

Appendix II

EMFAC-HK Modelling Assumptions¹

This document sets out the key EMFAC-HK assumptions.

The estimate in EMFAC-HK may deviate from the actual situations in future. The user shall revise the default values to ensure that they reflect the actual situations.

1. Population

In EMFAC-HK, the vehicle population forecast function reflects natural replacement as well as the program on mandatory retirement of pre-Euro IV diesel commercial vehicles as described in later sections.

Growth Rates

The growth rates for private cars (PC), motorcycles (MC) and goods vehicles were estimated based on the Transport Department (TD)'s latest inputs.

For other vehicle classes, the following assumptions were made:

- As the numbers of franchised buses, public light buses and taxis are **regulated** by TD **and there is no information predicting future trend**, their growth rates are assumed to be zero.
- For non-franchised buses and private light buses, **as there is no information predicting the future trend, their growth rates are assumed to be zero.**

Survival Rates

- Except for franchised buses, the survival rates are composed of a short-term one and a long-term one. Vehicle populations of years 2009-2012 were used to fit the short term survival rates while all available data from 2002 to 2012 (except for taxis which is from 2005 to 2012) were used to fit the long term survival rates. If the projecting year is 2020 or before, the short term curve will be used. If the projecting year after 2020, the long term curve will be used.
- For taxis, due to government subsidized policy to switch them from diesel to LPG, almost none was registered in the years before 2000 and around 300-500 were registered each year after 2003. Hence, the retention rate curves obtained from the 2003-2005 populations are not representative. More accurate natural replacement rates can be obtained further away from these years, so only population data from 2005-2012 were used for the estimation of their survival rates. However, even so, the available ages for taxis are insufficient to obtain accurate curve in the range for older age. Thus, for model years 1998 or before, old population for diesel taxis were used.
- For franchised buses, no replacement is done until the vehicle is forced to retire when it

¹ Changes made in the February 2018 are highlighted in red colour except misprint and grammatical changes.

reaches 18 years old. To cater for exemption granted by TD to extend some franchised buses for one more year in 2016, the survival rates are revised to retire franchised buses of 18 to 20 years old.

New Sales

A methodology in mitigating sharp anomalies in new sales was implemented for all vehicle classes except franchised buses. In this method, the number of new sales will be constant over every fixed 5-year windows (e.g. 2016 to 2020 or 2021 to 2025). This implies that the growth rates will only be followed over the 5-year period but not the years between. This methodology was disabled for taxis and public light buses from EMFAC-HK V3.4.

2. Mandatory retirement of pre-Euro IV diesel commercial vehicles² (DCV)

Under this programme, the following were taken into account:

- a) an ex-gratia payment for phasing out pre-Euro IV DCV with new ones;
- b) mandatory requirement to phase out pre-Euro IV DCV by their first registration dates according to the schedule below; and

Table 1 Phasing out schedule

Emission Standard	Start Year of Non-license renewal
Pre-Euro	2016
Euro I	2017
Euro II	2018
Euro III	2020

- c) a 15-year limit on service life of DCV first registered on or after 1 February 2014.

The gradual removal period spans across 4 years for individual Euro standards, with reduction fractions (on top of natural replacement) 10%, 33%, 80% and 100% till one year after the completion year (e.g. 2017 for Pre-Euro) respectively.

Also, effective from the **model** year 2014, the population forecast function will remove DCV equal to or older than 16 years old. For example, starting from the calendar year 2029, DCV with model years on or after 2014 will be removed.

3. Inspection and Maintenance (I/M) Program

The existing I/M program is the Strengthened Emissions Control for Petrol and LPG Vehicles (a I/M program using remote sensing and dynamometer testing) (the Existing I/M Program). Data

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

collected for petrol PC and LPG taxis in this program in 2015 were analysed to estimate their regime growth rates. The result had been incorporated into the model's regime growth rates.

For LPG public light buses and private light buses with gross vehicle weight greater than 3.5 tonnes, due to small data size, 40% and 20% of high/super emitting vehicles are assumed to be repaired to normal emitters due to the Existing I/M Program respectively.

The above default reductions for LPG light buses due to the Existing I/M Program will continue to apply in the model. However, users will not be able to alter these reductions. (The edit capability of such parameters can be changed in the GUI of the previous version (EMFAC-HK V3.3).)

4. Extra I/M Improvement

In the upgraded model, the “*Regime Size Change Data*” edit boxes in the main dialog screen is revised (Figure 1). The % reductions here now represent any extra reductions due to new I/M programs the users would like to apply independent of the Existing I/M Program. By default these reductions are zeros. Users can now change these values in the GUI or INP file. **Note that project proponents or environmental consultants have to provide justifications for any change of the default figures.**

Figure 1 – Screen shot in upgraded model showing that the extra reductions due to new I/M programs for all classes are set to zero by default. The Existing I&M Program is already incorporated in the model.

