Appendix 3-6 Estimation of Emission Factor

Determination of Vehicular Emissions from Open Roads

The latest EMFAC-HK V2.6 has been adopted to determine the total emission inventory of vehicular emissions from open road networks within the study area. The 24-hours emission factors for 16 vehicle classes for each road link obtained from EMFAC-HK was inputted into CALINE4 model to estimate the vehicular emissions of NO_2, RSP and FSP.

The detailed procedures and assumptions for the EMFAC-HK V2.6 have been derived in accordance with EPD's guideline on Modelling Vehicle Emissions and are described in below sections.

Vehicular Classes

With reference to the Appendix I of "Guideline on Modelling Vehicle Emissions" (EMFAC-HK guideline), all vehicle operating on roads included in the assessment are categorized into 16 vehicle classes as shown in **Table 1**. Details of road link and the traffic breakdown of different vehicle types in the forecast traffic are shown in **Appendix 3-2**.

Table 1 Vehicle Classifications in EMFAC-HK V2.6

Index	Vehicle Class Description	EMFAC Code	Gross Vehicle Weight (tonnes)
1	Private Cars (PC)	PC	ALL
3	Taxi	Taxi	ALL
4	Light Goods Vehicles (<2.5t)	LGV3	<=2.5t
5	Light Goods Vehicles (2.5 – 3.5t)	LGV4	>2.5 – 3t
6	Light Goods Vehicles (3.5 – 5.5t)	LGV6	>3.5 – 5.5t
7	Medium & Heavy Goods vehicles (5.5 – 15t)	HGV7	>5.5 – 15t
8	Medium & Heavy Vehicles (>=15t)	HGV8	>15t
11	Public Light Buses	PLB	ALL
12	Public Light Buses (<=3.5t)	PV4	<=3.5t
13	Private Light Buses (>3.5t)	PV5	>3.5t
14	Non-franchised Buses (<6.4t)	NFB6	<=6.36t
15	Non-franchised Buses (6.4 – 15t)	NFB7	>6.36 – 15t
16	Non-franchised Buses (>15t)	NFB8	>15t
17	Single Deck Franchised Buses	FBSD	ALL
18	Double Deck Franchised Buses	FBDD	ALL
19	Motor Cycles	MC	ALL

Road Groupings

Based on road types and the speed limit of the roads, the roads within the study area are grouped into 5 categories as shown in **Table 2** below.

Table 2 Road Types Classifications

Road Type	Description
Expressway	24 hour stopping restrictions
Urban District Distributor	Roads with speed limit of 50kph and with junctions, pedestrian crossing and bust stop, etc.
Urban Local Distributor	Roads with speed limit of 50kph and with capacity limited by waiting vehicles and etc.
Urban Primary Distributor	High capacity junctions, normally separated with limited frontage access, pedestrian facilities segregated. Usually 24 hour stopping restrictions.
Urban Trunk Road	High capacity roads with no frontage access or development, pedestrians segregated, widely spaced grade separated junctions. 24 hour stopping restrictions

Model Modes

In this project, EMFAC mode is adopted to generate emission factors in terms of grams of pollutant emitted per vehicle activity. The vehicle activity can be represented in terms of grams per kilometer or grams per hour, or grams per start, and depends on the emission process.

In 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 140 kmph) for each vehicle class/technology combination. For the output files generated by the EMFAC mode, an additional input form allows users to customize their output and select specific temperature, relative humidity and travelling speed.

Hourly Temperature and Relative Humidity

A full year meteorological data in Year 2012 including hourly temperature and relative humidity recorded in Tsuen Wan Shing Mun Valley Automatic Weather Station of Hong Kong Observatory (HKO) was adopted in the EMFAC-HK model. The validity of the data is over 98%.

Monthly average of temperature and relative humidity from January to December in 2012 are calculated to determine the ranges of the temperature and relative humidity to be adopted in the EMFAC-HK model.

Vehicle Speed

The hourly travelling speeds of each road link were obtained from the traffic data endorsed by Transport Department. The ranges of the speeds to be simulated under the EMFAC-HK are determined from the minimum and maximum hourly vehicle speeds among all road links under this study.

