Sphera® Managed LCA Content (MLC) Passenger Vehicles LCI Modelling 2024

Sphera Passenger Vehicles LCI Modelling – 2024

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General Description of Processes

This documentation describes transportation processes for petrol, diesel, LPG, CNG and electric driven passenger cars. The processes comprise the use phase with fuel demand and emissions released. Production and end of life can be integrated. The default functional unit is 1 vehicle kilometre.

Process Characterization/Naming

The internal combustion car processes are named according to the following system:
Vehicle category, fuel, emission category
Example*:* **Car, diesel, Euro 4**

The electric car processes are named according to the following system:
Vehicle category, fuel, size
Example: Car electric, large size

A list of all available processes is appended at the end of this documentation.

Classification

Vehicle Category, Fuel

- Car, diesel
- Car, petrol
- Car, LPG
- Car, CNG
- Car, electric

Emission Category (cf. [5])

- Euro 1 (petrol and diesel only)
- Euro 2
- Euro 3
- Euro 4
- Euro 5
- Euro 6 (CNG and LPG only)
- Euro 6 A-C (petrol and diesel only)
- Euro 6 D (petrol and diesel only)

For electric cars, the Euro standards do not apply. The life cycle emissions for electric cars depend on the size (weight) and the weather conditions. Thus, electric car processes have been divided based on the car sizes according to data provided in the EV database [7] and the driving share between summer and winter can be adjusted within the process.

Road Categories

- Average Motorway (MW)
- Average Rural (RU)
- Average Urban (UR)

For electric cars, differentiation is done only between urban (city) and motorway, given environmental relevance.

The default distribution between road categories stated in the MLC for internal engine processes is based on the values for the traffic situations in HBEFA 4.2 for the year 2022 [6] and for electric car processes is based on the information from the EV database [7] for the year 2022.

Emissions Calculation

The emission calculations are derived from emission factors from literature (HBEFA 4.2) [6] which are based on measurements. Additional calculation principles are explained below.

General Emissions Calculation

The total emissions (in internal combustion processes) for each pollutant are calculated based on emission factors (EM) by road category (Motorway = MW_{Em}, Rural = RU_{Em}, Urban = UR_{Em}) taken from literature in [g/km] and share of road categories (Motorway = MW_{share}, Rural = RU_{share}, Urban = UR_{share}) [-]:

$$Emission_X = \left((MW_{share} \cdot MW_{EM}) + (RU_{share} \cdot RU_{EM}) + UR_{share} \cdot UR_{EM}\right) \quad \left[\frac{g_{Emission}}{km}\right] \qquad (1)$$

There are no exhaust emissions for electric car processes.

Calculation of CO_2

The calculations for carbon dioxide emissions are based on the emission factors according to a constant relation of 3.18 kg CO_2/kg fuel for the fuel consumption that is assumed. Petrol: with a medium density of 0.74 kg/l; this is equal to a ratio of 2.36 kg CO_2/l petrol
Diesel: with a medium density of 0.832 kg/l; this is equal to a ratio of 2.64 kg CO_2/l diesel.

Calculation of SO_2

For sulphur dioxide, a complete stoichiometric conversion of the sulphur contained in the fuel and of oxygen into SO_2 is assumed. The sulphur content in the fuel is a variable parameter, which can be set individually by the user. Note that the values vary considerably among countries worldwide.

$$EF_{SO_2} = x_{ppm_S} * \frac{64\ kg_{SO_2}}{32\ kg_S} * fuel_{consumption} \left[\frac{m_{SO_2}}{m_{Cargo}}\right] \#(2)$$

EF_SO₂	Emission factor for SO_2
x_{ppm_S}	Mass share of sulphur in fuel in $\frac{m_S}{m_{fuel}}$
$fuel_{consumption}$	Fuel consumption in $\frac{m_{fuel}}{m_{cargo}}$

Production and End of Life

Production and End of Life are not part of the passenger car process itself. However, a model specific integration is pre-configured in the data sets: An input parameter is available in each process for the production of the specific vehicle and an output parameter is available for the End-of-Life treatment of the vehicle. The scaling to the kilometers driven, results from 1/km driving performance to the unit of 1 vehicle kilometer.

