Appendix II

EMFAC-HK Modelling Assumptions

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 as described in later sections.

Growth Rates

The growth rates have been estimated based on Transport Department (TD)'s latest inputs as follows:

Table 1 Vehicle Fleet Sizes

Year	Private Vehicles (private cars and motor cycles)	Goods Vehicles
	Average annual growth rates	
2011	2.5%	0.0%
2015	3.5%	0.5%
2016	4%	0.5%
2017	3%	0.5%
2021	3%	0.5%
2026	3%	0.5%
2031	3%	0.5%

For other vehicle classes, the following assumptions have been made:

- As the maximum numbers of franchised buses, public light buses and taxis are controlled by TD, their growth rates are assumed to be zero.
- The average annual growth rates from the historical data (2006 to 2008) for non-franchised buses and private light buses are about zero, so 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 are 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) are used to fit the long term survival rates. If the projecting year is 2015 or before, the short term curve will be used. If the projecting year after 2015, 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 have been 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 reaches 18 years old.

New Sales

A methodology in mitigating sharp anomalies in new sales is 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.

2. Mandatory retirement of pre-Euro IV diesel commercial vehicles[1] (DCV)

Under this programme, the following has been taken into account:

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

Table 2 Phase out schedule

Emission Standard	Start Year of Non-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 February 2014.

[1] The term "diesel commercial vehicles" refers to all diesel commercial vehicles excluding franchised buses.

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

Technology group (Tech group) fractions are updated for the full implementation of the programme as of 2017 onwards. Before 2017, parts of the input files containing tech group fractions are provided in EMFAC-HK webpage.

4. Subsidy programme for the replacement of catalytic converters and oxygen sensors on LPG/petrol taxi and LPG light bus

The programme is from October 2013 to October 2014. New tech groups with catalytic converter replacement are added for taxi, 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 will be assumed like new ones. 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 are also updated for the full implementation of the programme as of 2014. For scenario with calendar year before 2014, part of the input file containing tech group fractions is provided in EMFAC-HK webpage.

5. Regime-Specific Correction Factors

On or before EMFAC-HK V2.6, all correction factors are being applied equally to all regimes for a tech group. Starting from version 3.1, not every correction factors will be applied to high and super regimes. The load and air-condition correction factors are no longer applied to high or super regimes while the speed correction factors for some tech groups are regime-dependent.

6. More Technology Groups for After-Treatment Devices

In order to distinguish more accurately the emission levels for vehicles with various after-treatment devices, more tech groups are added and definitions of some original tech groups refined.

For example, for heavy goods vehicles with gross vehicle weight > 15 tonnes (shown in the below table), tech groups #163 and #164 are split from the original tech group #160, to represent vehicles fitted with after-treatment devices. In turn, tech group #160 no longer includes vehicles fitted with DPF (diesel particulate filter) or SCR (Selective Catalytic Reduction).

Table 3 Tech Group Index Example: Diesel Heavy Goods Vehicles with GVW >15 t (HGV8)

Vehicle Emission Standards	**Version 3.1 Technology Group Index**
pre-Euro	153
pre-Euro with DOC Retrofitted	155
Euro I	154
Euro II	157
Euro III	159
Euro IV	160
Euro IV - DPF	163
Euro IV - SCR	164
Euro V	161
Euro V - DPF	165
Euro V - SCR	166
Euro VI	162

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

7. Base Emission Factors and Speed Correction Factors

Vehicle emission measurement data obtained from about 200 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 200 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, 8 minutes and 1 hour 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 3.1, ZMEFs, DRs and SCFs of those vehicle classes with large emission contributions were updated. Table 4 and Table 5 below show the updated vehicle classes for ZMEFs/DRs and SCFs respectively.

Table 4 Vehicle classes with updated ZMEFs and DRs in version 3.1

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	*	*	*	*	*

#Refer to Appendix I for full vehicle class names

Table 5 Vehicle classes with updated SCFs in version 3.1

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	*	*	*	*	*

#Refer to Appendix I for full vehicle class names

There is relatively less PM data obtained in the PEMS testing and the PM data measured are trip-based (filter-based). Hence, only the following are updated for PM:

- ZMEFs and DRs for normal regimes of
  - Euro II franchised buses (FB) retrofitted with DPF, and
  - all Euro III and later diesel vehicle classes;
- SCFs for
  - normal regimes of Euro II franchised buses (FB) retrofitted with DPF,
  - normal regimes of all Euro III diesel vehicle classes,
  - all regime of Euro IV and later diesel vehicle classes