

HBEFA

Handbook emission factors for road transport 4.1

Quick reference

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Introduction

The Handbook of emission factors for Road Transport provides emission factors, i.e. the specific emission in g/km for all current vehicle categories (PC, LCV, HGV, buses, coaches, and motor cycles), each divided into different categories, for a wide variety of traffic situations. A first version (HBEFA 1.1) was published in December 1995, a second version (HBEFA 1.2) in January 1999. Version 2.1 followed in January 2004, HBEFA 3.1 in 2010, HBEFA 3.2 in 2014, and HBEFA 3.3 in 2017. The newest version is HBEFA 4.1 and dates from August 2019. This version provides emission for Germany [D], Austria [A], Switzerland [CH], Sweden [SE], Norway [N] and France [F]. The approach and functionalities and the range of parameters in principle have not changed. As before, one gets “hot” emission factors, excess cold start emissions and evaporation emissions (soak, diurnal, running losses). As a new feature in HBEFA 4.1, well-to-tank (WTT) emission factors for CO₂ equivalents (CO₂e) are also available. All relevant legislative concepts are covered. The result formats deliberately have not been changed in order to guarantee continuity for the users.

Operational aspects

As all previous versions, HBEFA 4.1 is an MS ACCESS application that can be installed as a runtime version. No further software (except Windows 7 or higher) is required. HBEFA 4.1 is available in three languages (German, English, French). The user can select the country of interest as well as the language (no need for a new installation).

The website www.hbefa.net provides also a (reduced) on-line version of the Handbook which was developed for occasional users with interest for aggregate values only. Therefore, the internet version provides aggregate values only while the full version gives many more options and provides emission factors on a more differentiated level (e.g. for different Euro-concepts, different traffic situations etc.).

Overview

As in the earlier versions, the handbook provides emission factors per traffic activity. Different levels of disaggregation are being offered:

- By type of emission: “hot” emissions, cold start excess emissions, evaporative emissions, well-to-tank (WTT) emissions.
- By vehicle category: passenger cars, light duty vehicles, heavy goods vehicles, buses, coaches and motorcycles.
- By year and implicitly by varying fleet compositions in the different countries (1990-2035 / 2060 – depending on the country),

- By pollutants. Factors for the following components are provided: CO, HC, NO_x, PM, several components of HC (CH₄, NMHC, benzene, toluene, xylene), fuel and energy consumption, CO₂, NH₃, N₂O, NO₂, PN, PM-nonexhaust and BC.
- The so called “hot” emission factors are given for several traffic situations which have been adapted to the scheme developed in the ARTEMIS project (HBEFA 4.1 uses the same scheme as HBEFA 3.x, with some additional traffic situations). Differentiated factors are provided for different gradient classes (0%, 2%, 4%, 6%). Also weighted average values (distributions over several traffic situations and gradient classes) are calculated.
- The cold start and the evaporation emission factors are based on typical temperature distributions and behavioural parameters (such as trip length distributions, parking time distributions).
- The program outputs the desired emission factors
 - by vehicle category,
 - by vehicle category and emission concept (e.g. conventional passenger cars, Euro-5 diesel passenger cars etc.),
 - by vehicle category and fuel type (or technology, respectively, e.g. petrol, diesel, gas, BEV, etc.)
 - or by subsegment (e.g. Euro-6d petrol passenger cars).
- The parameter sets (“cases”) are saved under a user-specified name. The program then calculates the desired emission factors. The results can be exported to Excel. Users with a full version of MS Access have direct access to the result database (User_xxx.MDB) for further processing of the emission factors.

[What was new in HBEFA 3.1 ?](#)

[click here](#)

[What was new in HBEFA 3.2 ?](#)

[click here](#)

[What was new in HBEFA 3.3 ?](#)

[click here](#)

[What is new in HBEFA 4.1 ?](#)

[click here](#)

Alphabetic reference

Abbreviations

2ST:	2 stroke petrol engine
4ST:	4 stroke petrol engine
a:	Acceleration
AC:	Air conditioning
ACR:	Active carbon reduction (for reducing the HC evaporation emissions)
AT:	Articulated truck
BAB:	German motorway driving cycle (Bundesautobahn)
BAFU:	Swiss Federal Office for the Environment (FOEN), Bundesamt für Umwelt
BEV:	Battery-electric vehicle
Case:	User-defined parameter combination for calculating emission factors
Cat:	Catalytic converter
CH:	Switzerland
CH ₄ :	Methane
CNG:	Compressed natural gas
CO:	Carbon monoxide
CO ₂ :	Carbon dioxide
CSF:	Cold start factor
D:	Diesel
DP:	Driving pattern
DPF:	Diesel Particle Filter
DT:	Distance travelled, mileage
ECE:	Economic Commission for Europe
EEA:	Exhaust Emissions Act. In the context of the Handbook, this term refers to the Swiss regulations: EEA 1 = Light motorised vehicles, EEA 2 = Heavy motorised vehicles, EEA 3 = Motorcycles, EEA 4 = Mopeds
EFA, E-Factor:	Emissions factor
EFA_weighted:	Emissions factor, weighted (according to fleet compositions)
EGR:	Exhaust Gas recirculation
EMPA:	Federal Materials Testing and Research Institute, Dübendorf
En:	Energy

EU:	European Union
EURO-1, -2, -3 etc:	European exhaust emissions regulations for passenger cars and light vehicles
EURO-I, -II, -III etc:	European exhaust emissions regulations for heavy vehicles
FEA:	Federal Environmental Agency (=UBA: Umweltbundesamt)
FFV:	Flex-fuel vehicle
FOEFL:	Federal Office of Environment, Forests and Landscape, Berne
FRG:	Federal Republic of Germany
HB:	Handbook
HC:	Hydrocarbons
HGV:	Heavy goods vehicles {= general term for trucks, truck trailers (TT) and articulated trucks (AT)}
HDV:	Heavy duty vehicle {= vehicles > 3.5 t total weight; = general term for heavy goods vehicles (HGV), coaches (RBus) and urban buses (LBus)}
HEV:	Hybrid-electric vehicle (Note: in HBEFA 4.1, HEVs are not differentiated from conventional vehicles – e.g. PC HEV are included in PC petrol or diesel)
IBA:	In built-up area
Lbus:	Bus, urban bus, public transport bus (German: Linienbus)
LEV:	Low Emission Vehicle
LCV:	Light commercial vehicle <3,5t (small buses, trucks, camper vans, other motor vehicles)
LDV:	Light duty vehicle, general term for passenger cars and light commercial vehicles
LNG:	Liquefied natural gas
MC:	Motorcycle
Moped:	Moped
NMHC:	Non-methane hydrocarbons
NMOG:	Non-methane organic gases
NOx:	Nitrogen oxide
OBA:	Outside built-up area
Pb:	Lead
PHEV:	Plug-In hybrid electric vehicle (=OVC-HEV, off-vehicle charging hybrid electric vehicle)
PM:	Particulate matters
PN:	Particle numbers