EMFAC-HK -- Editing data

File Run Help

Environmental Protection Department
The Government of the Hong Kong
Special Administrative Region

HONG KONG

permitted by
Air Resources Board
California

EMFAC-HK

MAIN

List of Available Scenarios

No file or scenario

Current Scenario Data

Number: 0 of 0
Name:

Calendar Year:
Season:
Type:

IM Program Parameters

Save

Save As...

Run

Add New Scenario

Edit Scenario

Finish Editing

Delete Scenario

Cancel

* Denotes currently active scenario

Regime Size Change Data

☒ Apply Regime Changes *

Category-Fuel	% reduction		Start Year
	Highs	Supers	
Private Car-Petrol	0	0	2020
Taxi-LPG	0	0	2020
Public Light Bus-LPG	0	0	2020
Private Light Bus >3.5t-LPG	0	0	2020
Public Light Bus-Diesel	0	0	2020
Light Goods Vehicle <=3.5t-Diesel	0	0	2020
Light Goods Vehicle 3.5-5.5t-Diesel	0	0	2020
Medium Goods Vehicle 6.4-15t-Diesel	0	0	2020
Medium and Heavy Goods Vehicle >15t-Diesel	0	0	2020
Non-Franchised Bus <=6.4t-Diesel	0	0	2020
Non-Franchised Bus 6.4-15t-Diesel	0	0	2020
Non-Franchised Bus >15t-Diesel	0	0	2020
Motorcycle-Petrol	0	0	2020

* The Model has taken into account the existing I/M programs for LC-Petrol, Taxi-LPG, PLB-LPG and P1LB-LPG

Users should note that some technology groups do not have high regime and thus the I/M reduction parameters for high regime are not applicable to them³.

5. Retrofitting franchised buses with selective catalytic reduction (SCR) devices

Technology group (Tech group) fractions were updated for the full implementation of the programme as of 2017 onwards.

6. Subsidy programme for the replacement of catalytic converters and oxygen sensors on LPG/petrol taxis and LPG light buses

The programme was postponed from October 2013 to October 2014. New tech groups with catalytic converter replacement were added for taxis, public light buses and private light buses with gross vehicle weight greater than 3.5 tonnes for the implementation of this programme. The vehicles in these tech groups were assumed like new ones. During the analysis of LPG taxis, little

³ See "Regime Assumptions" in later sections for more information.

difference was found for their NO_x emissions before and “more than 6 months” after CAT replacement. Hence, the CAT replaced taxis are not treated as new vehicles. Also, regime growth rates for these tech groups are different from that of the non-replaced one. The tech group fractions for the related vehicle classes were also updated for the full implementation of the programme as of 2014.

7. Regime-Specific Correction Factors

In version 3.3, the altitude, load and air-condition correction factors were not applied to high or super regimes while the speed correction factors for some tech groups are regime-dependent. In the updated version, all types of correction factors are applied to high and super regimes as to the normal regime.

8. Technology Groups (Tech Groups)

Three tech group descriptions are revised in version 3.4 as shown in Table 2 below.

Table 2 Revised Tech Group Descriptions in v3.4.

Vehicle Class	Vehicle Emission Standards	Version 3.1 or above Technology Group Index
Taxi	Euro 2 & 3	25
Taxi	Euro 2 & 3 CAT Replaced	19
MC	Euro 3 & 4	277

For all the current tech group definition, please visit our webpage here:

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

9. Base Emission Factors and Speed Correction Factors

Vehicle emission measurement data obtained from about 240 vehicles by using Portable Emission Measurement System (PEMS data) were used to update zero mile emission factors (ZMEFs), deterioration rates (DRs) and the speed correction factors (SCFs). These 240 vehicles were grouped by vehicle make, age, weight, technology type, and other characteristics for the purpose of calculating the emission factors (EFs) in durations of 1 minute and 8 minutes by average speed. Medians of EF at 30 km/hr +/- 5 km/hr for each vehicle for all vehicles within the same technology group are plotted against its mileage to determine ZMEFs and DRs of that technology group. A SCF of a technology group is obtained by fitting the ratios of medians of speed bins, each of 8 km/hr, over the ZMEF for that particular technology group.

In version 3.4, the following ZMEFs and DRs are updated:

- Petrol PC
 - Start basic emission factors of NO_x/VOC/CO and PM basic emission factors are updated with EMFAC2014's values.
- Petrol MC
 - For Tech Group 277, revised basic emission factors of NO_x for high emitters equal to that of the normal emitters.

Also for Tech Group 137 & 138, NO_x SCFs for high emitters are revised to be the same as those for the normal emitters.

10. Regimes Assumptions

Three Regimes are assumed for the following cases:

- For PM, Diesel vehicles with DPF installed except PC; and
- For NO_x/VOC/CO, LPG/Petrol vehicles.

All other cases only have two regimes.

Remarks:

- All Diesel Euro 6/VI vehicles are assumed to have DPF and SCR installed.
- Euro IV and V Diesel Public Light Buses are assumed to have DPF installed.
- Tech Group 204 is used for both petrol and diesel private light buses. Above convention for diesel will be followed.