Appendix 3.10 Derivation of Cumulative Annual Average NO_x to NO_2 Conversion Equation using Jenkin Method

Jenkin Method for Long-term Cumulative NO_2 Assessment

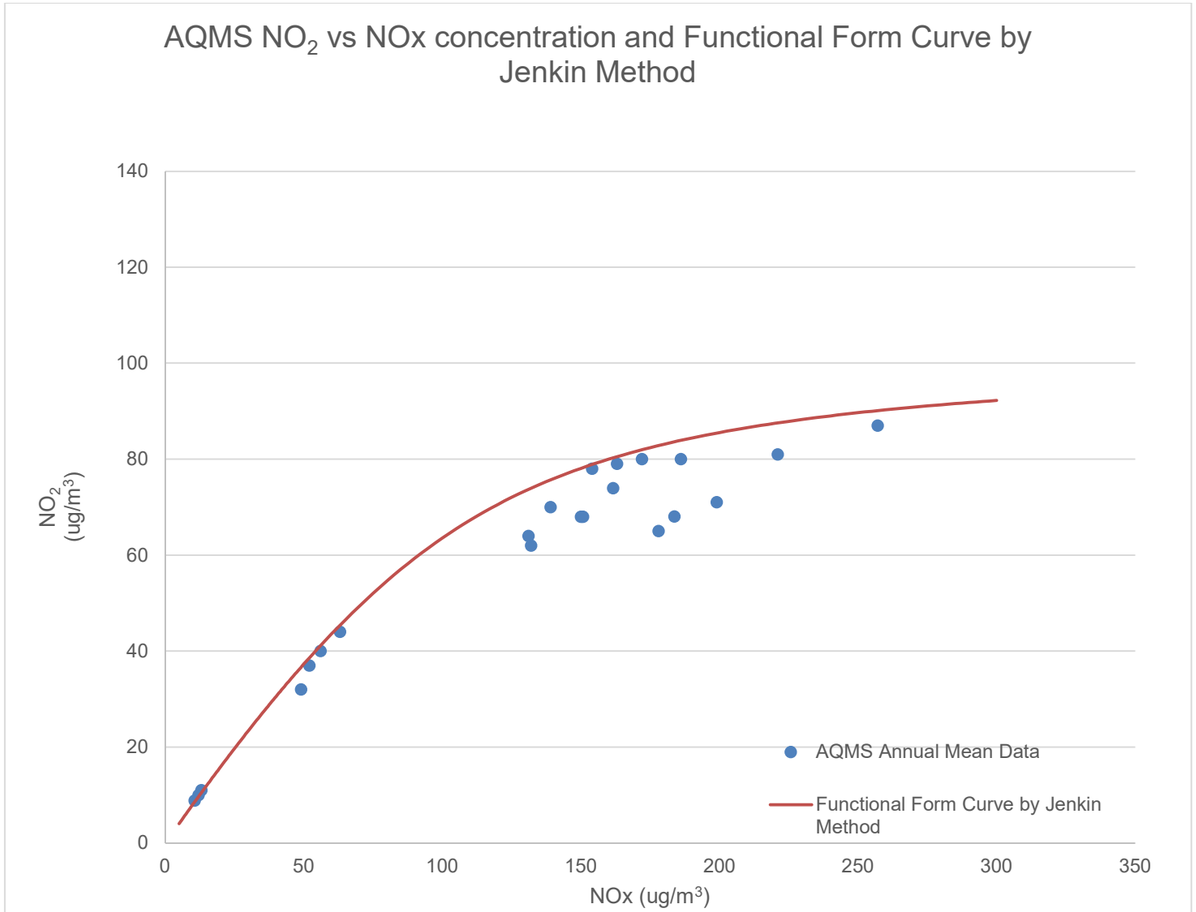
With reference to the *Review of Methods for NO to NO_2 Conversion in plumes at short ranges*[1], Jenkin method was adopted for the conversion of cumulative annual average NO_x to NO_2 by using the functional form of annual mean of NO_2-to-NOx. The mentioned functional form is referenced from (Jenkin, 2004)[2] and is presented below:

$$[NO_2] = \frac{\left([\mathrm{NOx}] + [\mathrm{OX}] + \frac{\mathrm{J}}{\mathrm{k}}\right) - \sqrt{([NOx] + [OX] + \frac{J}{k})^2 - 4[NOx][OX]}}{2}$$

where

$[NO_2]$	is the NO_2 concentration
$[NO_x]$	is the NOx concentration
[OX]	is the sum of NO_2 concentration and O_3 concentration (i.e. $[OX] = [NO_2] + [O_3]$)
J	is the photolysis rate of NO_2
k	is the rate coefficient for reaction between NO and O_3

The above functional form was used to analyze the annual mean data obtained from relevant EPD's air quality monitoring stations (AQMS) including Yuen Long general station, Tap Mun general station and three roadside stations (i.e., Causeway Bay, Central and Mong Kok roadside stations). The recent five years annual mean data are extracted and presented in **Annex A**. Scattered plot for recent 5 years annual means NO_2 versus NO_x concentrations obtained from relevant AQMS was created. The functional form curve would fit the annual mean data when [OX] = 102 μg/m^3 and J/k = 22 μg/m^3. The value of [OX] and J/k are considered reasonable as they are within typical value range for Hong Kong. The range of annual average [OX] from the selected air quality monitoring stations is 75 – 116 μg/m^3. The obtained functional form curve was adopted for the cumulative annual average NO_x to NO_2 conversion. The curve is slightly higher than all the annual mean data obtained from AQMS, the calculated annual average NO_2 concentration using the obtained functional form curve based on the measured annual average NO_x obtained from AQMS are presented in **Annex A**, the calculated annual average NO_2 concentration are higher than the measured annual average NO_2 concentration, no underestimation of the annual average NO_2 concentration is expected.



For long-term cumulative NO_2 assessment (i.e., predictions of annual average NO_2 concentration), cumulative annual average NO_x to NO_2 conversion equation for this assessment was calculated as follows:

$$[NO_2]_c = \frac{([NOx]_c + 102 + 22) - \sqrt{([NOx]_c + 102 + 22)^2 - 4[NOx]_c \times 102}}{2}$$

where

$[NO_2]_c$	is the predicted cumulative NO_2 concentration
$[NO_x]_c$	is the predicted cumulative NO_x concentration

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[1] Environment Agency. 2007. *Review of methods for NO to NO_2 conversion in plumes at short range*. Prepared by Environmental Agency.

[2] Jenkin, M.E. (2004). Analysis of sources and partitioning of oxidant in the UK – Part 1: The NOx-dependence of annual mean concentrations of nitrogen dioxide and ozone. *Atmospheric Environment, 38(30)*, 5117-5129.

Annex A

Annual Average NO_X, NO_2 and OX concentration in Recent Five Years (Year 2018 – 2022) at Selected EPD AQMS

AQMS	Year	Measured NO_x ($\mu g/m^3$)	Measured NO_2 ($\mu g/m^3$)	Measured $NO_2 + O_3$ ($\mu g/m^3$) Named as [OX]	Calculated NO_2 using the functional form curve based on measured NO_x ($\mu g/m^3$)
Yuen Long	2018	63	43	86	45
	2019	63	44	97	46
	2020	49	32	75	37
	2021	56	40	89	41
	2022	52	37	89	39
Tap Mun	2018	13	11	83	11
	2019	12	10	90	10
	2020	11	9	80	9
	2021	12	10	85	10
	2022	13	8	84	11
Causeway Bay	2018	257	87	108	90
	2019	221	81	110	88
	2020	184	68	98	84
	2021	199	71	100	85
	2022	178	65	97	83
Central	2018	186	80	105	84
	2019	172	80	116	82
	2020	151	68	103	78
	2021	150	68	100	78
	2022	132	62	99	74
Mong Kok	2018	163	79	106	81
	2019	154	78	110	79
	2020	162	74	104	80
	2021	139	70	102	76
	2022	131	64	98	74