PC:	Passenger car
RPA:	Relative positive acceleration ¹
Rbus:	Coach (German: Reisebus)
RWTÜV:	Rhine-West Phalia Technical Inspection Agency, Essen
SCR:	Selective catalytic reduction (for NOx-reduction)
SO ₂ :	Sulphur dioxide
T'comp.:	Traffic composition (= mix of vehicle segments), = Fleet Composition
TLEV:	Transient Low Emission Vehicle
TLS:	Traffic light system
Truck:	Truck
TS:	Traffic situation
TT:	Truck-trailer, Trailer truck
TTW:	Tank-to-wheel. Scope of direct emissions ("classical" HBEFA emission factors)
TÜV (RL):	Technical inspection agency, Rheinland, Cologne
TUG:	Technical University, Graz
TWV:	Two-wheeled vehicle
UBA:	Umweltbundesamt (Germany, Austria), Federal Environment Agency
ULEV:	Ultra Low Emission Vehicle
V:	Speed, velocity (in km/h)
VDA:	Verband der Automobilindustrie e.V.
VOC:	Volatile Organic Compounds
VS:	Vehicle segment
WTT:	Well-to-tank. Scope of indirect/upstream emissions from the production of fuels/energy.
WTW:	Well-to-wheel: Sum of WTT and TTW scopes (see respective abbreviations)
ZEV:	Zero Emission Vehicle

¹ RPA is the integral of vehicle speed multiplied by the time interval and the positive acceleration, divided by the total distance of the cycle

Air conditioning

The option for the user to explicitly select whether air conditioning emissions are calculated or not has been deactivated in HBEFA 4.1. A/C excess consumption and emissions are now included in the base emission factors calculated by the PHEM model. The share of vehicles with A/C corresponds to the European average for the respective subsegment, and the usage has been calibrated to real-world fuel consumption data.

Blank results tables

If you get blank tables or no result tables at all the reason might be that you have defined cases for which no emission factors are available. For example the following emission factors are not included:

- Heavy duty vehicles: no emission factors available for cold start nor for evaporation.
- Two-wheelers: no cold start factors are given.

Case

A "case" represents an emission factor query with a given combination of parameters that can be stored under a distinct name (= case). You can subsequently refer to this "case" and the associated results. To do this you have to enter a name (without any blank spaces or symbols). You can simultaneously enter a brief comment for your own documentation, containing a max. 50 letters or numbers (blank spaces are permitted for the comment). See also [-> [Name conventions](#); -> [Export to Excel](#)].

Category

Emission factors are available for the following vehicle categories:

- PC: Passenger cars
- LCV: light commercial vehicles: Van (<3.5 t), including mini-buses, trucks, camper vans and other vehicles (<3,5 t)
- HGV: Heavy goods vehicles (Trucks, TT, AT), where
 - truck: Single truck (>3,5 t), other vehicles (>3,5 t)
 - TT: truck + trailer
 - AT: articulated truck
- Coach: Tour coach, holiday coach
- Bus: Urban bus, public transport bus
- MC: Motorcycle

Note regarding terms used in HBEFA:

- Light duty vehicle (LDV) is a general term and includes passenger cars and light commercial vehicles.
- Heavy goods vehicle (HGV) is a general term and includes a mix consisting of single trucks, truck + trailers (= TT) and articulated trucks (= AT).
- Heavy duty vehicle (HDV) includes heavy goods vehicles (HGV) as well as buses and coaches.

Cold start emission factors

[-> [Emission factors "cold start"](#)]

Components

[-> [Pollutants/Components](#)]

Computing a case

- You can calculate emission factors for different levels of detail,
 - "per vehicle category",
 - "per emission concept",
 - "per fuel type", or
 - "per vehicle subsegment".
- The "per vehicle category" option provides a weighted emissions factor per year and vehicle category.
- The "per emission concept" provides emission factors for each emission concept as well as the percentages (weights) of the various concepts.
- The "per fuel type" produces emission factors for each fuel concept (petrol/diesel) as well as the percentages (weights) of the various concepts.
- The "per vehicle subsegment" provides emission factors for each vehicle subsegment as well as the percentages (weights) of the various subsegments.

Note: The "per vehicle subsegment" option may need extensive computing times and generates large volumes of output data. This option should therefore only be used for selected cases (e.g. for individual traffic situations and individual years only).

- Option whether to compute emission factors "weighted using a fleet composition" or "un-weighted":
 - "Weighted using a fleet composition": If you choose this option, you have to select a fleet composition (there is only one per country in the HBEFA Public Version) and select the years you want results for.

The resulting emission factors will take into account ageing/deterioration effects; the result column "KM" will contain the average cumulative mileage (odometer reading) of

the respective vehicles in the respective year.

Results will only be given for the subsegments that occur in the fleet composition for the respective country and year.

- “Unweighted”: If you choose this option, you cannot select a fleet composition or years you want results for.

The level of detail of the output will automatically be set to “Subsegment” because for any aggregation, a fleet composition would be required.

The resulting emission factors will be valid for the default mileage of 50'000 km; this corresponds to the point at which all mileage correction factors have a value of 1. The result column “KM” will 50'000 for all records.

Results will be given for all subsegments, regardless of their availability in a fleet composition.

Please note:

→ The fuel consumption, which depends on the construction year, is given for the first construction year of each subsegment;

→ The country-specific fuel mix (e.g. biofuel shares) for the default year (i.e. 2015 in HBEFA 4.1) is used for the “unweighted” option.

- Entering a name: Enter a short name for your case (no blanks, no symbols). Simultaneously you may add a brief comment of max. 50 letters or numbers (for your own documentation).

Computing time optimisation

In order to optimise the computing time it is advisable not to select all the possibilities for all parameters simultaneously. It is worthwhile to carry out this procedure on a step-by-step basis, e.g. creating a separate "case" for each year or a subset of years in which you are interested. If, on the other hand, you are interested in a particular time series, then it is worthwhile to select only a few traffic situations at one time.

Concept

The vehicle subsegments [-> [Subsegment](#)] can be aggregated to vehicle concepts resp. emission concepts. The differentiation between concepts is based on the regulations and/or technology, basically the so-called “Euro-Classes”. The new version of HBEFA provides emission factors now up to Euro-6/VI resp. Euro-6c. Also the fleet compositions have been adapted to these new technologies (See menu “Info: FleetComposition by emission concepts”).

CUMKM

[-> [Mileage](#)]

Deleting a case

The menu option “case definition” -> “delete” gives you the possibility to delete previously defined "cases". This is worth doing to save space. Delete unnecessary "cases" on a regular basis and then compress the databases using the "optimize" option (-> [Maintenance](#)).

DPF – diesel particle filter

Diesel particle filters reduce primarily the particle emissions (mass and numbers). DPFs can be implicit part of a concept or they are optional devices (e.g. retrofitting). The assumptions about the shares of vehicles with DPFs are accessible by the menus “Info: FleetComposition by ...”. There, the term “Attribute2” represents the % of DPF-equipped vehicles resp. vehkm. (PS: “Attribute1” used to represent the % of AirConditioning-equipped vehicles resp. vehkm up to HBEFA 3.3, but is now irrelevant; see Chapter [Air Conditioning](#)).

The names of the subsegments use the following convention: The appendix „... (DPF)” means DPF as option. Up to HBEFA 3.3, an appendix „...DFP” implied that a DPF is mandatory for this vehicle concept (e.g. for Euro-6). This was changed in HBEFA 4.1 since it caused more confusion than clarification, as users were wondering if there were Euro-6 vehicles without DPF. Therefore the suffix “...DPF” is now omitted for concepts in which the DPF is mandatory.

