



Documentation for Passenger Vehicle Processes in GaBi

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List of Contents

1	General Description of Processes	4
1.1	Process Characterization / Naming.....	4
1.2	Classification.....	4
1.2.1	<i>Vehicle Category, Fuel, Engine Size (cf. [5])</i>	4
1.2.2	<i>Emission Category (cf. [5])</i>	4
1.2.3	<i>Road Categories</i>	5
1.3	Emissions Calculation.....	5
1.3.1	<i>General Emissions Calculation</i>	5
1.3.2	<i>Calculation of CO₂</i>	5
1.3.3	<i>Calculation of SO₂</i>	5
1.4	Production and End of Life.....	6
1.5	Variable Parameters	6
1.6	Inputs.....	6
1.6.1	<i>Valuable Substances</i>	6
1.7	Outputs.....	6
1.7.1	<i>Valuable Substances</i>	6
1.7.2	<i>Emissions</i>	7
1.8	Systems and Emissions that are not considered	8
2	Application	9
2.1	Process Integration.....	9
2.2	Input Parameters	9
2.2.1	<i>Sulphur Content of Fuel</i>	9
2.2.2	<i>Driving Shares for Motorway, Rural, Urban (respective parameters: “share_mw”, “share_ru”, “share_ur”)</i>	9
2.2.3	<i>Driving Performance</i>	9
2.3	Representativeness.....	9
2.3.1	<i>Technological</i>	9
2.3.2	<i>Spatial</i>	9
2.3.3	<i>Temporal</i>	10
3	Literature	11
4	Process List (GaBi)	12

1 General Description of Processes

This documentation describes transportation processes for petrol, diesel, LPG and CNG 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.

1.1 Process Characterization / Naming

In general processes are named according to the following system:

Vehicle category, fuel, emission category, engine size (if applicable)

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

1.2 Classification

1.2.1 Vehicle Category, Fuel, Engine Size (cf. [5])

- ⇒ Car diesel, engine size up to 1.4l
- ⇒ Car petrol, engine size 1.4-2l
- ⇒ Car petrol, engine size more than 2l
- ⇒ Car diesel, engine size up to 1.4l
- ⇒ Car diesel, engine size 1.4-2l
- ⇒ Car diesel, engine size more than 2l
- ⇒ Car LPG
- ⇒ Car CNG

1.2.2 Emission Category (cf. [5])

- ⇒ ECE 15'04 (petrol only) without catalytic converter
- ⇒ non-controlled catalytic converter (petrol only)
- ⇒ controlled catalytic converter < 87 (petrol only)
- ⇒ controlled catalytic converter 87-90 (petrol only)
- ⇒ conventional (petrol only) other measures (e.g. exhaust gas recirculation)
- ⇒ 1986-88 (diesel only)
- ⇒ Euro 1 (petrol and diesel only)
- ⇒ Euro 2
- ⇒ Euro 3
- ⇒ Euro 4
- ⇒ Euro 5
- ⇒ Euro 6

- ⇒ Euro 6 (from Sept 2019)
- ⇒ Euro 6 (from Jan 2021)

For the Euro 6 standard, the measurement procedures will gradually become more stringent, thus the allowable emissions will change [4]. The new measurement procedures are reflected in the corresponding processes. “Euro 6” represents the current Euro 6 emission values as of December 2017. “Euro 6 (from Sept 2019)” and “Euro 6 (from Jan 2021)” represent the Euro 6 emission values according to the EU regulations regarding the new measurement procedures for all new registrations from September 2019 respectively January 2021.

1.2.3 Road Categories

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

The default distribution between road categories stated in the GaBi processes is based on the values for the traffic situations in HBEFA 3.3 for the year 2017 [6].

1.3 Emissions Calculation

The emission calculations are derived from emission factors from literature (HBEFA 3.3) [6] which are based on measurements. Additional calculation principles are explained below.

1.3.1 General Emissions Calculation

The total emissions 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}) [-]:

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

1.3.2 Calculation of CO₂

The calculations for carbon dioxide emissions are based on the emission factors according to the equation (1), whereas a constant relation of 3.18 kg_{CO2}/kg_{fuel} for the fuel consumption is assumed.

- ⇒ Petrol: with a medium density of 0.74 kg/l; this is equal to a ratio of 2.36 kg_{CO2}/l_{petrol}
- ⇒ Diesel: with a medium density of 0.832 kg/l; this is equal to a ratio of 2.64 kg_{CO2}/l_{diesel}.

