

Guideline on Modelling Vehicle Emissions¹

Environmental Protection Department

The Government of the Hong Kong Special Administrative Region

1. INTRODUCTION

1.1. This Guideline sets out a reference method and the basic considerations for estimating vehicle emissions.

2. CHOICE OF VEHICLE EMISSION MODELS

Respirable suspended particulates (RSP), nitrogen oxides (NO_x), nitrogen dioxide (NO₂), carbon monoxide (CO), carbon dioxide (CO₂) and volatile organic compounds (VOCs)

2.1. The EMFAC-HK model should be used for estimating vehicular tailpipe emissions of RSP, NO_x, NO₂, CO, CO₂, VOCs and evaporative emissions for petrol vehicles. The model can take into account both vehicle technologies and driving conditions. Its modelling methodology follows that of the California Air Resources Board's EMFAC2002 model but with modifications to cater for local factors and the substantial reduction of the smoky vehicle problem in recent years.

2.2. The upgraded EMFAC-HK model has no I/M program for calendar years from 1997 to 2014 and takes into account the effect of the I/M programs using remote sensing and dynamometer testing for petrol/ LPG vehicles for calendar years from 2015 to 2060.

2.3. All vehicle classes, except placeholders, are considered in the model. Details of emissions of specific vehicle classes are in Appendix I.

2.4. The EMFAC-HK model is updated from time to time. Project proponents or environmental consultants should use the latest version of the model, which can be downloaded from the website of the Environmental Protection Department (EPD) at:

¹ Changes made in the *January 2021* update are highlighted in red font except misprint and grammatical changes.

www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/emfac-hk.html

2.5. The user manual of EMFAC-HK model can also be found on the above EPD's website.

Project proponents and environmental consultants should read the User's Guide before using the EMFAC-HK model for estimating local vehicle emissions.

Fuel-Consumption-related Pollutants

2.6. The emissions of fuel-consumption-related pollutants, such as sulphur oxides and lead oxides, should be estimated by a mass-balance approach based on representative vehicular fuel consumption data. Project proponents and environmental consultants can refer to PART 5, the particulate emission factor model of the United States Environmental Protection Agency (USEPA), for the estimation methodology for sulphur oxides. The PART 5 model can be found on the USEPA website at:

www.epa.gov/otaq/part5.htm

The estimation of other fuel-consumption-related pollutants can also follow a similar approach.

Alternative Modelling methodologies

2.7. Project proponents or environmental consultants can adopt alternative motor vehicle emission modelling methodologies if the alternatives can also serve the purpose of the environmental impact assessment.

3. MODEL INPUT PARAMETERS

Please note that the major assumptions are listed in Appendix II

General

3.1. Vehicle emissions are affected by traffic flow patterns, ambient temperature, relative humidity, and vehicle fleet composition. In modelling vehicle emissions, project proponents or environmental consultants should use model input data as representative of the situations under study as practicable. When site-specific information is absent, project proponents or environmental consultants should make reference to data obtained from areas bearing relevant similarities for making reasonable estimates for their environmental impact assessment studies.

Inputs to EMFAC-HK

Annual or Month

3.2. Either individual month or “Annual” should be chosen.

Modelling Mode

The EMFAC-HK model supports calculation of emissions/ emission factors for the Burden and Emfac modes.

3.3. Burden Mode

The Burden mode is used for calculating area-specific emission inventories. In this mode, the model reports total emissions in tonnes per weekday for each pollutant, by vehicle class and the vehicle fleet. The burden mode uses emission factors that have been corrected for ambient conditions and speeds combined with vehicle activity to calculate emissions in tonnes per day. Vehicle activity includes the number of vehicles, the kilometres driven per day and the number of daily trips. In the burden mode, users may select either an hourly or daily total output.

3.4. Emfac Mode

The Emfac mode generates emission factors in terms of grams of pollutant emitted per vehicle activity. Vehicle activity can be in terms of grams per kilometre or grams per hour, or grams per start, according to the emission process. The emission factors depend on basic scenario data options for calendar year and month. In the Emfac mode, the model calculates a matrix of emission factors at specific values of temperature (0°C to 40°C), relative humidity (0% to 100%), and vehicle speed (1.6 kmph to 130 kmph)* for each vehicle class/technology combination. In the Emfac mode, an additional input form allows users to customize their output and select specific temperature, relative humidity and speed values. One important use of the Emfac mode is to generate files for use with the DTIM model. The output files are also used in other air quality models such as AIRSHED, CALINE and URBEMIS.