Displaying results

- See menu "results". You have various options:
 - View the results on the screen (default).
 - View the results as crosstab (by year or by pollutant)

See also -> [Further Processing in ACCESS](#), -> [Export to Excel](#)

Driving patterns

A "driving pattern" represents a typical driving behaviour and can be described with the help of kinematic parameters (typically average speed, dynamics). The emission factors are originally calculated for these driving patterns. However, for the practical application it is of more interest to know emission factors for different situations on the different types of roads. Therefore, the term "Traffic Situation" has been introduced, and the emission factors in the Handbook are given for different "traffic situations" by attributing the driving patterns to different traffic situations (based on statistical analyses). The term "[traffic situation](#)" is more flexible than e.g. a static term such as "road section" because different driving patterns in reality do occur on the

same road (e.g. stop and go at peak times, fast driving during off-peak periods). At the same time the term "traffic situation" can be applied equally to all vehicle categories, whereas the "driving patterns" are defined differently for each vehicle category.

The menus "Info: Traffic situations" and "Info: Average Traffic situations" inform you about the available traffic situations.

Edit a case

You can select various parameters and save these parameter combinations as a [Case](#) under whatever name you choose.

You can refer to previously defined cases and edit these cases (Menu command -> case definition -> edit). The "parameters" option shows the parameters of previously defined cases.

Emission concept

[-> [Concept](#)]

Emission factors

The Handbook allows you to select three types of emission factors for each year:

1. "Hot" emission factors [in g/km]. These emission factors for hot engines depend on the [Traffic Situation](#)
2. Cold start emissions are given as excess emission [in g / start]. They are produced after the engine has been started. They depend upon ambient temperature, the parking time before the start (as approximation for the engine temperature at the start) and the trip length after the start. HBEFA combines these parameters to "patterns of ambient conditions" (see menu "Info: Definition Ambient Conditions (cold start / evap patterns)").
3. Evaporation emissions (refer only to HC emissions). A distinction is made here between:
 - Hot/warm soak evaporation emission factors (= after switching off the engines when the engines are still hot or warm) are given in g/stop
 - Diurnal evaporation emission factors are given in g/day and vehicle
 - Running losses are the result of vapour generated in the fuel tank during vehicle operation, hence they are given in g/km.

In addition, from HBEFA 4.1 also WTT emission factors for CO₂ equivalents are available. These represent the emission from the production of fuels/energy and are therefore available for the above-mentioned emission types that include fuel or energy consumption – i.e. hot and cold start emissions. Please see Chapter [Emission factors "well-to-tank" \(WTT\)](#) for more infor-

mation.

Note:

- Please note that not all emission factors are available for all vehicle categories. The following emission factors are available:
 - PC/LCV: "hot", start emissions, evaporation emissions (HC)
 - HDV: "hot "
 - Motorised 2-wheelers: "warm", evaporation emissions (HC)

Emission factors per vehicle subsegment

For each case defined the program provides weighted emission factors "per vehicle category" for the selected year. At the same time, you can calculate the emission factors "per vehicle concept" or "per vehicle subsegment". You then also get the emission factors for all concepts or subsegments which occur in a specific case, including their share (= weight). Warning: these options (in particular the "per vehicle subsegment" option) can result in considerable volumes of output data as well as computing time if you simultaneously select several values (e.g. various traffic situations, several gradient classes, several vehicle categories, several years etc.). It is therefore sensible to take a stepwise approach (e.g. one year per query).

Please note:

There is an additional possibility provided for calculating the emission factors of all the vehicle subsegments stored in the database: select the fleet composition "EF per subsegment (without weighting)".

Emission factors "cold start"

The "cold start emission factors" are given as excess emissions during the starting procedures (unit: g/start). They depend on various influencing factors:

- the ambient temperature,
- the trip length after the start,
- the parking time before the start (as approximation for the engine temperature at the start).

A "pattern of ambient conditions" can be selected either by choosing area and season. This associates the corresponding temperature distributions of the selected area season, at the same time average trip length and parking time distributions are assumed. Alternatively you can select a fix temperature. In this case you can select between a "full" cold start (100%) with an engine fully cooled off, i.e. turnoff for more than 12 hours and a trip length of more than 20 km (while in general > 4km is appropriate), or an "average" cold start (∅). In the latter case,

average parking time and trip length distributions are assumed. For details see the HBEFA menu options “Info: Definition Ambient Conditions (cold start / evap patterns)”.

Please note:

- The cold start emission factors are stated in g/start and vehicle. It is up to the user to process the cold start emissions in line with the "warm" emission factors and if necessary to overlap the "warm" emission factors.
- The cold start emission factors are available for passenger cars and LCV only.
- The average values are calculated as follows:
 - First of all, 24 hourly cold start emission factors are calculated. This calculation takes into account the differing ambient temperatures (per hour, per season), average parking time distributions and average trip length distributions.
 - The hourly cold start emission factors are then weighted according to an average traffic volume distribution over the day (assuming weekday characteristics of urban main roads). This gives a daily average of the cold start emission factor per season.
 - The annual average value is produced by taking an average of the four seasons (25% each).

Emission factors “evaporation – soak”

These types of evaporation emissions are emitted after the engine has been switched off (=hot or warm soak); they refer to HC emissions and HC-components only (unit: g/stop).

These evaporation emissions depend upon the engine temperature (approximated by a parking time resp. parking time distribution) and the length of the previous trip. (Both parameters are also required to calculate the cold start emissions.) These emission factors are given as a weighted, average emission factor (in g/stop and vehicle). For calculating these factors HBEFA refers to the approach implemented in COPERT IV.

Please note that evaporation emission factors are not available for HDV.

Details about the assumptions used are given in the menus “Info: Definition Ambient Conditions (cold start / evap patterns)” as well as “Info: Fuel qualities RVP”.

Emission factors “evaporation – diurnal”

These evaporation emissions occur when the vehicle is stationary ("diurnal evaporation emissions"); they refer to HC emissions and HC-components only (unit: g/vehicle and day).

The main causes of these type of emissions are changes in the ambient temperature during the course of a day. The resultant emission factors (in g/vehicle and day) therefore depend on the temperature fluctuations used as a basis. For calculating these emissions the same parameter set as for cold starts is being used. In addition, the fuel quality has to be specified (in par-

ticular the vapour pressure varying over the seasons). For calculating these factors HBEFA refers to the approach implemented in COPERT IV.

Note that evaporation emission factors are not available for HDV.

Details about the assumptions used are given in the menus “Info: Definition Ambient Conditions (cold start / evap patterns)” as well as “Info: Fuel qualities RVP”.

Emission factors “hot”

Hot (or Warm) emission factors refer to the emission when the engine is hot. These emission factors are given as g/veh-km. They depend on the driving behaviour in a specific [Traffic Situation](#) and the [Gradient Classes](#).

Emission factors “well-to-tank” (WTT)

From Version 4.1, WTT emission factors for CO₂ equivalents (CO₂e) are available in HBEFA. These represent the emissions from the production of fuels/energy and are therefore available for the emission categories that include fuel or energy consumption – i.e. hot and cold start emissions.

Accordingly, WTT emission factors are not output via a separate result table, but are output via additional columns in the hot and cold start EF output tables. Concretely:

- The output column “EFA” has been renamed to “EFA_TTW” (tank-to-wheel) and contains the same direct/TTW emission factors as in previous versions.
- The new output column “EFA_WTT” contains the WTT emission factors. It contains values on the rows of the component/pollutant “CO₂e” if the checkmark to calculate WTT emission factors has been checked. On all non-CO₂e rows, this column is empty.
- Additionally, there is also a column “EFA_WTW” (well-to-wheel) that contains the sum of TTW and WTT emission factors. It also only contains values on the rows of the component/pollutant “CO₂e” if the checkmark to calculate WTT emission factors has been checked.

