%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	6.72E-10	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	6.59E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	2.69E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	5.65E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 8.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	3.07E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 4.57%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	9.21E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 1.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	1.19E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 1.77%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	3.76E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; Share in total NMVOC emissions: 0.56%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112

Tab. 4.26 Life cycle inventory of passenger transports by long-distance passenger coach. The vehicle size, fuel demand and occupancy rate are specific for the route Zurich - Munich. (continued)

	Name	Location	InfrastructureProcess	Unit	transport, passenger coach, InterCity-Bus	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
	Nitrogen oxides	-	-	kg	2.14E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; HBEFA database v3.2
	Ammonia	-	-	kg	1.07E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	8.00E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	1.99E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	3.47E-6	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor of average coaches in Switzerland in 2015 scaled by fuel consumption; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	7.79E-10	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.82E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	9.96E-13	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	9.96E-13	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	1.73E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	2.11E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	8.76E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	2.99E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	5.98E-13	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	5.28E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	8.66E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	5.19E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.21E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	4.97E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.61E-05 kg/vkm; Average occupancy rate: 32.5 passengers; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission Non material	Noise, road, lorry, average	-	-	km	3.08E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Noise emissions similar to lorries; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, lorry	RER	0	kg	4.62E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 7.00E-06 kg/(tGVW*km); Average occupancy rate: 32.5 passengers; Passenger weight: 75 kg; Vehicle weight: 19.0 t; Personal communication Fabian Scherer, SBB, 23.11.2015; Görgler
	tyre wear emissions, lorry	RER	0	kg	5.32E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.06E-05 kg/(tGVW*km); Average occupancy rate: 32.5 passengers; Passenger weight: 75 kg; Vehicle weight: 19.0 t; Personal communication Fabian Scherer, SBB, 23.11.2015; Görgler
	brake wear emissions, lorry	RER	0	kg	5.37E-6	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.13E-06 kg/(tGVW*km); Average occupancy rate: 32.5 passengers; Passenger weight: 75 kg; Vehicle weight: 19.0 t; Personal communication Fabian Scherer, SBB, 23.11.2015; Görgler
	disposal, bus	CH	1	unit	5.32E-8	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Input scaled by vehicle weight: 19.0 t (bus in ecoinvent: 11.0 t); Average occupancy rate: 32.5 passengers; Personal communication Fabian Scherer, SBB, 23.11.2015; Görgler 2014; Ecoinvent v2
	disposal, road	RER	1	ma	3.12E-4	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 1.00E+06 vkm; Input scaled by vehicle weight: 19.0 t (bus in ecoinvent: 11.0 t); Average occupancy rate: 32.5 passengers; Personal communication Fabian Scherer, SBB, 23.11.2015; Görgler 2014; Ecoinvent v2

4.10 Tram and trolleybus

4.10.1 Overview

The life cycle inventories of tram and trolleybus transport services published in ecoinvent data v2 were updated with new data on the transport performance, energy consumption as well as the load factor and emission factors provided in literature (BUWAL 2001a), national statistics (BFS 2015a; BFS 2015b) or by Swiss public transport operators (ZVV 2014; Bernmobil 2014; etc.). Data cover all tram and trolleybus networks in Switzerland.

The transport performance and the electricity consumption are described in section 4.10.2. The emissions during operation and the demand of infrastructure are documented in sections 4.10.3 and 4.10.4, respectively. The unit process life cycle inventory data are presented in section 4.10.5.

4.10.2 Transport performance and electricity consumption

Information on the total electricity consumption and the transport performance of tram and trolleybuses in Switzerland is available from the Swiss transport statistics (BFS 2015e). In Tab. 4.27 the figures and the resulting specific energy consumption are presented.

Tab. 4.27 Specific electricity consumption of trams and trolleybuses.

		Tram	Trolleybus
Total electricity consumption	kWh	162'000'000	79'200'000
Transport performance	pkm	1'120'000'000	515'700'000
Kilometric performance	vkm	32'855'000	27'506'000
Specific energy consumption per pkm	kWh/pkm	0.14	0.15
Specific energy consumption per vkm	kWh/vkm	4.93	2.88

4.10.3 Emissions during operation

Trams and trolleybuses run on electricity and thus do not cause combustion related emissions of pollutants. Nevertheless, emissions occur due to abrasion and due to refrigerant losses from air conditioners. Finally, noise emissions are quantified.

The particulate matter emissions by abrasion from wheels, rail tracks, brakes and overhead contact lines of trams are quantified based on information published in BUWAL (BUWAL 2001a). The amounts of particulate matter emissions were adjusted to the current transport performance in 2013 (see Tab. 4.28). In line with Spielmann et al. (2007) it is assumed that 50 % of the particulate matter emissions from wheels and rails is PM10 and 50 % PM>10. The remaining PM emissions of the brake are assumed to be non-volatile iron emissions. The emissions per pkm were calculated by dividing the emissions per km by the average number of passengers (34 passengers).

Tab. 4.28 Emission of abrasion from trams per year (BUWAL 2001b, Spielmann et al. 2007).

	PM 10 emission	Share of PM 10 of total PM emission
	g/km	
Brake	0.01	17%
Wheel	0.05	50%
Rail	0.09	50%
Total	0.15	

Tab. 4.29 Specific emission of tram transportation.

		PM 10 emission	PM >10 emission	Iron emission (no airborne)
Specific emission from abrasion	kg/pkm	4.40E-06	4.11E-06	1.43E-06

Electric trolleybuses cause emissions due to tyre, brake and road abrasion. These emissions were quantified using the emission factors of lorries as reported in the dataset published in ecoinvent data v3.1 (see subchapter 3.7).

Tab. 4.30 Road wear emission of trolleybus.

Emission factor road wear	7.00E-06	kg/(tGVW*km)
Emission factor tyre wear	8.06E-05	kg/(tGVW*km)
Emission factor brake wear	8.13E-06	kg/(tGVW*km)
Gross weight of trolleybus	18.41	tGVW
Specific road wear emissions	6.87E-06	kg/pkm
Specific tyre wear emissions	7.91E-05	kg/pkm
Specific brake wear emissions	7.98E-06	kg/pkm

The copper emissions from abrasion of the overhead contact line were quantified using data from Germany published in Hillenbrand et al. (Hillenbrand et al. 2005). According to this source, 7.8 t of copper are emitted to surface water and 28.9 t are emitted to soil, resulting in specific emissions to surface water and soil of 3.5 and 131 g Cu per meter and year, respectively (rail track length for Germany: 2’205 km). With a tram track length of 454 km (BFS 2015e) and an annual transport performance of 1’120’000’000 pkm, copper emissions to surface water and soil amount to $3.6 \cdot 10^{-7}$ kg/pkm and $5.3 \cdot 10^{-6}$ kg/pkm, respectively. For trolleybuses the same emission factors per passenger kilometre are used as for trams.

Tab. 4.31 Calculated copper emission factors (Hillenbrand et al. 2005; BFS 2015e).

Emission factor to soil	kg/m*a	0.0131
Emission factor to water	kg/m*a	0.0035
Length of overhead contact line	m	454'000
Emission to soil	kg/pkm	5.3E-06
Emission to water[1)]	kg/pkm	3.6E-07

1) 25% of the copper emissions are leaving the waste water treatment plant (Doka 2009).

Refrigerant emissions were quantified based on information published in the National Greenhouse Gas Inventory Report of Switzerland 2015 (BAFU 2015) (see subchapter 3.5 and Tab. 3.3). The refrigerant emissions of trams and of trolleybuses are $2.8 \cdot 10^{-7}$ kg/pkm and $1.1 \cdot 10^{-6}$ kg/pkm, respectively.

Noise emissions of trams are approximated with noise kilometres of trains. On one hand trams have a lower noise level compared to trains. On the other hand, trams predominantly circulate in higher populated areas compared to trains. Noise emissions of trolleybuses are approximated with 50 % of the noise level of lorries, based on the same noise level ratio of electric and fuel based passenger cars (see section 4.3.4).

4.10.4 Infrastructure demand

Tram manufacture is modelled based on a single wagon of the tram 2000 with a weight of 30 t and 120 seats. Trolleybus manufacture is modelled based on a Mercedes bus with a weight of 17 t and 92 seats. The average load of trams and trolleybuses is 34 and 19 persons, respectively (BFS 2015b).

The demand of vehicle manufacture per pkm is quantified using data on the average load, the number of trams and trolleybuses (670 trams and 606 trolleybuses, in public transport of all cities in Switzerland), the performed vehicle kilometres (32’855’000 vkm (trams) and 27’506’000 vkm (trolleybuses), BFS 2015a) and the life span of a tram (40 years) and trolleybus (17 years).

The total tram track length of Swiss tramlines is 227 km (double track). With an annual tram transport performance of 1’120’000’000 pkm per year (BFS 2015b) and a lifetime of 40 years of the tram tracks, the demand of tramline infrastructure is $2.03 \cdot 10^{-4}$ m·a/pkm.

Tram track construction is modelled according to Spielmann et al. (2007). The tram track construction dataset is complemented with information on the copper demand for the overhead contact lines.

The road infrastructure required by the trolleybus transport is complemented with a demand for an overhead contact line. The specific copper demand is determined with the average diameter and weight of the overhead contact line (120 mm^2 and 1.1 kg/m) and an average lifespan of 15 years (Hillenbrand et al. 2005). The trolleybus network in Switzerland has a length of 319 km according to national statistics (BFS 2015e). For the overhead contact line two copper cables are used. The demand of copper for the overhead contact line is 0.14 kg/(m·a). It is calculated by multiplying the copper demand per meter (1.1 kg/m) by 2 (two contact lines) and dividing it by the life span of the overhead contact line (15 a). The road demand, demand of road maintenance and disposal of the road have been calculated using the road demand factors described in Subchapter 3.2 and dividing or multiplying it by the average load (18 passenger) or by the GVW (18.4 t).

4.10.5 Unit process life cycle inventory data

The life cycle inventories of passenger transports by tram and by trolleybus are presented in Tab. 4.32 and Tab. 4.33, respectively.

Tab. 4.32 Life cycle inventory of passenger transport by tram.

	Name	Location	InfrastructureProcess	Unit	transport, tram	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
product	transport, tram	CH	0	pkm	1			
technosphere	electricity, medium voltage, at grid	CH	0	kWh	1.45E-1	1	1.22	(2,2,1,1,5,BU:1.05); Electricity consumption 161944444kWh and kilometric performance 32855000vkm ; BFS 2013
	tram	RER	1	unit	2.09E-8	1	3.05	(2,2,1,1,5,BU:3); kilometric transport performance 49037 vkm, lifespan 40a, load factor 34p/vehicle; BFS 2013
	maintenance, tram	CH	1	unit	2.09E-8	1	3.06	(3,2,1,1,5,BU:3); same as tram;
	disposal, tram	CH	1	unit	2.09E-8	1	3.06	(3,2,1,1,5,BU:3); same as tram;
	tram track	CH	1	ma	2.03E-4	1	3.05	(2,2,1,1,5,BU:3); Length 227km; Summe von Linienlänge einzelner Betriebe (Basel Land & Stadt dieselbe)
	operation, tram track	CH	1	ma	2.03E-4	1	3.05	(2,2,1,1,5,BU:3); same as tram track;
	disposal, tram track	CH	1	ma	2.03E-4	1	3.05	(2,2,1,1,5,BU:3); same as tram track;
	refrigerant R134a, at plant	RER	0	kg	2.85E-7	1	1.22	(2,2,1,1,5,BU:1.05); Consumption 9.71E-6 kg/vkm;
emission air, high population density	Particulates, > 10 um	-	-	kg	4.11E-6	1	1.94	(4,5,2,5,4,5,BU:1.5); ; Buwal 2001
	Particulates, > 2.5 um, and < 10um	-	-	kg	4.40E-6	1	2.38	(4,5,2,5,4,5,BU:2); ; Buwal 2001
emission soil, industrial	Copper	-	-	kg	5.31E-6	1	1.94	(4,5,2,5,4,5,BU:1.5); extrapolated from copper emission in Germany; Hillenbrand et al. 2005
emission water, river	Copper, ion	-	-	kg	3.58E-7	1	3.38	(4,5,2,5,4,5,BU:3); extrapolated from copper emission in Germany, 25% in effluent of wastewater treament; Hillenbrand et al. 2005
emission air, unspecified	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	2.85E-7	1	1.56	(2,2,1,1,1,5,BU:1.5); ;
emission soil, industrial	Iron	-	-	kg	1.43E-6	1	1.94	(4,5,2,5,4,5,BU:1.5); Own calculation;
emission Non material emissions, unspecified	Noise, rail, passenger train, average	-	-	pkm	2.93E-2	1	2.13	(5,5,2,5,4,5,BU:1.5); extrapolated from nois, rail passenger train, average; Forschungsprojekt Tramlärm 2013 Definition von Emissionswerten

Tab. 4.33 Life cycle inventory of passenger transports by trolleybus.

	Name	Location	InfrastructureProcess	Unit	transport, trolleybus	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				pkm			
product	transport, trolleybus	CH	0	pkm	1			
technosphere	bus	RER	1	unit	8.39E-8	1	3.05	(2,2,1,1,5,BU:3); Kilometric transport performance per vehicle and year 45389 km, load factor 19 p/vehicle and lifespan 17 years.; BFS 2013
	electricity, medium voltage, at grid	CH	0	kWh	1.54E-1	1	1.22	(2,2,1,1,5,BU:1.05); electric consumption in 2013 was 79166667kWh; BFS 2013
	maintenance, bus	CH	1	unit	8.39E-8	1	3.06	(3,2,1,1,5,BU:3); ;
	road, trolleybus	CH	1	ma	4.64E-4	1	2.05	(2,2,1,1,5,BU:2); road demand per vkm from process in ecoinvent 2.2; default value road transport ecoinvent 3.1
	operation, maintenance, road	CH	1	ma	6.24E-5	1	3.05	(2,2,1,1,5,BU:3); operation, maintenance per vkm from process in ecoinvent 2.2;
	refrigerant R134a, at plant	RER	0	kg	1.11E-6	1	1.22	(2,2,1,1,5,BU:1.05); 0,21E-06 kg/vkm; National Greenhouse Gas Inventory Report of Switzerland 2010 (Item 2F1, p. 156)
	road wear emissions, lorry	RER	0	kg	6.87E-6	1	2.38	(4,5,2,5,4,5,BU:2); 0,07E-06 kg/tGVW*km; default value road transport ecoinvent 3.1
	tyre wear emissions, lorry	RER	0	kg	7.91E-5	1	2.38	(4,5,2,5,4,5,BU:2); 0,81E-06 kg/tGVW*km; default value road transport ecoinvent 3.1
	brake wear emissions, lorry	RER	0	kg	7.98E-6	1	2.38	(4,5,2,5,4,5,BU:2); 0,08E-06 kg/tGVW*km; default value road transport ecoinvent 3.1
	disposal, bus	CH	1	unit	8.39E-8	1	3.38	(4,5,2,5,4,5,BU:3); ;
	disposal, road	RER	1	ma	4.64E-4	1	3.38	(4,5,2,5,4,5,BU:3); road demand per vkm from process in ecoinvent 2.2;
emission soil, industrial	Copper	-	-	kg	5.31E-6	1	1.94	(4,5,2,5,4,5,BU:1.5); extrapolated from tram emission in Germany; Hillenbrand et al. 2005
emission water, river	Copper, ion	-	-	kg	3.58E-7	1	3.38	(4,5,2,5,4,5,BU:3); extrapolated from tram emission in Germany, 25% in effluent of wastewater treatment; Hillenbrand et al. 2005
emission air, unspecified	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	1.11E-6	1	1.56	(2,2,1,1,1,5,BU:1.5); ;
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	2.67E-2	1	2.13	(5,5,2,5,4,5,BU:1.5); extrapolation with factor 0.5 for nois, road, lorry average;

5 Freight transport

5.1 Overview

The life cycle inventory of road freight transport services by light commercial vehicles was updated in this study and is presented in subchapter 5.2. Datasets on transport processes by lorries with a GVW of more than 32 t were updated and disaggregated (subchapter 5.3). In addition, fleet mixes for lorries of different size and emission classes were compiled. These are described in subchapter 5.4.

5.2 Light commercial vehicles

5.2.1 Overview

The life cycle inventories of freight transports by light commercial vehicles were updated in the present study. The production of the light commercial vehicle and some key characteristics are described in sections 5.2.2 and 5.2.3, respectively. The fuel consumption and the emissions during operation are documented in section 5.2.4. The unit process life cycle inventory data are shown in section 5.2.5.

5.2.2 Vehicle production and maintenance

The typical unladen weight of light commercial vehicles is 2’150 kg[14]. The engine of light commercial vehicles is often the same as in passenger cars whereas the glider is significantly heavier. The weight of the drivetrain was therefore assumed to be 401 kg as reported by Althaus and Gauch (2010) for passenger cars. The glider of the light commercial vehicle analysed has a mass of 1’750 kg. Data on the energy consumption of the manufacturing of light commercial vehicles were not available. Similar to the case of passenger car manufacture (see section 4.2.2), the energy consumption of assembling was taken from the passenger car manufacturing process in ecoinvent data v2 and divided by the weight of the light commercial vehicle (2’150 kg). It was thereby assumed that the energy demand of assembling a vehicle is mainly determined by the number of components rather than by their weight. The manual dismantling of the used light commercial vehicle at its end of life was modelled by the corresponding dataset for passenger cars published in ecoinvent data v3.1. The amounts of waste rubber and waste glass were taken from the dataset published in ecoinvent data v3.1, which represents dismantling of passenger cars. The amounts were scaled based on the weight of the glider. The same procedure was applied to the amount of waste mineral oil but this amount was scaled according to the weight of the engine. The life cycle inventory of the production of light commercial vehicles is presented in Tab. 5.1.

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14 ASTRA: MOFIS 2015, personal communication Christoph Schreyer, Swiss Federal Office for Energy, 31.05.2016.

The life cycle inventory of the maintenance of light commercial vehicles was adapted from Spielmann et al. (2007), adjusting for the difference in vehicle weight (van in ecoinvent v2 dataset: 2’500 kg).

Tab. 5.1 Life cycle inventory of the production (and dismantling) of light commercial vehicles.

	Name	Location	InfrastructureProcess	Unit	light commercial vehicle	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
product	light commercial vehicle	RER	0	kg	1			
technosphere	internal combustion engine, for passenger car	RER	1	kg	1.87E-1	1	3.10	(2,3,2,3,3,5,BU:3); Engine is assumed to be the same as in a diesel passenger car; Weight: 401 kg; Althaus & Gauch 2010; Ecoinvent v3.1
	glider, for passenger car	RER	1	kg	8.13E-1	1	3.10	(2,3,2,3,3,5,BU:3); Glider input calculated based on total vehicle weight (2150 kg) and engine weight (401 kg); ASTRA: MOFIS 2015; Althaus & Gauch 2010
	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	9.95E-1	1	1.31	(2,3,2,3,3,5,BU:1.05); Energy demand for vehicle assembling: 2140 kWh/vehicle; Vehicle weight: 2150 kg; Spielmann et al. 2007; ASTRA: MOFIS 2015
	heat, natural gas, at industrial furnace >100kW	RER	0	MJ	1.03E+0	1	1.31	(2,3,2,3,3,5,BU:1.05); Energy demand for vehicle assembling: 2220 MJ/vehicle; Vehicle weight: 2150 kg; Spielmann et al. 2007; ASTRA: MOFIS 2015
	heat, light fuel oil, at industrial furnace 1MW	RER	0	MJ	2.93E-2	1	1.31	(2,3,2,3,3,5,BU:1.05); Energy demand for vehicle assembling: 63 MJ/vehicle; Vehicle weight: 2150 kg; Spielmann et al. 2007; ASTRA: MOFIS 2015
	transport, lorry >16t, fleet average	RER	0	tkm	7.69E-4	1	2.10	(2,3,2,3,3,5,BU:2); Transport of waste materials; Standard distance: 10 km; Ecoinvent v2
	dismantling, manual dismantling of motor vehicles, mechanically, at plant	RER	1	kg	1.00E+0	1	3.10	(2,3,2,3,3,5,BU:3); Approximation; Ecoinvent v3.1
	disposal, rubber, unspecified, 0% water, to municipal incineration	CH	0	kg	4.41E-2	1	1.31	(2,3,2,3,3,5,BU:1.05); Rubber from the tyres; Amount taken from passenger car production and scaled based on share of glider; Ecoinvent v3.1
	disposal, glass, 0% water, to municipal incineration	CH	0	kg	3.12E-2	1	1.31	(2,3,2,3,3,5,BU:1.05); Waste glass from the manual dismantling of the vehicle; Amount taken from passenger car production and scaled based on share of glider; Ecoinvent v3.1
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.54E-3	1	1.31	(2,3,2,3,3,5,BU:1.05); Various lubricants used in the vehicle; Amount taken from passenger car production and scaled based on share of internal combustion engine; Ecoinvent v3.1

5.2.3 Load factor and road demand

The light commercial vehicle modelled in this project represents the average of this vehicle category in Switzerland. According to statistical data for Switzerland in 2013, 3.83 billion vkm were driven by light commercial vehicles and the transport performance was 0.873 billion tkm (BFS 2015d; BFS 2015c). This yields an average load of 228 kg. The capacity of the light commercial vehicle is calculated as the difference between the maximum permissible weight (3’500 kg) and the net vehicle weight (2’150 kg) and amounts to 1’350 kg. The vehicle life time performance of 220’000 vkm was adopted from the van transport process as described in Spielmann et al. (2007) because more recent information was not available. The road demand depends on the GVW, which is 2’380 kg. The road infrastructure demand factor is reported in subchapter 3.2 (construction and disposal: $4.73 \cdot 10^{-4}$ my/(tGVW·km), operation and maintenance: $1.17 \cdot 10^{-3}$ my/km; Spielmann et al. 2007).

5.2.4 Fuel consumption and emissions during operation

An average light commercial vehicle operated in Switzerland in 2015 is considered. According to HBEFA (INFRAS 2014), 85 % of the light commercial vehicles in Switzerland are diesel fuelled and 15 % use petrol. Data on the fuel consumption (0.073 kg/vkm) and the emissions of selected pollutants (CO_2, CO, CH_4, N_2O, NMVOC, NO_x, NH_3, SO_2, PM) were retrieved from HBEFA (INFRAS 2014). The emission factors were calculated for average light commercial vehicles in Switzerland in 2015 in order to ensure continuity with regard to the existing transport process by light commercial vehicles published in ecoinvent data v2. In addition to the fuel demand and the pollutant emissions during the hot operation of the light commercial vehicles, cold start emissions and fuel evaporation emissions due to running losses, soaking and diurnal temperature changes were taken into account as done for transports by passenger car (see section 4.2.3). Specific information on the average travel distance of light commercial vehicles was not available. The excess emission factors for cold starts and evaporation by soaking were therefore converted to the functional unit of 1 tkm by assuming an average travel distance of 32 km, which is valid for passenger cars (BFS/ARE 2012). For the evaporation emissions due to diurnal temperature changes, an average of two trips per day was estimated. A fraction of the total NMVOC emissions was further divided into main components based on the shares reported in the EMEP/EEA air pollutant emission inventory guidebook (see Tab. 3.1). The emissions of PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed and were calculated using the emission factors compiled in Tab. 3.2.

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The typical noise level of light commercial vehicles is 70-75 dB(A), which is similar to the noise level of passenger cars (VCS 2015b; Frischknecht & Büsser Knöpfel 2013). The noise emissions were therefore modelled by the respective elementary flow for passenger cars. The refrigerant emissions from air conditioners were extrapolated from the parameter values for lorries (see Tab. 3.3). The resulting HFC-134a emissions of light commercial vehicles are $1.86 \cdot 10^{-5}$ kg/tkm. The non-exhaust emissions by road, tyre and brake wear are a function of the GVW and were calculated using the emission factors presented in Tab. 3.5.

5.2.5 Unit process life cycle inventory data

The life cycle inventory of transports by an average light commercial vehicle in Switzerland is presented in Tab. 5.2.

Tab. 5.2 Life cycle inventory of freight transports by an average light commercial vehicle.