- * Idling is not displayed in the output file of the Emfac mode for no Hong Kong data is available and the consultants are discouraged to use the idling emissions produced by EMFAC-HK.

Exhaust Technology Fractions

3.5. Project proponents and environmental consultants are advised not to use the default exhaust technology fractions unless these fractions are representative of their environmental impact assessment studies. When estimating the exhaust technology fractions for each model year of a vehicle class, which may have more than one technology group index, project proponents or environmental consultants should consider:

- (a) committed vehicle exhaust emission control programmes for the vehicle class; and
- (b) a realistic estimation of the vehicle fleet composition of the year, for which the environmental impacts are to be assessed.

Vehicle Emission Control Programmes

3.6. EMFAC-HK already includes as default all the existing/committed vehicle emission control programmes. Major ones are

- i. Committed vehicle emission standards for first-registered vehicles;
- ii. Particulate removal device retrofit programme for pre-Euro diesel vehicles and Euro I franchised buses;
- iii. Introduction of Euro 6/VI for all vehicle classes except diesel private cars, motorcycles and motor tricycles;
- iv. Introduction of California LEV III for diesel private cars;
- v. Introduction of Euro 4 for petrol motorcycles except motor tricycles;
- vi. Strengthened Emissions Control for Petrol and LPG Vehicles (an I/M program using remote sensing and dynamometer testing) (the Existing I/M Program);
- vii. Incentive-cum-regulatory retirement of pre-Euro IV diesel commercial vehicles² including ex-gratia payment and mandatory retirement in phases and the 15-year limit on service life of diesel commercial vehicles first registered on or after 1 February 2014;
- viii. Retrofitting Euro II and III double-deck franchised buses with selective catalytic reduction (SCR) devices;
- ix. Subsidy programme for the replacement of catalytic converters and oxygen sensors on LPG/petrol taxis and LPG light buses;
- x. Incentive-cum-regulatory retirement of Euro 4/IV diesel commercial vehicles² including ex-gratia payment and mandatory retirement in phases.

The estimate in EMFAC-HK for the above programs may not truly reflect the actual situations in future. The user shall revise the default values to ensure they reflect the actual situations.

3.7. The implementation dates of the emission standards for newly registered vehicles in Hong Kong vary among vehicle classes. The details are summarized in Appendix III. Vehicles of different exhaust emission standards are represented in the model by specific technology group indexes. These indexes are different from those in the EMFAC model. The technology group indexes in the EMFAC-HK model are in Appendix IV.

3.8. The Exhaust Technology groups of more modern technologies, like Euro 4/IV or newer, are split into different technology groups depending on the aftertreatment devices being used because of different impacts of these aftertreatment devices on the emissions of different pollutants.

² The term “diesel commercial vehicles” refers to all diesel commercial vehicles excluding franchised buses.

3.9. The Existing I/M Program has already been built-in to the model since EMFAC-HK V3.4.

3.10. The project proponents or environmental consultants can modify the following parameters in Graphical User Interface (GUI) for any **NEW** (“extra”) I/M programs:

- Enabling or not
- Program Starting Year
- Percentage reduction of high and super regimes vehicles due to the programme for each vehicle class

However, the changes adopted should be technically sound, well supported and applicable to the situations in Hong Kong.

3.11. For environmental impact assessment studies involving vehicle emission control measures not included in the model, the additional assumptions that project proponents or environmental consultants adopt for working out their emissions should be technically sound, well supported and applicable to the situations in Hong Kong.

Vehicle Fleet Composition

3.12. When projecting the vehicle fleet composition for estimating the exhaust technology fractions, project proponents or environmental consultants can make reference to the latest vehicle age distribution data for various vehicle classes that are posted on the website of the Environmental Protection Department at:

www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/emfac-hk.html

and make any other necessary assumptions that are justifiable in the local context.