The reasons why WTT emission factors are only available for CO₂ equivalents (and not other pollutants) are:

- a) that WTT emission factors are primarily of interest from a global perspective regarding climate change. For local air pollution issues, the emissions from the production of energy are irrelevant because they usually occur elsewhere;
- b) the focus of HBEFA remains on the direct emissions of road transport. WTT emission factors are derived from other sources. It does not make sense to put a lot of effort in reproducing information that can also be obtained from its original source.

Ending the program

[-> [quit](#)]

Export to Excel

Used in the menu „Results“. With this option you can export the result tables to EXCEL:

- You can select and save the directory, where you want to store your results.
- Name conventions for result tables:
For each of the five types of emission factors (hot, cold start, evaporation hot/warm soak, evaporation diurnal, evaporation running losses) a separate table is created. The following name conventions are applied:
 - The first part of the name is „EFA_“
 - The second part of the name refers to the type of emissions („Hot_“, „ColdStart_“, „EvapSoak_“, „EvapDiurnal_“, „EvapRL_“)
 - The third part contains the level of aggregation
 - „VehCat_“ for aggregate value (per vehicle category)
 - „Concept_“ for emission factors per concept or fuel type
 - „Subsegm_“ for emission factors per subsegment
 - The fourth part is the name of the case (no blanks or symbols)
 - The last part is the file type (.XLS or .XLSX) which is appended automatically according to the user's selection.
- The individual data fields (columns) in the result tables carry self-explanatory names [-> [Abbreviations](#)].
- The emission factors are defined separately depending upon the aggregation level, either as “EFA” (=unweighted emission factor) or “EFA_weighted”.
- For the cold start emissions or the evaporation factors, the “patterns of ambient conditions” are provided as well.

Fleet composition

[-> [Traffic Composition](#)]

Fuel

- = Fuel consumption
- HBEFA 3.1/3.2/3.3 consider primarily diesel and petrol vehicles, but provides also emission factors for

- PC CNG Euro-2 to Euro-6, PC LPG Euro-2 to Euro-6 and PC E85 Euro-4 to Euro-6
- Urban buses: CNG

Fuel quality

In the versions HBEFA 3.x/4.1, the same fuel quality data are applied as in HBEFA 2.1, i.e. it is based on EPEFE and ARTEMIS. The influence is taken into account as follows:

In principle, the “base emission factors” assume that vehicles are driven with an “appropriate” fuel quality, e.g. a Euro-3 vehicle is driven using “Euro-3 fuel”. If for example a Euro-1 vehicle is using Euro-3 fuel, a correction factor is applied which corresponds to the ratio of the two emission levels of fuel quality “Euro-3” to fuel quality “Euro-1”. The emission levels of the different fuel qualities are given in the handbook in the menu “Info: Fuel qualities (per year)” which informs about the assumptions w.r.t. the fuel quality (i.e. the kind of fuel quality in the different years in the different countries). The fuel quality is determined to a large extent by the sulphur content which is shown by the menu “Info: Fuel qualities CO₂, Pb, S-content (timeseries)”.

Further processing in Access

All results are stored in the “HBEFA41_User.MDB”. If you have a full version of MS ACCESS, you can read and process your results in this database, and you also can import or link the results in the User-MDB to your own databases. (PS: If you try to open the other HBEFA back-end databases you will be denied access).

Please note:

- How to delete data in the HBEFAxx_User.MDB? Please do not delete the tables in the HBEFAxx_User.MDB directly but only by the Handbook menu option “case definition” -> “delete”.
- The program also creates two tables (G_User, B_User) in the User_HBEFAxx.MDB. These tables are required to enable the Handbook to access your cases. However, these two tables have no further relevance for you, but please do not delete them.

See also -> [Name conventions](#) or -> [Abbreviations](#)

Future vehicle concepts

The Handbook also contains emission factors for future concepts (in HBEFA 4.1, Euro-7 emission factors for petrol and diesel PC). The emission levels of these concepts were estimated on the basis of the future regulations on exhaust emissions. For details about limit values and assumed correction factors please check the underlying reports in www.hbefa.net (documents).

Gradient classes

There exist 3 types of gradient classes:

- Roads with gradients of 0%
- Average of the gradient classes "+%" and "-%", e.g.: +/-2% = (0.5 * emission factor at 2% + 0.5 * emission factor at -2%)
- Individual gradient classes (-6%, -4%, etc. up to +6%)

Note: For two-wheeled vehicles emissions factors are available only for roads with gradients of 0%.

HBEFA versions

- Previous versions:
 - HBEFA Version 1.1, October 1995 (for Germany and Switzerland).
 - HBEFA Version 1.1A, 1998 (for Austria).
 - HBEFA Version 1.2, January 1999 (for Germany and Switzerland).
 - HBEFA 2.1, February 2004, for all three D-A-CH-countries (Germany [D], Austria [A], Switzerland [CH])
 - HBEFA 3.1, January 2010, with data for 5 Countries (D, A, CH, SE, N)
 - HBEFA 3.2, June 2014, with data for 6 Countries (D, A, CH, SE, N, F)
 - HBEFA 3.3, April 2017, with data for 6 Countries (D, A, CH, SE, N, F)
- Current Version:
 - HBEFA 4.1, June 2019, with data for 6 Countries (D, A, CH, SE, N, F)

All versions of the Handbook have been developed by INFRAS on behalf of the Environmental Agencies of the countries involved. For information about the program, please check the menu options "program info" resp. "program settings".

Hot emission factors

[-> [Emission Factors "hot"](#)]

Literature

See in www.hbefa.net (documents).

Load

The load is only relevant for heavy duty vehicles. The load of HDV influences the emission level. In the standard option of "per vehicle category" the load is always set to a weighted value (in

general partially loaded; please check the info menus about the fleet composition, there you find the assumptions about the loads used).

In order to examine the influence of the load on the emission factors you should select one of the two options "per vehicle concept" or "per vehicle subsegment". You will then be given three emission factors for each concept or each vehicle segment as well as for the weighted average across all vehicle concepts or segments: load factor 0%, average load factor, load factor 100%. Note that the results depend on the fleet composition used:

- If you use the option „EF weighted with fleet composition“, the average emission factor (EFA) is calculated with the load patterns used in the fleet composition (see Menu “Info: FleetComposition by subsegments”).
- If you use the option “EF per subsegment (unweighted)”, the average emission factor (EFA) corresponds to a load of 50%.

Maintenance

Optimize Database: this option compacts the program database. This save computing time and hard disk space. Therefore, it is advisable to perform this regularly.

Memory management

HBEFA may sometimes reach the limits of random-access memory available to MS Access in Office 32-bit. Already in previous versions of HBEFA, “out of memory” errors sometimes occurred. With both the number of subsegments and traffic situations increased by roughly 30% compared to HBEFA 3.3, plus new features such as WTT emission factors, such errors occur more frequently in HBEFA 4.1.

The following measures may serve as a work-around if “out of memory” errors occur in HBEFA 4.1:

- Close other MS Office applications while running HBEFA 4.1, especially during initialization;
- Close and reopen HBEFA 4.1 when an out-of-memory error occurs;
- Close and reopen HBEFA 4.1 frequently to free up memory blocked from opening forms, tables etc.
- Run HBEFA and its back-end (System, User, Library) databases on a local drive (C:), not on network drives. Based on our observations, it even makes a difference if a location on the C: drive is also mounted as a network drive (e.g. “P:”) – an out-of-memory error may occur if the back-end databases are linked using the path on “P:”, but not when the physically identical files are linked using the path on “C:”.

