

Appendix 3.3 EMFAC-HK Model Assumptions

Estimation of Vehicular Emission for the Study Area with EMFAC-HK model

EMFAC-HK v4.3 model was adopted to estimate the vehicular emission rates of NO_x, NO₂, RSP, and FSP. The input parameters and model assumptions made in EMFAC-HK model are summarized as follows.

Model Year

EMFAC-HK considers 45 years of model years for the estimation of vehicular emissions. The model years start from 45 years preceding the year of interest to the year of interest as the final model year. The following table summarizes the starting and final model years of the assessment years implemented in EMFAC-HK.

Table 1 Starting and Final Model Years in EMFAC-HK

Scenario Year	Starting Model Year	Final Model Year
2030	1986	2030
2033	1989	2033
2041	1997	2041
2048	2004	2048

Vehicle Technology fraction

Exhaust technology fraction and evaporative technology fraction in the model are based on the default value.

The “2018 Licensed Vehicle by Age and Technology Group Fractions” provided in EPD’s website, was adopted in this assessment. Since the provided exhaust technology fractions are only up to Year 2018 at the time of the assessment, those after Year 2018 are projected in accordance with EPD’s *Guideline on Modelling Vehicle Emissions* – Appendix 3 “Implementation Schedule of Vehicle Emission Standards in Hong Kong (updated as of May 2020)” and Appendix 4 “EMFAC-HK Technology Group Indexes (Released in January 2021)”.

Vehicle Population

As recommended in the EPD’s *Guideline on Modelling Vehicle Emissions*, default vehicle populations forecast in EMFAC-HK was used.

Vehicle Accrual

The default accrual rates in EMFAC-HK are estimated from the local mileage data adjusted to reflect the total VKT for each vehicle class. The default value was used.

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Vehicle Kilometre Travel (VKT)

The “vehicle fleet” refers to all motor vehicles operating on roads within this assessment area. The modelled fleet was broken down into 18 vehicle classes based on the information in the Transport Monthly Digest and vehicle population provided by EPD.

Vehicle-kilometre-travelled (VKT) represents the total distance travelled on a weekday. The VKT is calculated by multiplying the number of vehicles, which based on the highest predicted hourly traffic flow, and the length of road travelled in the assessment area. The diurnal variation of VKT in the assessment area was provided by the traffic consultant.

Trips

Start emissions of vehicles in the assessment were simulated by two approaches, namely broad-brush approach and precise approach, which would be detailed later in this appendix. Given that no buses would be parked on street and start emission factors of franchised single-deck buses (FBSD) and franchised double-deck buses (FBDD) are more significant than other vehicle classes, the start emission of identified FBSD and FBDD were localized at the bus termini or bus depot and was assessed using precise approach.

Other than bus termini, public light bus (PLB) termini, heavy goods vehicle (HGV) parking sites and coach (NFB except NFB ≤ 6.4t) parking sites were identified within the study area. To avoid underestimation of air quality impact at the exit of termini and parking sites, precise approach has also been adopted to simulate the start emissions of PLB, HGV, and NFB (except NFB ≤ 6.4t) induced by these termini and parking sites. For other vehicle classes such as private cars, it was noted that the start emission factors are minimal when compared to FBSD and FBDD.

Diurnal variation of daily trips was used to estimate the start emissions of petrol, LPG vehicles and diesel vehicles fitted with selective catalytic reduction (SCR) devices. Zero trip was assumed for roads with post speed greater than 50 km/hr as no cold start would be anticipated on these roads.

Broad-brush Approach

Start emissions of vehicles were distributed on local and rural roads with posted speed of 50 km/hr or less with the number of trips for each vehicle class except PLB, FBDD, FBSD, and NFB (>6.4t) assumed directly proportional to VKT and estimated by the following formula.

$$\begin{aligned} \text{Trip for local and rural roads within the study area} &= \text{VKT for local and rural roads within the study area} \\ &\times \frac{\text{Trip for local and rural roads within Hong Kong}}{\text{VKT for local and rural roads within Hong Kong}} \end{aligned}$$

Trip within Hong Kong and VKT within Hong Kong were obtained from the default values from EMFAC-HK. The proportion of local and rural roads within Hong Kong was obtained from the Annual Traffic Census of Year 2021 and Year 2022 prepared by Transport Department and is presented in **Annex A**. Since the proportion of local and rural roads within Hong Kong in Year 2021 was smaller than that in Year 2022, the value in Year 2021 was adopted for this assessment as a worst-case scenario. VKT within the study area was calculated by multiplying the number of vehicles by the distance travelled within the study area. The trips per VKT is also presented in **Annex A**.

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The highest NO_x (and the corresponding NO and NO₂), RSP, and FSP start emission factors for each vehicle class among different soak time were adopted as a conservative approach.