	Name	Location	InfrastructureProcess	Unit	transport, freight, light commercial vehicle	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				tkm			
product	transport, freight, light commercial vehicle	CH	0	tkm	1			
technosphere	light commercial vehicle	RER	0	kg	4.29E-2	1	2.07	(3,1,3,2,1,5,BU:2); Vehicle weight: 2.15 t; Vehicle life time performance: 2.20E+05 vkm; Average load factor: 0.23 t; ASTRA: MOFIS 2015; Ecoinvent v2.2; Own assumption
	maintenance, van < 3.5t	RER	1	unit	1.71E-05	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 2.20E+05 vkm; Input scaled by vehicle weight: 2.15 t (light commercial vehicle in ecoinvent: 2.5 t); Average load factor: 0.23 t; ASTRA: MOFIS 2015; Ecoinvent v2.2; Own assumption
	road	CH	1	ma	4.93E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load factor: 0.23 t; Vehicle weight: 2.15 t; Ecoinvent v2; Own assumption
	operation, maintenance, road	CH	1	ma	5.14E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road operation demand: 1.17E-03 ; Average load factor: 0.23 t; Ecoinvent v2; Own assumption
	diesel, low-sulphur, at regional storage	CH	0	kg	2.79E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel consumption of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	petrol, low-sulphur, at regional storage	CH	0	kg	4.67E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel consumption of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	1.86E-5	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 4.25E-06 kg/vkm; Average load factor: 0.23 t; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	1.03E+0	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	3.62E-3	1	5.01	(2,2,2,3,1,2,BU:5); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	1.20E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.16E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; Petrol: 45.2% of total NMVOC emissions; Diesel: 53.0% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	5.75E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 3.19%; Diesel: 0.33%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	1.20E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.65%; Diesel: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	9.14E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 5.24%; Diesel: 0.11%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	3.75E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 2.15%; Diesel: 0.04%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Hexane	-	-	kg	2.79E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 1.61%; Diesel: 0.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Cyclohexane	-	-	kg	2.43E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 1.14%; Diesel: 0.65%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	1.42E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.74%; Diesel: 0.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethene	-	-	kg	2.04E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 7.30%; Diesel: 10.97%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propene	-	-	kg	9.16E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 3.82%; Diesel: 3.60%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	1-Pentene	-	-	kg	1.90E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.11%; Diesel: 0.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	1.11E-5	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: Petrol: 5.61%; Diesel: 1.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	1.95E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 10.98%; Diesel: 0.69%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	9.83E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 5.43%; Diesel: 0.61%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	4.10E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 2.26%; Diesel: 0.27%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.14E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 1.70%; Diesel: 12.00%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	5.88E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.75%; Diesel: 6.47%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	9.90E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.22%; Diesel: 0.86%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetone	-	-	kg	3.14E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.61%; Diesel: 2.94%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Methyl ethyl ketone	-	-	kg	9.37E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.05%; Diesel: 1.20%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	2.87E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 0.19%; Diesel: 3.58%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	2.01E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: Petrol: 1.01%; Diesel: 0.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112

Tab. 5.2 Life cycle inventory of freight transports by an average light commercial vehicle. (continued)

	Name	Location	InfrastructureProcess	Unit	transport, freight, light commercial vehicle	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				tkm			
	Nitrogen oxides	-	-	kg	4.14E-3	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	4.16E-5	1	1.21	(2,2,2,3,1,2,BU:1.2); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	2.21E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	6.32E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.59E-4	1	3.01	(2,2,2,3,1,2,BU:3); Emission factor of average light commercial vehicles in Switzerland in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.68E-8	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: Petrol: 2.02E-08 kg/kgfuel; Diesel: 5.69E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	4.19E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 3.00E-10 kg/kgfuel; Diesel: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	3.72E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 2.00E-10 kg/kgfuel; Diesel: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	5.85E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 2.16E-06 kg/kgfuel; Diesel: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	7.87E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 4.20E-08 kg/kgfuel; Diesel: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	3.06E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 1.30E-08 kg/kgfuel; Diesel: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	9.11E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 1.60E-08 kg/kgfuel; Diesel: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.82E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 3.20E-11 kg/kgfuel; Diesel: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	1.88E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 8.70E-09 kg/kgfuel; Diesel: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	2.93E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 1.08E-08 kg/kgfuel; Diesel: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.60E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: Petrol: 3.30E-08 kg/kgfuel; Diesel: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	1.86E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 4.25E-06 kg/vkm; Average load factor: 0.23 t; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, passenger car, average	-	-	km	4.39E+0	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Noise level of light commercial vehicles is comparable to passenger cars: 70-75 dB(A); Frischknecht & Büsser Knöpfel 2013; VCS 2016
technosphere	road wear emissions, passenger car	RER	0	kg	1.02E-4	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 9.77E-06 kg/(tGVW*km); Average load factor: 0.23 t; Vehicle weight: 2.15 t; Ecoinvent v3.1; Own assumption
	tyre wear emissions, passenger car	RER	0	kg	5.96E-4	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 5.72E-05 kg/(tGVW*km); Average load factor: 0.23 t; Vehicle weight: 2.15 t; Ecoinvent v3.1; Own assumption
	brake wear emissions, passenger car	RER	0	kg	4.63E-5	1	2.02	(2,2,3,3,1,2,BU:2); Modelled by passenger car non-exhaust emissions; Emission factor: 4.44E-06 kg/(tGVW*km); Average load factor: 0.23 t; Vehicle weight: 2.15 t; Ecoinvent v3.1; Own assumption
	disposal, road	RER	1	ma	4.93E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load factor: 0.23 t; Vehicle weight: 2.15 t; Ecoinvent v2; Own assumption

5.3 Lorries with a GVW exceeding 32 tons

5.3.1 Overview

The life cycle inventories of freight transports by lorry were already updated and published in ecoinvent data v3.1. However, the lorry size class exceeding a GVW of 32 t covers a wide range of different lorries up to 60 t GVW. Datasets representing transport by lorries > 32 t were therefore disaggregated in this study into datasets representing transport with lorries of the size classes (GVW) 32-40 t, 40-50 t and 50-60 t. In addition, it is distinguished between the emission classes Euro 3 to Euro 6. The determination of the payload and the load factors is explained in section 5.3.2. The demand of lorry manufacture and maintenance are described in section 5.3.3 and the fuel consumption and emissions during operation are documented in section 5.3.4. The section 5.3.5 contains the unit process life cycle inventory data of the freight transports by lorries exceeding a GVW of 32 t.

5.3.2 Payload and load factors

The net weight of lorries with a GVW of 32-40 t, 40-50 t and 50-60 t was estimated to 17 t, 20 t and 23 t, respectively, based on TRACCS data on the allowable weight and the maximum loading capacity (Papadimitriou et al. 2013). The average load factor of lorries with a GVW of 32-40 t operated in the EU15, Switzerland and Norway in the year 2015 is 11.6 t (TREMOVE 2009). This is consistent with freight transports by smaller lorries as modelled in ecoinvent data v3.1, which are based on the same data.

Different data sources were considered to define the average load factor of the heavier lorries. Data on the cumulated travel distance (vkm) and freight transport distance (tkm) were available from Papadimitriou et al. (2013) and Eurostat[15] for a number of European countries and allowed the calculation of load factors. There is a wide variation in the relative load factor (ratio of the average payload and the capacity of the lorry) between different lorry size classes and countries and the datasets deviate significantly from each other. Several studies report a weight utilisation factor of approximately 60 % for lorries with a GVW above 40 t (IFEU et al. 2014; Akerman & Jonsson 2007; Kraaijenhagen et al. 2014; Knight et al. 2008). However, it is doubtful whether this load factor includes empty runs of lorries, which account for a share of approximately 25 % in the total number of trips (Marti 2015; Knight et al. 2008). A load factor of 50 % (corresponding to an average load of 15.0 t and 18.5 t for the lorry size classes 40-50 t and 50-60 t, respectively) was assumed in this study, which is close to the statistical data provided by Eurostat[15] for EU28 countries in 2014.

5.3.3 Demand of lorry manufacture and maintenance and road infrastructure

The demand of lorry manufacture and maintenance were calculated with the average load and an estimated life time performance of 540’000 vkm (Spielmann et al. 2007). The demand for road construction is a function of the GVW and was calculated with the demand factor given in subchapter 3.2 ($4.73 \cdot 10^{-4}$ my/(tGVW·km); Spielmann et al. 2007). With GVW of 28.6 t, 35.0 t and 41.5 t, the road construction and maintenance demand is $1.17 \cdot 10^{-3}$, $1.10 \cdot 10^{-3}$ and $1.00 \cdot 10^{-3}$ my/tkm for freight transport with lorry 32-40 t, 40-50 t and 50-60 t, respectively. The demand factor for road operation and maintenance mainly depends on the vehicle kilometres travelled and equals $1.17 \cdot 10^{-3}$ my/vkm (Spielmann et al. 2007).

[15] Dataset „Annual road freight transport, by load capacity of vehicle”, retrieved from http://ec.europa.eu/eurostat/data/database on 22.10.2015.

5.3.4 Fuel consumption and emissions during operation

The fuel consumption as well as emission factors of the pollutants CO_2, CO, CH_4, NMVOC, NO_x, NH_3, N_2O, SO_2 and PM were obtained from HBEFA (INFRAS 2014). Data representative for lorries operated in Germany were used for the lorry size class 32-40 t, which is consistent with other freight transport process datasets published in ecoinvent data v3.1. Both articulated vehicles with a GVW of 34-40 t and rigid lorries with a GVW exceeding 32 t of the respective emission classes were taken into account. The fuel consumption and emission factors were weighted according to the shares in vehicle kilometres of the categories. The fuel consumption and emission factors for lorries with a GVW of 40-50 t and 50-60 t were determined for Sweden because the German lorry vehicle fleet does not contain any lorries with a GVW higher than 40 t. The fuel consumption factors were calculated by assuming a load factor of 50 % of the lorry capacity and amount to 0.263, 0.264 and 0.323 kg/vkm for lorries with a GVW of 32-40 t, 40-50 t and 50-60 t, respectively.

A fraction of the NMVOC emissions was further divided into main components based on the shares reported in the EMEP/EEA air pollutant emission inventory guidebook (see Tab. 3.1). The emissions of PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed and were calculated using the emission factors compiled in Tab. 3.2.

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The refrigerant emissions from air conditioning were estimated based on the parameter values provided in item 2F1 of Switzerland’s Greenhouse Gas Inventory (BAFU 2015). The refrigerant emissions include only the emissions from the air conditioners in the driver’s cabin and are therefore not suitable for application to refrigerated lorries. The calculation of refrigerant emissions from air conditioners is described in subchapter 3.5 and summarized in Tab. 3.3. The resulting refrigerant emissions are $1.49 \cdot 10^{-7}$, $1.15 \cdot 10^{-7}$ and $9.36 \cdot 10^{-7}$ kgHFC-134a/tkm for lorries with a GVW of 32-40 t, 40-50 t and 50-60 t, respectively. The non-exhaust emissions by road, tyre and brake wear were calculated using the emission factors shown in Tab. 3.5.

5.3.5 Unit process life cycle inventory data

The life cycle inventories of freight transports by lorry with a GVW of 32-40 t, 40-50 t and 50-60 t and for the emission classes Euro 3 to Euro 6 are shown in Tab. 5.3, Tab. 5.4 and Tab. 5.5, respectively.

Tab. 5.3 Life cycle inventory of freight transports by a 32-40 t lorry compliant with the emission standard Euro 3, Euro 4, Euro 5 and Euro 6.

	Name	Location	InfrastructureProcess	Unit	transport, freight, lorry 32-40 metric ton, EURO 3	transport, freight, lorry 32-40 metric ton, EURO 4	transport, freight, lorry 32-40 metric ton, EURO 5	transport, freight, lorry 32-40 metric ton, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				tkm	tkm	tkm	tkm			
product	transport, freight, lorry 32-40 metric ton, EURO 3	RER	0	tkm	1	0	0	0			
	transport, freight, lorry 32-40 metric ton, EURO 4	RER	0	tkm	0	1	0	0			
	transport, freight, lorry 32-40 metric ton, EURO 5	RER	0	tkm	0	0	1	0			
	transport, freight, lorry 32-40 metric ton, EURO 6	RER	0	tkm	0	0	0	1			
technosphere	lorry 40t	RER	1	unit	1.60E-7	1.60E-7	1.60E-7	1.60E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 11.61 t; Ecoinvent v2; Tremove model v2.7b
	maintenance, lorry 40t	CH	1	unit	1.60E-7	1.60E-7	1.60E-7	1.60E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 11.61 t; Ecoinvent v2; Tremove model v2.7b
	road	CH	1	ma	1.17E-3	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load factor: 11.61 t; Vehicle weight: 17 t; Ecoinvent v2; Tremove model v2.7b
	operation, maintenance, road	CH	1	ma	1.01E-4	1.01E-4	1.01E-4	1.01E-4	1	3.07	(3,1,3,2,1,5,BU:3); Road operation demand: 1.17E-03 my/km; Average load factor: 11.61 t; Ecoinvent v2; Tremove model v2.7b
	diesel, low-sulphur, at regional storage	RER	0	kg	2.34E-2	2.27E-2	2.26E-2	2.28E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	1.49E-7	1.49E-7	1.49E-7	1.49E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.73E-06 kg/vkm; Average load factor: 11.61 t; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	7.44E-2	7.20E-2	7.19E-2	7.23E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.18E-4	1.10E-4	9.90E-5	1.07E-5	1	5.01	(2,2,2,3,1,2,BU:5); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	6.00E-7	5.86E-8	8.11E-8	5.46E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.98E-5	1.93E-6	2.68E-6	1.80E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	7.32E-9	7.14E-10	9.89E-10	6.66E-10	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.03%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	2.44E-8	2.38E-9	3.30E-9	2.22E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.10%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	3.66E-8	3.57E-9	4.95E-9	3.33E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.46E-8	1.43E-9	1.98E-9	1.33E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.06%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	7.32E-8	7.14E-9	9.89E-9	6.66E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	1.71E-8	1.67E-9	2.31E-9	1.55E-9	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 0.07%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	2.44E-9	2.38E-10	3.30E-10	2.22E-10	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	2.39E-7	2.33E-8	3.23E-8	2.17E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	9.76E-8	9.53E-9	1.32E-8	8.88E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	2.05E-6	2.00E-7	2.77E-7	1.86E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 8.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	1.12E-6	1.09E-7	1.51E-7	1.01E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 4.57%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	3.34E-7	3.26E-8	4.52E-8	3.04E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	4.32E-7	4.22E-8	5.84E-8	3.93E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.77%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	1.37E-7	1.33E-8	1.85E-8	1.24E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.56%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	5.96E-4	3.23E-4	2.21E-4	2.77E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	2.58E-7	2.58E-7	2.58E-7	2.58E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	6.32E-7	1.69E-6	4.92E-6	4.38E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	3.75E-7	3.63E-7	3.62E-7	3.64E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.29E-5	3.13E-6	3.27E-6	3.17E-7	1	3.01	(2,2,2,3,1,2,BU:3); Average for the vehicle classes SZ/LZ >34-40t and SoloLkw >32t for Germany in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.83E-9	1.77E-9	1.77E-9	1.78E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.82E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	2.34E-12	2.27E-12	2.26E-12	2.28E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	2.34E-12	2.27E-12	2.26E-12	2.28E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	4.07E-8	3.94E-8	3.93E-8	3.95E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	4.96E-10	4.80E-10	4.80E-10	4.82E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	2.06E-10	1.99E-10	1.99E-10	2.00E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	7.02E-10	6.80E-10	6.79E-10	6.83E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.40E-12	1.36E-12	1.36E-12	1.37E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	1.24E-10	1.20E-10	1.20E-10	1.21E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	2.04E-10	1.97E-10	1.97E-10	1.98E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	1.22E-9	1.18E-9	1.18E-9	1.19E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.21E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	1.49E-7	1.49E-7	1.49E-7	1.49E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.73E-06 kg/vkm; Average load factor: 11.61 t; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	8.61E-2	8.61E-2	8.61E-2	8.61E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, lorry	RER	0	kg	1.72E-5	1.72E-5	1.72E-5	1.72E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 7.00E-06 kg/(tGVW*km); Average load factor: 11.61 t; Vehicle weight: 17 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, lorry	RER	0	kg	1.98E-4	1.98E-4	1.98E-4	1.98E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.06E-05 kg/(tGVW*km); Average load factor: 11.61 t; Vehicle weight: 17 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, lorry	RER	0	kg	2.00E-5	2.00E-5	2.00E-5	2.00E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.13E-06 kg/(tGVW*km); Average load factor: 11.61 t; Vehicle weight: 17 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, lorry 40t	CH	1	unit	1.60E-7	1.60E-7	1.60E-7	1.60E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 11.61 t; Ecoinvent v2; Tremove model v2.7b
	disposal, road	RER	1	ma	1.17E-3	1.17E-3	1.17E-3	1.17E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load factor: 11.61 t; Vehicle weight: 17 t; Ecoinvent v2; Tremove model v2.7b

Tab. 5.4 Life cycle inventory of freight transports by a 40-50 t lorry compliant with the emission standard Euro 3, Euro 4, Euro 5 and Euro 6.

	Name	Location	InfrastructureProcess	Unit	transport, freight, lorry 40-50 metric ton, EURO 3	transport, freight, lorry 40-50 metric ton, EURO 4	transport, freight, lorry 40-50 metric ton, EURO 5	transport, freight, lorry 40-50 metric ton, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				tkm	tkm	tkm	tkm			
product	transport, freight, lorry 40-50 metric ton, EURO 3	RER	0	tkm	1	0	0	0			
	transport, freight, lorry 40-50 metric ton, EURO 4	RER	0	tkm	0	1	0	0			
	transport, freight, lorry 40-50 metric ton, EURO 5	RER	0	tkm	0	0	1	0			
	transport, freight, lorry 40-50 metric ton, EURO 6	RER	0	tkm	0	0	0	1			
technosphere	lorry 40t	RER	1	unit	1.45E-7	1.45E-7	1.45E-7	1.45E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 15 t; Lorry scaled based on vehicle weight; Ecoinvent v2; Tremove model v2.7b
	maintenance, lorry 40t	CH	1	unit	1.45E-7	1.45E-7	1.45E-7	1.45E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 15 t; Lorry scaled based on vehicle weight; Ecoinvent v2; Tremove model v2.7b
	road	CH	1	ma	1.10E-3	1.10E-3	1.10E-3	1.10E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load factor: 15 t; Vehicle weight: 20 t; Ecoinvent v2; Tremove model v2.7b
	operation, maintenance, road	CH	1	ma	7.81E-5	7.81E-5	7.81E-5	7.81E-5	1	3.07	(3,1,3,2,1,5,BU:3); Road operation demand: 1.17E-03 my/km; Average load factor: 15 t; Ecoinvent v2; Tremove model v2.7b
	diesel, low-sulphur, at regional storage	RER	0	kg	1.83E-2	1.77E-2	1.76E-2	1.79E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	1.15E-7	1.15E-7	1.15E-7	1.15E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.73E-06 kg/vkm; Average load factor: 15.00 t; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	5.76E-2	5.57E-2	5.55E-2	5.64E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.17E-4	9.47E-5	1.14E-4	9.64E-6	1	5.01	(2,2,2,3,1,2,BU:5); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	5.43E-7	5.74E-8	4.49E-8	5.16E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.79E-5	1.90E-6	1.48E-6	1.71E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	6.62E-9	7.00E-10	5.47E-10	6.30E-10	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.03%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	2.21E-8	2.33E-9	1.82E-9	2.10E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.10%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	3.31E-8	3.50E-9	2.74E-9	3.15E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.32E-8	1.40E-9	1.09E-9	1.26E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.06%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	6.62E-8	7.00E-9	5.47E-9	6.30E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	1.54E-8	1.63E-9	1.28E-9	1.47E-9	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 0.07%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	2.21E-9	2.33E-10	1.82E-10	2.10E-10	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	2.16E-7	2.29E-8	1.79E-8	2.06E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	8.83E-8	9.34E-9	7.30E-9	8.40E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.85E-6	1.96E-7	1.53E-7	1.76E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 8.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	1.01E-6	1.07E-7	8.34E-8	9.59E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 4.57%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	3.02E-7	3.20E-8	2.50E-8	2.88E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	3.91E-7	4.13E-8	3.23E-8	3.72E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.77%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	1.24E-7	1.31E-8	1.02E-8	1.18E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.56%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	5.07E-4	3.14E-4	2.00E-4	1.81E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	2.00E-7	2.00E-7	2.00E-7	2.00E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	5.32E-7	1.41E-6	4.04E-6	3.72E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	7.32E-8	7.08E-8	7.05E-8	7.16E-8	1	1.09	(2,2,2,3,1,2,BU:1.05); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.08E-5	2.90E-6	3.16E-6	2.91E-7	1	3.01	(2,2,2,3,1,2,BU:3); Vehicle classes SZ/LZ >40-50t for Sweden in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.43E-9	1.38E-9	1.38E-9	1.40E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.82E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	1.83E-12	1.77E-12	1.76E-12	1.79E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	1.83E-12	1.77E-12	1.76E-12	1.79E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	3.18E-8	3.07E-8	3.06E-8	3.11E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	3.88E-10	3.75E-10	3.74E-10	3.79E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	1.61E-10	1.56E-10	1.55E-10	1.57E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	5.49E-10	5.31E-10	5.29E-10	5.37E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.10E-12	1.06E-12	1.06E-12	1.07E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	9.70E-11	9.38E-11	9.34E-11	9.48E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	1.59E-10	1.54E-10	1.53E-10	1.56E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	9.53E-10	9.22E-10	9.18E-10	9.32E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.21E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	1.15E-7	1.15E-7	1.15E-7	1.15E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.73E-06 kg/vkm; Average load factor: 15.00 t; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	6.67E-2	6.67E-2	6.67E-2	6.67E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, lorry	RER	0	kg	1.63E-5	1.63E-5	1.63E-5	1.63E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 7.00E-06 kg/(tGVW*km); Average load factor: 15 t; Vehicle weight: 20 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, lorry	RER	0	kg	1.88E-4	1.88E-4	1.88E-4	1.88E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.06E-05 kg/(tGVW*km); Average load factor: 15 t; Vehicle weight: 20 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, lorry	RER	0	kg	1.90E-5	1.90E-5	1.90E-5	1.90E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.13E-06 kg/(tGVW*km); Average load factor: 15 t; Vehicle weight: 20 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, lorry 40t	CH	1	unit	1.45E-7	1.45E-7	1.45E-7	1.45E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 15 t; Lorry scaled based on vehicle weight; Ecoinvent v2; Tremove model v2.7b
	disposal, road	RER	1	ma	1.10E-3	1.10E-3	1.10E-3	1.10E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load factor: 15 t; Vehicle weight: 20 t; Ecoinvent v2; Tremove model v2.7b

Tab. 5.5 Life cycle inventory of freight transports by a 50-60 t lorry compliant with the emission standard Euro 3, Euro 4, Euro 5 and Euro 6.

	Name	Location	InfrastructureProcess	Unit	transport, freight, lorry 50-60 metric ton, EURO 3	transport, freight, lorry 50-60 metric ton, EURO 4	transport, freight, lorry 50-60 metric ton, EURO 5	transport, freight, lorry 50-60 metric ton, EURO 6	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RER	RER	RER	RER			
	InfrastructureProcess				0	0	0	0			
	Unit				tkm	tkm	tkm	tkm			
product	transport, freight, lorry 50-60 metric ton, EURO 3	RER	0	tkm	1	0	0	0			
	transport, freight, lorry 50-60 metric ton, EURO 4	RER	0	tkm	0	1	0	0			
	transport, freight, lorry 50-60 metric ton, EURO 5	RER	0	tkm	0	0	1	0			
	transport, freight, lorry 50-60 metric ton, EURO 6	RER	0	tkm	0	0	0	1			
technosphere	lorry 40t	RER	1	unit	1.35E-7	1.00E-7	1.00E-7	1.00E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 18.5 t; Lorry scaled based on vehicle weight; Ecoinvent v2; Tremove model v2.7b
	maintenance, lorry 40t	CH	1	unit	1.35E-7	1.00E-7	1.00E-7	1.00E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 18.5 t; Lorry scaled based on vehicle weight; Ecoinvent v2; Tremove model v2.7b
	road	CH	1	ma	1.06E-3	1.06E-3	1.06E-3	1.06E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load factor: 18.5 t; Vehicle weight: 23 t; Ecoinvent v2; Tremove model v2.7b
	operation, maintenance, road	CH	1	ma	6.33E-5	6.33E-5	6.33E-5	6.33E-5	1	3.07	(3,1,3,2,1,5,BU:3); Road operation demand: 1.17E-03 my/km; Average load factor: 18.5 t; Ecoinvent v2; Tremove model v2.7b
	diesel, low-sulphur, at regional storage	RER	0	kg	1.77E-2	1.74E-2	1.75E-2	1.80E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	refrigerant R134a, at plant	RER	0	kg	9.36E-8	9.36E-8	9.36E-8	9.36E-8	1	1.09	(2,2,2,3,1,2,BU:1.05); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.73E-06 kg/vkm; Average load factor: 18.50 t; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	5.57E-2	5.47E-2	5.50E-2	5.67E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	Carbon monoxide, fossil	-	-	kg	1.12E-4	8.97E-5	1.09E-4	8.68E-6	1	5.01	(2,2,2,3,1,2,BU:5); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	Methane, fossil	-	-	kg	4.94E-7	5.54E-8	4.28E-8	4.80E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.63E-5	1.83E-6	1.41E-6	1.59E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Ethane	-	-	kg	6.03E-9	6.75E-10	5.23E-10	5.86E-10	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.03%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Propane	-	-	kg	2.01E-8	2.25E-9	1.74E-9	1.95E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.10%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Butane	-	-	kg	3.02E-8	3.38E-9	2.61E-9	2.93E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.15%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Pentane	-	-	kg	1.21E-8	1.35E-9	1.05E-9	1.17E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.06%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Heptane	-	-	kg	6.03E-8	6.75E-9	5.23E-9	5.86E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.30%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzene	-	-	kg	1.41E-8	1.58E-9	1.22E-9	1.37E-9	1	3.01	(2,2,2,3,1,2,BU:3); Share in total NMVOC emissions: 0.07%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Toluene	-	-	kg	2.01E-9	2.25E-10	1.74E-10	1.95E-10	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.01%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	m-Xylene	-	-	kg	1.97E-7	2.21E-8	1.71E-8	1.91E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.98%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	o-Xylene	-	-	kg	8.04E-8	9.00E-9	6.97E-9	7.81E-9	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Formaldehyde	-	-	kg	1.69E-6	1.89E-7	1.46E-7	1.64E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 8.40%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acetaldehyde	-	-	kg	9.19E-7	1.03E-7	7.96E-8	8.93E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 4.57%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Benzaldehyde	-	-	kg	2.75E-7	3.08E-8	2.39E-8	2.68E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.37%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Acrolein	-	-	kg	3.56E-7	3.98E-8	3.08E-8	3.46E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 1.77%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Styrene	-	-	kg	1.13E-7	1.26E-8	9.75E-9	1.09E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Share in total NMVOC emissions: 0.56%; HBEFA database v3.2; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-112
	Nitrogen oxides	-	-	kg	4.90E-4	2.91E-4	1.71E-4	1.60E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	Ammonia	-	-	kg	1.62E-7	1.62E-7	1.62E-7	1.62E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	Dinitrogen monoxide	-	-	kg	4.31E-7	1.14E-6	3.28E-6	3.01E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	Sulfur dioxide	-	-	kg	7.07E-8	6.94E-8	6.99E-8	7.20E-8	1	1.09	(2,2,2,3,1,2,BU:1.05); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.02E-5	2.76E-6	3.00E-6	2.73E-7	1	3.01	(2,2,2,3,1,2,BU:3); Vehicle classes SZ/LZ >50-60t for Sweden in 2015; HBEFA database v3.2
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.38E-9	1.36E-9	1.37E-9	1.41E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 7.82E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-8 and 3-9
	Arsenic	-	-	kg	1.77E-12	1.74E-12	1.75E-12	1.80E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	1.77E-12	1.74E-12	1.75E-12	1.80E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Zinc	-	-	kg	3.07E-8	3.02E-8	3.04E-8	3.13E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.74E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Copper	-	-	kg	3.75E-10	3.68E-10	3.70E-10	3.82E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 2.12E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Nickel	-	-	kg	1.56E-10	1.53E-10	1.54E-10	1.58E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.80E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium	-	-	kg	5.31E-10	5.21E-10	5.24E-10	5.40E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Chromium VI	-	-	kg	1.06E-12	1.04E-12	1.05E-12	1.08E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 6.00E-11 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Mercury	-	-	kg	9.37E-11	9.20E-11	9.26E-11	9.54E-11	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	1.54E-10	1.51E-10	1.52E-10	1.57E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 8.70E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Lead	-	-	kg	9.21E-10	9.05E-10	9.10E-10	9.38E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.21E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	-	-	kg	9.36E-8	9.36E-8	9.36E-8	9.36E-8	1	1.51	(2,2,2,3,1,2,BU:1.5); Refrigerant used for air conditioning. Calculated based on average refrigerant charge and emission rates during production, use and end of life. Refrigerant emissions: 1.73E-06 kg/vkm; Average load factor: 18.50 t; National Greenhouse Gas Inventory Report of Switzerland 2015, Item 2F1; Personal communication Cornelia Stettler, Carbotech
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	5.41E-2	5.41E-2	5.41E-2	5.41E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Frischknecht & Büsser Knöpfel 2013
technosphere	road wear emissions, lorry	RER	0	kg	1.57E-5	1.57E-5	1.57E-5	1.57E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 7.00E-06 kg/(tGVW*km); Average load factor: 18.5 t; Vehicle weight: 23 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vii, Tab. 3-2
	tyre wear emissions, lorry	RER	0	kg	1.81E-4	1.81E-4	1.81E-4	1.81E-4	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.06E-05 kg/(tGVW*km); Average load factor: 18.5 t; Vehicle weight: 23 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	brake wear emissions, lorry	RER	0	kg	1.82E-5	1.82E-5	1.82E-5	1.82E-5	1	2.02	(2,2,3,3,1,2,BU:2); Emission factor: 8.13E-06 kg/(tGVW*km); Average load factor: 18.5 t; Vehicle weight: 23 t; Ecoinvent v3.1; Tremove model v2.7b; EMEP/EEA guidebook 2013, 1.A.3.b.vi, Tab. 3-1
	disposal, lorry 40t	CH	1	unit	1.35E-7	1.00E-7	1.00E-7	1.00E-7	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 540000 vkm; Average load factor: 18.5 t; Lorry scaled based on vehicle weight; Ecoinvent v2; Tremove model v2.7b
	disposal, road	RER	1	ma	1.06E-3	1.06E-3	1.06E-3	1.06E-3	1	3.07	(3,1,3,2,1,5,BU:3); Road demand: 4.73E-04 my/(tGVW*km); Average load factor: 18.5 t; Vehicle weight: 23 t; Ecoinvent v2; Tremove model v2.7b

5.4 Lorry fleet mixes

5.4.1 Overview

The updated freight transport processes by lorry from ecoinvent data v3.1 were transferred to KBOB life cycle inventory data v2.2:2016 for the calculation of the environmental indicator results contained in mobitool. Fleet mixes of different emission classes of lorries with a GVW of 3.5-7.5 t, 7.5-16 t, 16-32 t and 32-40 t operated in Switzerland in the year 2015 were compiled. In addition, an average lorry fleet composed of different size and emission classes was defined. The shares of the individual lorry classes are based on data from HBEFA (2014).