For users that have installed HBEFA and never moved the databases and never linked other back-ends, this is irrelevant since the installation is always on "C:".

- Optimizing/defragmenting the hard drive on which HBEFA (via Windows 10 settings or Control Panel in older Windows versions) is stored may also help.

Mileage

Mileage represents the number of kilometres a vehicle has travelled in total up to the corresponding date (acc. to the odometer). This is important for vehicles with catalytic converters where the age of the vehicle resp. the km driven lead to a deterioration in the effectiveness of the catalytic converter. The correction factors applied are based on

- a) for CO, NO_x, NO₂ in Light Duty Vehicles (PC, LCV): On remote sensing data from the CON-OX project
- b) for HC in Light Duty Vehicles (PC, LCV): a study by LAT in the context of ARTEMIS
- c) for Euro-6 HGV: On measurement data of IVT of the Technical University of Graz

For details see the reports on www.hbefa.net.

The emission factors of the "Handbook" take into account the varying mileage (depending on the year). The emission factors given for the fleet composition option "option "EF per subsegment (unweighted)" are based on a mileage of 50'000 km, while in the fleet composition of the "base case" the actual mileage is taken as basis for calculating the emission factors. The menu option "Info: FleetComposition by subsegments" shows the actual mileage (odometer; see field "CumKM" in the view "table").

Name conventions

- Define a short name for a "case" (no blanks, no symbols, no special cases). The additional comment containing a max. 50 letters or numbers (for your own documentation) is optional.
- See also -> [Export to Excel](#)

Online version

The website www.hbefa.net contains an online version with aggregate emission factors (for the 6 countries D, A, CH, SE, N, F). Note the difference between the handbook and the online version:

- The handbook provides emission factors per type of emission (hot, cold start, evaporation).
- The online version provides overall emission factors, i.e. those values sum up all emission factors of all type of emissions. This aggregation is based on certain assumptions about the traffic activities (vehkm, nr of starts etc.) which are not available in the handbook.

Optimize

[-> [Maintenance](#)]

Parameters

You can select all "cases" you have defined (menu command "results" -> "view" -> "show parameter set").

Parking times

Cold start emission factors and evaporation emissions (after the engine has been switched off; hot/warm soak) depend on the engine temperature. This in turn is dependent upon the time the vehicle was previously parking. Instead of entering the engine temperature a parking time or parking times distribution should be selected. See menu "Info: Definition Parking time distributions".

Particle filters, particle traps

[-> [DPF – diesel particle filter](#)]

Pollutants/Components

You have the following pollutants or components available:

- CO (carbon monoxide)
- HC (hydrocarbons [total HC])
- NO_x (nitrogen oxide)
- PM (particulate matter of size below 10µm, i.e. equivalent to PM10)
- fuel (fuel consumption)
- CO₂-total (= carbon dioxide "total", computed as total CO₂ from fuel consumption; see below)
- CO₂-rep (= carbon dioxide "reported", i.e. without the biofuel share in the fuel, see below)
- CO₂e CO₂ equivalents²
- Pb (lead; see below)
- SO₂ (sulphur dioxide; see below)
- CH₄ (methane, taken from total HC; see below)

² CO₂ equivalents contain CO₂, CH₄ and N₂O, i.e. the relevant greenhouse gases from the transport sector, multiplied with their respective 100-year Global Warming Potentials and summed up.

- NNHC (non-methane HC; taken from the total HC; see below)
- Benzene (taken from total HC; see below)
- Toluene (taken from total HC; see below)
- Xylene (taken from total HC; see below)
- N2O (nitrous oxide; see below)
- NH3 (ammonia; see below)
- NO2 (provided as g/km, but based on %-values of NOx)
- PN (Partikel number)

The following pollutants have been introduced with HBEFA 4.1:

- PM-nonexhaust PM10 from non-exhaust sources (e.g. road, tyre wear)
- BC Black carbon
- BC-nonexhaust Black carbon from non-exhaust sources (e.g. road, tyre wear)

Please note:

- The CO₂ emissions are calculated as “total CO₂” – based on the assumption that the carbon in the fuel is totally oxidised into CO₂. In addition, HBEFA 3.1/3.2 also provide “„CO₂-rep(orted)” which considers only the „fossil” part of the fuel without the biofuel share. This fraction is based on country specific assumptions (see details in menu “Info: Fuel qualities CO₂, Pb, S-content (timeseries)”)”
- Lead and SO₂: Lead and SO₂-emission factors are calculated as a weighted average per vehicle category and reference year. These factors depend on the country since the level of sulphur in the fuel or the ratio of leaded/unleaded petrol varies in the different countries. For further information see the menu option “Info: Fuel qualities CO₂, Pb, S-content (timeseries)”.
- Several HC components are defined as shares of total HC. For further information see the menu option “Info: HC components”.
- Only HC emissions occur under evaporation emissions.
- The emission factors depend also on the [Fuel quality](#)
- The emission factors of NH₃ and N₂O in HBEFA 3.1/3.2 are based on COPERT 4.
- The assumptions about NO₂ as % of NO_x are given in the menu “Info: NO₂ (% of NO_x)”.
- The “PM” components refer to PM₁₀ (sizes up to 10 µm). For exhaust particles, this is virtually equivalent to PM_{2.5} (sizes up to 2.5 µm). The sizes up to 2.5 µm are also available as “PM_{2.5}” and “PM_{2.5} (non-exhaust)”

Print out results - removed

The functionality to print out results has been removed in HBEFA 4.1. We recommend exporting the data to EXCEL for printing [-> [Export to Excel](#)]. This gives you more flexibility in formatting and printing the data according to your own requirements.

Quit

see menu "Case definition" -> "Exit HBEFA"

Result tables

- The results are displayed in (max.) five tables, one table per emission type: "hot", start, evaporation (hot/warm soak, diurnal, running losses). You can display these tables and print them out immediately or process them further using ACCESS or EXCEL.
- The individual columns carry in general self-explanatory abbreviated names for further processing in EXCEL or ACCESS [-> [Abbreviations](#); -> [Export to Excel](#); -> [Further Processing in ACCESS](#)].

Additional explanatory notes on the tables of results:

- If the contents of a field are not fully visible you can view the entire field content by double clicking on the relevant field.
- Share: This information refers to the percentages of the corresponding concepts or subsegment of the total held by the corresponding vehicle category.
- Weighted emission factors always refer to all the vehicle types of a vehicle category.
- The speed (velocity) is understood as average journey speed of the individual traffic situation and is intended as supplementary information.
- Differentiation according to load factor: in the "per vehicle category" standard option no distinction is made according to the load level for the "warm" emission factors. The stated values are understood as having a load factor according to the load in the fleet compositions (see menus "Info: FleetComposition ..."). However, with the "per vehicle concept" or "per vehicle segment" option, a distinction can be made between "empty" (=0%), average" and "full load" (=100%).

PS: with the option "EF per subsegment with-out weighting" the term "Average" means an average load of 50%.

Segment

"Segments" are vehicle groups of the same size class and fuel type (e.g. for PC: <1.4L or 1.4-2L or >2L for petrol resp. diesel). In the context of the emission factors they are further split up into subsegmente [-> [Subsegment](#)].

Software updates

HBEFA aims to account for the software updates after the Dieselgate scandal. In HBEFA 4.1, emission factors for the Euro-5 diesel cars with an EA189 engine updated in the compulsory VW update round are available based on the current availability of measurement data. Additional update rounds may be included in later HBEFA versions.