Precise Approach

Bus (FBSD and FBDD) and PLB termini, NFB (>6.4t) and HGV parking sites were identified within the study area. For these termini and parking sites, the number of trips for FBSD, FBDD, PLB, NFB (>6.4t), and HGV was obtained by on-site survey and information from the operators (if applicable). Calculations of emissions associated with these termini and parking sites were referenced to the *Calculation of Start Emissions in Air Quality Impact Assessment (Appendix 3.9)* published by EPD. Idling emissions were not considered in the calculations for HGV parking sites due to the statutory ban against idling of motor vehicle engines under the Motor Vehicle Idling (Fixed Penalty) Ordinance (Cap. 611).

Travelling Speed

Based on the available speed information provided by traffic consultant, emission factors of each vehicle class were adopted according to the travelling speed of each road link at each hour. All the vehicle classes on the same road link were assumed to have the same travelling speed, except medium goods vehicles, heavy goods vehicles, buses, and public light buses, on which speed limit has been imposed.

In accordance with the Road Traffic Ordinance, for any road with design speed limit of 70 kph or above, the speed limit for medium goods vehicles, heavy goods vehicles, and buses would be limited to not more than 70 kph. Thus, for medium goods vehicles, heavy goods vehicles and buses, the flow speed or 70 kph, whichever is lower, was adopted. For the public light buses, the speed limit should be restricted to the speed limit of the carriageway or 80 kph, whichever is lower.

Temperature and Humidity Profile

For the estimation of short-term and long-term air quality impact of NO₂, RSP, and FSP except long-term air quality impact of NO₂ (i.e., annual average NO₂), the lowest hourly temperature (5°C) and relative humidity data (20%) (>90% valid data) provided by Hong Kong Observatory (HKO) at Wetland Park weather station for Year 2022 were adopted for the model input.

For the estimation of long-term air quality impact of NO₂ (i.e., annual average NO₂), the daily profile of averaged temperature and relative humidity data in each hour for each month (i.e., 24 hours data in each month and for 12 months) provided by HKO at Wetland Park weather station for Year 2022 were adopted for the model input. A summary table for the temperature and relative humidity adopted is provided in **Annex B**.

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Estimation of Composite Vehicular Emission Factor

Referring to the EPD's *Guideline on Modelling Vehicle Emissions*, "Emfac mode" was used for calculating emission factors in terms of grams of pollutants emitted per vehicle activity. It was applied for this Project since it provides the emission factors according to the actual hourly travelling speeds of vehicles of each road.

Assuming that NO_x is comprised of NO and NO₂ only, the hourly emission of NO was calculated as the difference in emissions between NO_x and NO₂ extracted from EMFAC-HK model for each vehicle type. The NO, NO₂, RSP, and FSP running exhaust and start emission factors of 18 vehicle classes for the estimation air quality impact except long-term air quality impact of NO₂ (i.e., annual average NO₂) are presented in **Appendix 3.5**.

Given that there would be no cold starts on roads with speed limit greater than 50 km/hr, only running exhaust was considered for these road sections, while both running exhaust and starting emissions were considered for local road with speed limit of 50km/hr. The 24-hour traffic flows and composite emission factors for each road adopted in the subsequent air dispersion modelling for the estimation air quality impact except long-term air quality impact of NO₂ (i.e., annual average NO₂) are presented in **Appendix 3.6**.

Vehicular Emission Burden by EMFAC-HK (for Determination of Assessment Year) – Operation Phase

Vehicular emission burdens (NO_x, RSP, and FSP) for the Years of 2033, 2041 and 2048 were calculated based on the traffic forecast and composite emission factors. In view that there will be additional road network, which will be committed by other projects, commencing before Year 2041, the vehicular emission burden of combining Year 2033 and the road network in Year 2041 was also calculated as a conservative approach. The results are summarized in Table 2. According to the results, the combination of Year 2033 EMFAC modelling year and Year 2041 road network was selected as the worst affected year for the air quality assessment of operation phase.

Table 2 Vehicular Emission Burden of Open Road Source during Operation Phase

EMFAC Model Year	Road Network Year	NO _x (g/day)	RSP (g/day)	FSP (g/day)
2033	2041	257,468	9,569	8,811
2033	2033	187,360	7,298	6,720
2041	2041	224,303	7,892	7,272
2048	2048	200,697	7,123	6,566

Proportion of Local and Rural Roads within Hong Kong in Year 2021

Table with 3 columns: Region, Major Roads, Minor Roads, Total. Rows include HK Island, Kowloon, New Territories, and Total.

Proportion of Local and Rural Roads within Hong Kong in Year 2022

Table with 3 columns: Region, Major Roads, Minor Roads, Total. Rows include HK Island, Kowloon, New Territories, and Total.

Trips per VKT (Calculated by the proportion of local and rural roads within Hong Kong in Year 2021)

Table with 10 columns: Vehicle Classes, No. of Trips within HK (Petrol, Diesel, LPG), VKT within HK (Petrol, Diesel, LPG), VKT for Local and Rural Roads within HK (Petrol, Diesel, LPG), Trips per VKT. Rows include Private Cars, Taxi, Light Goods Vehicles, etc.

Year 2033

Table with 10 columns: Vehicle Classes, No. of Trips within HK, VKT within HK, VKT for Local and Rural Roads within HK, Trips per VKT. Rows include Private Cars, Taxi, Light Goods Vehicles, etc.

