

Methodology on Emission Adjustment of PATH v2.1 Model for the Assessment Year 2033

1. Introduction

To assess the air quality impact from the Project, an integrated modelling system, Pollutants in the Atmosphere and their Transport over Hong Kong model (PATH v2.1) was used to predict the future background air pollutant concentrations. This model is developed by Environmental Protection Department (EPD) to simulate air quality over Hong Kong territory including those in Pearl River Delta Economic Zone, and background contributions from roads, marine, airport, power plants and industries within Hong Kong.

The assessment year for this Project is Year 2033. Given the emission inventory for the PATH v2.1 is up to Year 2025, this paper aims to outline the methodology for adjustment of vehicular emission in PATH v2.1 model for the Assessment Year 2033 in order to avoid over-estimation of background pollutant concentrations for the cumulative air quality impact assessment.

2. Methodology for Emission Adjustment in PATH V2.1 Model

In order to obtain more realistic background air pollutant concentrations for this Project, the vehicular emissions in the PATH v2.1 model have been adjusted. By achieving this, the assumptions made in the following sections are discussed.

The Study Area, covers five (5) grid cells of PATH v2.1 model namely grid (33,39), (34,39), (34,38) (35,38) and (35,37).

To avoid the double-counting of emissions from the vehicle within the Study Area, vehicle emission in the PATH v2.1 model for the abovementioned grid cells are deducted. The removal of NO₂, NO, FSP and RSP emissions at these 5 grids are calculated by the following equation:

$$E' = E_{\text{all},2025} - E_{\text{mv},2025} \quad \text{Equation 1}$$

Where E' is the removal of vehicular emission at the concerned grids;
 $E_{\text{all},2025}$ is the total emission from PATH v2.1 model in Year 2025; and
 $E_{\text{mv},2025}$ is the vehicular emission from PATH v2.1 in Year 2025.

Apart from this, the vehicular emission for the remaining grids has been projected to the Year 2033 (i.e., project assessment year). The latest EMFAC version (i.e., EMFAC-HK v4.3) is used to calculate the adjustment factor for this assessment. The summary of emission inventory from PATH v2.1 is presented in **Annex A**. The estimated NO, NO₂, FSP, and RSP emissions in PATH v2.1 model at the remaining grids are corrected based on the following equation:

$$E'' = E_{\text{all},2025} - E_{\text{mv},2025} + E_{\text{mv},2025} \times F_{\text{adj}} \quad \text{Equation 2}$$

Where E'' is the vehicular emission adjustment at the remaining grids;
 $E_{\text{all},2025}$ is the total emission from PATH v2.1 model in Year 2025;
 $E_{\text{mv},2025}$ is the vehicular emission from PATH v2.1 in Year 2025; and
 F_{adj} is the effective adjustment factor based on the emission from EMFAC-HK. The detailed effective adjustment factor F_{adj} is presented in **Annex A**.

Annex A
Summary of Emission Inventory from
PATH v2.1 and Scale Factor to be
Adopted

Summary of Emission Inventory from PATH v2.1 and Effective Adjustment Factor to be Adopted

Concerned Grids - (33.34), (34.39), (34.38), (35.38) and (35.37) [6]