Software update EF are implemented in such a way that not only emission factors for the updated PC are available in addition to the “normal” emission factors, but also the effect of vehicles being updated on the non-updated rest of the fleet can be accounted for. This was achieved by differentiating three subsegments for every source subsegment in which software updates take place. For the compulsory software updates accounted for in HBEFA 4.1, these include:

- The vehicles not affected by the update: these are essentially the non-VW cars, i.e. subsegment “PC diesel Euro-5”
- The affected vehicles before the update, e.g. subsegment “PC diesel Euro-5 EA189 before software update”
- The affected vehicles after the update, e.g. subsegment “PC diesel Euro-5 EA189 after software update”

Subsegment

The following definitions are used in HBEFA:

- “Segments” are vehicle groups of the same size class and fuel type (e.g. for PC: <1.4L or 1.4-2L or >2L for petrol resp. diesel)
- “Subsegments” are “segments” which are further split up according to the “emission concept” (e.g. EURO-1, -2, -3, -4 etc.). In the previous versions of the handbook the term “vehicle layer” was used for “subsegments”.

Subsegment* (“tampered”)

For some newer concepts of Heavy Duty Vehicles (for Euro-IV, V and VI with SCR [Selective catalytic reduction]) HBEFA provides also emission factors for subsegments which are marked with an asterisk (e.g. TT/AT >34-40t Euro-IV SCR*). These vehicles are assumed to run without AdBlue (aqueous urea solution), i.e. without NOx-reduction. These emission factors are only given as background information to show the effect of a deactivating SCR. However, in the standard national fleet compositions these subsegments are not taken into account.

Temperature

The ambient temperature is required for calculating the cold start or evaporation factors as well as air conditioning corrections. For further information see the menu “Info: Definition Ambient Conditions (cold start / evap patterns)” and “Info: Definition Temperature distributions”.

Note: The influence of the ambient temperature on the "warm" emission factors is only taken into account for diesel passenger cars and light commercial vehicles (Euro-4, Euro-5, Euro-6).

Traffic composition

The term "traffic composition" (or fleet composition) means a vehicle mix (= mix of various vehicle subsegments [-> [Subsegment](#)]) within a vehicle category (and not the percentage of different vehicle categories in the traffic). This mix changes from year to year. Depending on the country different fleet composition are available. Details about the underlying fleet composition are given in the menus “Info: FleetComposition ...” with the following options:

- by [Concept](#),
- by [Segment](#),
- by [Subsegment](#).

In all versions the percentage of the individual subsegments are weighted differently depending upon the type of emission and road category [-> [Weighting](#)].

You also can select a vehicle composition "EF per subsegment (without weighting)". This option gives the emission factors for all available vehicle [Subsegments](#). In this case a weighting of the vehicle segment would be meaningless.

Traffic situation

From a user point of view the new definition of the traffic situations was the most obvious and relevant change in the version HBEFA 3.1. The subsequent versions up to 4.1 use the same “traffic situation scheme”. This scheme has been introduced in order to harmonize the definitions used so far between the different countries. The new scheme has been developed in the ARTEMIS project and adapted for HBEFA. The scheme distinguishes the traffic situations along 4 dimensions: urban/rural areas, 5 functional road types, different speed limits and originally 4 levels of service. This increased the number of traffic situations considerably in HBEFA 3.x (to 276). With HBEFA 4.1, several additional traffic situations have been introduced, namely a 5th level of service (“Heavy stop+go”, i.e. gridlock with average speeds 5-10 km/h), and speed limits 30 km/h on urban main roads. There are 365 traffic situations differentiated in HBEFA 4.1. Each traffic situation is characterized by a typical driving pattern (i.e. a speed-time curve).

Area	Road type	Levels of service	Speed Limit [km/h]													
			30	40	50	60	70	80	90	100	110	120	130	>130		
Rural	Motorway-Nat.	5 levels of service														
	Semi-Motorway	5 levels of service														
	TrunkRoad/Primary-Nat.	5 levels of service														
	Distributor/Secondary	5 levels of service														
	Distributor/Secondary(sinuuous)	5 levels of service														
	Local/Collector	5 levels of service														
	Local/Collector(sinuuous)	5 levels of service														
	Access-residential	5 levels of service														
Urban	Motorway-Nat.	5 levels of service														
	Motorway-City	5 levels of service														
	TrunkRoad/Primary-Nat.	5 levels of service														
	TrunkRoad/Primary-City	5 levels of service														
	Distributor/Secondary	5 levels of service														
	Local/Collector	5 levels of service														
	Access-residential	5 levels of service														

In addition, HBEFA also provides „average“ (i.e. aggregated) traffic situations. These are distributions of individual traffic situations in a given country, either overall or differentiated by road category (motorway, urban, rural). The definitions of individual traffic situations as well as average traffic situations are accessible by the menus “Info: Traffic situations” and “Info: Average traffic situations”. These menus also provide further attributes per traffic situation (such as average speed, RPA, % Stop time).

Trip lengths

Trip length or trip length distributions are used for calculating cold start emission factors and evaporation losses after the engine has been switched off (hot/warm soak). For further information about trip length definitions see the menu „Info: Definition Trip length distributions“.

Un-install

To un-install HBEFA, please use the standard control panel.

Note that all HBEFA versions run independently of previous versions, they also run in parallel.

Using the dialogue field

You can select a parameter (i.e. move from the left to the right selection box [or vice versa]) by either positioning the mouse on the corresponding topic (double click!) or by then clicking on the ">" key. The ">>" key causes all the available parameters to be simultaneously moved from the left to the right (or from the right back to the left).

Variation in traffic composition

The Handbook defines one or more realistic [Traffic Compositions](#) or fleet compositions (= mix of various vehicle segment) for specific years for each vehicle category. The traffic composition (e.g. higher or lower percentages of diesel vehicles, changing splits of Euro-Classes etc) cannot

be changed directly in the Handbook. However, you can achieve this by selecting a specific year and then selecting the level of detail "per vehicle concept" or "per vehicle subsegment". This will give you all the emission factors for the relevant concepts or the relevant vehicle subsegments, including their percentages assumed for the corresponding year. If needed, you can export these results e.g. to EXCEL and, depending on the specific application, vary the weighted percentages and consequently calculate the effect on the emission factors on your own.

Vehicle category

[-> [Category](#)]

Vehicle concept

[-> [Concept](#)]

Weighting

The percentages of the individual vehicle types or concepts are weighted differently, depending on the type of emission and road category:

- A traffic composition based on the km driven is applied to the hot emission factors. The weights differ by the 3 types of fleet compositions (motorway, rural, urban).
- For calculating the cold start emissions and the evaporation emissions (hot/warm soak), the "urban" traffic composition is applied.
- A vehicle composition based on the numbers of vehicles is applied to calculate the diurnal evaporation emissions.

The percentages (weights) used in the various versions of [Traffic Composition](#) are given in the results tables (for the "per vehicle concept" or "per vehicle segment" aggregation types). The shares are also given the menus "Info: FleetComposition ...".

What was new in HBEFA 3.1 ?

The most important changes in HBEFA 3.1 (2010):

New definition of traffic situations

From a user point of view the new definition of the traffic situations was the most obvious and relevant change. A new "traffic situation scheme" has been introduced in order to harmonize the definitions used so far between the different countries. The new scheme has been developed in the ARTEMIS project and adapted for HBEFA. The new scheme distinguishes the traffic situations along 4 components: urban/rural areas, 5 functional road types, speed limit and 4 levels of service. This increases the number of traffic situations considerably (276). Each traffic

situation is characterized by a typical driving pattern (i.e. a speed-time curve). Hence all emission factors had to be recalculated. This may lead to differences compared to the values in previous versions.