5.4.2 Shares of lorry sizes

The shares of both rigid and articulated lorries were considered in the fleet mix. The definition of size classes in HBEFA did not always comply with the size classes distinguished in the transport datasets. In these cases, the respective vehicle segment was assigned to the ecoinvent size class with the larger overlap. For instance, transport performance data on articulated lorries with a GVW of 28-34 t distinguished in HBEFA were assigned to datasets representing transports by 16-32 t lorries. The fleet mixes include lorries of the emission classes Euro 3 to Euro 6. The (small) shares of lorries, which do not comply with any one of these emission classes, were not considered due to missing life cycle inventory data.

5.4.3 Shares of emission classes

The shares of the emission classes in the fleet mix of a given size class were determined based on their respective shares in the vehicle kilometres travelled as reported in HBEFA (2014). This approach is based on the assumption that the average load of lorries is independent of the emission class.

5.4.4 Swiss average lorry

The fleet mix of all lorry transports in Switzerland contains lorries with a GVW of 3.5-7.5 t, 7.5-16 t, 16-32 t and 32-40 t and of the emission classes Euro 3, Euro 4, Euro 5 and Euro 6. Lorries with a GVW of more than 40 tons are not permitted to circulate on Swiss roads. The shares of the individual lorry size and emission classes were calculated based on the shares of vehicle kilometres travelled according to HBEFA (2014) multiplied by the average load of the respective size class.

5.4.5 Emissions during operation

In order to ensure consistency between the means of transport considered in this study, the emissions of noise according to the recommendation in the ecological scarcity method 2013 (Frischknecht & Büsser Knöpfel 2013) and the use and emissions of refrigerants from air conditioners were added to the original processes for freight transports by lorry. The procedure followed to calculate the refrigerant and the noise emissions by lorries is described in some more detail in the subchapters 3.5 and 3.6, respectively.

5.4.6 Unit process life cycle inventory data

The life cycle inventories of the fleet mixes of lorries with a GVW of 3.5-7.5 t, 7.5-16 t, 16-32 t and 32-40 t are shown in Tab. 5.6 to Tab. 5.9. The composition of the whole lorry fleet in Switzerland is listed in Tab. 5.10.

Tab. 5.6 Life cycle inventory of the fleet mix of lorries with a GVW of 3.5-7.5 t in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, freight, lorry 3.5-7.5 metric ton, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				tkm			
product	transport, freight, lorry 3.5-7.5 metric ton, fleet average	CH	0	tkm	1			
technosphere	transport, freight, lorry 3.5-7.5 metric ton, EURO 3	RER	0	tkm	1.68E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 3.5-7.5 metric ton, EURO 4	RER	0	tkm	1.23E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 3.5-7.5 metric ton, EURO 5	RER	0	tkm	5.25E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 3.5-7.5 metric ton, EURO 6	RER	0	tkm	1.84E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2

Tab. 5.7 Life cycle inventory of the fleet mix of lorries with a GVW of 7.5-16 t in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, freight, lorry 7.5-16 metric ton, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				tkm			
product	transport, freight, lorry 7.5-16 metric ton, fleet average	CH	0	tkm	1			
technosphere	transport, freight, lorry 7.5-16 metric ton, EURO 3	RER	0	tkm	2.21E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 7.5-16 metric ton, EURO 4	RER	0	tkm	5.07E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 7.5-16 metric ton, EURO 5	RER	0	tkm	5.38E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 7.5-16 metric ton, EURO 6	RER	0	tkm	1.91E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2

Tab. 5.8 Life cycle inventory of the fleet mix of lorries with a GVW of 16-32 t in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, freight, lorry 16-32 metric ton, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				tkm			
product	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	1			
technosphere	transport, freight, lorry 16-32 metric ton, EURO 3	RER	0	tkm	1.25E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 16-32 metric ton, EURO 4	RER	0	tkm	2.73E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 16-32 metric ton, EURO 5	RER	0	tkm	6.70E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 16-32 metric ton, EURO 6	RER	0	tkm	1.78E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2

Tab. 5.9 Life cycle inventory of the fleet mix of lorries with a GVW of 32-40 t in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, freight, lorry 32-40 metric ton, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				tkm			
product	transport, freight, lorry 32-40 metric ton, fleet average	CH	0	tkm	1			
technosphere	transport, freight, lorry 32-40 metric ton, EURO 3	RER	0	tkm	3.88E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 32-40 metric ton, EURO 4	RER	0	tkm	1.36E-2	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 32-40 metric ton, EURO 5	RER	0	tkm	6.30E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 32-40 metric ton, EURO 6	RER	0	tkm	3.18E-1	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2

Tab. 5.10 Life cycle inventory of the average Swiss lorry, based on the fleet mix of lorries of different size and emission classes in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	transport, freight, lorry, fleet average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				tkm			
product	transport, freight, lorry, fleet average	CH	0	tkm	1			
technosphere	transport, freight, lorry 3.5-7.5 metric ton, EURO 3	RER	0	tkm	4.56E-04	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 3.5-7.5 metric ton, EURO 4	RER	0	tkm	3.34E-04	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 3.5-7.5 metric ton, EURO 5	RER	0	tkm	1.42E-03	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 3.5-7.5 metric ton, EURO 6	RER	0	tkm	4.99E-04	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 7.5-16 metric ton, EURO 3	RER	0	tkm	6.98E-03	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 7.5-16 metric ton, EURO 4	RER	0	tkm	1.60E-03	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 7.5-16 metric ton, EURO 5	RER	0	tkm	1.70E-02	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 7.5-16 metric ton, EURO 6	RER	0	tkm	6.04E-03	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 16-32 metric ton, EURO 3	RER	0	tkm	4.09E-02	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 16-32 metric ton, EURO 4	RER	0	tkm	8.93E-03	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 16-32 metric ton, EURO 5	RER	0	tkm	2.19E-01	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 16-32 metric ton, EURO 6	RER	0	tkm	5.84E-02	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 32-40 metric ton, EURO 3	RER	0	tkm	2.47E-02	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 32-40 metric ton, EURO 4	RER	0	tkm	8.68E-03	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 32-40 metric ton, EURO 5	RER	0	tkm	4.02E-01	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 32-40 metric ton, EURO 6	RER	0	tkm	2.03E-01	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 40-50 metric ton, EURO 3	RER	0	tkm	0.00E+00	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 40-50 metric ton, EURO 4	RER	0	tkm	0.00E+00	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 40-50 metric ton, EURO 5	RER	0	tkm	0.00E+00	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 40-50 metric ton, EURO 6	RER	0	tkm	0.00E+00	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 50-60 metric ton, EURO 3	RER	0	tkm	0.00E+00	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 50-60 metric ton, EURO 4	RER	0	tkm	0.00E+00	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 50-60 metric ton, EURO 5	RER	0	tkm	0.00E+00	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2
	transport, freight, lorry 50-60 metric ton, EURO 6	RER	0	tkm	0.00E+00	1	2.05	(2,1,1,2,1,5,BU:2); Share for Switzerland in 2015; HBEFA v3.2

6 Non-road vehicles

6.1 Overview

Non-road vehicles are mobile machines equipped with a combustion engine. They serve various purposes in the construction, industry, agriculture and forestry sectors. Non-road machines are not intended for the transport of passengers or goods by road (Notter & Schmied 2015). This chapter covers two non-road vehicles, namely an average building machine and hydraulic diggers. The life cycle inventories of the operation of building machines and hydraulic diggers were updated in the present study and are described in subchapters 6.2 and 6.3, respectively.

6.2 Building machine

6.2.1 Overview

Building machines encompass a wide variety of vehicles such as asphalt finishers, rollers, vibrators, graders, compressors and cranes (Notter & Schmied 2015). The existing life cycle inventory published in ecoinvent data v2 of the operation of an average building machine was updated.

Data on the specific machines of all power classes used in the construction sector available in the Swiss non-road database[16] were aggregated to an average building machine (weighted by fuel consumption) based on the respective stock, the specific fuel consumption per working hour and the respective working hours. The categories excavators, lorries without license for use on road, generators and pumps were disregarded because more specific life cycle inventory datasets are available representing these processes in KBOB life cycle inventory data v2.2:2016. Furthermore, all petrol-fuelled machines were excluded because only building machines operated with diesel fuel are supposed to be represented by the life cycle inventories.

The fuel consumption and air pollutant emission factors were calculated for building machines equipped with particle filter and for machines with minimal particle filter (in the following called “without particle filter” to facilitate the differentiation of the two groups), which is installed only if it is legally required in Switzerland (this applies to some specific machine categories from a certain power level) as well as for the average of both (Notter & Schmied 2015). In Switzerland in 2015 the weighted share of building machines equipped with particle filters is 92 %.

The manufacture of building machines is described in section 6.2.2. The calculation of the fuel demand and the emission factors are documented in section 6.2.3. The section

[16] Federal Office for the Environment: Non-road database, http://www.bafu.admin.ch/luft/00596/06906/offroad-daten/index.html?lang=en, accessed on 21.03.2016.

6.2.4 contains the unit process life cycle inventory data of the operation of building machines.

6.2.2 Manufacture of building machines

The manufacture of the building machine was modelled using the existing dataset published in ecoinvent data v2 since more recent data on its manufacturing or material composition were not available. As reported by Kellenberger et al. (2007), an average service life of 10’000 h was used in this study and the weight of the building machine was assumed to be unchanged at 10 t. Due to the difference in hourly fuel consumption of building machines with and without particle filter, the demand of building machine construction differs. Furthermore, as the hourly fuel consumption of building machines of a size of about 10 t is substantially lower than 20 years ago, the demand in machines per MJ diesel increased by a factor of 2.5. A wheel loader of the power class 75-130 kW with a fuel consumption close to the one of the average building machine was considered to plausibilize this reduction. The wheel loaders L 528 has a mechanical power of 100 kW and a weight of approximately 10.8 t (Liebherr 2015). However, the building machines considered are very heterogeneous and include also lighter machines such as compressors.

6.2.3 Fuel consumption and emissions during operation

The diesel consumption and the emission factors of the air pollutants CO_2, CO, CH_4, NMVOC, NO_x, N_2O and PM were quantified using information obtained from the Swiss non-road database for the year 2015[16] and are compiled in Tab. 6.1. The diesel consumption of building machines with and without particle filter amounts to 6.99 kg/h (299 MJ/h) and 6.79 kg/h (290 MJ/h), respectively. The PM emission factors of building machines without particle filter are higher by a factor of 9.3 compared to those equipped with a particle filter. Building machines without particle filter have approximately 3 % higher emission factors per kilogram diesel than building machines with particle filter when considering the other air pollutants, with the exception of CO_2.

Tab. 6.1 Fuel consumption and emission factors for the operation of building machines without and with particle filter and for average building machines in Switzerland 2015 according to the non-road database.

Substance	Unit	Building machine		
		Without PF	With PF	Average
Fuel consumption	kgDiesel/h	6.79E+00	6.99E+00	6.98E+00
Carbon dioxide	kgCO_2/kgDiesel	3.15E+00	3.15E+00	3.15E+00
Carbon monoxide	kgCO/kgDiesel	5.51E-03	5.35E-03	5.35E-03
Methane	kgCH_4/kgDiesel	2.67E-05	2.59E-05	2.59E-05
Non-methane volatile organic compounds	kgNMVOC/kgDiesel	1.09E-03	1.06E-03	1.06E-03
Nitrogen oxides	kgNO_x/kgDiesel	1.45E-02	1.41E-02	1.41E-02
Dinitrogen monoxide	kgN_2O/kgDiesel	1.47E-04	1.43E-04	1.43E-04
Particulates, < 2.5 um	kg$PM_{2.5}$/kgDiesel	1.02E-03	1.10E-04	1.79E-04

A fraction of the total NMVOC emissions was further divided into main components based on the shares reported in the EMEP/EEA air pollutant emission inventory guidebook (see Tab. 3.1). The emissions of NH_3, SO_2, PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed and were calculated using the emission factors compiled in Tab. 3.2.

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The conversion of the noise emissions of an average building machine to the unit of the corresponding elementary flows, namely kilometre, is complex and requires simplifying assumptions. It is assumed that noise emissions correlate with the power of a machine and hence should be proportional to its fuel consumption. The noise of an average lorry in Switzerland was used as an approximation and scaled based on the fuel consumption. 1 MJ diesel burned in an average building machine causes 0.0955 noise kilometres of a lorry[17].

The consumption of lubricating oil ($5.14 \cdot 10^{-4}$ kg/MJ) was adopted from the dataset documented in Kellenberger et al. (2007).

6.2.4 Unit process life cycle inventory data

The life cycle inventories of the operation of building machines with and without particle filter are shown in Tab. 6.2 and Tab. 6.3, respectively. The life cycle inventory of diesel burnt in an average building machine in Switzerland in 2015 is presented in Tab. 6.4.

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[17] The average lorry in Switzerland in 2015, considering all size and emission classes, has a diesel consumption of 0.245 kg/km (10.4 MJ/km, INFRAS 2014) and causes 1 noise km.

Tab. 6.2 Life cycle inventory of diesel burned in a building machine with particle filter.

	Name	Location	InfrastructureProcess	Unit	diesel, burned in building machine, with particle filter	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				MJ			
product	diesel, burned in building machine, with particle filter	CH	0	MJ	1			
technosphere	building machine	RER	1	unit	3.34E-07	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 10'000 h; Average fuel consumption: 299 MJ/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII; BAFU 2015
	diesel, low-sulphur, at regional storage	CH	0	kg	2.34E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Net calorific value diesel: 42.8 MJ/kg; Frischknecht et al. 2007: ecoinvent report 1, Tab. 4.6
	lubricating oil, at plant	RER	0	kg	5.14E-4	1	1.09	(2,2,2,3,1,2,BU:1.05); Amount taken from ecoinvent data v2; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	7.36E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Carbon monoxide, fossil	-	-	kg	1.25E-4	1	5.01	(2,2,2,3,1,2,BU:5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Methane, fossil	-	-	kg	6.06E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.01E-5	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Ethane	-	-	kg	7.41E-9	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.03%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	2.47E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.10%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Butane	-	-	kg	3.70E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.15%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	1.48E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.06%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	7.41E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.30%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzene	-	-	kg	1.73E-8	1	3.05	(2,2,2,3,3,2,BU:3); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.07%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	2.47E-9	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.01%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	2.42E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.98%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	9.88E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	2.07E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 8.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	1.13E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 4.57%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	3.38E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.37%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acrolein	-	-	kg	4.37E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.77%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	1.38E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.56%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Nitrogen oxides	-	-	kg	3.29E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Ammonia	-	-	kg	1.87E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Fuel dependent emission factor: 8.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Dinitrogen monoxide	-	-	kg	3.34E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Sulfur dioxide	-	-	kg	4.67E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel dependent emission factor: 2.00E-05 kg/kgfuel; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	2.57E-6	1	3.01	(2,2,2,3,1,2,BU:3); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Benzo(a)pyrene	-	-	kg	7.01E-10	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	7.69E-8	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.29E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	2.34E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	2.34E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	2.34E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	3.97E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.70E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	1.64E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 7.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	1.17E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	2.34E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	1.24E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	2.34E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	1.21E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	9.55E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Estimated based on fuel consumption of an average lorry in Switzerland in 2015: 0.245 kg/km; Frischknecht & Büsser Knöpfel 2013; HBEFA database v3.2
technosphere	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	5.14E-4	1	1.13	(2,2,3,3,1,2,BU:1.05); Amount taken from ecoinvent data v2; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII

Tab. 6.3 Life cycle inventory of diesel burned in a building machine without particle filter.

	Name	Location	InfrastructureProcess	Unit	diesel, burned in building machine, without particle filter	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				MJ			
product	diesel, burned in building machine, without particle filter	CH	0	MJ	1			
technosphere	building machine	RER	1	unit	3.44E-07	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 10'000 h; Average fuel consumption: 290 MJ/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII; BAFU 2015
	diesel, low-sulphur, at regional storage	CH	0	kg	2.34E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Net calorific value diesel: 42.8 MJ/kg; Frischknecht et al. 2007: ecoinvent report 1, Tab. 4.6
	lubricating oil, at plant	RER	0	kg	5.14E-4	1	1.09	(2,2,2,3,1,2,BU:1.05); Amount taken from ecoinvent data v2; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	7.36E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Carbon monoxide, fossil	-	-	kg	1.29E-4	1	5.01	(2,2,2,3,1,2,BU:5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Methane, fossil	-	-	kg	6.24E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.07E-5	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Ethane	-	-	kg	7.63E-9	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.03%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	2.54E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.10%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Butane	-	-	kg	3.82E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.15%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	1.53E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.06%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	7.63E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.30%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzene	-	-	kg	1.78E-8	1	3.05	(2,2,2,3,3,2,BU:3); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.07%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	2.54E-9	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.01%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	2.49E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.98%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	1.02E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	2.14E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 8.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	1.16E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 4.57%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	3.49E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.37%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acrolein	-	-	kg	4.50E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.77%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	1.42E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.56%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Nitrogen oxides	-	-	kg	3.39E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Ammonia	-	-	kg	1.87E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Fuel dependent emission factor: 8.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Dinitrogen monoxide	-	-	kg	3.44E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Sulfur dioxide	-	-	kg	4.67E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel dependent emission factor: 2.00E-05 kg/kgfuel; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	2.39E-5	1	3.01	(2,2,2,3,1,2,BU:3); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Benzo(a)pyrene	-	-	kg	7.01E-10	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	7.69E-8	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.29E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	2.34E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	2.34E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	2.34E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	3.97E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.70E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	1.64E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 7.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	1.17E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	2.34E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	1.24E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	2.34E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	1.21E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	9.55E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Estimated based on fuel consumption of an average lorry in Switzerland in 2015: 0.245 kg/km; Frischknecht & Büsser Knöpfel 2013; HBEFA database v3.2
technosphere	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	5.14E-4	1	1.13	(2,2,3,3,1,2,BU:1.05); Amount taken from ecoinvent data v2; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII

Tab. 6.4 Life cycle inventory of diesel burned in an average building machine in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	diesel, burned in building machine, average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				MJ			
product	diesel, burned in building machine, average	CH	0	MJ	1			
technosphere	building machine	RER	1	unit	3.35E-07	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 10'000 h; Average fuel consumption: 299 MJ/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII; BAFU 2015
	diesel, low-sulphur, at regional storage	CH	0	kg	2.34E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Net calorific value diesel: 42.8 MJ/kg; Frischknecht et al. 2007: ecoinvent report 1, Tab. 4.6
	lubricating oil, at plant	RER	0	kg	5.14E-4	1	1.09	(2,2,2,3,1,2,BU:1.05); Amount taken from ecoinvent data v2; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	7.36E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Carbon monoxide, fossil	-	-	kg	1.25E-4	1	5.01	(2,2,2,3,1,2,BU:5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Methane, fossil	-	-	kg	6.06E-7	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.01E-5	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Ethane	-	-	kg	7.42E-9	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.03%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	2.47E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.10%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Butane	-	-	kg	3.71E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.15%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	1.48E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.06%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	7.42E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.30%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzene	-	-	kg	1.73E-8	1	3.05	(2,2,2,3,3,2,BU:3); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.07%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	2.47E-9	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.01%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	2.42E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.98%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	9.89E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	2.08E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 8.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	1.13E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 4.57%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	3.39E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.37%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acrolein	-	-	kg	4.38E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.77%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	1.38E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.56%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Nitrogen oxides	-	-	kg	3.29E-4	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Ammonia	-	-	kg	1.87E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Fuel dependent emission factor: 8.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Dinitrogen monoxide	-	-	kg	3.35E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Sulfur dioxide	-	-	kg	4.67E-7	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel dependent emission factor: 2.00E-05 kg/kgfuel; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	4.17E-6	1	3.01	(2,2,2,3,1,2,BU:3); Average building machine in Switzerland in 2015; BAFU 2015: Non-road database
	Benzo(a)pyrene	-	-	kg	7.01E-10	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	7.69E-8	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.29E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	2.34E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	2.34E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	2.34E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	3.97E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.70E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	1.64E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 7.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	1.17E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	2.34E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	1.24E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	2.34E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	1.21E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	9.55E-2	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Estimated based on fuel consumption of an average lorry in Switzerland in 2015: 0.245 kg/km; Frischknecht & Büsser Knöpfel 2013; HBEFA database v3.2
technosphere	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	5.14E-4	1	1.13	(2,2,3,3,1,2,BU:1.05); Amount taken from ecoinvent data v2; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII

6.3 Hydraulic Digger

6.3.1 Overview

The hydraulic diggers considered include both crawler and wheeled excavators (Notter & Schmied 2015). The existing life cycle inventory dataset published in ecoinvent data v2 of excavation activities by an average hydraulic digger was updated based on fuel consumption and air pollutant emission factors obtained from the Swiss non-road database[16]. The hydraulic diggers considered have an average excavation capacity of 100 m^3/h and a mechanical power of approximately 100 kW (Kellenberger et al. 2007). The fuel consumption and air pollutant emission factors were calculated for crawler and wheeled excavators of the power class 75-130 kW. Separate life cycle inventories were compiled for hydraulic diggers equipped with particle filter and for excavators with minimal particle filter (in the following called “without particle filter” to facilitate the differentiation of the two groups), which is installed only if it is legally required in Switzerland (this applies to some specific machine categories from a certain power level). In addition, an average was calculated including both machines with and without particle filter (Notter & Schmied 2015). In Switzerland in 2015 the share of hydraulic diggers with particle filters is 98 %.

The manufacture of hydraulic diggers is described in section 6.3.2. The calculation of the fuel demand and the emission factors are documented in section 6.3.3. The section 6.3.4 contains the unit process life cycle inventory data of the excavation by hydraulic diggers.

6.3.2 Manufacture of hydraulic diggers

The hydraulic digger was modelled by the existing dataset in ecoinvent v2 since more recent data on its manufacturing or material composition were not available. As reported by Kellenberger et al. (2007), an average service life of 10’000 h was used in this study and the weight of the hydraulic digger was assumed to be unchanged at 15 t.

6.3.3 Fuel consumption and emissions during operation

The diesel consumption and the emission factors of the air pollutants CO_2, CO, CH_4, NMVOC, NO_x, N_2O and PM were quantified using the information obtained from the Swiss non-road database for the year 2015[16] and are compiled in Tab. 6.5. The diesel consumption of hydraulic diggers with and without particle filter amounts to 9.47 kg/h and 9.20 kg/h, respectively. The PM emission factors of hydraulic diggers without particle filter are higher by a factor of 9.6 compared to those equipped with a particle filter. Hydraulic diggers without particle filter have approximately 3 % higher emission factors per kilogram diesel than hydraulic diggers with particle filter when considering the other air pollutants, with the exception of CO_2.

Tab. 6.5 Fuel consumption and emission factors for the operation of hydraulic diggers without and with particle filter and for average hydraulic diggers in Switzerland 2015 according to the non-road database.

Substance	**Unit**	**Hydraulic digger**		
		Without PF	**With PF**	**Average**
Fuel consumption	kgDiesel/h	9.20E+00	9.47E+00	9.47E+00
Carbon dioxide	kgCO_2/kgDiesel	3.15E+00	3.15E+00	3.15E+00
Carbon monoxide	kgCO/kgDiesel	7.64E-03	7.42E-03	7.42E-03
Methane	kgCH_4/kgDiesel	4.02E-05	3.90E-05	3.90E-05
Non-methane volatile organic compounds	kgNMVOC/kgDiesel	1.55E-03	1.51E-03	1.51E-03
Nitrogen oxides	kgNO_x/kgDiesel	1.87E-02	1.81E-02	1.81E-02
Dinitrogen monoxide	kgN_2O/kgDiesel	1.57E-04	1.53E-04	1.53E-04
Particulates, < 2.5 um	kg$PM_{2.5}$/kgDiesel	1.37E-03	1.42E-04	1.60E-04

A fraction of the total NMVOC emissions was further divided into main components based on the shares reported in the EMEP/EEA air pollutant emission inventory guidebook (see Tab. 3.1). The emissions of NH_3, SO_2, PAHs, arsenic, selenium and heavy metals (cadmium, chromium, chromium VI, copper, lead, mercury, nickel, zinc) depend on the amount of fuel consumed and were calculated using the emission factors compiled in Tab. 3.2.

