Appendix II

EMFAC-HK Modelling Assumptions[1]

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 programmes on mandatory retirement of pre-Euro IV and 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 January 2019 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

Starting with EMFAC-HK V4.1, the methodology in mitigating sharp anomalies in new sales was deemed unnecessary and disabled for all vehicle classes.

2. Mandatory retirement of pre-Euro IV diesel commercial vehicles[2] (DCV)

Under this programme, the following were taken into account:

a) an ex-gratia payment for phasing out pre-Euro IV DCVs;
b) mandatory requirement to phase out pre-Euro IV DCVs 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. Mandatory retirement of Euro IV diesel commercial vehicles[3] (DCV)

The Government planned to progressively phased out from early 2021 to end 2023 Euro IV DCVs, subject to trade consultation. The number of Euro IV DCVs by model year since the

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

announcement of the programme in October 2018 was assumed to remain unchanged until the programme starts.

4. Inspection and Maintenance (I/M) Programme

The existing I/M programme is the Strengthened Emissions Control for Petrol and LPG Vehicles (a I/M programme using remote sensing and dynamometer testing) (the Existing I/M Programme). Data collected for petrol PC and LPG taxis in this programme in 2016-2017 were analysed to estimate their regime growth rates. The result had been incorporated into the model's regime growth rates.

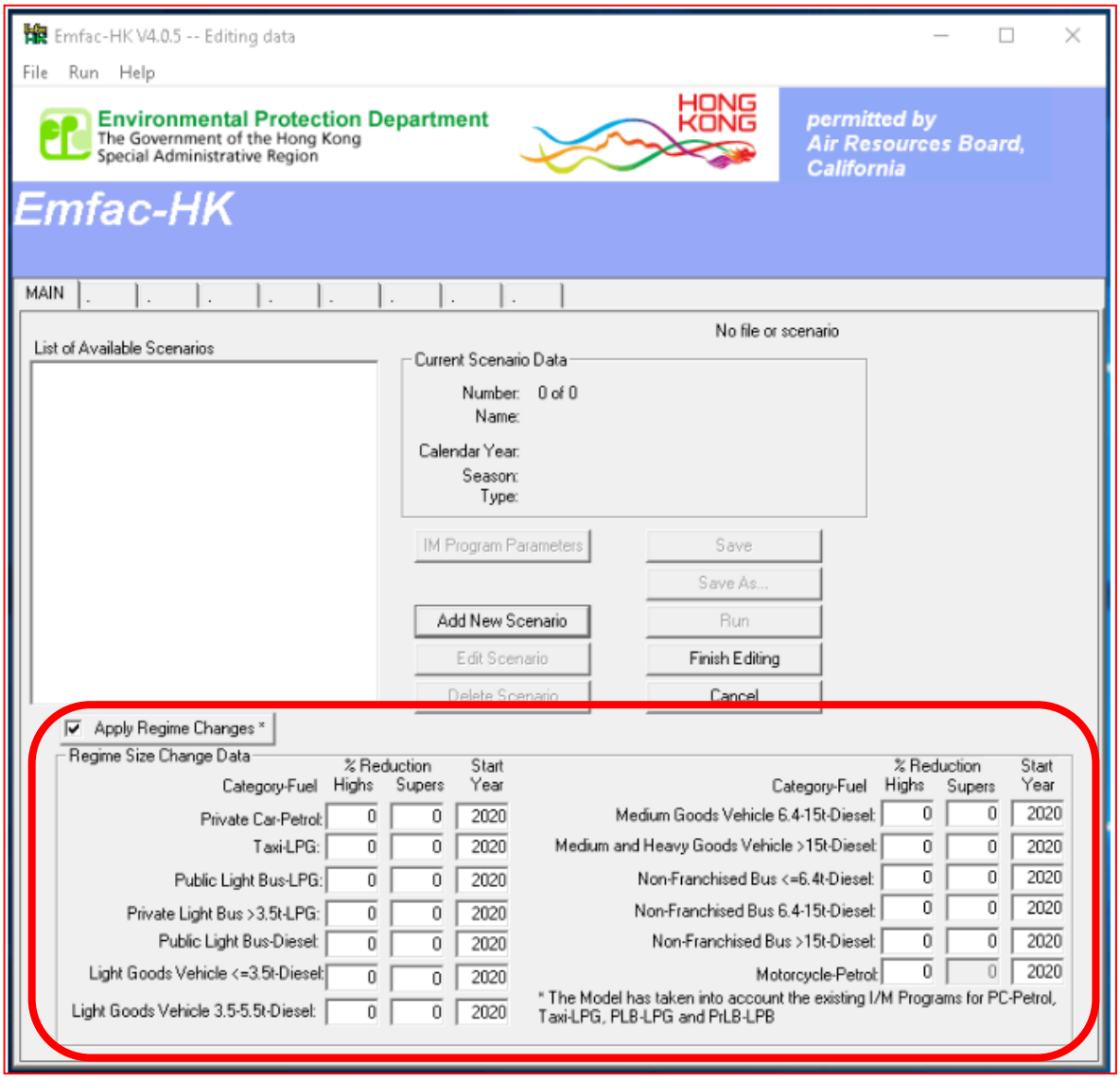
For LPG public light buses and private light buses with gross vehicle weight greater than 3.5 tonnes, due to small data size, 40% and 20% of high/super emitting vehicles are assumed to be repaired to normal emitters due to the Existing I/M Programme respectively.