New country data

HBEFA 3.1 provided updated country specific data like fleet compositions etc. for Germany (by IFEU Heidelberg), Austria (by TU Graz) and Switzerland (by Infrac). In addition, data for Sweden (by VTI) and Norway (Norway Statistics) were included. In general, the country specific data are provided for the period 1990 – 2030 on a yearly basis.

Emission factors of passenger cars and light commercial vehicles

- The emission factors of passenger cars in HBEFA 3.1 were fully revised. They are now based on the PHEM model of the Technical University of Graz, the same model which has been used already in HBEFA 2.1 for the heavy duty vehicles. For calibrating the model, a broad set of emission measurements up to Euro 4 could be used. The EF for the concepts of Euro 5 and 6 were based on assumptions in view of the future legislation.
- The cold start emissions were fully revised for HBEFA 3.1 as well and are based on a new approach proposed by EMPA.
- The evaporative emissions since HBEFA 3.1 are replaced and rely now on the approach used in COPERT IV.

Emission factors of light commercial vehicles

The emission factors of light commercial vehicles in HBEFA 3.1 were fully revised as well and rely also on the TU Graz' model PHEM.

Emission factors of heavy duty vehicles

HBEFA 3.1 provided EF for basically the same set of vehicle groups using the same weight classes as previous versions, but the range of emission concepts has been extended (up to Euro VI, differentiating SCR and EGR for the concepts Euro IV and V). The emission factors of heavy duty vehicles rely on the same model as HBEFA 2.1 (the PHEM model of the TU Graz). However, the model has been improved, and the number of measurements for calibrating the model was extended significantly. The efforts to collect measurement data was started in the projects COST 349 and ARTEMIS and was continued for HBEFA 3.1.

Emission factors of motorcycles

The model for providing emission factors for motorcycles has been adapted to the PC model in the sense that accelerations in the cycles are taken into account, too. The underlying database

of emission measurements has also been extended (ARTEMIS database, extended for HBEFA 3.1).

New pollutants

HBEFA 3.1 provided emission factors for NO₂, PN (particle numbers) and PM for petrol cars.

Additional emission parameters

- Fuel consumption and CO₂ emissions (of PC) were calculated by taking into account the fact that vehicles in general are getting more energy efficient (e.g. with country specific yearly reduction rates based on the CO₂ emission monitoring of new passenger cars of the European Union).
- For air condition, a new approach (proposed by EMPA) has been integrated.
- Emission factors of non regulated emissions (e.g. N₂O, NH₃) are based on COPERT IV values.

What was new in HBEFA 3.2?

HBEFA 3.2 (2014) is considered as a “light update” of HBEFA 3.1. Hence the focus is on updates – and not on new approaches. The following elements were changed compared to HBEFA 3.1:

Hot emission factors

- All EF up to Euro 4/IV are deliberately unchanged (with one exception³).
- Hot emission factors of Euro 5/V and Euro 6/VI for passenger cars, light commercial vehicles and heavy duty vehicles (trucks, buses and coaches) are updated. The EF of the Euro 5/V concepts are based on measurements, the ones for Euro 6/VI are indicative and only partially based on measurements.
- For PC and LCV an additional concept “Euro 6c” (additional to Euro 6 which is to be interpreted as Euro 6a/b) was defined which will be introduced slightly later than Euro 6 and assumes a considerable effectiveness of additional implementation procedures (as Random driving [RDE]) and hence lower emissions. As a consequence, the fleet compositions had to be adapted to this new concept.

Cold start excess emissions

- The approach is unchanged compared to HBEFA 3.1. However, the parking time (before the engine starts) has been adjusted (in HBEFA 3.1 the parking time effects were considered as

³ the PM emission factors of the HDV Euro IV/SCR have been updated; in this manner some negative values of the EF in HBEFA 3.1 are eliminated.

linear, they now are considered as nonlinear. As a consequence, the (weighted) cold start EF are lower than the ones in HBEFA 3.1 since the EF with short parking times are reduced while the EF with long parking times remain unchanged.

Traffic situations

- The traffic situation scheme is unchanged. However, one sets of traffic situations (for PC and LCV) was adapted, i.e. for the TS⁴ “urban area / distributor road / speed limit 50” and “urban area / local road / speed limit 50” new driving cycles and hence emission factors have been specified for the LOS freeflow, heavy traffic and saturated.
- Traffic situations: originally it was planned to add more stop+go cycles (with lower average speed). Since this would be a change of the traffic scheme it was decided to postpone this amendment for a next version (probably HBEFA 4.1) and foresee a review of the whole traffic situation scheme.

Alternative concepts (as CNG, LPG etc):

- In HBEFA 3.2 the same concepts as in HBEFA 3.1 are available (i.e. PC CNG, LPG and FlexFuel [E85]; and CNG Urban Busses). However, as in HBEFA 3.1 the alternative concepts were not a primary focus of work. Some EF were changed only where indicative data were available.
- Concerning fuel consumption, it was assumed that all alternative PC concepts have the same energy consumption as their petrol counterparts (energy related, not mass related). For CNG urban buses an increased energy consumption by 19% is assumed (energy related).

Fleet compositions

Particularly due to the introduction of a new concept (Euro 6/6c) all fleet compositions were updated. Depending on the country, some additional changes were introduced (e.g. the shares of Diesel cars etc.). See the menus “Info: FleetComposition ...” for details.

Operational aspects

- HBEFA 3.2 was migrated to Access 2010, hence the menus look slightly different but they basically remain the same as in HBEFA 3.1.
- An addition option was added which allows a more compact view on results in crosstab-format (by years or by pollutants).

⁴ in German: Agglo/HVS/Tempolimit 50 resp. Agglo/Sammelstrasse/Tempolimit 50

What was new in HBEFA 3.3?

HBEFA 3.3 (2017) is a “quick update” of HBEFA 3.2 and is focusing on the “hot” NO_x-emission of diesel passenger cars. The other parts of HBEFA 3.2 remain unchanged. The following elements were adapted:

Hot emission factors (NO_x) of diesel passenger cars

- The “hot” NO_x emission factors (EF) of diesel passenger cars of the concepts Euro-4, Euro-5 and Euro-6 are updated taking into account new measurements from different sources (laboratory and real world measurements using portable emission monitoring systems PEMS as well as remote sensing data).
- As a new element the influence of ambient temperature on the hot NO_x EF of diesel cars (Euro-4, Euro-5 and Euro-6) is introduced. This influence is taken into account by correction factors. They are applied to the “base EF” provided by the PHEM model of the TU Graz as in previous HBEFA versions. The correction factors are derived mainly from remote sensing data (in Sweden and Switzerland). The empirical basis of the temperature influence so far is limited, hence the correction factors are considered as indicative and require further investigation.
- With version HBEFA 3.2 (2014) a new concept “Euro-6c” was introduced (in addition to Euro-6). With the new version HBEFA 3.3 this concept is replaced by two concepts “Euro-6d1” (=step 1) and “Euro-6d2” (=step 2) assuming a stepwise increased effectiveness of additional implementation procedures, particularly RDE (real driving emissions) and hence lower emissions. These concepts will be introduced at later points in time than previously assumed. As a consequence, the fleet compositions of diesel passenger cars had to be adapted. The fleet compositions of all other vehicle categories and technologies (e.g. petrol cars) remain unchanged.
- The “base EF” of Euro-4 (PC diesel) were updated in 2010. New measurements indicated an adaptation (particularly for motorway-driving).
- The “base EF” of Euro-5 (PC diesel) were updated in 2014 (HBEFA 3.2) and remain unchanged.
- The “base EF” of Euro-6 are updated again (i.e. increased compared to HBEFA 3.2); however, they still rely on a limited amount of measurements and hence are of indicative character; since the available measurements were taken from a sample of comparatively new vehicles a slight deterioration (with age and mileage, respectively) is assumed. The concepts Euro-6d1 and Euro-6d2 are not yet on the roads hence their EF rely on expectations about the effect of the corresponding regulations (particularly RDE)

Traffic situations

- The traffic situation scheme as well as the driving cycles assigned to the traffic situations are unchanged.
- Only for France new “aggregate” traffic situations (weighting of individual traffic situations in order to calculate averages) were specified.