Noise emissions were accounted for as recommended by Frischknecht and Büsser Knöpfel (2013). The conversion of the noise emissions of an average building machine to the unit of the corresponding elementary flows, namely kilometre, is complex and requires simplifying assumptions. It is assumed that noise emissions correlate with the power of a machine and hence should be proportional to its fuel consumption. The noise of an average lorry in Switzerland was used as an approximation and scaled based on the fuel consumption. The excavation of 1 m^3 by an average hydraulic digger causes 0.387 noise kilometres of a lorry[17].

The consumption of lubricating oil (0.0025 kg/m^3) was taken from the life cycle inventory of excavation by hydraulic diggers in ecoinvent data v2 and scaled according to the fuel demand (Kellenberger et al. 2007).

6.3.4 Unit process life cycle inventory data

The unit process life cycle inventory data of the excavation by hydraulic diggers with and without particle filter are shown in Tab. 6.6 and Tab. 6.7, respectively. The unit process life cycle inventory data of the operation of the average hydraulic digger operated in Switzerland in 2015 are presented in Tab. 6.8.

Tab. 6.6 Life cycle inventory of the excavation by a hydraulic digger with particle filter.

	Name	Location	InfrastructureProcess	Unit	excavation, hydraulic digger, with particle filter	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				m3			
product	excavation, hydraulic digger, with particle filter	CH	0	m3	1			
technosphere	hydraulic digger	RER	1	unit	1.00E-06	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 10'000 h; Average excavation capacity: 100 m3/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
	diesel, low-sulphur, at regional storage	CH	0	kg	9.47E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average excavation capacity: 100 m3/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
	lubricating oil, at plant	RER	0	kg	1.81E-3	1	1.09	(2,2,2,3,1,2,BU:1.05); Amount scaled based on fuel demand; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	2.98E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Carbon monoxide, fossil	-	-	kg	7.03E-4	1	5.01	(2,2,2,3,1,2,BU:5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Methane, fossil	-	-	kg	3.69E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.16E-4	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Ethane	-	-	kg	4.28E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.03%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	1.43E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.10%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Butane	-	-	kg	2.14E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.15%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	8.56E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.06%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	4.28E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.30%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzene	-	-	kg	9.99E-8	1	3.05	(2,2,2,3,3,2,BU:3); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.07%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	1.43E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.01%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	1.40E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.98%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	5.71E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	1.20E-5	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 8.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	6.52E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 4.57%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	1.96E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.37%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acrolein	-	-	kg	2.53E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.77%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	7.99E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.56%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Nitrogen oxides	-	-	kg	1.72E-3	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Ammonia	-	-	kg	7.58E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Fuel dependent emission factor: 8.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Dinitrogen monoxide	-	-	kg	1.45E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Sulfur dioxide	-	-	kg	1.89E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel dependent emission factor: 2.00E-05 kg/kgfuel; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.35E-5	1	3.01	(2,2,2,3,1,2,BU:3); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Benzo(a)pyrene	-	-	kg	2.84E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	3.12E-7	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.29E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	9.47E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	9.47E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	9.47E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	1.61E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.70E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	6.63E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 7.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	4.74E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	9.47E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	5.02E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	9.47E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	4.93E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	3.87E-1	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Estimated based on fuel consumption of an average lorry in Switzerland in 2015: 0.245 kg/km; Frischknecht & Büsser Knöpfel 2013; HBEFA database v3.2
technosphere	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.81E-3	1	1.13	(2,2,3,3,1,2,BU:1.05); Amount scaled based on fuel demand; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII

Tab. 6.7 Life cycle inventory of the excavation by a hydraulic digger without particle filter.

	Name	Location	InfrastructureProcess	Unit	excavation, hydraulic digger, without particle filter	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				m3			
product	excavation, hydraulic digger, without particle filter	CH	0	m3	1			
technosphere	hydraulic digger	RER	1	unit	1.00E-06	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 10'000 h; Average excavation capacity: 100 m3/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
	diesel, low-sulphur, at regional storage	CH	0	kg	9.20E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average excavation capacity: 100 m3/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
	lubricating oil, at plant	RER	0	kg	1.76E-3	1	1.09	(2,2,2,3,1,2,BU:1.05); Amount scaled based on fuel demand; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	2.90E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Carbon monoxide, fossil	-	-	kg	7.03E-4	1	5.01	(2,2,2,3,1,2,BU:5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Methane, fossil	-	-	kg	3.69E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.16E-4	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Ethane	-	-	kg	4.28E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.03%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	1.43E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.10%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Butane	-	-	kg	2.14E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.15%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	8.56E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.06%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	4.28E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.30%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzene	-	-	kg	9.99E-8	1	3.05	(2,2,2,3,3,2,BU:3); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.07%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	1.43E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.01%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	1.40E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.98%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	5.71E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	1.20E-5	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 8.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	6.52E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 4.57%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	1.96E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.37%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acrolein	-	-	kg	2.53E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.77%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	7.99E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.56%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Nitrogen oxides	-	-	kg	1.72E-3	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Ammonia	-	-	kg	7.36E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Fuel dependent emission factor: 8.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Dinitrogen monoxide	-	-	kg	1.45E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Sulfur dioxide	-	-	kg	1.84E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel dependent emission factor: 2.00E-05 kg/kgfuel; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.26E-4	1	3.01	(2,2,2,3,1,2,BU:3); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Benzo(a)pyrene	-	-	kg	2.76E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	3.03E-7	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.29E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	9.20E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	9.20E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	9.20E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	1.56E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.70E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	6.44E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 7.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	4.60E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	9.20E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	4.87E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	9.20E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	4.78E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	3.76E-1	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Estimated based on fuel consumption of an average lorry in Switzerland in 2015: 0.245 kg/km; Frischknecht & Büsser Knöpfel 2013; HBEFA database v3.2
technosphere	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.76E-3	1	1.13	(2,2,3,3,1,2,BU:1.05); Amount scaled based on fuel demand; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII

Tab. 6.8 Life cycle inventory of the excavation by an average hydraulic digger in Switzerland in 2015.

	Name	Location	InfrastructureProcess	Unit	excavation, hydraulic digger, average	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				m3			
product	excavation, hydraulic digger, average	CH	0	m3	1			
technosphere	hydraulic digger	RER	1	unit	1.00E-06	1	3.07	(3,1,3,2,1,5,BU:3); Vehicle life time performance: 10'000 h; Average excavation capacity: 100 m3/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
	diesel, low-sulphur, at regional storage	CH	0	kg	9.47E-2	1	1.09	(2,2,2,3,1,2,BU:1.05); Average excavation capacity: 100 m3/h; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
	lubricating oil, at plant	RER	0	kg	1.81E-3	1	1.09	(2,2,2,3,1,2,BU:1.05); Amount scaled based on fuel demand; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII
emission air, unspecified	Carbon dioxide, fossil	-	-	kg	2.98E-1	1	1.09	(2,2,2,3,1,2,BU:1.05); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Carbon monoxide, fossil	-	-	kg	7.03E-4	1	5.01	(2,2,2,3,1,2,BU:5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Methane, fossil	-	-	kg	3.69E-6	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	1.16E-4	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Unspecified NMVOC for which no elementary exchange exists; 81.2% of total NMVOC emissions; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Ethane	-	-	kg	4.28E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.03%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Propane	-	-	kg	1.43E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.10%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Butane	-	-	kg	2.14E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.15%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Pentane	-	-	kg	8.56E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.06%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Heptane	-	-	kg	4.28E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.30%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzene	-	-	kg	9.99E-8	1	3.05	(2,2,2,3,3,2,BU:3); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.07%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Toluene	-	-	kg	1.43E-8	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.01%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	m-Xylene	-	-	kg	1.40E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.98%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	o-Xylene	-	-	kg	5.71E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Formaldehyde	-	-	kg	1.20E-5	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 8.40%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acetaldehyde	-	-	kg	6.52E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 4.57%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Benzaldehyde	-	-	kg	1.96E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.37%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Acrolein	-	-	kg	2.53E-6	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 1.77%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Styrene	-	-	kg	7.99E-7	1	1.57	(2,2,2,3,3,2,BU:1.5); Modelled by NMVOC speciation of lorries; Share in total NMVOC emissions: 0.56%; BAFU 2015: Non-road database; EMEP/EEA guidebook 2013, Tab. 3-112
	Nitrogen oxides	-	-	kg	1.72E-3	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Ammonia	-	-	kg	7.58E-7	1	1.21	(2,2,2,3,1,2,BU:1.2); Fuel dependent emission factor: 8.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Dinitrogen monoxide	-	-	kg	1.45E-5	1	1.51	(2,2,2,3,1,2,BU:1.5); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Sulfur dioxide	-	-	kg	1.89E-6	1	1.09	(2,2,2,3,1,2,BU:1.05); Fuel dependent emission factor: 2.00E-05 kg/kgfuel; HBEFA database v3.2
	Particulates, < 2.5 um	-	-	kg	1.52E-5	1	3.01	(2,2,2,3,1,2,BU:3); Average hydraulic digger in Switzerland in 2015; BAFU 2015: Non-road database
	Benzo(a)pyrene	-	-	kg	2.84E-9	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	3.12E-7	1	3.01	(2,2,2,3,1,2,BU:3); Fuel dependent emission factor: 3.29E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Arsenic	-	-	kg	9.47E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Selenium	-	-	kg	9.47E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Zinc	-	-	kg	9.47E-8	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Copper	-	-	kg	1.61E-7	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.70E-06 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Nickel	-	-	kg	6.63E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 7.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium	-	-	kg	4.74E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Chromium VI	-	-	kg	9.47E-12	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-10 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Mercury	-	-	kg	5.02E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.30E-09 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-103
	Cadmium	-	-	kg	9.47E-10	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 1.00E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.2.f.ii, Tab. 3-1
	Lead	-	-	kg	4.93E-9	1	5.01	(2,2,2,3,1,2,BU:5); Fuel dependent emission factor: 5.20E-08 kg/kgfuel; EMEP/EEA guidebook 2013, 1.A.3.b.i-iv, Tab. 3-10
emission Non material emissions, unspecified	Noise, road, lorry, average	-	-	km	3.87E-1	1	1.51	(2,2,2,3,1,2,BU:1.5); Ecological Scarcity method 2013; Estimated based on fuel consumption of an average lorry in Switzerland in 2015: 0.245 kg/km; Frischknecht & Büsser Knöpfel 2013; HBEFA database v3.2
technosphere	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.81E-3	1	1.13	(2,2,3,3,1,2,BU:1.05); Amount scaled based on fuel demand; Kellenberger et al. 2007: ecoinvent report 7, Part XVIII

7 Conclusion

The life cycle inventories of several road and non-road transport processes were updated or newly created in this study and linked to KBOB life cycle inventory data v2.2:2016. A special focus was given at the continuity and consistency of the datasets with regard to the original processes contained in ecoinvent data v2.

The most recent and most reliable data available were used to compile or update the life cycle inventories. Nevertheless, some parts of the life cycle of transport services could not be updated due to a lack of more recent data and limited resources. This holds particularly true for the production, maintenance and disposal of the vehicles. In addition, some assumptions were unavoidable in cases where data and information were available but contradictory. For instance, the average load factor of lorries could be calculated based on a number of different data sources but still had to be defined in the end. In general, the data quality of the road and non-road transport processes compiled in this study is classified as good and data gaps as well as assumptions are transparently documented.

The environmental indicator results of the road and non-road transport processes compiled in this study will be made available via mobitool[2] and the KBOB recommendation 2009/1:2017 in late November 2016 and fall 2017, respectively. Several impact assessment methods were employed to quantify the environmental impacts: total environmental impacts according to the Ecological Scarcity method 2013 and the ReCiPe 2008 endpoint method, primary energy total and non-renewable, greenhouse gas emissions, as well as the emissions of PM10, PM2.5, NMVOC and NO_x.

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A Appendix: NCM Li-ion battery

A.1 Overview

A new life cycle assessment study of a lithium-ion battery vehicle pack was recently published by Ager-Wick Ellingsen et al. (2014). In this study recent data of the battery production were used and detailed life cycle inventory data were published in the supporting information. This new data of the battery production was therefore added to the KBOB life cycle inventory database v2.2:2016. In the following section the NCM Li-ion battery pack (section A.2) and the different components (single cell (section A.3), anode (section A.4), cathode (section A.5), electrolyte (section A.6), separator (section A.7), battery management system (section A.8) and battery cooling system (section A.9)) are presented.

A.2 Assembly of the NCM Li-ion battery

In Tab. A. 1 the life cycle inventory of the NCM Li-ion battery pack is presented. It includes single cell, battery management system, battery cooling system as well as battery packing. The assembly process takes place in Norway (NO) but the battery cells are produced in East Asia (RAS). These data correspond to the data published by Ager-Wick Ellingsen et al. (2014) and can be found in the supporting information in Tab. S2. However the battery packing was not modelled separately as in the supporting information and added directly to the battery pack. The data of the battery packing can be found in the supporting information in Tab. S17 to Tab. S33.

Tab. A. 1 Life cycle inventory of 1 kg NCM Li-ion battery pack.

	Name	Location	InfrastructureProcess	Unit	battery, rechargeable, prismatic, LiNCM, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				NO			
	InfrastructureProcess				0			
	Unit				kg			
product	battery, rechargeable, prismatic, LiNCM, at plant	NO	0	kg	1			
technosphere	single cell, lithium-ion battery,NCM, at plant	RAS	0	kg	6.00E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	battery-managment-system, at plant	RAS	0	kg	3.70E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	battery-cooling-system, passive, at plant	RAS	0	kg	4.10E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	electricity, medium voltage, at grid	NO	0	kWh	4.00E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	steel, low-alloyed, at plant	RER	0	kg	1.15E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	nylon 6, at plant	RER	0	kg	7.79E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	nylon 66, at plant	RER	0	kg	5.36E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	steel product manufacturing, average metal working	RER	0	kg	1.15E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	injection moulding	RER	0	kg	8.22E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	aluminium, production mix, at plant	RER	0	kg	1.14E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	anodising, aluminium sheet	RER	0	m2	4.98E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	sheet rolling, aluminium	RER	0	kg	1.13E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	copper, primary, at refinery	GLO	0	kg	3.90E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	copper, secondary, at refinery	RER	0	kg	6.91E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	acrylonitrile-butadiene-styrene copolymer, ABS, at plant	RER	0	kg	6.43E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	copper product manufacturing, average metal working	RER	0	kg	4.56E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	aluminium product manufacturing, average metal working	RER	0	kg	1.88E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	synthetic rubber, at plant	RER	0	kg	3.52E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	polypropylene, granulate, at plant	RER	0	kg	2.13E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	butyl acrylate, at plant	RER	0	kg	3.94E-5	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	transport, freight, rail	RER	0	tkm	1.27E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >32t, EURO3	RER	0	tkm	2.24E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >16t, fleet average	RER	0	tkm	4.80E-2	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, transoceanic freight ship	OCE	0	tkm	6.44E+0	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	facilities precious metal refinery	SE	1	unit	2.26E-8	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	aluminium casting, plant	RER	1	unit	1.76E-11	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	plastics processing factory	RER	1	unit	5.99E-11	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	metal working factory	RER	1	unit	6.12E-11	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
emission air, high population density	Heat, waste	-	-	MJ	1.40E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information

A.3 Manufacture of the single cell

In Tab. A. 2 the life cycle inventory of the battery cell is presented. It includes the components anode, cathode, electrolyte, separator as well as cell container. The battery cell is produced in East Asia. These data correspond to the data published by Ager-Wick Ellingsen et al. (2014) in the supporting information in Tab. S3. However the cell container was not modelled separately as in the supporting information and added directly to the single cell. The data of the cell container can be found in Tab. S13. To take the energy efficiency and the development of the battery manufacture into account, the electricity used for the single cell production was reduced by 20 %.[18]

For the manufacture of the battery cells a specific electricity mix was established for East Asia (see Tab. A. 3). The specific electricity mix is based on the following energy sources: 46.0 % hard coal, 32.5 % nuclear, 15.5 % natural gas, 4.4 % oil, 1.4 % hydro, 0.15 % wind, 0.12 % photovoltaic, 0.044 % waste incineration and 0.038 % peat (Ager-Wick Ellingsen et al. 2014). The transmission and transformation of the electricity to medium voltage was modelled according to the infrastructure demand and emission factors reported by Itten et al. (2014).

[18] Personal communication Linda Ager-Wick Ellingsen, 03.08.2015.

Tab. A. 2 Life cycle inventory of the manufacture of single cells.

	Name	Location	InfrastructureProcess	Unit	single cell, lithium-ion battery,NCM, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kg			
product	single cell, lithium-ion battery,NCM, at plant	RAS	0	kg	1			
technosphere	anode, lithium-ion battery, graphite, at plant	RAS	0	kg	3.90E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	electrolyte, LiPF6, at plant	RAS	0	kg	1.60E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	cathode, lithium-ion battery, NCM, at plant	RAS	0	kg	4.30E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	separator, lithium-ion battery, at plant	RAS	0	kg	2.20E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	electricity, medium voltage, production Eastern Asia, at grid	RAS	0	kWh	2.27E+1	1	1.34	(1,4,1,5,3,5,BU:1.05); Due energy efficiency and the development of the battery manufacture electricity consumption was reduced by 20%; Ellingsen, 2014 supporting information
	water, decarbonised, at plant	RER	0	kg	3.80E+2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	transport, freight, rail	RER	0	tkm	2.62E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >32t, EURO3	RER	0	tkm	1.01E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	facilities precious metal refinery	SE	1	unit	1.90E-8	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	sheet rolling, aluminium	RER	0	kg	2.81E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	aluminium casting, plant	RER	1	unit	4.27E-13	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	copper, primary, at refinery	GLO	0	kg	2.16E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	copper, secondary, at refinery	RER	0	kg	3.82E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	sheet rolling, copper	RER	0	kg	2.55E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	metal working factory	RER	1	unit	1.17E-12	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	polyethylene terephthalate, granulate, amorphous, at plant	RER	0	kg	2.09E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	nylon 6, at plant	RER	0	kg	2.14E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	polypropylene, granulate, at plant	RER	0	kg	8.58E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	polyethylene, LDPE, granulate, at plant	RER	0	kg	6.70E-5	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	injection moulding	RER	0	kg	1.26E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	plastics processing factory	RER	1	unit	9.38E-13	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
emission air, high population density	Heat, waste	-	-	MJ	1.00E+2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information

Tab. A. 3 Life cycle inventory of the electricity mix of Eastern Asia (RAS) specific for single cell manufacture.

	Name	Location	InfrastructureProcess	Unit	electricity, production mix Eastern Asia	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kWh			
product	electricity, production mix Eastern Asia	RAS	0	kWh	1.00E+0			
technosphere	electricity, peat, at power plant	NORDEL	0	kWh	0.000380490	1	1.05	(1,1,1,3,1,1); according to paper of L. Ager-Wick Ellingsen, 2014
	electricity, hard coal, at power plant	UCTE	0	kWh	0.459748349	1	1.05	(1,1,1,3,1,1); according to paper of L. Ager-Wick Ellingsen, 2014
	electricity, oil, at power plant	UCTE	0	kWh	0.043571590	1	1.05	(1,1,1,3,1,1); according to paper of L. Ager-Wick Ellingsen, 2014
	electricity, natural gas, at power plant	UCTE	0	kWh	0.154566868	1	1.05	(1,1,1,2,1,1); according to paper of L. Ager-Wick Ellingsen, 2014
	electricity from waste, at municipal waste incineration plant	CH	0	kWh	0.000439873	1	1.05	(1,1,1,3,1,1); according to paper of L. Ager-Wick Ellingsen, 2014
	electricity, nuclear, at power plant	UCTE	0	kWh	0.325002144	1	1.05	(1,1,1,3,1,1); according to paper of L. Ager-Wick Ellingsen, 2014
	electricity, hydropower, at power plant	CH	0	kWh	0.013539282	1	1.05	(1,1,1,1,1,1); according to paper of L. Ager-Wick Ellingsen, 2014
	electricity, production mix photovoltaic, at plant	US	0	kWh	0.001244840	1	1.05	(1,1,1,2,1,1); according to paper of L. Ager-Wick Ellingsen, 2014
	electricity, at wind power plant	RER	0	kWh	0.001506564	1	1.05	(1,1,1,2,1,1); according to paper of L. Ager-Wick Ellingsen, 2014

A.4 Manufacture of the anode

In Tab. A. 4 the life cycle inventory of the anode is presented. It includes a negative current collector Cu and a negative electrode paste. These data correspond to the data published by Ager-Wick Ellingsen et al. (2014) in the supporting information in Tab. S4. The negative current collector and the negative electrode paste were not modelled separately as in the supporting information and added directly to the anode. The data of those components can be found in Tab. S5 and Tab. S6 in the supporting information. To avoid double counting and according to the information in Ager-Wick Ellingsen (2014), the energy requirement for the coating is included in the energy demand of the battery cell manufacture only.

Tab. A. 4 Life cycle inventory of the anode.

	Name	Location	InfrastructureProcess	Unit	anode, lithium-ion battery, graphite, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kg			
product	anode, lithium-ion battery, graphite, at plant	RAS	0	kg	1			
technosphere	transport, freight, rail	RER	0	tkm	9.87E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >32t, EURO3	RER	0	tkm	2.40E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	copper, primary, at refinery	GLO	0	kg	4.88E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	copper, secondary, at refinery	RER	0	kg	8.60E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	sheet rolling, copper	RER	0	kg	5.74E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	metal working factory	RER	1	unit	2.63E-10	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	graphite, battery grade, at plant	CN	0	kg	4.09E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	carboxymethyl cellulose, powder, at plant	RER	0	kg	1.09E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	acrylic acid, at plant	RER	0	kg	1.09E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	N-methyl-2-pyrrolidone, at plant	RER	0	kg	4.05E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	chemical plant, organics	RER	1	unit	1.71E-10	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information

A.5 Manufacture of the cathode

In Tab. A. 5 the life cycle inventory of the cathode is presented. It includes a positive current collector Al and a positive electrode paste. The data correspond to the data published by Ager-Wick Ellingsen et al. (2014) in the supporting information in Tab. S7. The positive current collector and the positive electrode paste were not modelled separately as in the supporting information and added directly to the cathode. The data of those components can be found in Tab. S8 and Tab. S9. The modelling of the positive active material used for the positive electrode paste was adapted by Ager-Wick Ellingsen et al. (2014) from Majeau-Bettez et al. (2011).[19] The energy consumption of the coating is already included in the battery cell manufacture and thus not included in the cathode manufacture process. The energy consumption reported in the life cycle inventory of the cathode manufacture corresponds to the energy consumption of the production of positive electrode paste (nickel sulfate, cobalt sulfate and manganese sulfate).

[19] Personal communication Linda Ager-Wick Ellingsen, 03.08.2015.

Tab. A. 5 Life cycle inventory of the cathode.

	Name	Location	InfrastructureProcess	Unit	cathode, lithium-ion battery, NCM, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kg			
product	cathode, lithium-ion battery, NCM, at plant	RAS	0	kg	1			
technosphere	transport, freight, rail	RER	0	tkm	2.97E+0	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >32t, EURO3	RER	0	tkm	2.42E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >16t, fleet average	RER	0	tkm	1.06E+0	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	aluminium, production mix, at plant	RER	0	kg	1.14E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	sheet rolling, aluminium	RER	0	kg	1.14E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	aluminium casting, plant	RER	1	unit	1.76E-11	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	polyvinylfluoride, at plant	US	0	kg	3.54E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	carbon black, at plant	GLO	0	kg	1.77E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	N-methyl-2-pyrrolidone, at plant	RER	0	kg	4.18E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	chemical plant, organics	RER	1	unit	1.00E-9	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	lithium hydroxide, at plant	GLO	0	kg	2.07E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	heat, unspecific, in chemical plant	RER	0	MJ	4.58E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	soda, powder, at plant	RER	0	kg	6.92E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	ammonia, liquid, at regional storehouse	RER	0	kg	1.42E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	chemicals organic, at plant	GLO	0	kg	7.30E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	chemicals inorganic, at plant	GLO	0	kg	2.49E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	carbon monoxide, CO, at plant	RER	0	kg	4.96E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	hydrogen cyanide, at plant	RER	0	kg	1.14E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	hydrogen, liquid, at plant	RER	0	kg	4.31E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	limestone, milled, loose, at plant	CH	0	kg	3.35E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	portland calcareous cement, at plant	CH	0	kg	1.06E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	sand, at mine	CH	0	kg	1.34E+1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	silica sand, at plant	DE	0	kg	3.20E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	blasting	RER	0	kg	4.86E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	diesel, burned in building machine	GLO	0	MJ	3.43E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	electricity, high voltage, production ENTSO, at grid	ENTSO	0	kWh	4.48E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	electricity, hydropower, at run-of-river power plant	RER	0	kWh	6.71E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	1.02E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	heat, at hard coal industrial furnace 1-10MW	RER	0	MJ	3.16E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	heavy fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	2.05E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	natural gas, burned in industrial furnace >100kW	RER	0	MJ	1.24E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	aluminium hydroxide, at plant	RER	0	kg	3.73E-10	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	conveyor belt, at plant	RER	1	m	1.23E-6	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	non-ferrous metal mine, underground	GLO	1	unit	1.61E-9	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	non-ferrous metal smelter	GLO	1	unit	5.67E-12	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	disposal, nickel smelter slag, 0% water, to residual material landfill	CH	0	kg	1.62E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	disposal, sulfidic tailings, off-site	GLO	0	kg	1.23E+1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	disposal, non-sulfidic tailings, off-site	GLO	0	kg	1.14E+1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	disposal, non-sulfidic overburden, off-site	GLO	0	kg	5.93E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	manganese concentrate, at beneficiation	GLO	0	kg	4.66E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	sulphuric acid, liquid, at plant	RER	0	kg	2.83E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	natural gas, high pressure, at consumer	CH	0	MJ	1.58E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	hard coal coke, at plant	RER	0	MJ	6.23E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information

Tab. A. 5 Life cycle inventory of the cathode. (continued)

	Name	Location	InfrastructureProcess	Unit	cathode, lithium-ion battery, NCM, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kg			
product	cathode, lithium-ion battery, NCM, at plant	RAS	0	kg	1			
resource, in ground	Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground	-	-	kg	2.13E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	Cobalt, in ground	-	-	kg	2.24E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
resource, in water	Water, river	-	-	m3	1.12E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	Water, well, in ground	-	-	m3	6.44E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
emission air, unspecified	Aluminium	-	-	kg	2.48E-4	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Arsenic	-	-	kg	9.01E-7	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Calcium	-	-	kg	1.74E-4	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Carbon dioxide, fossil	-	-	kg	1.44E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	Carbon disulfide	-	-	kg	3.22E-3	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Cobalt	-	-	kg	1.88E-4	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Copper	-	-	kg	5.59E-5	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	1.54E-12	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	Heat, waste	-	-	MJ	1.18E+1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	Lead	-	-	kg	5.31E-6	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Magnesium	-	-	kg	1.49E-4	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Nickel	-	-	kg	6.60E-5	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	3.09E-5	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Particulates, < 2.5 um	-	-	kg	2.87E-3	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	Particulates, > 10 um	-	-	kg	3.71E-3	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Particulates, > 2.5 um, and < 10um	-	-	kg	5.26E-3	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	Silver	-	-	kg	2.14E-8	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Sulfur dioxide	-	-	kg	2.30E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	Tin	-	-	kg	1.01E-6	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Zinc	-	-	kg	1.56E-5	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
emission water, unspecified	Aluminium	-	-	kg	5.56E-6	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Arsenic, ion	-	-	kg	2.27E-7	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	BOD5, Biological Oxygen Demand	-	-	kg	2.83E-4	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Cadmium, ion	-	-	kg	2.57E-8	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	Calcium, ion	-	-	kg	3.14E-2	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	Calcium, ion	-	-	kg	1.28E-2	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	Chromium, ion	-	-	kg	9.12E-8	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	Cobalt	-	-	kg	5.04E-8	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	COD, Chemical Oxygen Demand	-	-	kg	6.74E-4	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Copper, ion	-	-	kg	6.15E-7	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	Cyanide	-	-	kg	1.21E-4	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	DOC, Dissolved Organic Carbon	-	-	kg	1.10E-4	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Iron, ion	-	-	kg	1.87E-5	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Lead	-	-	kg	2.12E-7	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
emission water, fossil-	Manganese	-	-	kg	1.59E-6	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
emission water, unspecified	Mercury	-	-	kg	2.99E-9	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Nickel, ion	-	-	kg	1.61E-6	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	Nitrogen, organic bound	-	-	kg	6.16E-4	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Nitrogen	-	-	kg	8.53E-4	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Suspended solids, unspecified	-	-	kg	3.34E-4	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Sulfate	-	-	kg	1.52E-1	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Tin, ion	-	-	kg	5.58E-8	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
	TOC, Total Organic Carbon	-	-	kg	1.10E-4	1	1.65	(1,4,1,5,3,5,BU:1.5); ; Ellingsen, 2014 supporting information
	Zinc, ion	-	-	kg	5.08E-6	1	5.13	(1,4,1,5,3,5,BU:5); ; Ellingsen, 2014 supporting information
emission air, high population density	Heat, waste	-	-	MJ	1.11E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ;

A.6 Manufacture of the electrolyte

In Tab. A. 6 the life cycle inventory of the electrolyte is presented. The inventory data correspond to the data published by Ager-Wick Ellingsen et al. (2014) in the supporting information in Tab. S11. The energy consumption of the electrolyte production is included in the life cycle inventory of battery cell production.