In accordance with Road Traffic Ordinance, Cap 374 Section 40, medium goods vehicle, heavy goods vehicle, and bus shall travel on any road at a maximum speed of 70 km an hour. Therefore, such vehicles are assumed to travel at speeds not exceeding 70 km on all roads. In order to reflect actual situations according to this ordinance, adjustments had been made in calculations for the medium good vehicles, heavy good vehicles and buses vehicles, which are travelling in road with speed limit greater than 70 km/hr.

Exhaust Technology Fractions

As all existing vehicle emission control programmes have been included in the EMFAC-HK V2.6 as default. The implementation dates of the emission standards for various vehicle classes are adopted in accordance with Appendix II of the EMFAC-HK guideline.

Vehicle Population

The vehicle population forecast function in EMFAC-HK is only for natural replacement, no policy change can be reflected in this function. As the Project will not change the age distribution, the default vehicle populations forecast in EMFAC-HK is adopted.

Vehicle Accrual

As there is an absence of forecast information in the model year, “Default values and compositions” have been adopted in accordance with the EMFAC-HK guideline.

Daily Trips

According to the EMFAC-HK guideline, diurnal variation of daily trips is used to estimate the start emissions of petrol and LPG vehicles. Hence, trips for vehicles other than petrol and LPG type vehicles are assumed to be zero. Estimations on the number of trips for petrol and LPG type vehicles in different road sections as summarized below:

Expressway, Urban Trunk Road & Urban Primary Distributor

It is assumed that number of trips on expressway, urban trunk road and urban primary distributor would be zero as no cold start would be reasonably expected on this road section under normal circumstances.

Urban District Distributor and Urban Local Distributor

It is assumed that the number of trips would be equal to the number of cold starts in the road sections, including urban district distributor and urban local distributor. It is also assumed that the number of trips is directly proportional to Vehicle-Kilometer-Travelled (VKT) and that the pattern would be similar throughout the Hong Kong territory. The number of trips in this Study area has been estimated by multiplying $VKT_{\text{within Study Area}}$ and Trips per $VKT_{\text{within Hong Kong}}$ as follows:

$$\text{Trip}_{\text{within Study Area}} = \frac{\text{Trip}_{\text{within HK}}}{\text{VKT}_{\text{wihtin HK}}} \times \text{VKT}_{\text{within Study Area}}$$

Trips per $VKT_{\text{within Hong Kong}}$ are calculated based on the default data of EMFAC-HK, whereas $VKT_{\text{within Study Area}}$ have been calculated by multiplying the number of vehicles by the length of road travelled in this Study Area.

Daily Vehicle Kilometre Travelled (VKT)

VKT represents the total distance travelled on a typical weekday. The area specific VKTs for different types of vehicle of each road link have been calculated by multiplying the vehicle flows by the road section length.

24 hours VKT for each road links are considered in the emission factors estimations in order to include the effect of diurnal variations of traffic flows of each road.

Emission Factors

Output Frequency

Diurnal variations effects were taken into account for the emission factor estimations using 24-hour traffic flow for each road link.

Calculation of Emission Factors

Two types of emission factors are generated namely “Run Exhaust” and “Start Exhaust” in the EMFAC output. “Run Exhaust” represents the continuous flow emissions and can be applied to all types of roads, whereas “Start Exhaust” reflects the emissions by cold starts and only considered for urban local distributor and urban district distributor. As mentioned in **Section 3.6**, the “Start Exhaust” is also only confined to petrol vehicles and LPG vehicles only.

Emission inventories and VKT have been extracted from the model. The emission factors for each road link are estimated by adding the results obtained from both “Start Exhaust” and “Running Exhaust”. The overall emission factor for each road is obtained using the below equation:

Overall Emission Factor (g/VKT) = “Running Exhaurst” Emission Factor (g/VKT) + “Start Exhaust” Emission Factor (g/trips) x (No. of trips / VKT)

Generic emission factors for each vehicle class under different temperature, relative humidity and speed conditions are extracted from the EMFAC output files. Composite emission factors are then calculated for each road section using 24 hours diurnal traffic flows. The calculated hourly emission factors in grams per miles per vehicle (g/VMT) have been adopted as inputs in CALINE4 model and summarized in **Appendix 3-7**.