Variable Parameters

Table 1: Variable Parameters

Internal Combustion Engine based processes:

Parameter Name	Comment	Unit
share_MW	Driving Share on Motorway (MW)	-
share_RU	Driving Share Rural (RU)	-
share UR	Driving Share Urban (UR)	-
share_CO_2_bio	Share of Biogenic C in Fuel	-
driving performance	Life-time Mileage of Vehicle	km
ppm_sulfur	Mass Share of Sulphur in Fuel	ppm
switch_part_NE	switch: 0= no non-exhaust PM, 1 = non-exhaust PM included.	[0;1]

Table 2: Variable Parameters

Electric car processes:

Parameter Name	Comment	Unit
share_ci	Percentage in the town	-
share_summer	Percentage of driving in summer conditions	-
Charg_loss	Percentage of charging losses	-
driving performance	Life-time Mileage of Vehicle	km
switch_part_NE	switch: 0= no non-exhaust PM, 1 = non-exhaust PM included.	[0;1]

Inputs

Table 3: Valuable Substances

Flow	Flow Group	Unit
Petrol/Diesel/Electricity	Crude Oil Products/ Electricity	kg

Flow	Flow Group	Unit
Vehicle	Material Systems	pcs

Outputs

Table 4: Valuable Substances

Flow	Flow Group	Unit
Vehicle Kilometres	Others	1000m
Vehicle	Material Systems	pcs

Emissions

Table 5: Emissions

Flow	Flow Group	Unit
Ammonia	Inorganic Emissions to Air	kg
Benzene	Group NMVOC to Air	kg
Carbon Dioxide	Inorganic Emissions to Air	kg
Carbon Dioxide (biotic)	Inorganic Emissions to Air	kg
Carbon Monoxide	Inorganic Emissions to Air	kg
Dust (PM2.5)	Particles to Air	kg
Methane	Organic Emissions to Air (Group VOC)	kg
Nitrogen Dioxide	Inorganic Emissions to Air	kg
Nitrogen Monoxide	Inorganic Emissions to Air	kg
Nitrous Oxide (Laughing Gas)	Inorganic Emissions to Air	kg
NMVOC (unspecific)	Group NMVOC to Air	kg
Sulphur Dioxide	Inorganic Emissions to Air	kg

Note: Not all of the above emissions are present for LPG, CNG and electric driven vehicles.

Systems and Emissions that are not considered

The datasets only include the emissions from the combustion of the fuel. The following aspects are not considered:

- Vehicle production, repair, and maintenance (integration optional where required)
- Vehicle recycling (integration optional where required)
- Infrastructure (roads etc.)

- Noise
- Diurnal losses and refuelling losses (see [6])
- Hot-Soak-Emissions
- Oil use
- Cold-Start Emissions
- Emissions from air conditioning (relevance < 1 %, see [4])
- Abrasion of tyres and brakes
- Production and emissions of glycol and detergent from window washing systems

Application

Process Integration

The passenger car process is integrated into the model by the flow “vehicle kilometres“.

Input Parameters

The transport processes can be adapted to specific conditions by changing the variable parameters.

Sulphur Content of Fuel

The sulphur content in diesel fuel varies significantly worldwide; the transport processes can be adapted accordingly.

The default sulphur content is set for the EU standard of 10 ppm [2].

Driving Shares for Motorway, Rural, Urban (respective parameters: “share_mw”, “share_ru”, “share_ur”) – Internal combustion engine vehicles

The driving shares for Motorway (MW), Rural (RU), Urban (UR) can be adapted to specific boundary conditions. The predefined standard values represent the shares of Germany for each respective vehicle. The shares must add up to 1 in total.

Driving Shares for Motorway (“share_mw”), City (“share_ci”) and Share of driving in Summer season (“share_summer”) – electric vehicles

The driving shares for Motorway (MW) and City (Ci) along with the share of driving in summer season can be adapted to specific boundary conditions. The predefined standard values represent the shares of Germany for each respective vehicle class.

The shares of motorway and city must add up to 1 in total and the percentage share driving in for summer season can be set between 0 and 1.

Driving Performance

The parameter “driving performance” is used to scale production and End of Life. In the case that neither production, nor end of life is considered (the respective processes are not connected), the parameter remains constant.

For electric vehicles, the default charging losses can also be adjusted by adjusting the parameter “charg_loss”.

Representativeness

Technological

The standard emission classes are covered by different datasets. The technologies are representative Europe-wide and can be adapted for worldwide locations with some minor restrictions. There is a need to identify the corresponding emission classes.

Spatial

The reference locations are Germany, Austria, and Switzerland. However due to the similarity of the vehicle structures and the same emissions limit values, the models are representative for the entire EU. The model can be adjusted to conditions in other countries worldwide with limited uncertainty. Note: uncertainty increases with the increase of deviation of the vehicle structure, the road categories and the utilization behaviour – these can be adapted by modifying the driving share (MW/RU/UR) or (MW/Ci) as well as the utilization ratio (driving_perform/summer) and sulphur content in the fuel (ppm_sulphur) for individual conditions.

Temporal

The reference year of the data sets is 2022; representativeness may be assumed for the period of 2022 to 2025.