Tab. A. 6 Life cycle inventory of the electrolyte.

	Name	Location	InfrastructureProcess	Unit	electrolyte, LiPF6, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kg			
product	electrolyte, LiPF6, at plant	RAS	0	kg	1			
technosphere	lithium hexafluorophosphate, at plant	CN	0	kg	1.20E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	ethylene carbonate, at plant	CN	0	kg	8.80E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	transport, freight, rail	RER	0	tkm	6.00E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >32t, EURO3	RER	0	tkm	1.00E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	chemical plant, organics	RER	1	unit	4.10E-10	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information

A.7 Manufacture of the separator

In Tab. A. 7 the life cycle inventory of the seperator is presented. The inventory data correspond to the data published by Ager-Wick Ellingsen et al. (2014) in the supporting information in Tab. S12.

Tab. A. 7 Life cycle inventory of the separator.

	Name	Location	InfrastructureProcess	Unit	separator, lithium-ion battery, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kg			
product	separator, lithium-ion battery, at plant	RAS	0	kg	1			
technosphere	polypropylene, granulate, at plant	RER	0	kg	1.00E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	injection moulding	RER	0	kg	1.00E+0	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	transport, freight, rail	RER	0	tkm	2.00E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >32t, EURO3	RER	0	tkm	1.00E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	plastics processing factory	RER	1	unit	7.40E-10	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information

A.8 Manufacture of the battery management system

In Tab. A. 8 the life cycle inventory of the battery management system is presented. It includes battery module boards, integrated battery interface system, fasteners, high voltage system and low voltage system. These data correspond to the data published by Ager-Wick Ellingsen et al. (2014) in the supporting information in Tab. S34. However the components were added directly to the battery management system process and were not modelled separately as in the supporting information. The data of the different components can be found in Tab. S35 to Tab. S38 in the supporting information.

Tab. A. 8 Life cycle inventory of the battery management system.

	Name	Location	InfrastructureProcess	Unit	battery-managment-system, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kg			
product	battery-managment-system, at plant	RAS	0	kg	1			
technosphere	printed wiring board, through-hole mounted, unspec., Pb free, at plant	GLO	0	kg	8.93E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	transport, freight, rail	RER	0	tkm	3.69E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >32t, EURO3	RER	0	tkm	1.71E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	nylon 66, at plant	RER	0	kg	1.70E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	electronic component, passive, unspecified, at plant	GLO	0	kg	1.29E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	injection moulding	RER	0	kg	4.46E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	electronic component production plant	GLO	1	unit	1.82E-8	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	steel, low-alloyed, at plant	RER	0	kg	3.40E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	aluminium, production mix, at plant	RER	0	kg	3.64E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	synthetic rubber, at plant	RER	0	kg	1.06E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	polyethylene terephthalate, granulate, amorphous, at plant	RER	0	kg	1.69E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	copper, primary, at refinery	GLO	0	kg	6.91E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	copper, secondary, at refinery	RER	0	kg	1.23E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	polyphenylene sulfide, at plant	GLO	0	kg	9.57E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	tin, at regional storage	RER	0	kg	5.02E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	cable, ribbon cable, 20-pin, with plugs, at plant	GLO	0	kg	1.34E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	steel product manufacturing, average metal working	RER	0	kg	3.40E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	aluminium product manufacturing, average metal working	RER	0	kg	3.64E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	copper product manufacturing, average metal working	RER	0	kg	8.14E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	metal product manufacturing, average metal working	RER	0	kg	5.02E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information

A.9 Manufacture of the battery cooling system

In Tab. A. 9 the life cycle inventory of the battery cooling system is presented. It includes radiator, manifolds, clamps and fastener, pipe fitting, thermal gap pad and coolant. The data correspond to the data published by Ager-Wick Ellingsen et al. (2014) in the supporting information in Tab. S39. However the components were added directly to the battery cooling system process and were not modelled separately as in the supporting information. The data of the different components can be found in Tab. S40 to Tab. S44 in the supporting information.

Tab. A. 9 Life cycle inventory of the battery cooling system.

	Name	Location	InfrastructureProcess	Unit	battery-cooling-system, passive, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				RAS			
	InfrastructureProcess				0			
	Unit				kg			
product	battery-cooling-system, passive, at plant	RAS	0	kg	1			
technosphere	ethylene glycol, at plant	RER	0	kg	4.78E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	transport, freight, rail	RER	0	tkm	4.10E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	transport, lorry >32t, EURO3	RER	0	tkm	1.95E-1	1	2.12	(1,4,1,5,3,5,BU:2); ; Ellingsen, 2014 supporting information
	aluminium, production mix, at plant	RER	0	kg	9.11E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	sheet rolling, aluminium	RER	0	kg	8.73E-1	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	aluminium casting, plant	RER	1	unit	1.40E-10	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	aluminium product manufacturing, average metal working	RER	0	kg	3.82E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	steel, low-alloyed, at plant	RER	0	kg	2.29E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	steel product manufacturing, average metal working	RER	0	kg	2.29E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	metal working factory	RER	1	unit	1.05E-11	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	polyvinylchloride, at regional storage	RER	0	kg	7.16E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	synthetic rubber, at plant	RER	0	kg	2.39E-4	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	injection moulding	RER	0	kg	2.08E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	plastics processing factory	RER	1	unit	1.56E-11	1	3.12	(1,4,1,5,3,5,BU:3); ; Ellingsen, 2014 supporting information
	glass fibre, at plant	RER	0	kg	1.99E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	silicon, electronic grade, at plant	DE	0	kg	5.96E-3	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information
	acrylonitrile-butadiene-styrene copolymer, ABS, at plant	RER	0	kg	1.19E-2	1	1.34	(1,4,1,5,3,5,BU:1.05); ; Ellingsen, 2014 supporting information

B Appendix: Petrol and diesel supply

B.1 Overview

The life cycle inventories of petrol and diesel supply in Switzerland and in Europe were updated with the most recent information about the crude oil mix processed in Swiss and European refineries and the share of imported petrol and diesel in the Swiss supply mixes available in June 2016. The previous life cycle inventories compiled by Jungbluth (2007) served as a basis for the update. A detailed description of the data sources, calculations and assumptions is given in a separate report by Stolz and Frischknecht (2016). The life cycle inventories of crude oil production and long distance transport, the production of petrol and diesel in refineries and the regional transport in Switzerland are presented in the following subchapters B.2 to B.5.

B.2 Crude oil production

The crude oil used in Swiss and European refineries is mainly extracted in the Middle East, North Africa, Nigeria, Kazakhstan, Azerbaijan, Russia, Latin America, the USA, Norway, Great Britain and the Netherlands (EV/UP 2014; IEA 2015). Life cycle inventories of crude oil production in most of these countries and regions exist in the KBOB life cycle inventory database v2.2:2016 and are documented in Jungbluth (2007). The crude oil production in Azerbaijan (mainly offshore oilfields; EIA 2014) and in Kazakhstan (both offshore and onshore oilfields; EIA 2015c) was modelled in new life cycle inventories. The life cycle inventory of crude oil produced onshore in Russia was used as a basis for the onshore production in Kazakhstan and the life cycle inventory of offshore crude oil production in Great Britain was adapted to the situation of offshore production in Azerbaijan and Kazakhstan. The air emissions due to flaring and venting of natural gas were estimated for Russia, Azerbaijan and Kazakhstan based on information published in Carbon Limits (2013) and adjusted in the life cycle inventories. The new life cycle inventories of crude oil production are shown in Tab. B. 1 to Tab. B. 3.

Tab. B. 1 Life cycle inventory of 1 kg crude oil produced offshore in Azerbaijan.

	Name	Location	Infrastructure-Process	Unit	crude oil, at production offshore	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				AZ			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	chemicals inorganic, at plant	GLO	0	kg	5.67E-5	1	1.05	(1,1,1,1,1,3); Environmental report
	chemicals organic, at plant	GLO	0	kg	5.03E-5	1	1.05	(1,1,1,1,1,3); Environmental report
	transport, lorry >16t, fleet average	RER	0	tkm	1.09E-5	1	2.00	(4,5,na,na,na,na); Standard distance 100km
	transport, freight, rail	RER	0	tkm	6.42E-5	1	2.00	(4,5,na,na,na,na); Standard distance 600km
	diesel, at regional storage	RER	0	kg	2.74E-3	1	1.05	(1,1,1,1,1,3); Environmental report
	heavy fuel oil, at regional storage	RER	0	kg	2.25E-3	1	1.05	(1,1,1,1,1,3); Environmental report
	natural gas, vented	GLO	0	m3	3.94E-3	1	2.15	(3,4,3,5,3,5); Generic value 7.5% of total; Venting rate of Russian crude oil production scaled by the factor 0.47/0.75 based on CarbonLimits (2014)
	natural gas, sour, burned in production flare	GLO	0	MJ	1.99E+0	1	2.10	(4,3,2,1,1,5); Literature, 92.5% of total; Flaring rate of Russian crude oil production scaled by the factor 0.47/0.75 based on CarbonLimits (2014)
	well for exploration and production, offshore	OCE	1	m	4.81E-6	1	3.00	(1,1,1,1,1,3); Environmental report
	platform, crude oil, offshore	OCE	1	p	3.36E-11	1	3.00	(1,1,1,1,1,3); Environmental report, 15a life time
	pipeline, crude oil, offshore	OCE	1	km	3.41E-9	1	3.00	(1,1,1,1,1,3); Environmental report
	discharge, produced water, offshore	OCE	0	kg	1.20E+0	1	1.05	(1,1,1,1,1,3); Environmental report
	low active radioactive waste	CH	0	m3	1.31E-7	1	2.00	(4,4,3,5,1,3); Generic assumption, basic uncertainity = 2
	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	1.80E-6	1	1.05	(1,1,1,1,1,3); Environmental report
resource, in ground	Gas, natural/m3			m3	4.61E-2	1	1.05	(1,1,1,1,1,3); Environmental report
	Oil, crude			kg	1.00E+0	1	1.05	(1,1,1,1,1,3); Environmental report
air, low population density	Heat, waste			MJ	1.46E+0	1	1.05	(3,1,1,1,3,3); Calculation from fuel use
	Benzene			kg	2.35E-9	1	1.50	(3,1,1,1,3,3); Calculation from fuel use
	Benzo(a)pyrene			kg	1.44E-11	1	1.50	(3,1,1,1,3,3); Calculation from fuel use
	Carbon dioxide, fossil			kg	1.56E-2	1	1.05	(3,1,1,1,1,3); Direct emissions from fuel combustion
	Carbon monoxide, fossil			kg	1.71E-4	1	5.00	(3,1,1,1,1,3); Extrapolation from 1998
	Dinitrogen monoxide			kg	1.71E-6	1	1.50	(3,1,1,1,3,3); Calculation from fuel use
	Helium			kg	1.41E-5	1	5.00	(3,1,1,1,3,3); Calculation from fuel use
	Mercury			kg	6.29E-9	1	5.00	(3,1,1,1,3,3); Calculation from fuel use
	Methane, fossil			kg	2.59E-5	1	1.50	(3,1,1,1,1,3); Direct emissions from crude oil production assumed to be identical to onshore production in Russia; Emissions from fuel combustion
	Nitrogen oxides			kg	2.74E-4	1	1.50	(3,1,1,1,1,3); Extrapolation from 1998
	NMVOC, non-methane volatile organic compounds, unspecified origin			kg	8.95E-4	1	1.50	(3,1,1,1,1,3); Extrapolation from 1998
	Particulates, > 2.5 um, and < 10um			kg	2.99E-5	1	2.00	(3,1,1,1,3,3); Calculation from fuel use
	Radon-222			kBq	7.81E-3	1	5.00	(3,1,1,1,3,3); Calculation from fuel use
	Sulfur dioxide			kg	2.29E-5	1	1.05	(3,1,1,1,1,3); Extrapolation from 1998
	Methane, bromotrifluoro-, Halon 1301			kg	4.79E-10	1	5.00	(4,4,3,5,1,3); Literature for NO
water, ocean	Oils, unspecified			kg	6.41E-4	1	3.00	(1,1,1,1,1,3); Environmental report
	BOD5, Biological Oxygen Demand			kg	2.02E-3	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	COD, Chemical Oxygen Demand			kg	2.02E-3	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	DOC, Dissolved Organic Carbon			kg	5.55E-4	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	TOC, Total Organic Carbon			kg	5.55E-4	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	AOX, Adsorbable Organic Halogen as Cl			kg	6.61E-9	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	Nitrogen			kg	4.95E-7	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	Sulfur			kg	1.72E-6	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
Outputs	crude oil, at production offshore	AZ	0	kg	1.00E+0			

Tab. B. 2 Life cycle inventory of 1 kg crude oil produced offshore in Kazakhstan.

	Name	Location	Infrastructure-Process	Unit	crude oil, at production offshore	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				KZ			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	chemicals inorganic, at plant	GLO	0	kg	5.67E-5	1	1.05	(1,1,1,1,1,3); Environmental report
	chemicals organic, at plant	GLO	0	kg	5.03E-5	1	1.05	(1,1,1,1,1,3); Environmental report
	transport, lorry >16t, fleet average	RER	0	tkm	1.09E-5	1	2.00	(4,5,na,na,na,na); Standard distance 100km
	transport, freight, rail	RER	0	tkm	6.42E-5	1	2.00	(4,5,na,na,na,na); Standard distance 600km
	diesel, at regional storage	RER	0	kg	2.74E-3	1	1.05	(1,1,1,1,1,3); Environmental report
	heavy fuel oil, at regional storage	RER	0	kg	2.25E-3	1	1.05	(1,1,1,1,1,3); Environmental report
	natural gas, vented	GLO	0	m3	2.82E-3	1	2.15	(3,4,3,5,3,5); Generic value 7.5% of total; Venting rate of Russian crude oil production scaled by the factor 0.47/0.75 based on CarbonLimits (2014)
	natural gas, sour, burned in production flare	GLO	0	MJ	1.42E+0	1	2.10	(4,3,2,1,1,5); Literature, 92.5% of total; Flaring rate of Russian crude oil production scaled by the factor 0.47/0.75 based on CarbonLimits (2014)
	well for exploration and production, offshore	OCE	1	m	4.81E-6	1	3.00	(1,1,1,1,1,3); Environmental report
	platform, crude oil, offshore	OCE	1	p	3.36E-11	1	3.00	(1,1,1,1,1,3); Environmental report, 15a life time
	pipeline, crude oil, offshore	OCE	1	km	3.41E-9	1	3.00	(1,1,1,1,1,3); Environmental report
	discharge, produced water, offshore	OCE	0	kg	1.20E+0	1	1.05	(1,1,1,1,1,3); Environmental report
	low active radioactive waste	CH	0	m3	1.31E-7	1	2.00	(4,4,3,5,1,3); Generic assumption, basic uncertainity = 2
	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	1.80E-6	1	1.05	(1,1,1,1,1,3); Environmental report
resource, in ground	Gas, natural/m3			m3	4.61E-2	1	1.05	(1,1,1,1,1,3); Environmental report
	Oil, crude			kg	1.00E+0	1	1.05	(1,1,1,1,1,3); Environmental report
air, low population density	Heat, waste			MJ	1.46E+0	1	1.05	(3,1,1,1,3,3); Calculation from fuel use
	Benzene			kg	2.35E-9	1	1.50	(3,1,1,1,3,3); Calculation from fuel use
	Benzo(a)pyrene			kg	1.44E-11	1	1.50	(3,1,1,1,3,3); Calculation from fuel use
	Carbon dioxide, fossil			kg	1.56E-2	1	1.05	(3,1,1,1,1,3); Direct emissions from fuel combustion
	Carbon monoxide, fossil			kg	1.71E-4	1	5.00	(3,1,1,1,1,3); Extrapolation from 1998
	Dinitrogen monoxide			kg	1.71E-6	1	1.50	(3,1,1,1,3,3); Calculation from fuel use
	Helium			kg	1.41E-5	1	5.00	(3,1,1,1,3,3); Calculation from fuel use
	Mercury			kg	6.29E-9	1	5.00	(3,1,1,1,3,3); Calculation from fuel use
	Methane, fossil			kg	2.59E-5	1	1.50	(3,1,1,1,1,3); Direct emissions from crude oil production assumed to be identical to onshore production in Russia; Emissions from fuel combustion
	Nitrogen oxides			kg	2.74E-4	1	1.50	(3,1,1,1,1,3); Extrapolation from 1998
	NMVOC, non-methane volatile organic compounds, unspecified origin			kg	8.95E-4	1	1.50	(3,1,1,1,1,3); Extrapolation from 1998
	Particulates, > 2.5 um, and < 10um			kg	2.99E-5	1	2.00	(3,1,1,1,3,3); Calculation from fuel use
	Radon-222			kBq	7.81E-3	1	5.00	(3,1,1,1,3,3); Calculation from fuel use
	Sulfur dioxide			kg	2.29E-5	1	1.05	(3,1,1,1,1,3); Extrapolation from 1998
	Methane, bromotrifluoro-, Halon 1301			kg	4.79E-10	1	5.00	(4,4,3,5,1,3); Literature for NO
water, ocean	Oils, unspecified			kg	6.41E-4	1	3.00	(1,1,1,1,1,3); Environmental report
	BOD5, Biological Oxygen Demand			kg	2.02E-3	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	COD, Chemical Oxygen Demand			kg	2.02E-3	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	DOC, Dissolved Organic Carbon			kg	5.55E-4	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	TOC, Total Organic Carbon			kg	5.55E-4	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	AOX, Adsorbable Organic Halogen as Cl			kg	6.61E-9	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	Nitrogen			kg	4.95E-7	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	Sulfur			kg	1.72E-6	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
Outputs	crude oil, at production offshore	KZ	0	kg	1.00E+0			

Tab. B. 3 Life cycle inventory of 1 kg crude oil produced onshore in Kazakhstan.

	Name	Location	Infrastructure-Process	Unit	crude oil, at production onshore	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				KZ			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	chemicals inorganic, at plant	GLO	0	kg	1.20E-4	1	3.14	(3,4,3,5,3,5); Generic value, basic uncertainity = 3
	chemicals organic, at plant	GLO	0	kg	9.00E-5	1	3.14	(3,4,3,5,3,5); Generic value, basic uncertainity = 3
	transport, lorry >16t, fleet average	RER	0	tkm	3.10E-5	1	2.09	(4,5,na,na,na,na); Standard distance 100km
	transport, freight, rail	RER	0	tkm	1.26E-4	1	2.09	(4,5,na,na,na,na); Standard distance 600km
	well for exploration and production, onshore	GLO	1	m	2.55E-5	1	3.06	(3,1,4,1,1,3); Calculation for 2009 with data from Rosneft and Lukoil
	pipeline, crude oil, onshore	RER	1	km	3.29E-8	1	3.10	(4,3,2,1,1,5); Lodewijkx et al. 2001, p28, 20tsd km pipeline, 62 Mio. tonnes
	production plant crude oil, onshore	GLO	1	p	5.13E-9	1	3.10	(4,3,2,1,1,5); Lodewijkx et al. 2001
	diesel, burned in diesel-electric generating set	GLO	0	MJ	4.22E-1	1	2.15	(3,4,3,5,3,5); Generic value, basic uncertainity = 2
	natural gas, vented	GLO	0	m3	2.82E-3	1	2.15	(3,4,3,5,3,5); Generic value 7.5% of total; Venting rate of Russian crude oil production scaled by the factor 0.47/0.75 based on CarbonLimits (2014)
	natural gas, sour, burned in production flare	GLO	0	MJ	1.42E+0	1	2.10	(4,3,2,1,1,5); Literature, 92.5% of total; Flaring rate of Russian crude oil production scaled by the factor 0.47/0.75 based on CarbonLimits (2014)
	sour gas, burned in gas turbine, production	NO	0	MJ	9.04E-2	1	2.15	(3,4,3,5,3,5); Generic value, basic uncertainity = 2
	heavy fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	2.40E-1	1	2.10	(4,3,2,1,1,5); Generic value, basic uncertainity = 2
	discharge, produced water, onshore	GLO	0	kg	1.37E+0	1	2.10	(4,3,2,1,1,5); Generic value, basic uncertainity = 2
	low active radioactive waste	CH	0	m3	2.00E-7	1	2.15	(3,4,3,5,3,5); Generic value, basic uncertainity = 2
	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	1.00E-4	1	2.15	(3,4,3,5,3,5); Generic value, basic uncertainity = 2
resource, in ground	Gas, natural/m3			m3	8.00E-5	1	1.38	(3,4,3,5,3,5); Losses
	Oil, crude			kg	1.02E+0	1	1.07	(2,na,1,na,1,na); Incl. losses
resource, in water	Water, unspecified natural origin/m3			m3	1.36E-3	1	1.31	(4,3,2,1,1,5); Literature
air, low population density	Methane, fossil			kg	2.50E-5	1	3.23	(5,na,na,na,na,na); Generic value, basic uncertainity = 3
	NMVOC, non-methane volatile organic compounds, unspecified origin			kg	7.50E-5	1	3.23	(5,na,na,na,na,na); Generic value, basic uncertainity = 3
water, river	Oils, unspecified			kg	2.00E-2	1	3.10	(4,3,2,1,1,5); Literature, estimation for share to water
	BOD5, Biological Oxygen Demand			kg	6.30E-2	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	COD, Chemical Oxygen Demand			kg	6.30E-2	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	DOC, Dissolved Organic Carbon			kg	1.73E-2	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	TOC, Total Organic Carbon			kg	1.73E-2	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	AOX, Adsorbable Organic Halogen as Cl			kg	2.06E-7	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	Nitrogen			kg	1.55E-5	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
	Sulfur			kg	5.36E-5	1	1.58	(3,na,na,3,1,5); Extrapolation for sum parameter
soil, forestry	Oils, unspecified			kg	2.50E-2	1	3.10	(4,3,2,1,1,5); Literature, estimation for oil contaminated area, basic uncertainity estimated = 3
Outputs	crude oil, at production onshore	KZ	0	kg	1.00E+0			

B.3 Long distance transport of crude oil

B.3.1 Crude oil in Switzerland

The life cycle inventories of the long distance transport of crude oil produced in Azerbaijan, Kazakhstan and Russia to Switzerland were newly established based on the transport routes and distances estimated by Jungbluth (2007). The transport distances from the major oilfields to Novorossiysk, an important transition point of crude oil at the Black Sea, were determined with Google Maps. The life cycle inventories of the long distance transport of crude oil from Azerbaijan, Kazakhstan and Russia to Switzerland are presented in Tab. B. 4 to Tab. B. 6.

In addition, the life cycle inventory of the long distance transport of crude oil produced in Latin America to Switzerland was updated. The shares of onshore and offshore production were estimated for Venezuela, Mexico and Brazil (EIA 2015b; EIA 2015a; EIA 2015d), which are the most important oil producing countries in the region. The onshore crude oil production was then approximated by the life cycle inventory of crude oil produced in the Middle East and the offshore production was modelled with the situation in Great Britain. The life cycle inventory of the long distance transport of crude oil from Latin America to Switzerland is shown in Tab. B. 7.

Tab. B. 4 Life cycle inventory of the long distance transport of 1 kg crude oil produced in Azerbaijan to Switzerland.