1.3.3 Calculation of SO₂

For sulphur dioxide, a complete stoichiometric conversion of the sulphur contained in the fuel and of oxygen into SO₂ 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.

$$EF_{SO_2} = x_{ppm_S} * \frac{64 \text{ kg}_{SO_2}}{32 \text{ kg}_S} * fuel_{consumption} \left[\frac{m_{SO_2}}{m_{cargo}} \right] \quad (2)$$

EF_{SO_2} Emission factor for SO₂
 x_{ppm_S} Mass share of sulphur in fuel in $\frac{m_S}{m_{fuel}}$
 $fuel_{consumption}$ Fuel consumption in $\frac{m_{fuel}}{m_{cargo}}$

1.4 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 kilometres driven, results from 1/km driving performance to the unit of 1 vehicle kilometre.

1.5 Variable Parameters

Parameter Name	Comment	Unit
share_MW	Driving Share on Motorway (MW)	-
share_RU	Driving Share Rural (RU)	-
share_UR	Driving Share Urban (UR)	-
share_CO2_bio	Share of Biogenic C in Fuel	-
driving performance	Life-time Mileage of Vehicle	km
ppm_sulfur	Mass Share of Sulphur in Fuel	ppm

1.6 Inputs

1.6.1 Valuable Substances

Flow	Flow Group	Unit
Petrol/Diesel	Crude Oil Products	kg
Vehicle	Material Systems	pcs

1.7 Outputs

1.7.1 Valuable Substances

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

1.7.2 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 emissions are present for LPG and CNG driven vehicles.

1.8 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, 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

2 Application

2.1 Process Integration

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

2.2 Input Parameters

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

2.2.1 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].

2.2.2 Driving Shares for Motorway, Rural, Urban (respective parameters: “share_mw”, “share_ru”, “share_ur”)

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.

2.2.3 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.

2.3 Representativeness

2.3.1 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.

2.3.2 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) as well as the utilization ratio and sulphur content in the fuel for individual conditions.

2.3.3 Temporal

The reference year of the data sets is 2019; representativeness may be assumed for the period of 2019 to 2022.

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 2022). Findings in HBEFA [6], based on comprehensive time series (1994-2020), report that there has been changes to the NO_x emission values for passenger vehicles according to Euro 4 to 6 categories, especially for diesel driven passenger cars. Besides NO_x 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 2018 and 2021.

3 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 fuelled 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 3.3 – Background documentation, 2017
- [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 3.3, <http://www.hbefa.net>, Berlin, Bern, Vienna / Germany, Switzerland, Austria, 2017.
- [7] UMWELTLEXIKON: Umweltlexikon: Betankungsverlust. <http://www.umweltlexikon-online.de/RUBluft/Betankungsverlust.php>

4 Process List (GaBi)

The following processes for passenger cars are available:

Region	Fuel	Emission standard	Type	Engine size
GLO	petrol	ECE 15'04	consumption mix	engine size up to 1.4l
GLO	petrol	non-controlled catalytic converter	consumption mix	engine size up to 1.4l
GLO	petrol	controlled catalytic converter < 87	consumption mix	engine size up to 1.4l
GLO	petrol	controlled catalytic converter 87-90	consumption mix	engine size up to 1.4l
GLO	petrol	conventional	consumption mix	engine size up to 1.4l
GLO	petrol	Euro 1	consumption mix	engine size up to 1.4l
GLO	petrol	Euro 2	consumption mix	engine size up to 1.4l
GLO	petrol	Euro 3	consumption mix	engine size up to 1.4l
GLO	petrol	Euro 4	consumption mix	engine size up to 1.4l
GLO	petrol	Euro 5	consumption mix	engine size up to 1.4l
GLO	petrol	Euro 6	consumption mix	engine size up to 1.4l
GLO	petrol	ECE 15'04	consumption mix	engine size 1.4-2l
GLO	petrol	non-controlled catalytic converter	consumption mix	engine size 1.4-2l
GLO	petrol	controlled catalytic converter < 87	consumption mix	engine size 1.4-2l
GLO	petrol	controlled catalytic converter 87-90	consumption mix	engine size 1.4-2l
GLO	petrol	conventional	consumption mix	engine size 1.4-2l
GLO	petrol	Euro 1	consumption mix	engine size 1.4-2l
GLO	petrol	Euro 2	consumption mix	engine size 1.4-2l
GLO	petrol	Euro 3	consumption mix	engine size 1.4-2l
GLO	petrol	Euro 4	consumption mix	engine size 1.4-2l
GLO	petrol	Euro 5	consumption mix	engine size 1.4-2l
GLO	petrol	Euro 6	consumption mix	engine size 1.4-2l
GLO	petrol	ECE 15'04	consumption mix	engine size more than 2l
GLO	petrol	non-controlled catalytic converter	consumption mix	engine size more than 2l
GLO	petrol	controlled catalytic converter < 87	consumption mix	engine size more than 2l
GLO	petrol	controlled catalytic converter 87-90	consumption mix	engine size more than 2l
GLO	petrol	conventional	consumption mix	engine size more than 2l
GLO	petrol	Euro 1	consumption mix	engine size more than 2l
GLO	petrol	Euro 2	consumption mix	engine size more than 2l
GLO	petrol	Euro 3	consumption mix	engine size more than 2l
GLO	petrol	Euro 4	consumption mix	engine size more than 2l
GLO	petrol	Euro 5	consumption mix	engine size more than 2l
GLO	petrol	Euro 6	consumption mix	engine size more than 2l