Modification of the age structure of vehicles for each emission class leads to changes in the emission profile. The validity of the data set is given for approximately 3 years (until 2025). Findings in HBEFA [6], based on comprehensive time series (1994-2022), report that there has been changes to the NOx emission values for passenger vehicles according to Euro 4 to 6 categories, especially for diesel driven passenger cars. Besides NOx emissions there has been no relevant change in emission profiles within a certain size class, emissions class or road category according to [6]. Only a different composition of a total vehicle fleet results in changes between 2022 and 2025.

Literature

[1] EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION: Directive 1999/96/EC of the European Parliament and of the Council of 13 December 1999 on the approximation of the laws of the Member States relating to measures to be taken against the emission of gaseous and particulate pollutants from compression ignition engines for use in vehicles, and the emission of gaseous pollutants from positive ignition engines fueled with natural gas or liquefied petroleum gas for use in vehicles and amending Council Directive 88/77/EEC. Brussels, Official Journal L 044, 16/02/2000 P. 0001 – 0155.

[2] EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION: Directive 2003/17/EC of the European Parliament and of the Council of 3 March 2003 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels. Brussels, Official Journal of the European Union L76/10, 22/03/2003.

[3] EUROPÄISCHE UNION: EUROPA – Environment – Auto-Oil II Programme. http://ec.europa.eu/environment/archives/autooil/index.htm

[4] MKC Consulting GmbH: HBEFA Version 4.2 – Background documentation, 2022

[5] SCHWARZ, Dr. Winfried; LEISEWITZ, Dr. André: Emissionen und Minderungspotential von HFKW, FKW und SF6 in Deutschland, Im Auftrag des Umweltbundesamtes, Forschungsbericht 29841256, Frankfurt, 1999.

[6] Umweltbundesamt Berlin; BUWAL/OFEFP Bern; Umweltbundesamt Wien: Handbuch Emissionsfaktoren des Straßenverkehrs, Version 4.2, http://www.hbefa.net , Berlin, Bern, Vienna/Germany, Switzerland, Austria, 2022.

[7] Reichweite von Elektroautos. EV Database. Retrieved June 2022, from https://ev-database.de/cheatsheet/range-electric-car

Process List (MLC)

The following processes for passenger cars are available. The region code “GLO” indicates global applicability, in connection with the respective fuel upstream dataset and setting the process parameter values to the correct sulphur content as well as other transport characteristics:

Region	Fuel	Emission Standard	Name	Type
GLO	Electric	-	Car electric, large size	Consumption mix
GLO	Electric	-	Car electric, medium size	Consumption mix
GLO	Electric	-	Car electric, small size	Consumption mix
GLO	CNG	Euro 2	Car, CNG, Euro 2	Consumption mix
GLO	CNG	Euro 3	Car, CNG, Euro 3	Consumption mix
GLO	CNG	Euro 4	Car, CNG, Euro 4	Consumption mix
GLO	CNG	Euro 5	Car, CNG, Euro 5	Consumption mix
GLO	CNG	Euro 6	Car, CNG, Euro 6	Consumption mix
GLO	Diesel	Euro 1	Car, diesel, Euro 1	Consumption mix
GLO	Diesel	Euro 2	Car, diesel, Euro 2	Consumption mix
GLO	Diesel	Euro 3	Car, diesel, Euro 3	Consumption mix
GLO	Diesel	Euro 4	Car, diesel, Euro 4	Consumption mix
GLO	Diesel	Euro 5	Car, diesel, Euro 5	Consumption mix
GLO	Diesel	Euro 6 A-C	Car, diesel, Euro 6 A-C	Consumption mix
GLO	Diesel	Euro 6 D	Car, diesel, Euro 6 D	Consumption mix
GLO	LPG	Euro 2	Car, LPG, Euro 2	Consumption mix
GLO	LPG	Euro 3	Car, LPG, Euro 3	Consumption mix
GLO	LPG	Euro 4	Car, LPG, Euro 4	Consumption mix
GLO	LPG	Euro 5	Car, LPG, Euro 5	Consumption mix
GLO	LPG	Euro 6	Car, LPG, Euro 6	Consumption mix
GLO	Gasoline	Euro 1	Car, petrol, Euro 1	Consumption mix
GLO	Gasoline	Euro 2	Car, petrol, Euro 2	Consumption mix
GLO	Gasoline	Euro 3	Car, petrol, Euro 3	Consumption mix
GLO	Gasoline	Euro 4	Car, petrol, Euro 4	Consumption mix
GLO	Gasoline	Euro 5	Car, petrol, Euro 5	Consumption mix
GLO	Gasoline	Euro 6 A-C	Car, petrol, Euro 6 A-C	Consumption mix
GLO	Gasoline	Euro 6 D	Car, petrol, Euro 6 D	Consumption mix

Region	Fuel	Emission Standard	Name	Type
GLO	Gasoline and Diesel	Euro 3-5	Passenger car, average, Euro 3-5	Consumption and Technology mix