	Name	Location	Infrastructure-Process	Unit	crude oil, production AZ, at long distance transport	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	crude oil, at production offshore	AZ	0	kg	1.00E+0	1	1.05	(1,1,1,1,1,1); Transported good
	transport, transoceanic tanker	OCE	0	tkm	1.00E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007) and Google Maps; Tanker transport to European sites at the Mediterranean Sea (1000 km)
	transport, crude oil pipeline, onshore	RER	0	tkm	2.14E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007) and Google Maps; Transport by pipeline from extraction sites in Azerbaijan (e.g. Azeri) to the Black Sea (Noworossiysk) (1400 km), and from the Mediterranean Sea to Switzerland (740 km)
air, high population density	Hydrocarbons, aliphatic, alkanes, unspecified			kg	1.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Benzene			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Butane			kg	3.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Methane, fossil			kg	1.60E-6	1	1.46	(3,5,4,1,1,5); Literature
	Ethane			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Hexane			kg	1.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Pentane			kg	5.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Propane			kg	2.90E-6	1	2.15	(3,5,4,1,1,5); Literature
	Toluene			kg	2.70E-7	1	2.15	(3,5,4,1,1,5); Literature
Outputs	crude oil, production AZ, at long distance transport	CH	0	kg	1.00E+0			

Tab. B. 5 Life cycle inventory of the long distance transport of 1 kg crude oil produced in Kazakhstan to Switzerland.

	Name	Location	Infrastructure-Process	Unit	crude oil, production KZ, at long distance transport	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	crude oil, at production onshore	KZ	0	kg	6.85E-1	1	1.05	(1,1,1,1,1,1); Transported good; share of onshore production estimated based on information from EIA (2015) on the three largest oil fields in Kazakhstan
	crude oil, at production offshore	KZ	0	kg	3.15E-1	1	1.05	(1,1,1,1,1,1); Transported good; share of offshore production estimated based on information from EIA (2015) on the three largest oil fields in Kazakhstan
	transport, transoceanic tanker	OCE	0	tkm	1.00E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007) and Google Maps; Tanker transport to European sites at the Mediterranean Sea (1000 km)
	transport, crude oil pipeline, onshore	RER	0	tkm	2.54E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007) and Google Maps; Transport by pipeline from extraction sites in Kazakhstan (e.g. Tengiz, Karachaganak, Kashagan) to the Black Sea (Noworossiysk) (1800 km), and from the Mediterranean Sea to Switzerland (740 km)
air, high population density	Hydrocarbons, aliphatic, alkanes, unspecified			kg	1.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Benzene			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Butane			kg	3.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Methane, fossil			kg	1.60E-6	1	1.46	(3,5,4,1,1,5); Literature
	Ethane			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Hexane			kg	1.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Pentane			kg	5.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Propane			kg	2.90E-6	1	2.15	(3,5,4,1,1,5); Literature
	Toluene			kg	2.70E-7	1	2.15	(3,5,4,1,1,5); Literature
Outputs	crude oil, production KZ, at long distance transport	CH	0	kg	1.00E+0			

Tab. B. 6 Life cycle inventory of the long distance transport of 1 kg crude oil produced in Russia to Switzerland.

	Name	Location	Infrastructure-Process	Unit	crude oil, production RU, at long distance transport	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	crude oil, at production onshore	RU	0	kg	1.00E+0	1	1.05	(1,1,1,1,1,1); Transported good
	transport, transoceanic tanker	OCE	0	tkm	1.00E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007); tanker transport to European sites at the Mediterranean Sea
	transport, crude oil pipeline, onshore	RER	0	tkm	5.74E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007); transport by pipeline from Russian extraction sites to the Black Sea, and from the Mediterranean Sea to Switzerland
air, high population density	Hydrocarbons, aliphatic, alkanes, unspecified			kg	1.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Benzene			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Butane			kg	3.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Methane, fossil			kg	1.60E-6	1	1.46	(3,5,4,1,1,5); Literature
	Ethane			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Hexane			kg	1.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Pentane			kg	5.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Propane			kg	2.90E-6	1	2.15	(3,5,4,1,1,5); Literature
	Toluene			kg	2.70E-7	1	2.15	(3,5,4,1,1,5); Literature
Outputs	crude oil, production RU, at long distance transport	CH	0	kg	1.00E+0			

Tab. B. 7 Life cycle inventory of the long distance transport of 1 kg crude oil produced in Latin America to Switzerland.

	Name	Location	Infrastructure-Process	Unit	crude oil, production RLA, at long distance transport	uncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	crude oil, at production onshore	RME	0	kg	4.65E-1	1	1.05	(1,1,1,1,1,1); Onshore production modelled by situation in the Middle East; Share estimated based on information from EIA country analyses of Venezuela, Mexico and Brazil
	crude oil, at production offshore	GB	0	kg	5.35E-1	1	1.05	(1,1,1,1,1,1); Offshore production modelled by situation in Great Britain; Share estimated based on information from EIA country analyses of Venezuela, Mexico and Brazil
	transport, transoceanic tanker	OCE	0	tkm	7.50E+0	1	2.06	(4,1,3,3,1,na); Calculation for 1994; Tanker transport from Latin America to Europe (7500 km)
	transport, crude oil pipeline, offshore	OCE	0	tkm	1.00E-1	1	2.06	(4,1,3,3,1,na); Calculation for 1994; Pipeline transport from oil fields to loading station (100 km)
	transport, crude oil pipeline, onshore	RER	0	tkm	7.40E-1	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007); Pipeline transport from the Mediterranean Sea to Switzerland (740 km)
air, high population density	Hydrocarbons, aliphatic, alkanes, unspecified			kg	1.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Benzene			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Butane			kg	3.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Methane, fossil			kg	1.60E-6	1	1.46	(3,5,4,1,1,5); Literature
	Ethane			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Hexane			kg	1.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Pentane			kg	5.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Propane			kg	2.90E-6	1	2.15	(3,5,4,1,1,5); Literature
	Toluene			kg	2.70E-7	1	2.15	(3,5,4,1,1,5); Literature
Outputs	crude oil, production RLA, at long distance transport	CH	0	kg	1.00E+0			

B.3.2 Crude oil in Europe

The life cycle inventories of long distance transport of crude oil produced in Azerbaijan and Kazakhstan to Europe were newly established based on the transport routes and distances estimated by Jungbluth (2007) and by using Google Maps. Furthermore, an updated life cycle inventory of the long distance transport of Latin American crude oil to Europe was compiled as described in section B.3.1. The new and updated life cycle inventories are shown in Tab. B. 8 to Tab. B. 10.

Tab. B. 8 Life cycle inventory of the long distance transport of 1 kg crude oil produced in Azerbaijan to Europe.

	Name	Location	Infrastructure-Process	Unit	crude oil, production AZ, at long distance transport	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	crude oil, at production offshore	AZ	0	kg	1.00E+0	1	1.05	(1,1,1,1,1,1); Transported good
	transport, transoceanic tanker	OCE	0	tkm	1.00E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007) and Google Maps; Tanker transport to European sites at the Mediterranean Sea (1000 km)
	transport, crude oil pipeline, onshore	RER	0	tkm	1.50E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007) and Google Maps; Transport by pipeline from extraction sites in Azerbaijan (e.g. Azeri) to the Black Sea (Noworossiysk) (1400 km), and from the Mediterranean Sea to refineries (100 km)
air, high population density	Hydrocarbons, aliphatic, alkanes, unspecified			kg	1.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Benzene			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Butane			kg	3.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Methane, fossil			kg	1.60E-6	1	1.46	(3,5,4,1,1,5); Literature
	Ethane			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Hexane			kg	1.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Pentane			kg	5.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Propane			kg	2.90E-6	1	2.15	(3,5,4,1,1,5); Literature
	Toluene			kg	2.70E-7	1	2.15	(3,5,4,1,1,5); Literature
Outputs	crude oil, production AZ, at long distance transport	RER	0	kg	1.00E+0			

Tab. B. 9 Life cycle inventory of the long distance transport of 1 kg crude oil produced in Kazakhstan to Europe.

	Name	Location	Infrastructure-Process	Unit	crude oil, production KZ, at long distance transport	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	crude oil, at production onshore	KZ	0	kg	6.85E-1	1	1.05	(1,1,1,1,1,1); Transported good; share of onshore production estimated based on information from EIA (2015) on the three largest oil fields in Kazakhstan
	crude oil, at production offshore	KZ	0	kg	3.15E-1	1	1.05	(1,1,1,1,1,1); Transported good; share of offshore production estimated based on information from EIA (2015) on the three largest oil fields in Kazakhstan
	transport, transoceanic tanker	OCE	0	tkm	1.00E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007) and Google Maps; Tanker transport to European sites at the Mediterranean Sea (1000 km)
	transport, crude oil pipeline, onshore	RER	0	tkm	1.90E+0	1	2.06	(4,1,3,3,1,na); Calculation based on information from Jungbluth (2007) and Google Maps; Transport by pipeline from extraction sites in Kazakhstan (e.g. Tengiz, Karachaganak, Kashagan) to the Black Sea (Noworossiysk) (1800 km), and from the Mediterranean Sea to refineries (100 km)
air, high population density	Hydrocarbons, aliphatic, alkanes, unspecified			kg	1.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Benzene			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Butane			kg	3.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Methane, fossil			kg	1.60E-6	1	1.46	(3,5,4,1,1,5); Literature
	Ethane			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Hexane			kg	1.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Pentane			kg	5.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Propane			kg	2.90E-6	1	2.15	(3,5,4,1,1,5); Literature
	Toluene			kg	2.70E-7	1	2.15	(3,5,4,1,1,5); Literature
Outputs	crude oil, production KZ, at long distance transport	RER	0	kg	1.00E+0			

Tab. B. 10 Life cycle inventory of the long distance transport of 1 kg crude oil produced in Latin America to Europe.

	Name	Location	Infrastructure-Process	Unit	crude oil, production RLA, at long distance transport	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	crude oil, at production onshore	RME	0	kg	4.65E-1	1	1.05	(1,1,1,1,1,1); Onshore production modelled by situation in the Middle East; Share estimated based on information from EIA (2014) for Venezuela, Mexico and Brazil
	crude oil, at production offshore	GB	0	kg	5.35E-1	1	1.05	(1,1,1,1,1,1); Offshore production modelled by situation in Great Britain; Share estimated based on information from EIA (2014) for Venezuela, Mexico and Brazil
	transport, transoceanic tanker	OCE	0	tkm	7.50E+0	1	2.06	(4,1,3,3,1,na); Calculation for 1994; Tanker transport from Latin America to Europe (7500 km)
	transport, crude oil pipeline, offshore	OCE	0	tkm	1.00E-1	1	2.06	(4,1,3,3,1,na); Calculation for 1994; Pipeline transport from oil fields to loading station (100 km)
	transport, crude oil pipeline, onshore	RER	0	tkm	1.00E-1	1	2.06	(4,1,3,3,1,na); Calculation for 1994; Pipeline transport to European refineries (100 km)
air, high population density	Hydrocarbons, aliphatic, alkanes, unspecified			kg	1.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Benzene			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Butane			kg	3.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Methane, fossil			kg	1.60E-6	1	1.46	(3,5,4,1,1,5); Literature
	Ethane			kg	4.50E-7	1	2.15	(3,5,4,1,1,5); Literature
	Hexane			kg	1.80E-6	1	2.15	(3,5,4,1,1,5); Literature
	Pentane			kg	5.40E-6	1	2.15	(3,5,4,1,1,5); Literature
	Propane			kg	2.90E-6	1	2.15	(3,5,4,1,1,5); Literature
	Toluene			kg	2.70E-7	1	2.15	(3,5,4,1,1,5); Literature
Outputs	crude oil, production RLA, at long distance transport	RER	0	kg	1.00E+0			

B.4 Refinery

B.4.1 Petrol and diesel in Switzerland

The crude oil mix processed in Swiss refineries was updated based on statistics of the Swiss Oil Association for 2014 (EV/UP 2014). The total amount of crude oil used, the consumption of chemicals and the emissions of pollutants were not changed and are documented in Jungbluth (2007). The life cycle inventories of unleaded petrol and diesel produced in Swiss refineries are shown in Tab. B. 11 and Tab. B. 12, respectively. The data representing the production of low-sulphur petrol and low-sulphur diesel were not updated due to lacking information and limited resources.

Tab. B. 11Life cycle inventory of the production of 1 kg unleaded petrol in Switzerland.

	Name	Location	Infrastructure-Process	Unit	petrol, unleaded, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	methyl tert-butyl ether, at plant	RER	0	kg	5.00E-2	1	1.10	(2,3,1,3,1,3); Estimation 5% for gasoline
	tap water, at user	CH	0	kg	1.50E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	calcium chloride, CaCl2, at plant	RER	0	kg	1.60E-5	1	1.10	(2,3,1,3,1,3); Average of plant data
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	8.79E-5	1	1.14	(2,4,1,3,1,3); Env. reports DE
	iron sulphate, at plant	RER	0	kg	4.94E-5	1	1.34	(3,4,4,3,3,na); Literature, waste water treatment
	lime, hydrated, packed, at plant	CH	0	kg	3.46E-5	1	1.26	(3,4,1,3,3,na); Estimation based on literature
	lubricating oil, at plant	RER	0	kg	2.45E-5	1	1.14	(2,4,1,3,1,3); Env. reports DE
	nitrogen, liquid, at plant	RER	0	kg	8.14E-4	1	1.14	(2,4,1,3,1,3); Env. reports DE
	soap, at plant	RER	0	kg	2.65E-6	1	1.10	(2,3,1,3,1,3); Average of plant data
	sodium hypochlorite, 15% in H2O, at plant	RER	0	kg	4.94E-5	1	1.34	(3,4,4,3,3,na); Literature, waste water treatment
	sulphuric acid, liquid, at plant	RER	0	kg	1.18E-5	1	1.10	(2,3,1,3,1,3); Average of plant data
	transport, lorry >16t, fleet average	RER	0	tkm	1.32E-3	1	2.10	(4,5,na,na,na,na); Standard distance 100km
	transport, freight, rail	RER	0	tkm	7.95E-3	1	2.10	(4,5,na,na,na,na); Standard distance 600km
	crude oil, production RME, at long distance transport	CH	0	kg	5.42E-2	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production RAF, at long distance transport	CH	0	kg	3.39E-1	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production NG, at long distance transport	CH	0	kg	2.09E-1	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production KZ, at long distance transport	CH	0	kg	1.93E-1	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014, Turkmenistan included
	crude oil, production AZ, at long distance transport	CH	0	kg	8.32E-2	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production RU, at long distance transport	CH	0	kg	6.90E-3	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production RLA, at long distance transport	CH	0	kg	6.45E-2	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	electricity, medium voltage, at grid	CH	0	kWh	2.85E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	refinery gas, burned in furnace	CH	0	MJ	2.32E+0	1	1.09	(2,1,1,1,1,3); Swiss statistic
	heavy fuel oil, burned in refinery furnace	CH	0	MJ	5.35E-1	1	1.09	(2,1,1,1,1,3); Swiss statistic
	refinery gas, burned in flare	GLO	0	MJ	8.45E-2	1	1.16	(2,4,1,3,1,4); Swiss plant
	refinery	RER	1	p	5.10E-11	1	3.03	(3,3,1,1,1,4); Estimation
	ammonia, liquid, at regional storehouse	RER	0	kg	1.98E-6	1	1.34	(3,4,4,3,3,na); Literature
	chlorine, liquid, production mix, at plant	RER	0	kg	1.64E-4	1	1.14	(2,4,1,3,1,3); Env. reports DE
	chemicals organic, at plant	GLO	0	kg	1.74E-4	1	1.19	(3,4,2,1,1,4); IPPC European plant data
	propylene glycol, liquid, at plant	RER	0	kg	2.27E-5	1	1.26	(3,4,1,3,3,na); Literature
	molybdenum, at regional storage	RER	0	kg	9.40E-8	1	2.83	Range for RER refineries, Co/Mo Catalyst
	nickel, 99.5%, at plant	GLO	0	kg	1.46E-8	1	4.18	Range for RER refineries, Ni/Mo Catalyst
	palladium, at regional storage	RER	0	kg	9.72E-8	1	1.41	Range for RER refineries, Vanadium Catalyst
	platinum, at regional storage	RER	0	kg	3.08E-9	1	1.12	Range for RER refineries, Reformer Catalyst
	rhodium, at regional storage	RER	0	kg	3.08E-9	1	1.12	Range for RER refineries, Reformer Catalyst
	zeolite, powder, at plant	RER	0	kg	2.03E-5	1	1.34	Range for RER refineries
	zinc, primary, at regional storage	RER	0	kg	2.19E-7	1	1.00	Range for RER refineries, Zn Catalyst
	disposal, refinery sludge, 89.5% water, to hazardous waste incineration	CH	0	kg	1.21E-4	1	1.09	(2,2,1,1,1,3); Average of plant data
	disposal, catalytic converter NOx reduction, 0% water, to underground deposit	DE	0	kg	2.04E-6	1	1.10	(2,3,1,3,1,3); Estimation based on literature data
resource, in ground	Rhenium			kg	3.23E-9	1	1.12	Range for RER refineries, Reformer Catalyst
resource, in water	Water, river			m3	5.59E-4	1	1.16	(3,3,1,3,1,4); Average of plant data
	Water, cooling, unspecified natural origin/m3			m3	3.98E-3	1	1.12	(3,3,1,1,1,na); Average of plant data

Tab. B. 11Life cycle inventory of the production of 1 kg unleaded petrol in Switzerland. (continued)

	Name	Location	Infrastructure-Process	Unit	petrol, unleaded, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
air, high population density	Ammonia			kg	7.26E-8	1	1.54	(3,4,1,3,1,3); Plant data
	Dinitrogen monoxide			kg	1.51E-6	1	1.52	(3,na,na,na,1,na); Average of plant data
	Nitrogen oxides			kg	2.86E-5	1	1.51	(2,1,1,1,1,3); Swiss plants
	Benzene			kg	5.82E-6	1	1.65	(3,5,4,3,1,4); Literature
	Benzene, ethyl-			kg	1.45E-6	1	1.65	(3,5,4,3,1,4); Literature
	Butane			kg	5.82E-5	1	1.65	(3,5,4,3,1,4); Literature
	Butene			kg	1.45E-6	1	1.65	(3,5,4,3,1,4); Literature
	Ethane			kg	1.45E-5	1	1.65	(3,5,4,3,1,4); Literature
	Ethene			kg	2.91E-6	1	1.65	(3,5,4,3,1,4); Literature
	Heptane			kg	1.45E-5	1	1.65	(3,5,4,3,1,4); Literature
	Hexane			kg	2.91E-5	1	1.65	(3,5,4,3,1,4); Literature
	Hydrocarbons, aliphatic, alkanes, unspecified			kg	4.43E-11	1	1.51	(2,3,1,3,1,3); Average of plant data
	Hydrocarbons, aliphatic, unsaturated			kg	2.43E-12	1	1.51	(2,3,1,3,1,3); Average of plant data
	Hydrocarbons, aromatic			kg	6.65E-13	1	1.51	(2,3,1,3,1,3); Average of plant data
	Methane, fossil			kg	1.63E-5	1	1.23	(3,na,na,na,1,na); Average of plant data
	Particulates, > 10 um			kg	9.89E-6	1	2.12	(3,5,4,3,1,4); Literature
	Pentane			kg	7.28E-5	1	1.65	(3,5,4,3,1,4); Literature
	Propane			kg	5.82E-5	1	1.65	(3,5,4,3,1,4); Literature
	Propene			kg	2.91E-6	1	1.65	(3,5,4,3,1,4); Literature
	Toluene			kg	8.73E-6	1	1.65	(3,5,4,3,1,4); Literature
	Xylene			kg	5.82E-6	1	1.65	(3,5,4,3,1,4); Literature
	Heat, waste			MJ	2.72E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	Sulfur dioxide			kg	3.18E-5	1	1.51	(2,1,1,1,1,3); Swiss plants
water, river	t-Butyl methyl ether			kg	7.65E-7	1	3.16	Range for RER refineries
	Aluminium			kg	2.80E-8	1	5.13	(3,5,4,3,1,4); Literature
	Barium			kg	5.59E-8	1	5.13	(3,5,4,3,1,4); Literature
	Boron			kg	2.23E-7	1	1.65	(3,5,4,3,1,4); Literature
	Calcium			kg	2.80E-5	1	1.65	(3,5,4,3,1,4); Literature
	Chloride			kg	4.45E-5	1	5.02	(2,4,1,2,1,3); Average of CH plant, basic uncertainity = 5 estimated based on range
	Cyanide			kg	9.68E-8	1	5.77	Range for RER refineries
	Fluoride			kg	2.50E-6	1	4.47	Range for RER refineries
	Hydrocarbons, aromatic			kg	4.02E-7	1	3.01	(2,3,1,1,1,3); Average of plant data
	Iron			kg	2.80E-7	1	5.13	(3,5,4,3,1,4); Literature
	Magnesium			kg	1.39E-5	1	5.13	(3,5,4,3,1,4); Literature
	Manganese			kg	1.12E-7	1	5.13	(3,5,4,3,1,4); Literature
	Mercury			kg	5.59E-11	1	5.13	(3,5,4,3,1,4); Literature
	Molybdenum			kg	5.59E-9	1	5.13	(3,5,4,3,1,4); Literature
	Nitrate			kg	4.59E-6	1	1.65	(3,5,4,3,1,4); Literature
	Phosphorus			kg	2.16E-7	1	3.87	Range for RER refineries
	Potassium			kg	5.59E-6	1	1.65	(3,5,4,3,1,4); Literature
	Selenium			kg	8.39E-9	1	5.13	(3,5,4,3,1,4); Literature
	Silver			kg	2.80E-8	1	5.13	(3,5,4,3,1,4); Literature
	Sodium			kg	1.68E-4	1	1.65	(3,5,4,3,1,4); Literature
	Sulfide			kg	5.59E-8	1	10.00	Range for RER refineries
	Suspended solids, unspecified			kg	5.59E-6	1	5.00	Range for RER refineries
	Toluene			kg	5.59E-7	1	3.12	(3,5,4,3,1,4); Literature
	Xylene			kg	5.59E-8	1	3.12	(3,5,4,3,1,4); Literature
	Ammonium, ion			kg	3.79E-6	1	6.32	Range for RER refineries
	AOX, Adsorbable Organic Halogen as Cl			kg	9.02E-9	1	3.16	Range for RER refineries
	Benzene			kg	1.28E-8	1	44.70	Range for RER refineries
	PAH, polycyclic aromatic hydrocarbons			kg	9.02E-9	1	3.16	Range for RER refineries
	Sulfate			kg	1.14E-4	1	1.65	(3,5,4,3,1,4); Literature
	Arsenic			kg	5.55E-9	1	5.13	(3,5,4,3,1,4); Literature
	Cadmium			kg	5.55E-9	1	5.13	(3,5,4,3,1,4); Literature
	Chromium			kg	1.25E-7	1	2.24	Range for RER refineries
	Copper			kg	5.55E-9	1	5.13	(3,5,4,3,1,4); Literature
	Lead			kg	1.76E-7	1	5.02	(2,3,1,1,1,4); Range for RER refineries
	Nickel			kg	7.33E-9	1	5.02	(2,4,1,2,1,3); Average of CH plant
	Strontium			kg	3.89E-7	1	5.13	(3,5,4,3,1,4); Literature
	Vanadium			kg	1.67E-8	1	5.13	(3,5,4,3,1,4); Literature
	Zinc			kg	9.57E-8	1	5.02	(2,4,1,2,1,3); Average of CH plant
	Benzene, ethyl-			kg	1.11E-10	1	3.12	(3,5,4,3,1,4); Literature
	BOD5, Biological Oxygen Demand			kg	4.01E-6	1	3.16	Range for RER refineries
	DOC, Dissolved Organic Carbon			kg	3.91E-8	1	1.53	(2,4,1,2,1,3); Average of CH plant
	TOC, Total Organic Carbon			kg	1.58E-5	1	1.65	(3,5,4,3,1,4); Estimation
	COD, Chemical Oxygen Demand			kg	4.10E-5	1	2.04	Range for RER refineries
	Hydrocarbons, unspecified			kg	2.26E-7	1	5.48	Range for RER refineries
	Nitrogen, organic bound			kg	1.09E-5	1	2.65	Range for RER refineries
	Oils, unspecified			kg	5.77E-7	1	14.00	Range for RER refineries
	Phenol			kg	9.95E-8	1	5.77	Range for RER refineries
Outputs	petrol, unleaded, at refinery	CH	0	kg	1.00E+0			

Tab. B. 12Life cycle inventory of the production of 1 kg diesel in Switzerland.