The above default reductions for LPG light buses due to the Existing I/M Programme 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).)

5. Extra I/M Improvement

Starting from EMFAC-HK V3.4 (with GUI layout further revised on V4.1), 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 programmes the users would like to apply in addition to the Existing I/M Programmes. 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 programmes for all classes are set to zero by default. Please note that the existing I&M Programme is already incorporated in the model.



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 them[4].

6. Retrofitting Euro II and III double deck franchised buses with Selective Catalytic Reduction (SCR) devices

Technology group (Tech group) fractions of double deck franchised buses for 2017 and beyond were updated in line with the completion of the programme in end 2017.

[4] See "Regime Assumptions" in later sections for more information.

7. 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 difference was found for their NOx 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.

8. 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. Starting from EMFAC-HK V3.4, all types of correction factors are applied to high and super regimes as to the normal regime.

9. Technology Groups (Tech Groups)

A tech group is added in EMFAC-HK V4.1 as shown in Table 2 below.

Table 2 Revised Exhaust Tech Group Descriptions in V3.4.

Vehicle Class	Vehicle Emission Standards	Version 3.1 or above Technology Group Index
MC	Euro 4	278

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

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

10. Base Emission Factors and Speed Correction Factors

Real-world vehicle emission measurement data obtained from about 320 vehicles with 200 of Euro IV to VI 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 320 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.

Table 3 and Table 4 below show the updated vehicle classes for ZMEFs/DRs and SCFs respectively in EMFAC-HK V4.1.

Table 3 Update of ZMEFs and/or DRs in EMFAC-HK V4.1

Vehicle Class#	Fuel	NOx	PM	THC	CO	CO2
MC	Petrol	*	*	*	*	*
PC	Petrol	*	*		*	*
	Diesel					
Taxi	LPG	*	*	*	*	*
LGV3	Petrol	*		*	*	*
LGV3/4	Diesel					
LGV4	Petrol					
LGV6	Diesel	*				*
HGV7	Diesel	*				*
HGV8	Diesel	*		*	*	*
PV4	Petrol					*
	Diesel	*				
PV5	Petrol	*	*	*	*	*
	LPG					*
	Diesel	*				*
PLB	LPG	*		*	*	*
	Diesel	*				*
NFB6	Diesel	*				*
NFB7	Diesel	*				*
NFB8	Diesel	*				*
FBSD	Diesel	*				*
FBDD	Diesel	*				*

* ZMEF/DR updated.
# Full vehicle class names are at Appendix I

Table 4 Update of SCFs since EMFAC-HK V4.1

Vehicle Class#	Fuel	NOx	PM	THC	CO	CO2
MC	Petrol					
PC	Petrol	*			*	
	Diesel					

Vehicle Class#	Fuel	NOx	PM	THC	CO	CO2
Taxi	LPG	*			*	
LGV3	Petrol					*
LGV3/4	Diesel					
LGV4	Petrol					
LGV6	Diesel	*			*	
HGV7	Diesel	*	*		*	
HGV8	Diesel	*	*		*	
PV4	Petrol					
	Diesel	*				
PV5	Petrol	*	*		*	*
	LPG	*				
	Diesel	*	*			
PLB	LPG	*			*	
	Diesel	*	*			
NFB6	Diesel	*	*			
NFB7	Diesel	*	*		*	
NFB8	Diesel	*	*			
FBSD	Diesel	*	*		*	
FBDD	Diesel	*			*	

* ZMEF/DR updated.
# Full vehicle class names are at Appendix I

11. Regimes Assumptions

Three Regimes are assumed for the following cases:

- For PM, diesel vehicles equipped with DPF except PC; and
- For NOx/VOC/CO, LPG/petrol vehicles.

All other cases only have two regimes.

Remarks:

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

12. NOx Start Emissions for SCR-Equipped Vehicles

For EMFAC-HK V3.4 and before, start exhaust emissions of diesel vehicles were set to 0. Beginning in EMFAC-HK V4.1, NOx start emissions are added for diesel vehicles equipped with SCR which is aligned with EMFAC2014 developed by the California Air Resources Board (CARB)[5]. This is because the temperature of SCR should be higher than 200ºC for its effective

[5] CARB, California Environmental Protection Agency, EMFAC2014 Volume III - Technical Documentation v1.0.7, 2015.

operation that cold start NOx emissions of these vehicles are much higher than hot running NOx emissions.