Region	Fuel	Emission standard	Type	Engine size
GLO	diesel	1986-88	consumption mix	engine size up to 1.4l
GLO	diesel	Euro 1	consumption mix	engine size up to 1.4l
GLO	diesel	Euro 2	consumption mix	engine size up to 1.4l
GLO	diesel	Euro 3	consumption mix	engine size up to 1.4l
GLO	diesel	Euro 4	consumption mix	engine size up to 1.4l
GLO	diesel	Euro 5	consumption mix	engine size up to 1.4l
GLO	diesel	Euro 6	consumption mix	engine size up to 1.4l
GLO	diesel	Euro 6 (from Sept 2019)	consumption mix	engine size up to 1.4l
GLO	diesel	Euro 6 (from Jan 2021)	consumption mix	engine size up to 1.4l
GLO	diesel	1986-88	consumption mix	engine size 1.4-2l
GLO	diesel	Euro 1	consumption mix	engine size 1.4-2l
GLO	diesel	Euro 2	consumption mix	engine size 1.4-2l
GLO	diesel	Euro 3	consumption mix	engine size 1.4-2l
GLO	diesel	Euro 4	consumption mix	engine size 1.4-2l
GLO	diesel	Euro 5	consumption mix	engine size 1.4-2l
GLO	diesel	Euro 6	consumption mix	engine size 1.4-2l
GLO	diesel	Euro 6 (from Sept 2019)	consumption mix	engine size 1.4-2l
GLO	diesel	Euro 6 (from Jan 2021)	consumption mix	engine size 1.4-2l
GLO	diesel	1986-88	consumption mix	engine size more than 2l
GLO	diesel	Euro 1	consumption mix	engine size more than 2l
GLO	diesel	Euro 2	consumption mix	engine size more than 2l
GLO	diesel	Euro 3	consumption mix	engine size more than 2l
GLO	diesel	Euro 4	consumption mix	engine size more than 2l
GLO	diesel	Euro 5	consumption mix	engine size more than 2l
GLO	diesel	Euro 6	consumption mix	engine size more than 2l
GLO	diesel	Euro 6 (from Sept 2019)	consumption mix	engine size more than 2l
GLO	diesel	Euro 6 (from Jan 2021)	consumption mix	engine size more than 2l
GLO	LPG	Euro 2	consumption mix	engine size unspecified
GLO	LPG	Euro 3	consumption mix	engine size unspecified
GLO	LPG	Euro 4	consumption mix	engine size unspecified
GLO	LPG	Euro 5	consumption mix	engine size unspecified
GLO	LPG	Euro 6	consumption mix	engine size unspecified
GLO	CNG	Euro 2	consumption mix	engine size unspecified
GLO	CNG	Euro 3	consumption mix	engine size unspecified
GLO	CNG	Euro 4	consumption mix	engine size unspecified
GLO	CNG	Euro 5	consumption mix	engine size unspecified
GLO	CNG	Euro 6	consumption mix	engine size unspecified



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