	Name	Location	Infrastructure-Process	Unit	diesel, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	tap water, at user	CH	0	kg	1.50E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	calcium chloride, CaCl2, at plant	RER	0	kg	1.60E-5	1	1.10	(2,3,1,3,1,3); Average of plant data
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	8.78E-5	1	1.14	(2,4,1,3,1,3); Env. reports DE
	iron sulphate, at plant	RER	0	kg	4.94E-5	1	1.34	(3,4,4,3,3,na); Literature, waste water treatment
	lime, hydrated, packed, at plant	CH	0	kg	3.45E-5	1	1.26	(3,4,1,3,3,na); Estimation based on literature
	lubricating oil, at plant	RER	0	kg	2.45E-5	1	1.14	(2,4,1,3,1,3); Env. reports DE
	nitrogen, liquid, at plant	RER	0	kg	8.13E-4	1	1.14	(2,4,1,3,1,3); Env. reports DE
	soap, at plant	RER	0	kg	2.65E-6	1	1.10	(2,3,1,3,1,3); Average of plant data
	sodium hypochlorite, 15% in H2O, at plant	RER	0	kg	4.94E-5	1	1.34	(3,4,4,3,3,na); Literature, waste water treatment
	sulphuric acid, liquid, at plant	RER	0	kg	1.17E-5	1	1.10	(2,3,1,3,1,3); Average of plant data
	transport, lorry >16t, fleet average	RER	0	tkm	1.32E-3	1	2.10	(4,5,na,na,na,na); Standard distance 100km
	transport, freight, rail	RER	0	tkm	7.95E-3	1	2.10	(4,5,na,na,na,na); Standard distance 600km
	crude oil, production RME, at long distance transport	CH	0	kg	5.70E-2	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production RAF, at long distance transport	CH	0	kg	3.57E-1	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production NG, at long distance transport	CH	0	kg	2.20E-1	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production KZ, at long distance transport	CH	0	kg	2.03E-1	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014, Turkmenistan included
	crude oil, production AZ, at long distance transport	CH	0	kg	8.75E-2	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production RU, at long distance transport	CH	0	kg	7.25E-3	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	crude oil, production RLA, at long distance transport	CH	0	kg	6.78E-2	1	1.07	(1,1,1,1,1,3); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	electricity, medium voltage, at grid	CH	0	kWh	1.25E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	refinery gas, burned in furnace	CH	0	MJ	1.28E+0	1	1.09	(2,1,1,1,1,3); Swiss statistic
	heavy fuel oil, burned in refinery furnace	CH	0	MJ	2.97E-1	1	1.09	(2,1,1,1,1,3); Swiss statistic
	refinery gas, burned in flare	GLO	0	MJ	4.69E-2	1	1.16	(2,4,1,3,1,4); Swiss plant
	refinery	RER	1	p	2.83E-11	1	3.03	(3,3,1,1,1,4); Estimation
	ammonia, liquid, at regional storehouse	RER	0	kg	1.98E-6	1	1.34	(3,4,4,3,3,na); Literature
	chemicals organic, at plant	GLO	0	kg	4.05E-4	1	1.19	(3,4,2,1,1,4); IPPC European plant data
	propylene glycol, liquid, at plant	RER	0	kg	6.33E-7	1	1.26	(3,4,1,3,3,na); Literature
	molybdenum, at regional storage	RER	0	kg	1.88E-8	1	2.83	Range for RER refineries, Co/Mo Catalyst
	zeolite, powder, at plant	RER	0	kg	3.86E-6	1	1.34	Range for RER refineries
	zinc, primary, at regional storage	RER	0	kg	4.16E-8	1	1.00	Range for RER refineries, Zn Catalyst
	disposal, refinery sludge, 89.5% water, to hazardous waste incineration	CH	0	kg	1.20E-4	1	1.09	(2,2,1,1,1,3); Average of plant data
	disposal, catalytic converter NOx reduction, 0% water, to underground deposit	DE	0	kg	3.89E-7	1	1.10	(2,3,1,3,1,3); Estimation based on literature data
resource, in ground	Cobalt			kg	2.70E-8	1	2.00	Range for RER refineries, Co/Mo Catalyst
resource, in water	Water, river			m3	5.59E-4	1	1.16	(3,3,1,1,1,4); Average of plant data
	Water, cooling, unspecified natural origin/m3			m3	3.98E-3	1	1.12	(3,3,1,1,1,na); Average of plant data
air, high population density	Ammonia			kg	7.25E-8	1	1.54	(3,4,1,3,1,3); Plant data
	Dinitrogen monoxide			kg	8.35E-7	1	1.52	(3,na,na,na,1,na); Average of plant data
	Nitrogen oxides			kg	1.59E-5	1	1.51	(2,1,1,1,1,3); Swiss plants
	Benzene			kg	5.82E-6	1	1.65	(3,5,4,3,1,4); Literature
	Benzene, ethyl-			kg	1.45E-6	1	1.65	(3,5,4,3,1,4); Literature
	Butane			kg	5.82E-5	1	1.65	(3,5,4,3,1,4); Literature
	Butene			kg	1.45E-6	1	1.65	(3,5,4,3,1,4); Literature
	Ethane			kg	1.45E-5	1	1.65	(3,5,4,3,1,4); Literature
	Ethene			kg	2.90E-6	1	1.65	(3,5,4,3,1,4); Literature
	Heptane			kg	1.45E-5	1	1.65	(3,5,4,3,1,4); Literature
	Hexane			kg	2.90E-5	1	1.65	(3,5,4,3,1,4); Literature
	Hydrocarbons, aliphatic, alkanes, unspecified			kg	4.43E-11	1	1.51	(2,3,1,3,1,3); Average of plant data
	Hydrocarbons, aliphatic, unsaturated			kg	2.43E-12	1	1.51	(2,3,1,3,1,3); Average of plant data
	Hydrocarbons, aromatic			kg	6.64E-13	1	1.51	(2,3,1,3,1,3); Average of plant data

Tab. B. 12Life cycle inventory of the production of 1 kg diesel in Switzerland. (continued)

	Name	Location	Infrastructure-Process	Unit	diesel, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
	Methane, fossil			kg	1.63E-5	1	1.23	(3,na,na,na,1,na); Average of plant data
	Particulates, > 10 um			kg	9.88E-6	1	2.12	(3,5,4,3,1,4); Literature
	Pentane			kg	7.27E-5	1	1.65	(3,5,4,3,1,4); Literature
	Propane			kg	5.82E-5	1	1.65	(3,5,4,3,1,4); Literature
	Propene			kg	2.90E-6	1	1.65	(3,5,4,3,1,4); Literature
	Toluene			kg	8.72E-6	1	1.65	(3,5,4,3,1,4); Literature
	Xylene			kg	5.82E-6	1	1.65	(3,5,4,3,1,4); Literature
	Sulfur dioxide			kg	1.77E-5	1	1.51	(2,1,1,1,1,3); Swiss plants
	Heat, waste			MJ	1.51E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
water, river	Aluminium			kg	2.79E-8	1	5.13	(3,5,4,3,1,4); Literature
	Barium			kg	5.59E-8	1	5.13	(3,5,4,3,1,4); Literature
	Boron			kg	2.23E-7	1	1.65	(3,5,4,3,1,4); Literature
	Calcium			kg	2.79E-5	1	1.65	(3,5,4,3,1,4); Literature
	Chloride			kg	4.44E-5	1	5.02	(2,4,1,2,1,3); Average of CH plant, basic uncertainity = 5 estimated based on range
	Cyanide			kg	9.67E-8	1	5.77	Range for RER refineries
	Fluoride			kg	2.50E-6	1	4.47	Range for RER refineries
	Hydrocarbons, aromatic			kg	4.02E-7	1	3.01	(2,3,1,1,1,3); Average of plant data
	Iron			kg	2.79E-7	1	5.13	(3,5,4,3,1,4); Literature
	Magnesium			kg	1.39E-5	1	5.13	(3,5,4,3,1,4); Literature
	Manganese			kg	1.12E-7	1	5.13	(3,5,4,3,1,4); Literature
	Mercury			kg	5.59E-11	1	5.13	(3,5,4,3,1,4); Literature
	Molybdenum			kg	5.59E-9	1	5.13	(3,5,4,3,1,4); Literature
	Nitrate			kg	4.59E-6	1	1.65	(3,5,4,3,1,4); Literature
	Phosphorus			kg	2.16E-7	1	3.87	Range for RER refineries
	Potassium			kg	5.59E-6	1	1.65	(3,5,4,3,1,4); Literature
	Selenium			kg	8.38E-9	1	5.13	(3,5,4,3,1,4); Literature
	Silver			kg	2.79E-8	1	5.13	(3,5,4,3,1,4); Literature
	Sodium			kg	1.68E-4	1	1.65	(3,5,4,3,1,4); Literature
	Sulfide			kg	5.59E-8	1	10.00	Range for RER refineries
	Suspended solids, unspecified			kg	5.59E-6	1	5.00	Range for RER refineries
	Toluene			kg	5.59E-7	1	3.12	(3,5,4,3,1,4); Literature
	Xylene			kg	5.59E-8	1	3.12	(3,5,4,3,1,4); Literature
	Ammonium, ion			kg	3.78E-6	1	6.32	Range for RER refineries
	AOX, Adsorbable Organic Halogen as Cl			kg	9.01E-9	1	3.16	Range for RER refineries
	Benzene			kg	1.28E-8	1	44.70	Range for RER refineries
	PAH, polycyclic aromatic hydrocarbons			kg	9.01E-9	1	3.16	Range for RER refineries
	Sulfate			kg	1.14E-4	1	1.65	(3,5,4,3,1,4); Literature
	Arsenic			kg	5.55E-9	1	5.13	(3,5,4,3,1,4); Literature
	Cadmium			kg	5.55E-9	1	5.13	(3,5,4,3,1,4); Literature
	Chromium			kg	1.25E-7	1	2.24	Range for RER refineries
	Copper			kg	5.55E-9	1	5.13	(3,5,4,3,1,4); Literature
	Lead			kg	1.76E-7	1	5.02	(2,3,1,1,1,4); Range for RER refineries
	Nickel			kg	7.32E-9	1	5.02	(2,4,1,2,1,3); Average of CH plant
	Strontium			kg	3.88E-7	1	5.13	(3,5,4,3,1,4); Literature
	Vanadium			kg	1.67E-8	1	5.13	(3,5,4,3,1,4); Literature
	Zinc			kg	9.56E-8	1	5.02	(2,4,1,2,1,3); Average of CH plant
	Benzene, ethyl-			kg	1.10E-10	1	3.12	(3,5,4,3,1,4); Literature
	BOD5, Biological Oxygen Demand			kg	4.01E-6	1	3.16	Range for RER refineries
	DOC, Dissolved Organic Carbon			kg	3.91E-8	1	1.53	(2,4,1,2,1,3); Average of CH plant
	TOC, Total Organic Carbon			kg	1.58E-5	1	1.65	(3,5,4,3,1,4); Estimation
	COD, Chemical Oxygen Demand			kg	4.09E-5	1	2.04	Range for RER refineries
	Hydrocarbons, unspecified			kg	5.64E-8	1	5.48	Range for RER refineries
	Nitrogen, organic bound			kg	2.72E-6	1	2.65	Range for RER refineries
	Oils, unspecified			kg	1.44E-7	1	14.00	Range for RER refineries
	Phenol			kg	9.94E-8	1	5.77	Range for RER refineries
Outputs	diesel, at refinery	CH	0	kg	1.00E+0			

B.4.2 Petrol and diesel in Europe

The crude oil mix processed in European refineries was updated based on statistics of the International Energy Agency for 2015 (IEA 2015). The total amount of crude oil used, the consumption of chemicals and the emissions of pollutants were not changed and are documented in Jungbluth (2007). The life cycle inventories of unleaded petrol and diesel produced in European refineries are shown in Tab. B. 13 and Tab. B. 14, respectively. The data representing the production of low-sulphur petrol and low-sulphur diesel were not updated due to lacking information and limited resources.

Tab. B. 13Life cycle inventory of the production of 1 kg unleaded petrol in Europe.

	Name	Location	Infrastructure-Process	Unit	petrol, unleaded, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	methyl tert-butyl ether, at plant	RER	0	kg	2.49E-2	1	1.09	(2,1,1,1,1,3); Estimation 2.5% for gasoline
	tap water, at user	RER	0	kg	1.45E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	calcium chloride, CaCl2, at plant	RER	0	kg	1.55E-5	1	1.10	(2,3,1,3,1,3); Average of plant data
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	8.49E-5	1	1.14	(2,4,1,3,1,3); Env. reports DE
	iron sulphate, at plant	RER	0	kg	4.77E-5	1	1.34	(3,4,4,3,3,na); Literature, waste water treatment
	lime, hydrated, packed, at plant	CH	0	kg	3.34E-5	1	1.26	(3,4,1,3,3,na); Estimation based on literature
	lubricating oil, at plant	RER	0	kg	2.37E-5	1	1.14	(2,4,1,3,1,3); Env. reports DE
	nitrogen, liquid, at plant	RER	0	kg	7.86E-4	1	1.14	(2,4,1,3,1,3); Env. reports DE
	soap, at plant	RER	0	kg	2.56E-6	1	1.10	(2,3,1,3,1,3); Average of plant data
	sodium hypochlorite, 15% in H2O, at plant	RER	0	kg	4.77E-5	1	1.34	(3,4,4,3,3,na); Literature, waste water treatment
	sulphuric acid, liquid, at plant	RER	0	kg	1.14E-5	1	1.10	(2,3,1,3,1,3); Average of plant data
	transport, lorry >16t, fleet average	RER	0	tkm	6.75E-4	1	2.10	(4,5,na,na,na,na); Standard distance 100km
	transport, freight, rail	RER	0	tkm	4.05E-3	1	2.10	(4,5,na,na,na,na); Standard distance 600km
	crude oil, production RU, at long distance transport	RER	0	kg	2.63E-1	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production KZ, at long distance transport	RER	0	kg	5.04E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production AZ, at long distance transport	RER	0	kg	2.67E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production RLA, at long distance transport	RER	0	kg	4.97E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production RME, at long distance transport	RER	0	kg	1.71E-1	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production RAF, at long distance transport	RER	0	kg	7.36E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production NG, at long distance transport	RER	0	kg	1.41E-1	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production NO, at long distance transport	RER	0	kg	1.01E-1	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production GB, at long distance transport	RER	0	kg	5.62E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production NL, at long distance transport	RER	0	kg	7.25E-3	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	5.54E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	refinery gas, burned in furnace	RER	0	MJ	3.55E+0	1	1.09	(2,1,1,1,1,3); IPPC European plant data
	heavy fuel oil, burned in refinery furnace	RER	0	MJ	1.22E+0	1	1.09	(2,1,1,1,1,3); IPPC European plant data
	refinery gas, burned in flare	GLO	0	MJ	1.50E-1	1	1.34	(3,4,4,3,3,na); Literature
	refinery	RER	1	p	4.93E-11	1	3.03	(3,3,1,1,1,4); Estimation
	ammonia, liquid, at regional storehouse	RER	0	kg	1.92E-6	1	1.34	(3,4,4,3,3,na); Literature
	naphtha, at regional storage	RER	0	kg	3.82E-2	1	1.10	(2,3,1,3,1,3); Calculation as input-output balance, not considered for transports
	chlorine, liquid, production mix, at plant	RER	0	kg	1.31E-4	1	1.14	(2,4,1,3,1,3); Env. reports DE
	chemicals organic, at plant	GLO	0	kg	1.82E-4	1	1.19	(3,4,2,1,1,4); IPPC European plant data
	propylene glycol, liquid, at plant	RER	0	kg	1.97E-5	1	1.26	(3,4,1,3,3,na); Literature
	molybdenum, at regional storage	RER	0	kg	7.87E-8	1	2.83	Range for RER refineries, Co/Mo Catalyst
	nickel, 99.5%, at plant	GLO	0	kg	1.22E-8	1	4.18	Range for RER refineries, Ni/Mo Catalyst
	palladium, at regional storage	RER	0	kg	7.96E-8	1	1.41	Range for RER refineries, Vanadium Catalyst
	platinum, at regional storage	RER	0	kg	2.52E-9	1	1.12	Range for RER refineries, Reformer Catalyst
	rhodium, at regional storage	RER	0	kg	2.52E-9	1	1.12	Range for RER refineries, Reformer Catalyst
	zeolite, powder, at plant	RER	0	kg	1.76E-5	1	1.34	Range for RER refineries
	zinc, primary, at regional storage	RER	0	kg	1.90E-7	1	1.00	Range for RER refineries, Zn Catalyst
	disposal, refinery sludge, 89.5% water, to sanitary landfill	CH	0	kg	1.79E-4	1	1.10	(2,3,1,3,1,3); Average of plant data
	disposal, refinery sludge, 89.5% water, to hazardous waste incineration	CH	0	kg	1.91E-4	1	1.10	(2,3,1,3,1,3); Estimation
	disposal, catalytic converter NOx reduction, 0% water, to underground deposit	DE	0	kg	1.77E-6	1	1.10	(2,3,1,3,1,3); Estimation based on literature data
resource, in ground	Rhenium			kg	3.16E-9	1	1.12	Range for RER refineries, Reformer Catalyst
resource, in water	Water, river			m3	6.68E-4	1	1.16	(3,3,1,3,1,4); Average of plant data
	Water, cooling, unspecified natural origin/m3			m3	3.82E-3	1	1.12	(3,3,1,1,1,na); Average of plant data

Tab. B. 13Life cycle inventory of the production of 1 kg unleaded petrol in Europe. (continued)

	Name	Location	Infrastructure-Process	Unit	petrol, unleaded, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
air, high population density	Ammonia			kg	7.02E-8	1	1.54	(3,4,1,3,1,3); Plant data
	Dinitrogen monoxide			kg	1.69E-6	1	1.51	(2,3,1,3,1,3); Average of plant data
	Nitrogen oxides			kg	3.96E-5	1	2.89	11% of Range for RER refineries
	Benzene			kg	5.14E-6	1	1.65	(3,5,4,3,1,4); Literature
	Benzene, ethyl-			kg	1.29E-6	1	1.65	(3,5,4,3,1,4); Literature
	Butane			kg	5.14E-5	1	1.65	(3,5,4,3,1,4); Literature
	Butene			kg	1.29E-6	1	1.65	(3,5,4,3,1,4); Literature
	Ethane			kg	1.29E-5	1	1.65	(3,5,4,3,1,4); Literature
	Ethene			kg	2.57E-6	1	1.65	(3,5,4,3,1,4); Literature
	Heptane			kg	1.29E-5	1	1.65	(3,5,4,3,1,4); Literature
	Hexane			kg	2.57E-5	1	1.65	(3,5,4,3,1,4); Literature
	Hydrocarbons, aliphatic, alkanes, unspecified			kg	4.30E-11	1	1.51	(2,3,1,3,1,3); Average of plant data
	Hydrocarbons, aliphatic, unsaturated			kg	2.36E-12	1	1.51	(2,3,1,3,1,3); Average of plant data
	Hydrocarbons, aromatic			kg	6.44E-13	1	1.51	(2,3,1,3,1,3); Average of plant data
	Methane, fossil			kg	3.84E-5	1	1.41	(3,5,4,3,1,4); Literature
	Particulates, > 10 um			kg	9.59E-6	1	2.12	(3,5,4,3,1,4); Literature
	Pentane			kg	6.43E-5	1	1.65	(3,5,4,3,1,4); Literature
	Propane			kg	5.14E-5	1	1.65	(3,5,4,3,1,4); Literature
	Propene			kg	2.57E-6	1	1.65	(3,5,4,3,1,4); Literature
	Toluene			kg	7.71E-6	1	1.65	(3,5,4,3,1,4); Literature
	Xylene			kg	5.14E-6	1	1.65	(3,5,4,3,1,4); Literature
	Heat, waste			MJ	9.27E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	Sulfur dioxide			kg	3.00E-4	1	14.10	Range for RER refineries, Share for sulphur recovery and FCC
water, river	t-Butyl methyl ether			kg	3.76E-7	1	3.16	Range for RER refineries
water, ocean	TOC, Total Organic Carbon			kg	5.16E-5	1	1.65	(3,5,4,3,1,4); Estimation
water, river	Aluminium			kg	1.22E-8	1	5.13	(3,5,4,3,1,4); Literature
	Barium			kg	2.44E-8	1	5.13	(3,5,4,3,1,4); Literature
	Boron			kg	9.74E-8	1	1.65	(3,5,4,3,1,4); Literature
	Calcium			kg	1.22E-5	1	1.65	(3,5,4,3,1,4); Literature
	Chloride			kg	1.94E-5	1	5.02	(2,4,1,2,1,3); Average of CH plant, basic uncertainity = 5 estimated based on range
	Cyanide			kg	4.23E-8	1	5.77	Range for RER refineries
	Fluoride			kg	1.09E-6	1	4.47	Range for RER refineries
	Hydrocarbons, aromatic			kg	1.76E-7	1	3.01	(2,3,1,1,1,3); Average of plant data
	Iron			kg	1.22E-7	1	5.13	(3,5,4,3,1,4); Literature
	Magnesium			kg	6.10E-6	1	5.13	(3,5,4,3,1,4); Literature
	Manganese			kg	4.88E-8	1	5.13	(3,5,4,3,1,4); Literature
	Mercury			kg	2.44E-11	1	5.13	(3,5,4,3,1,4); Literature
	Molybdenum			kg	2.44E-9	1	5.13	(3,5,4,3,1,4); Literature
	Nitrate			kg	2.00E-6	1	1.65	(3,5,4,3,1,4); Literature
	Phosphorus			kg	9.45E-8	1	3.87	Range for RER refineries
	Potassium			kg	2.44E-6	1	1.65	(3,5,4,3,1,4); Literature
	Selenium			kg	3.66E-9	1	5.13	(3,5,4,3,1,4); Literature
	Silver			kg	1.22E-8	1	5.13	(3,5,4,3,1,4); Literature
	Sodium			kg	7.32E-5	1	1.65	(3,5,4,3,1,4); Literature
	Sulfide			kg	2.44E-8	1	10.00	Range for RER refineries
	Suspended solids, unspecified			kg	2.44E-6	1	5.00	Range for RER refineries
	Toluene			kg	2.43E-7	1	3.12	(3,5,4,3,1,4); Literature
	Xylene			kg	2.44E-8	1	3.12	(3,5,4,3,1,4); Literature
water, ocean	Aluminium			kg	2.12E-8	1	5.13	(3,5,4,3,1,4); Literature
	Barium			kg	4.24E-8	1	5.13	(3,5,4,3,1,4); Literature
	Boron			kg	1.70E-7	1	1.65	(3,5,4,3,1,4); Literature
	Calcium			kg	2.12E-5	1	1.65	(3,5,4,3,1,4); Literature
	Chloride			kg	3.38E-5	1	5.02	(2,4,1,2,1,3); Average of CH plant, basic uncertainity = 5 estimated based on range
	Cyanide			kg	7.35E-8	1	5.77	Range for RER refineries
	Fluoride			kg	1.90E-6	1	4.47	Range for RER refineries
	Hydrocarbons, aromatic			kg	3.05E-7	1	3.01	(2,3,1,1,1,3); Average of plant data
	Iron			kg	2.12E-7	1	5.13	(3,5,4,3,1,4); Literature
	Magnesium			kg	1.06E-5	1	5.13	(3,5,4,3,1,4); Literature
	Manganese			kg	8.48E-8	1	5.13	(3,5,4,3,1,4); Literature
	Mercury			kg	4.24E-11	1	5.13	(3,5,4,3,1,4); Literature
	Molybdenum			kg	4.25E-9	1	5.13	(3,5,4,3,1,4); Literature
	Nitrate			kg	3.48E-6	1	1.65	(3,5,4,3,1,4); Literature
	Phosphorus			kg	1.64E-7	1	3.87	Range for RER refineries
	Potassium			kg	4.24E-6	1	1.65	(3,5,4,3,1,4); Literature
	Selenium			kg	6.37E-9	1	5.13	(3,5,4,3,1,4); Literature
	Sodium			kg	1.27E-4	1	1.65	(3,5,4,3,1,4); Literature
	Strontium			kg	2.97E-7	1	5.13	(3,5,4,3,1,4); Literature
	Suspended solids, unspecified			kg	4.24E-6	1	5.00	Range for RER refineries
	t-Butyl methyl ether			kg	1.35E-7	1	3.16	Range for RER refineries
	Vanadium			kg	1.27E-8	1	5.13	(3,5,4,3,1,4); Literature
	Zinc			kg	7.31E-8	1	5.02	(2,4,1,2,1,3); Average of CH plant
water, river	Ammonium, ion			kg	1.62E-6	1	6.32	Range for RER refineries
water, ocean	Ammonium, ion			kg	2.83E-6	1	6.32	Range for RER refineries

Tab. B. 13Life cycle inventory of the production of 1 kg unleaded petrol in Europe. (continued)

	Name	Location	Infrastructure-Process	Unit	petrol, unleaded, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
water, river	AOX, Adsorbable Organic Halogen as Cl			kg	3.92E-9	1	3.16	Range for RER refineries
	Benzene			kg	5.55E-9	1	44.70	Range for RER refineries
	PAH, polycyclic aromatic hydrocarbons			kg	3.92E-9	1	3.16	Range for RER refineries
	Sulfate			kg	4.96E-5	1	1.65	(3,5,4,3,1,4); Literature
water, ocean	AOX, Adsorbable Organic Halogen as Cl			kg	6.83E-9	1	3.16	Range for RER refineries
	Benzene			kg	9.65E-9	1	44.70	Range for RER refineries
	PAH, polycyclic aromatic hydrocarbons			kg	6.83E-9	1	3.16	Range for RER refineries
	Sulfide			kg	4.31E-8	1	10.00	Range for RER refineries
water, river	Arsenic			kg	2.42E-9	1	5.13	(3,5,4,3,1,4); Literature
	Cadmium			kg	2.42E-9	1	5.13	(3,5,4,3,1,4); Literature
	Chromium			kg	5.39E-8	1	2.24	Range for RER refineries
	Copper			kg	2.42E-9	1	5.13	(3,5,4,3,1,4); Literature
	Lead			kg	7.63E-8	1	5.02	(2,3,1,1,1,4); Range for RER refineries
	Nickel			kg	3.18E-9	1	5.02	(2,4,1,2,1,3); Average of CH plant
	Strontium			kg	1.69E-7	1	5.13	(3,5,4,3,1,4); Literature
	Vanadium			kg	7.23E-9	1	5.13	(3,5,4,3,1,4); Literature
	Zinc			kg	4.16E-8	1	5.02	(2,4,1,2,1,3); Average of CH plant
water, ocean	Arsenic			kg	4.20E-9	1	5.13	(3,5,4,3,1,4); Literature
	Cadmium			kg	4.20E-9	1	5.13	(3,5,4,3,1,4); Literature
	Chromium			kg	9.39E-8	1	2.24	Range for RER refineries
	Copper			kg	4.20E-9	1	5.13	(3,5,4,3,1,4); Literature
	Lead			kg	1.33E-7	1	5.02	(2,3,1,1,1,4); Range for RER refineries
	Nickel			kg	5.54E-9	1	5.02	(2,4,1,2,1,3); Average of CH plant
	Sulfate			kg	8.39E-5	1	1.65	(3,5,4,3,1,4); Literature
	Xylene			kg	4.19E-8	1	3.12	(3,5,4,3,1,4); Literature
water, river	Benzene, ethyl-			kg	4.82E-11	1	3.12	(3,5,4,3,1,4); Literature
water, ocean	Benzene, ethyl-			kg	8.39E-11	1	3.12	(3,5,4,3,1,4); Literature
water, river	BOD5, Biological Oxygen Demand			kg	1.72E-6	1	3.16	Range for RER refineries
	DOC, Dissolved Organic Carbon			kg	1.68E-8	1	1.53	(2,4,1,2,1,3); Average of CH plant
	TOC, Total Organic Carbon			kg	6.79E-6	1	1.65	(3,5,4,3,1,4); Estimation
water, ocean	BOD5, Biological Oxygen Demand			kg	2.99E-6	1	3.16	Range for RER refineries
	DOC, Dissolved Organic Carbon			kg	2.91E-8	1	1.53	(2,4,1,2,1,3); Average of CH plant
	Toluene			kg	4.72E-7	1	3.12	(3,5,4,3,1,4); Literature
water, river	COD, Chemical Oxygen Demand			kg	1.74E-5	1	2.04	Range for RER refineries
water, ocean	COD, Chemical Oxygen Demand			kg	3.03E-5	1	2.04	Range for RER refineries
water, river	Hydrocarbons, unspecified			kg	9.21E-8	1	5.48	Range for RER refineries
	Nitrogen, organic bound			kg	4.45E-6	1	2.65	Range for RER refineries
	Oils, unspecified			kg	8.93E-7	1	14.00	Range for RER refineries
water, ocean	Hydrocarbons, unspecified			kg	1.60E-7	1	5.48	Range for RER refineries
	Nitrogen, organic bound			kg	7.73E-6	1	2.65	Range for RER refineries
	Oils, unspecified			kg	1.55E-6	1	14.00	Range for RER refineries
water, river	Phenol			kg	3.74E-8	1	5.77	Range for RER refineries
water, ocean	Phenol			kg	6.49E-8	1	5.77	Range for RER refineries
Outputs	petrol, unleaded, at refinery	RER	0	kg	1.00E+0			

Tab. B. 14Life cycle inventory of the production of 1 kg diesel in Europe.