Layer	Grid	Total Annual Emission from PATH V2.1 (in tonne/yr) (A)											Annual Vehicular Emission from PATH V2.1 (in tonne/yr) (B)											Emission After Adjustment (in tonne/yr) (A) - (B)											Effective Adjustment Factor (C)				Methodology for Emission Adjustment
		NO [1]	NO ₂ [2]	PEC	PMFINE	PNO ₃	PSO ₄	POA	PMC	RSP [3]	FSP [4]	NO [1]	NO ₂ [2]	PEC	PMFINE	PNO ₃	PSO ₄	POA	PMC	RSP [3]	FSP [4]	NO [1]	NO ₂ [2]	PEC	PMFINE	PNO ₃	PSO ₄	POA	PMC	RSP [3]	FSP [4]	NO	NO ₂	PMC	PMFINE/ PNO ₃ / PSO ₄ /PEC/PO A				
Layer 1	3339	46.49	5.12	1.95	0.55	0.04	0.14	1.41	1.83	5.92	4.09	42.06	4.67	1.66	0.26	0.02	0.13	1.34	1.54	4.95	3.41	4.43	0.44	0.29	0.30	0.01	0.01	0.04	0.29	0.97	0.68	-	-	-	-	The adjustment of vehicular emissions from PATH V2.1 is based on Equation 1.			
	3439	78.88	8.72	3.22	2.86	0.18	0.33	2.05	5.78	14.42	8.64	61.89	6.88	2.74	0.36	0.03	0.17	1.98	2.67	7.95	5.29	16.99	1.84	0.48	2.50	0.15	0.16	0.07	3.12	6.47	3.35	-	-	-	-				
	3438	66.20	7.32	2.56	0.66	0.04	0.19	1.91	2.42	7.79	5.36	61.89	6.88	2.28	0.35	0.03	0.17	1.84	2.11	6.78	4.67	4.31	0.44	0.29	0.32	0.02	0.01	0.07	0.31	1.01	0.70	-	-	-	-				
	3538	76.35	8.44	3.65	1.44	0.10	0.29	2.20	4.49	12.17	7.68	61.89	6.88	3.24	0.37	0.03	0.18	2.13	3.26	9.21	5.95	14.47	1.57	0.41	1.07	0.07	0.11	0.07	1.24	2.96	1.73	-	-	-	-				
	3537	73.47	8.12	5.01	0.87	0.06	0.22	2.60	5.05	13.80	8.75	61.89	6.88	4.38	0.40	0.03	0.18	2.48	4.62	12.09	7.47	11.59	1.24	0.63	0.47	0.03	0.04	0.12	0.43	13.80	8.75	-	-	-	-				

Remaining Grids [5] [6]

Layer	Grid	Total Annual Emission from PATH V2.1 (in tonne/yr) (A)											Annual Vehicular Emission from PATH V2.1 (in tonne/yr) (B)											Emission After Adjustment (in tonne/yr) (A) - (B) + (B) × (C)											Effective Adjustment Factor (C)				Methodology for Emission Adjustment
		NO [1]	NO ₂ [2]	PEC	PMFINE	PNO ₃	PSO ₄	POA	PMC	RSP [3]	FSP [4]	NO [1]	NO ₂ [2]	PEC	PMFINE	PNO ₃	PSO ₄	POA	PMC	RSP [3]	FSP [4]	NO [1]	NO ₂ [2]	PEC	PMFINE	PNO ₃	PSO ₄	POA	PMC	RSP [3]	FSP [4]	NO	NO ₂	PMC	PMFINE/ PNO ₃ / PSO ₄ /PEC/PO A				
Layer 1	3338	63.24	6.71	2.13	0.97	0.06	0.12	1.07	2.16	6.52	4.36	24.76	2.75	1.23	0.15	0.01	0.07	0.86	1.21	3.53	2.33	48.83	5.76	1.75	0.92	0.06	0.10	0.79	1.93	5.55	3.62	0.418	0.654	0.808	0.684	The adjustment of vehicular emissions from PATH V2.1 is based on Equation 2.			
	3440	7.76	0.82	0.44	0.14	0.01	0.02	0.18	0.19	0.97	0.78	3.36	0.37	0.15	0.02	0.00	0.01	0.11	0.15	0.44	0.29	5.80	0.69	0.39	0.13	0.01	0.02	0.14	0.17	0.85	0.69	0.418	0.654	0.808	0.684				
	3441	0.23	0.01	0.14	0.64	0.00	0.02	0.00	0.29	1.10	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.01	0.14	0.64	0.00	0.02	0.00	0.29	1.10	0.81	0.418	0.654	0.808	0.684				
	3539	51.91	5.72	2.28	1.40	0.10	0.22	1.29	3.26	8.55	5.29	36.15	4.02	1.85	0.21	0.02	0.10	1.22	1.86	5.26	3.40	30.87	4.33	1.70	1.34	0.09	0.19	0.90	2.90	7.12	4.21	0.418	0.654	0.808	0.684				
	3536	108.10	11.97	5.29	0.64	0.04	0.19	2.53	2.13	10.83	8.69	61.89	6.88	2.25	0.35	0.03	0.17	1.83	2.09	6.72	4.64	72.08	9.59	4.58	0.53	0.03	0.14	1.95	1.73	8.96	7.23	0.418	0.654	0.808	0.684				

Notes:

[1] Total Annual NO Emission in tons/yr = Total annual NO emission in mole/s × molar mass of NO (i.e., 30.01 g/mol) × 3600 × 10⁶.