Year 2041

Table with 10 columns: Vehicle Classes, No. of Trips within HK, VKT within HK, VKT for Local and Rural Roads within HK, Trips per VKT. Rows include Private Cars, Taxi, Light Goods Vehicles, etc.

Year 2048

Table with 10 columns: Vehicle Classes, No. of Trips within HK, VKT within HK, VKT for Local and Rural Roads within HK, Trips per VKT. Rows include Private Cars, Taxi, Light Goods Vehicles, etc.

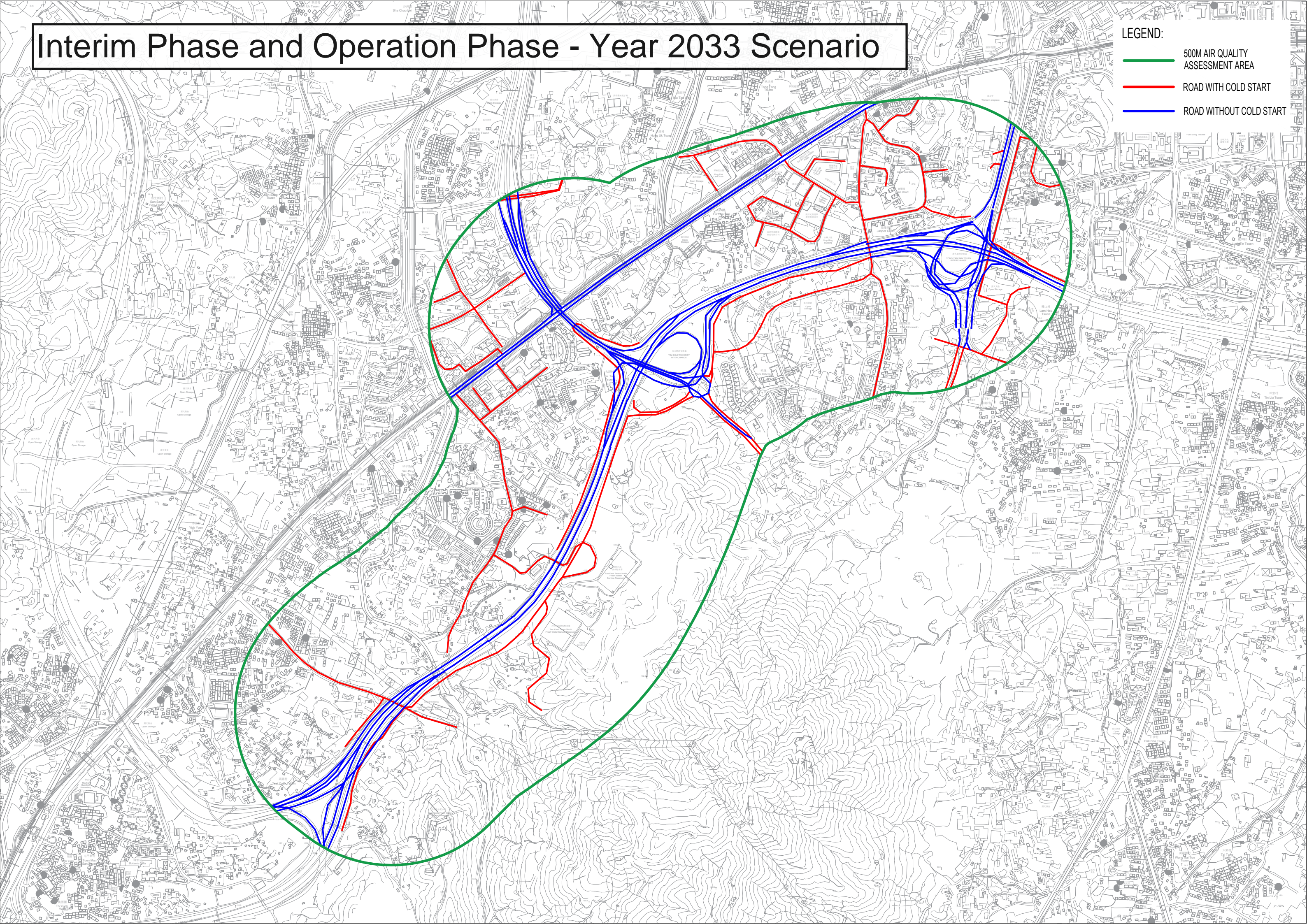
Temperature and Relative Humidity Data Adopted for Estimation of Long-Term Air Quality Impact of NO2

Weather Station: Wetland Park

Large table with columns for Year (2022), Hours (0000-2300), and months (January to December). Rows show RH and Temp values for each hour and month.

Interim Phase and Operation Phase - Year 2033 Scenario

- LEGEND:
- 500M AIR QUALITY ASSESSMENT AREA
 - ROAD WITH COLD START
 - ROAD WITHOUT COLD START



Operation Phase - Year 2041 & 2048 Scenario

- LEGEND:
- 500M AIR QUALITY ASSESSMENT AREA
 - ROAD WITH COLD START
 - ROAD WITHOUT COLD START