	Name	Location	Infrastructure-Process	Unit	diesel, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	tap water, at user	RER	0	kg	1.46E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	calcium chloride, CaCl2, at plant	RER	0	kg	1.56E-5	1	1.10	(2,3,1,3,1,3); Average of plant data
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	8.54E-5	1	1.14	(2,4,1,3,1,3); Env. reports DE
	iron sulphate, at plant	RER	0	kg	4.80E-5	1	1.34	(3,4,4,3,3,na); Literature, waste water treatment
	lime, hydrated, packed, at plant	CH	0	kg	3.36E-5	1	1.26	(3,4,1,3,3,na); Estimation based on literature
	lubricating oil, at plant	RER	0	kg	2.38E-5	1	1.14	(2,4,1,3,1,3); Env. reports DE
	nitrogen, liquid, at plant	RER	0	kg	7.91E-4	1	1.14	(2,4,1,3,1,3); Env. reports DE
	soap, at plant	RER	0	kg	2.57E-6	1	1.10	(2,3,1,3,1,3); Average of plant data
	sodium hypochlorite, 15% in H2O, at plant	RER	0	kg	4.80E-5	1	1.34	(3,4,4,3,3,na); Literature, waste water treatment
	sulphuric acid, liquid, at plant	RER	0	kg	1.14E-5	1	1.10	(2,3,1,3,1,3); Average of plant data
	transport, lorry >16t, fleet average	RER	0	tkm	6.79E-4	1	2.10	(4,5,na,na,na,na); Standard distance 100km
	transport, freight, rail	RER	0	tkm	4.07E-3	1	2.10	(4,5,na,na,na,na); Standard distance 600km
	crude oil, production RU, at long distance transport	RER	0	kg	2.71E-1	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production KZ, at long distance transport	RER	0	kg	5.20E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production AZ, at long distance transport	RER	0	kg	2.75E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production RLA, at long distance transport	RER	0	kg	5.13E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production RME, at long distance transport	RER	0	kg	1.76E-1	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production RAF, at long distance transport	RER	0	kg	7.59E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production NG, at long distance transport	RER	0	kg	1.45E-1	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production NO, at long distance transport	RER	0	kg	1.05E-1	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production GB, at long distance transport	RER	0	kg	5.80E-2	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	crude oil, production NL, at long distance transport	RER	0	kg	7.48E-3	1	1.07	(1,1,1,1,1,3); IEA Monthly Oil Statistics (2015), Tab. 3.4
	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	2.45E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	refinery gas, burned in furnace	RER	0	MJ	1.98E+0	1	1.09	(2,1,1,1,1,3); IPPC European plant data
	heavy fuel oil, burned in refinery furnace	RER	0	MJ	6.80E-1	1	1.09	(2,1,1,1,1,3); IPPC European plant data
	refinery gas, burned in flare	GLO	0	MJ	8.36E-2	1	1.34	(3,4,4,3,3,na); Literature
	refinery	RER	1	p	2.76E-11	1	3.03	(3,3,1,1,1,4); Estimation
	ammonia, liquid, at regional storehouse	RER	0	kg	1.93E-6	1	1.34	(3,4,4,3,3,na); Literature
	naphtha, at regional storage	RER	0	kg	3.84E-2	1	1.10	(2,3,1,3,1,3); Calculation as input-output balance, not considered for transports
	chemicals organic, at plant	GLO	0	kg	4.27E-4	1	1.19	(3,4,2,1,1,4); IPPC European plant data
	propylene glycol, liquid, at plant	RER	0	kg	5.52E-7	1	1.26	(3,4,1,3,3,na); Literature
	molybdenum, at regional storage	RER	0	kg	1.58E-8	1	2.83	Range for RER refineries, Co/Mo Catalyst
	zeolite, powder, at plant	RER	0	kg	3.37E-6	1	1.34	Range for RER refineries
	zinc, primary, at regional storage	RER	0	kg	3.64E-8	1	1.00	Range for RER refineries, Zn Catalyst
	disposal, refinery sludge, 89.5% water, to sanitary landfill	CH	0	kg	1.80E-4	1	1.10	(2,3,1,3,1,3); Average of plant data
	disposal, refinery sludge, 89.5% water, to hazardous waste incineration	CH	0	kg	1.92E-4	1	1.10	(2,3,1,3,1,3); Estimation
	disposal, catalytic converter NOx reduction, 0% water, to underground deposit	DE	0	kg	3.40E-7	1	1.10	(2,3,1,3,1,3); Estimation based on literature data
resource, in ground	Cobalt			kg	2.92E-8	1	2.00	Range for RER refineries, Co/Mo Catalyst
resource, in water	Water, river			m3	6.72E-4	1	1.16	(3,3,1,3,1,4); Average of plant data
	Water, cooling, unspecified natural origin/m3			m3	3.84E-3	1	1.12	(3,3,1,1,1,na); Average of plant data
air, high population density	Ammonia			kg	7.06E-8	1	1.54	(3,4,1,3,1,3); Plant data
	Dinitrogen monoxide			kg	9.44E-7	1	1.51	(2,3,1,3,1,3); Average of plant data
	Nitrogen oxides			kg	2.21E-5	1	2.89	11% of Range for RER refineries
	Benzene			kg	5.17E-6	1	1.65	(3,5,4,3,1,4); Literature
	Benzene, ethyl-			kg	1.29E-6	1	1.65	(3,5,4,3,1,4); Literature
	Butane			kg	5.17E-5	1	1.65	(3,5,4,3,1,4); Literature
	Butene			kg	1.29E-6	1	1.65	(3,5,4,3,1,4); Literature
	Ethane			kg	1.29E-5	1	1.65	(3,5,4,3,1,4); Literature
	Ethene			kg	2.59E-6	1	1.65	(3,5,4,3,1,4); Literature
	Heptane			kg	1.29E-5	1	1.65	(3,5,4,3,1,4); Literature
	Hexane			kg	2.59E-5	1	1.65	(3,5,4,3,1,4); Literature
	Hydrocarbons, aliphatic, alkanes, unspecified			kg	4.32E-11	1	1.51	(2,3,1,3,1,3); Average of plant data
	Hydrocarbons, aliphatic, unsaturated			kg	2.37E-12	1	1.51	(2,3,1,3,1,3); Average of plant data
	Hydrocarbons, aromatic			kg	6.48E-13	1	1.51	(2,3,1,3,1,3); Average of plant data
	Methane, fossil			kg	3.86E-5	1	1.41	(3,5,4,3,1,4); Literature
	Particulates, > 10 um			kg	9.65E-6	1	2.12	(3,5,4,3,1,4); Literature

Tab. B. 14Life cycle inventory of the production of 1 kg diesel in Europe. (continued)

	Name	Location	Infrastructure-Process	Unit	diesel, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
	Pentane			kg	6.47E-5	1	1.65	(3,5,4,3,1,4); Literature
	Propane			kg	5.17E-5	1	1.65	(3,5,4,3,1,4); Literature
	Propene			kg	2.59E-6	1	1.65	(3,5,4,3,1,4); Literature
	Toluene			kg	7.76E-6	1	1.65	(3,5,4,3,1,4); Literature
	Xylene			kg	5.17E-6	1	1.65	(3,5,4,3,1,4); Literature
	Heat, waste			MJ	5.18E-2	1	1.10	(2,3,1,3,1,3); Average of plant data
	Sulfur dioxide			kg	1.68E-4	1	14.10	Range for RER refineries, Share for sulphur recovery and FCC
water, river	Aluminium			kg	1.23E-8	1	5.13	(3,5,4,3,1,4); Literature
	Barium			kg	2.46E-8	1	5.13	(3,5,4,3,1,4); Literature
	Boron			kg	9.79E-8	1	1.65	(3,5,4,3,1,4); Literature
	Calcium			kg	1.23E-5	1	1.65	(3,5,4,3,1,4); Literature
	Chloride			kg	1.95E-5	1	5.02	(2,4,1,2,1,3); Average of CH plant, basic uncertainity = 5 estimated based on range
	Cyanide			kg	4.25E-8	1	5.77	Range for RER refineries
	Fluoride			kg	1.09E-6	1	4.47	Range for RER refineries
	Hydrocarbons, aromatic			kg	1.77E-7	1	3.01	(2,3,1,1,1,3); Average of plant data
	Iron			kg	1.23E-7	1	5.13	(3,5,4,3,1,4); Literature
	Magnesium			kg	6.13E-6	1	5.13	(3,5,4,3,1,4); Literature
	Manganese			kg	4.91E-8	1	5.13	(3,5,4,3,1,4); Literature
	Mercury			kg	2.46E-11	1	5.13	(3,5,4,3,1,4); Literature
	Molybdenum			kg	2.46E-9	1	5.13	(3,5,4,3,1,4); Literature
	Nitrate			kg	2.02E-6	1	1.65	(3,5,4,3,1,4); Literature
	Phosphorus			kg	9.50E-8	1	3.87	Range for RER refineries
	Potassium			kg	2.46E-6	1	1.65	(3,5,4,3,1,4); Literature
	Selenium			kg	3.68E-9	1	5.13	(3,5,4,3,1,4); Literature
	Silver			kg	1.23E-8	1	5.13	(3,5,4,3,1,4); Literature
	Sodium			kg	7.36E-5	1	1.65	(3,5,4,3,1,4); Literature
	Sulfide			kg	2.46E-8	1	10.00	Range for RER refineries
	Suspended solids, unspecified			kg	2.46E-6	1	5.00	Range for RER refineries
	Toluene			kg	2.45E-7	1	3.12	(3,5,4,3,1,4); Literature
	Xylene			kg	2.46E-8	1	3.12	(3,5,4,3,1,4); Literature
water, ocean	Aluminium			kg	2.13E-8	1	5.13	(3,5,4,3,1,4); Literature
	Barium			kg	4.26E-8	1	5.13	(3,5,4,3,1,4); Literature
	Boron			kg	1.71E-7	1	1.65	(3,5,4,3,1,4); Literature
	Calcium			kg	2.13E-5	1	1.65	(3,5,4,3,1,4); Literature
	Chloride			kg	3.40E-5	1	5.02	(2,4,1,2,1,3); Average of CH plant, basic uncertainity = 5 estimated based on range
	Cyanide			kg	7.39E-8	1	5.77	Range for RER refineries
	Fluoride			kg	1.91E-6	1	4.47	Range for RER refineries
	Hydrocarbons, aromatic			kg	3.07E-7	1	3.01	(2,3,1,1,1,3); Average of plant data
	Iron			kg	2.13E-7	1	5.13	(3,5,4,3,1,4); Literature
	Magnesium			kg	1.07E-5	1	5.13	(3,5,4,3,1,4); Literature
	Manganese			kg	8.53E-8	1	5.13	(3,5,4,3,1,4); Literature
	Mercury			kg	4.26E-11	1	5.13	(3,5,4,3,1,4); Literature
	Molybdenum			kg	4.27E-9	1	5.13	(3,5,4,3,1,4); Literature
	Nitrate			kg	3.50E-6	1	1.65	(3,5,4,3,1,4); Literature
	Phosphorus			kg	1.65E-7	1	3.87	Range for RER refineries
	Potassium			kg	4.26E-6	1	1.65	(3,5,4,3,1,4); Literature
	Selenium			kg	6.40E-9	1	5.13	(3,5,4,3,1,4); Literature
	Sodium			kg	1.28E-4	1	1.65	(3,5,4,3,1,4); Literature
	Strontium			kg	2.99E-7	1	5.13	(3,5,4,3,1,4); Literature
	Suspended solids, unspecified			kg	4.26E-6	1	5.00	Range for RER refineries
	t-Butyl methyl ether			kg	1.35E-7	1	3.16	Range for RER refineries
	Vanadium			kg	1.28E-8	1	5.13	(3,5,4,3,1,4); Literature
	Zinc			kg	7.35E-8	1	5.02	(2,4,1,2,1,3); Average of CH plant
water, river	Ammonium, ion			kg	1.63E-6	1	6.32	Range for RER refineries
water, ocean	Ammonium, ion			kg	2.85E-6	1	6.32	Range for RER refineries
water, river	AOX, Adsorbable Organic Halogen as Cl			kg	3.95E-9	1	3.16	Range for RER refineries
	Benzene			kg	5.58E-9	1	44.70	Range for RER refineries
	PAH, polycyclic aromatic hydrocarbons			kg	3.95E-9	1	3.16	Range for RER refineries
	Sulfate			kg	4.99E-5	1	1.65	(3,5,4,3,1,4); Literature
water, ocean	AOX, Adsorbable Organic Halogen as Cl			kg	6.87E-9	1	3.16	Range for RER refineries
	Benzene			kg	9.71E-9	1	44.70	Range for RER refineries
	PAH, polycyclic aromatic hydrocarbons			kg	6.87E-9	1	3.16	Range for RER refineries
	Sulfide			kg	4.34E-8	1	10.00	Range for RER refineries
water, river	Arsenic			kg	2.43E-9	1	5.13	(3,5,4,3,1,4); Literature
	Benzene, ethyl-			kg	4.85E-11	1	3.12	(3,5,4,3,1,4); Literature
	Cadmium			kg	2.43E-9	1	5.13	(3,5,4,3,1,4); Literature
	Chromium			kg	5.42E-8	1	2.24	Range for RER refineries
	Copper			kg	2.43E-9	1	5.13	(3,5,4,3,1,4); Literature
	Lead			kg	7.68E-8	1	5.02	(2,3,1,1,1,4); Range for RER refineries
	Nickel			kg	3.20E-9	1	5.02	(2,4,1,2,1,3); Average of CH plant
	Strontium			kg	1.70E-7	1	5.13	(3,5,4,3,1,4); Literature
	Vanadium			kg	7.28E-9	1	5.13	(3,5,4,3,1,4); Literature
	Zinc			kg	4.19E-8	1	5.02	(2,4,1,2,1,3); Average of CH plant

Tab. B. 14Life cycle inventory of the production of 1 kg diesel in Europe. (continued)

	Name	Location	Infrastructure-Process	Unit	diesel, at refinery	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				RER			
	InfrastructureProcess				0			
	Unit				kg			
water, ocean	Arsenic			kg	4.23E-9	1	5.13	(3,5,4,3,1,4); Literature
	Benzene, ethyl-			kg	8.45E-11	1	3.12	(3,5,4,3,1,4); Literature
	Cadmium			kg	4.23E-9	1	5.13	(3,5,4,3,1,4); Literature
	Chromium			kg	9.44E-8	1	2.24	Range for RER refineries
	Copper			kg	4.23E-9	1	5.13	(3,5,4,3,1,4); Literature
	Lead			kg	1.34E-7	1	5.02	(2,3,1,1,1,4); Range for RER refineries
	Nickel			kg	5.58E-9	1	5.02	(2,4,1,2,1,3); Average of CH plant
	Sulfate			kg	8.45E-5	1	1.65	(3,5,4,3,1,4); Literature
	Xylene			kg	4.22E-8	1	3.12	(3,5,4,3,1,4); Literature
water, river	BOD5, Biological Oxygen Demand			kg	1.73E-6	1	3.16	Range for RER refineries
	DOC, Dissolved Organic Carbon			kg	1.69E-8	1	1.53	(2,4,1,2,1,3); Average of CH plant
	TOC, Total Organic Carbon			kg	6.83E-6	1	1.65	(3,5,4,3,1,4); Estimation
water, ocean	BOD5, Biological Oxygen Demand			kg	3.00E-6	1	3.16	Range for RER refineries
	DOC, Dissolved Organic Carbon			kg	2.93E-8	1	1.53	(2,4,1,2,1,3); Average of CH plant
	Toluene			kg	4.75E-7	1	3.12	(3,5,4,3,1,4); Literature
water, river	COD, Chemical Oxygen Demand			kg	1.75E-5	1	2.04	Range for RER refineries
water, ocean	COD, Chemical Oxygen Demand			kg	3.04E-5	1	2.04	Range for RER refineries
water, river	Hydrocarbons, unspecified			kg	2.32E-8	1	5.48	Range for RER refineries
	Nitrogen, organic bound			kg	1.12E-6	1	2.65	Range for RER refineries
	Oils, unspecified			kg	2.25E-7	1	14.00	Range for RER refineries
water, ocean	Hydrocarbons, unspecified			kg	4.04E-8	1	5.48	Range for RER refineries
	Nitrogen, organic bound			kg	1.95E-6	1	2.65	Range for RER refineries
	Oils, unspecified			kg	3.91E-7	1	14.00	Range for RER refineries
water, river	Phenol			kg	3.76E-8	1	5.77	Range for RER refineries
water, ocean	Phenol			kg	6.53E-8	1	5.77	Range for RER refineries
Outputs	diesel, at refinery	RER	0	kg	1.00E+0			

B.5 Regional distribution in Switzerland

The supply of unleaded petrol, low-sulphur petrol, diesel and low-sulphur diesel at regional storage in Switzerland was updated. The shares of petrol and diesel imported from Europe were taken from statistics of the Swiss Oil Association for 2014. The transport distances were calculated based on the most important countries of origin and their respective means of transport (EV/UP 2014). The calculation procedure is explained in Stolz and Frischknecht (2016). The petrol and diesel were assumed to be distributed to regional storage by lorry over a distance of 150 km (Jungbluth 2007). The updated life cycle inventories of the regional distribution of petrol and diesel are presented in Tab. B. 15 to Tab. B. 18.

Tab. B. 15Life cycle inventory of the supply of 1 kg unleaded petrol at regional storage in Switzerland.

	Name	Location	Infrastructure-Process	Unit	petrol, unleaded, at regional storage	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	petrol, unleaded, at refinery	CH	0	kg	5.26E-1	1	1.05	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	petrol, unleaded, at refinery	RER	0	kg	4.74E-1	1	1.05	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	electricity, low voltage, at grid	CH	0	kWh	6.70E-3	1	1.14	(2,4,1,3,1,3); Environmental report
	light fuel oil, burned in boiler 100kW, non-modulating	CH	0	MJ	6.21E-4	1	1.14	(2,4,1,3,1,3); Environmental report
	tap water, at user	RER	0	kg	6.89E-4	1	1.14	(2,4,1,3,1,3); Environmental report
	transport, lorry 20-28t, fleet average	CH	0	tkm	1.50E-1	1	2.02	(3,2,1,1,1,3); Distribution in Switzerland; Jungbluth 2007
	transport, lorry >16t, fleet average	RER	0	tkm	5.83E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, freight, rail	RER	0	tkm	1.09E-1	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, barge tanker	RER	0	tkm	5.26E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, crude oil pipeline, onshore	RER	0	tkm	6.88E-3	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, aircraft, freight, Europe	RER	0	tkm	1.54E-5	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	regional distribution, oil products	RER	1	p	2.78E-10	1	3.01	(3,na,1,3,1,na); Calculation
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	6.89E-7	1	1.14	(2,4,1,3,1,3); Used water
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH	0	m3	7.50E-5	1	1.32	(4,5,3,3,1,na); Rainwater with pollutants
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	6.27E-6	1	1.14	(2,4,1,3,1,3); Environmental report
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg	1.68E-4	1	2.03	(2,4,3,3,1,3); Environmental report and literature
air, high population density	Heat, waste			MJ	2.41E-2	1	1.14	(2,4,1,3,1,3); Calculation
	Hydrocarbons, aliphatic, alkanes, unspecified			kg	2.68E-4	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Hydrocarbons, aliphatic, unsaturated			kg	4.90E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Hydrocarbons, aromatic			kg	4.90E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Benzene			kg	4.90E-6	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Methane, fossil			kg	1.47E-7	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	t-Butyl methyl ether			kg	2.45E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Toluene			kg	2.45E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Xylene			kg	5.39E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Benzene, ethyl-			kg	1.03E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Hexane			kg	6.37E-6	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
Outputs	petrol, unleaded, at regional storage	CH	0	kg	1.00E+0			

Tab. B. 16Life cycle inventory of the supply of 1 kg low-sulphur petrol at regional storage in Switzerland.

	Name	Location	Infrastructure-Process	Unit	petrol, low-sulphur, at regional storage	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	petrol, low-sulphur, at refinery	CH	0	kg	5.26E-1	1	1.05	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	petrol, low-sulphur, at refinery	RER	0	kg	4.74E-1	1	1.05	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	electricity, low voltage, at grid	CH	0	kWh	6.70E-3	1	1.14	(2,4,1,3,1,3); Environmental report
	light fuel oil, burned in boiler 100kW, non-modulating	CH	0	MJ	6.21E-4	1	1.14	(2,4,1,3,1,3); Environmental report
	tap water, at user	RER	0	kg	6.89E-4	1	1.14	(2,4,1,3,1,3); Environmental report
	transport, lorry 20-28t, fleet average	CH	0	tkm	1.50E-1	1	2.02	(3,2,1,1,1,3); Distribution in Switzerland; Jungbluth 2007
	transport, lorry >16t, fleet average	RER	0	tkm	5.83E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, freight, rail	RER	0	tkm	1.09E-1	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, barge tanker	RER	0	tkm	5.26E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, crude oil pipeline, onshore	RER	0	tkm	6.88E-3	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, aircraft, freight, Europe	RER	0	tkm	1.54E-5	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	regional distribution, oil products	RER	1	p	2.78E-10	1	3.01	(3,na,1,3,1,na); Calculation
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	6.89E-7	1	1.14	(2,4,1,3,1,3); Used water
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH	0	m3	7.50E-5	1	1.32	(4,5,3,3,1,na); Rainwater with pollutants
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	6.27E-6	1	1.14	(2,4,1,3,1,3); Environmental report
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg	1.68E-4	1	2.03	(2,4,3,3,1,3); Environmental report and literature
air, high population density	Heat, waste			MJ	2.41E-2	1	1.14	(2,4,1,3,1,3); Calculation
	Hydrocarbons, aliphatic, alkanes, unspecified			kg	2.68E-4	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Hydrocarbons, aliphatic, unsaturated			kg	4.90E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Hydrocarbons, aromatic			kg	4.90E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Benzene			kg	4.90E-6	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Methane, fossil			kg	1.47E-7	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	t-Butyl methyl ether			kg	2.45E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Toluene			kg	2.45E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Xylene			kg	5.39E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Benzene, ethyl-			kg	1.03E-5	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
	Hexane			kg	6.37E-6	1	3.02	(2,4,1,3,1,3); Literature with VOC from Env. Report
Outputs	petrol, low-sulphur, at regional storage	CH	0	kg	1.00E+0			

Tab. B. 17Life cycle inventory of the supply of 1 kg diesel at regional storage in Switzerland.

	Name	Location	Infrastructure-Process	Unit	diesel, at regional storage	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	diesel, at refinery	CH	0	kg	5.44E-1	1	1.05	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	diesel, at refinery	RER	0	kg	4.56E-1	1	1.05	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	electricity, low voltage, at grid	CH	0	kWh	6.70E-3	1	1.14	(2,4,1,3,1,3); Environmental report
	light fuel oil, burned in boiler 100kW, non-modulating	CH	0	MJ	6.21E-4	1	1.14	(2,4,1,3,1,3); Environmental report
	tap water, at user	RER	0	kg	6.89E-4	1	1.14	(2,4,1,3,1,3); Environmental report
	transport, lorry 20-28t, fleet average	CH	0	tkm	1.50E-1	1	2.02	(3,2,1,1,1,3); Distribution in Switzerland; Jungbluth 2007
	transport, lorry >16t, fleet average	RER	0	tkm	3.56E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, freight, rail	RER	0	tkm	6.65E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, barge tanker	RER	0	tkm	1.51E-1	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, crude oil pipeline, onshore	RER	0	tkm	2.54E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, aircraft, freight, Europe	RER	0	tkm	3.95E-5	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	regional distribution, oil products	RER	1	p	2.48E-10	1	3.01	(3,na,1,3,1,na); Calculation
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	6.89E-7	1	1.14	(2,4,1,3,1,3); Used water
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH	0	m3	7.50E-5	1	1.32	(4,5,3,3,1,na); Rainwater with pollutants
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	6.27E-6	1	1.14	(2,4,1,3,1,3); Environmental report
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg	1.68E-4	1	2.03	(2,4,3,3,1,3); Environmental report and literature
air, high population density	Heat, waste			MJ	2.41E-2	1	1.14	(2,4,1,3,1,3); Calculation
Outputs	diesel, at regional storage	CH	0	kg	1.00E+0			

Tab. B. 18Life cycle inventory of the supply of 1 kg low-sulphur diesel at regional storage in Switzerland.

	Name	Location	Infrastructure-Process	Unit	diesel, low-sulphur, at regional storage	uncertaintyType	StandardDeviation 95%	GeneralComment
	Location				CH			
	InfrastructureProcess				0			
	Unit				kg			
Technosphere	diesel, low-sulphur, at refinery	CH	0	kg	5.44E-1	1	1.05	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	diesel, low-sulphur, at refinery	RER	0	kg	4.56E-1	1	1.05	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	electricity, low voltage, at grid	CH	0	kWh	6.70E-3	1	1.14	(2,4,1,3,1,3); Environmental report
	light fuel oil, burned in boiler 100kW, non-modulating	CH	0	MJ	6.21E-4	1	1.14	(2,4,1,3,1,3); Environmental report
	tap water, at user	RER	0	kg	6.89E-4	1	1.14	(2,4,1,3,1,3); Environmental report
	transport, lorry 20-28t, fleet average	CH	0	tkm	1.50E-1	1	2.02	(3,2,1,1,1,3); Distribution in Switzerland; Jungbluth 2007
	transport, lorry >16t, fleet average	RER	0	tkm	3.56E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, freight, rail	RER	0	tkm	6.65E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, barge tanker	RER	0	tkm	1.51E-1	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, crude oil pipeline, onshore	RER	0	tkm	2.54E-2	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	transport, aircraft, freight, Europe	RER	0	tkm	3.95E-5	1	2.02	(1,1,1,1,1,1); Swiss Petroleum Association (Erdölvereinigung): Annual Report 2014
	regional distribution, oil products	RER	1	p	2.48E-10	1	3.01	(3,na,1,3,1,na); Calculation
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	6.89E-7	1	1.14	(2,4,1,3,1,3); Used water
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH	0	m3	7.50E-5	1	1.32	(4,5,3,3,1,na); Rainwater with pollutants
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	6.27E-6	1	1.14	(2,4,1,3,1,3); Environmental report
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg	1.68E-4	1	2.03	(2,4,3,3,1,3); Environmental report and literature
air, high population density	Heat, waste			MJ	2.41E-2	1	1.14	(2,4,1,3,1,3); Calculation
Outputs	diesel, low-sulphur, at regional storage	CH	0	kg	1.00E+0			