[2] Total Annual NO₂ Emission in tons/yr = Total Annual NO₂ Emission in mole/s × molar mass of NO₂ (i.e., 46.0055 g/mol) × 3600 × 10⁶.

[3] RSP for vehicular emission = PEC + PMFINE + PNO₃ + PSO₄ + POA + PMC.

[4] FSP for vehicular emission = PEC + PMFINE + PNO₃ + PSO₄ + POA.

[5] Remaining grids refer to the grid cells other than the concerned grids (33.34), (34.39), (34.38), (35.38) and (35.37). The grid cells (33.38), (34.40), (34.41), (35.39), (35.36) are selected to demonstrate the effective adjustment factor applied to PATH v2.1 emission inventory.

[6] The values of emission (in tonne/yr) are rounded to 2 decimal places.

Adjustment Factor to PATH Vehicular Emission Inventory for Year 2033 Based on EMFAC-HK

Vehicular Emission Burden by EMFAC-HK V4.3

Year	NO Emission (kg/day)	NO ₂ Emission (kg/day)	PM ₁₀ Emission (kg/day)	PM _{2.5} Emission (kg/day)
2025	19511.05	2917.64	909.67	836.46
2033	8916.79	1551.78	464.90	428.00

Annual Vehicular Emission Burden (EMFAC-HK V4.3 + Paved Road Dust)

Year	NO Emission (tonne/annum)	NO ₂ Emission (tonne/annum)	PM ₁₀ - PM _{2.5} (tonne/annum) ^[1]	FSP Emission (tonne/annum) ^[1]
2025	7121.53	1064.94	336.72	655.31
2033	3254.63	566.40	323.47	506.22

Future Adjustment Factor (future_adj_factor)	NO	NO ₂	PMC	FSP
2033	0.457	0.532	0.961	0.772

Adjustment Factor for Year-2025 Mvonly

Source	NO Emission (tonne/annum)	NO ₂ Emission (tonne/annum)	PMC Emission (tonne/annum) ^[3]	FSP Emission (tonne/annum) ^[2]
EMFAC-HK (v4.3)	4645.47	1064.94	336.72	655.31
Year-2025 Mvonly (from PATH v2.1)	5083.42	865.84	400.46	740.58

MV Adjustment Factor (mv_adj_factor)	NO	NO ₂	PMC	FSP
EMFAC-HK/ Year-2025 Mvonly (from PATH v2.1)	0.914	1.230	0.841	0.885

Emission Inventory of Year 2025 is to be replaced with future MV emission , the vehicular emission projected to Year 2033 can be calculated by the following equation:

Year2025 - Year2025_Mvonly + Year2025_Mvonly*effective_adj_factor

where effective_adj_factor = mv_adj_factor*future_adj_factor

Effective Factor (effective_adj_factor)

Year	NO Factor	NO ₂ Factor	PMC Factor	FSP Factor
2025	0.418	0.654	0.808	0.684

Note:

[1] The paved road dust emissions of PM₁₀ (i.e., 660 tonne/annum) and PM_{2.5} (i.e., 350 tonne/annum) are obtained from PATH model.

[2] FSP for vehicular Emission = PEC + PMFINE + PNO₃ + PSO₄ + POA; The effective factors for PEC, PMFINE, PNO₃, PSO₄ and POA are equivalent to FSP Factor.

[3] PMC = RSP - FSP in PATH, RSP for vehicular Emission = PEC + PMFINE + PNO₃ + PSO₄ + POA + PMC