Vehicle Population

3.13. The vehicle population forecast function in EMFAC-HK is only for

natural replacement and mandatory retirement of pre-Euro IV and Euro IV diesel commercial vehicles, no policy change other than aforementioned can be reflected in this function. Project proponents or environmental consultants may use the default vehicle population forecast in EMFAC-HK. If necessary, additional information reflecting local situations has to be gathered.

3.14. In line with EMFAC, a vehicle population forecast function has been incorporated in the model with default base year³ as its base year. For each vehicle class, the forecast function is based on two parameters: the growth rates of the vehicle fleet in the future and the survival rates of the existing fleet in that class.

3.15. The emissions/emission factors of a particular Calendar Year between 1997 and 2060 can be estimated with the vehicle population projected from the default base year.

3.16. The user may like to change the base year from default base year to a different base year and/or change the vehicle population distribution of the base year by using the function “the alternate base year” (optional). The model will then project from the alternative base year to the Calendar Year.

Accrual Rate

3.17. Defaults are estimated from the local mileage data adjusted to reflect the total vehicle-kilometre-travelled (VKT) for each vehicle class. The default should be used unless project proponents or environmental consultants have their own accrual rates that are more representative for their environmental impact assessment studies.

Diurnal Variation of Daily Trips

3.18. The diurnal variation of daily trips is used to estimate the start emissions of diesel vehicles fitted with selective catalytic reduction (SCR) devices, petrol and LPG vehicles. If start emissions are important for the environmental impact assessment of a project, its project proponent or environmental consultant should estimate the diurnal variation of the traffic in the impact assessment study area.

³ The default base year is shown in Default Base Year on the EPD’s website.

Diurnal Variation of VKT

3.19. Project proponents or environmental consultants should provide site-specific figures for their environmental impact assessment studies. If there are no site specific figures, reference can be made to the diurnal variation of daily VKTs of roads bearing similar road traffic patterns.

Burden mode

Hourly Temperature and Relative Humidity Profile

3.20. Project proponents or environmental consultants should obtain representative data from the Hong Kong Observatory. As the minimum requirement, at least one year of recent hourly ambient temperature and relative humidity data from a weather station either being the nearest or having similar characteristics as the assessment areas should be used. The data set should at least have ninety percentage valid data for the period.

Speed Fractions

3.21. Project proponents and environmental consultants should estimate representative speed fractions for the roads in their assessment study areas. The default speed fractions in EMFAC-HK should not be used. In estimating the speed fractions, they may make reference to the Road Traffic Ordinance, "Car Journey Time Survey for Monitoring Traffic Congestions" conducted by the Transport Department (TD), design speed limits of the roads concerned and Link Speed Flow Curves from traffic model such as TD's Comprehensive Transport Study.

(Reference can also be made to "Guidance for the Development of Facility Type VMT and Speed Distributions" of the USEPA, "Planning Techniques to Estimate Speeds and Service Volumes for Planning Applications" and "Highway Capacity Manual" of the Transportation Research Board, National Research Council, U.S.)

Emfac mode

3.22. Project proponents or environmental consultants shall choose whatever combinations of ambient temperatures, relative humidity and average speeds they deem fit for their project at hand. They will have to provide justification for their choices. **Representative data for ambient temperature and relative**

humidity can be obtained from the Hong Kong Observatory.

Deviations from the Modelling Input Requirements

3.23. In general, it is **not** acceptable to deviate from the above requirements for the inputs to EMFAC-HK unless the deviation can provide more realistic estimates of vehicle emissions or can also serve the purpose of their environmental impact assessments.

Inputs to Mass-Balance Equation

3.24. When applying the mass-balance equation for estimating the emissions of sulphur oxides, and other fuel-consumption-related pollutants, project proponents or environmental consultants should use for model input data such as fuel economy, fuel sulphur and lead contents, etc. as representative and practicable for their studies.

4. REVISION OF THIS GUIDELINE

4.1 This Guideline is reviewed from time to time. Project proponents or environmental consultants should make reference to its latest version before modelling the vehicle emissions of their projects.

Hong Kong Environmental Protection Department