Fleet compositions

- Due to the re-specification of the concepts Euro-6 of diesel passenger cars (Euro-6/6d1/6d2 replacing Euro-6/6c) the PC fleet compositions from 2017 onward were updated.
- For France, the fleet compositions of passenger cars as well as light commercial vehicles were reassessed and changed.

Operational aspects

Operationally the version HBEFA 3.3 is comparable to versions 3.1 resp. 3.2. The only new elements are the ambient temperature distributions for the hot NOx emission factors for diesel passenger cars. This element was already part of the parameter set of earlier versions (used in the context of cold start and evaporation emissions). Hence the same temperature distributions are used for calculating the hot NOx emission factors of the diesel PC fleet.

What is new in HBEFA 4.1?

HBEFA 4.1 is a “major” update and includes several new features and updates. They are briefly summarized in the paragraphs below. For more details, please consult the reports on HBEFA 4.1 development on <http://www.hbefa.net>.

Alternative drivetrains

Alternative drivetrains are a focus of HBEFA 4.1. Electric vehicles (BEV, PHEV) are newly introduced. For CNG/LNG vehicles, emission factors based on measurements and modelled by traffic situation within the PHEM model are available (in previous versions, emission factors were available, but only derived from other subsegments).

Hot emission factor updates

All hot emission factors are updated based on:

- Currently available measurements. Due to PEMS and Dieselgate, large amounts of new measurement data have become available since the last HBEFA version. As in previous HBE-

FA versions, the measurement data base especially the more recent emission standards has been improved.

- A new version of the PHEM (Passenger car and Heavy-duty Emission Model) by the Technical University of Graz), which models the hot base emission factors by driving cycle. It features a new gearshift model and improvements in the simulation of SCR catalysts such as a new NH3 storage module. Input data such as vehicle parameters were also updated.

The updates to the hot emission factors include further:

- Emission factors for motorcycles (except for mopeds) are now differentiated by gradient class as for other vehicle categories.
- Consumption/emissions due to A/C usage are now included by default and do not need to be selected separately by the user.
- Estimated emission factors for Euro-7 PC are available when querying emission factors without fleet composition weighting (but the respective vehicles are not included in the fleet compositions).

New traffic situations and driving cycles

Several additional traffic situations have been introduced, namely a 5th level of service (“Heavy stop+go”, i.e. gridlock with average speeds 5-10 km/h), and speed limits 30 km/h on urban main roads. There are 365 traffic situations differentiated in HBEFA 4.1 (compared to 276 up to HBEFA 3.3).

In addition, all driving cycles for traffic situations have been revised (see report by Steven and Ericsson on <http://www.hbefa.net>). On average, the new cycles tend to have lower average speed but higher dynamics than the old ones, which in tendency leads to higher emission factors.

Real-world fuel consumption and CO2 emissions

The real-world fuel consumption and CO2 emissions of passenger cars have been assessed in detail in a project commissioned by the UBA Germany (research project FKZ 3716 58 180 0, carried out by ICCT, DLR, ifeu, INFRAS and TU Graz). Its results have been integrated into HBEFA 4.1. Fuel consumption is not anymore based on Euro-3 petrol and diesel PC only, but base EF for all technologies and emission standards are included. These are calibrated by country and year based on CO2 monitoring and real-world excess rates.

WTT emission factors

WTT emission factors for CO₂ equivalents (CO₂e) are newly available in HBEFA 4.1. These represent the emissions from the production of fuels/energy and are therefore available for the emission categories that include fuel or energy consumption – i.e. hot and cold start emissions. Please see Chapter [Emission factors “well-to-tank” \(WTT\)](#) for additional information.

Updates of cold start and evaporation emission factors

Cold start and evaporation emission factors have been updated:

- For cold start emission factors, the methodology has remained unchanged, but new measurement data have been included.
- The methodology for evaporation emission has traditionally been adopted from the COPERT model. In HBEFA 4.1, it has been updated to the methodology of COPERT V (equivalent to the Tier 3 methodology in the EMEP/EEA 2016 Emission Inventory Guidebook).

Updates of non-regulated emission factors

The emission factors of non-regulated pollutants such as HC species, NO₂, N₂O, NH₃, and non-exhaust particles have been updated based on new measurement data and literature. PM-nonexhaust and BC are now available in the Public Version of HBEFA 4.1.

Simplified segmentation

The size classes of PC and MC have been simplified in HBEFA 4.1:

- For PC, no size classes are differentiated anymore
- For MC, fewer size classes are differentiated

For users who may miss the three capacity classes distinguished for PC so far, these are the reasons they have been abolished:

- There is no actual information lost by this simplification. For air pollutants, the same EF were used for all three size classes already in the previous HBEFA versions. The fuel consumption and CO₂ emission factors, which were differentiated, were not measured, but calibrated – based on the same information still used in HBEFA 4.1, i.e. CO₂ monitoring plus secondary information like fuel logs or fuel sales.
- There is no legal differentiation, e.g. regarding limit values, within the PC.
- The capacity classes used so far have more and more lost their meaning. With engine downsizing, engine capacity does not correlate so well with engine power anymore. On the other hand, any obvious classification that would have been well-accepted and for which data to implement it would be available in all HBEFA countries was not available. E.g. the “market

segments” used in Germany are not available in the registration databases of any of the other HBEFA countries.

In addition, alternative drivetrains for HGV newly introduced in HBEFA 4.1 (e.g. BEV, CNG, PHEV) are not differentiated by the same detailed size classes as conventional trucks, but only by 3 size classes for rigid trucks and one size class for TT/AT.

Updated country data

All country data in HBEFA 4.1 have been updated. The current time series include the years 1990-2050 for most countries, with the following exceptions:

- Germany: 1994-2050
- Switzerland: 1990-2060
- Norway: 1990-2035

Software updates of Diesel PC

HBEFA aims to account for the software updates after the Dieselgate scandal. In HBEFA 4.1, emission factors for the Euro-5 diesel cars with an EA189 engine updated in the compulsory VW update round are available based on the current availability of measurement data. For more information, please consult the Chapter [Software updates](#).

www.hbefa.net

A Website www.hbefa.net contains background information and reports describing the sources of the emission factors of the handbook. The website offers also an [Online version](#) of the handbook with aggregate emission factors for the 6 countries (D, A, CH, SE, N, F).

Years

The [Traffic Compositions](#) change from year to year. Therefore, the weighted emission factors are given for the different years (in general 1990 – 2050). For details about the fleet compositions in the different years resp. countries see the menu “Info: FleetComposition ...”.