

Appendix 3.5 – Emission Inventory of Industrial Emissions

Building	Model ID	Source	X-Coordinate	Y-Coordinate	Base	Stack Height	Exit Temperature	Exit Velocity	Stack Diameter	Emission Rates			Operation Period
										NOx	RSP	FSP	
(Name)	(#)	(Type)	(HK1980)	(HK1980)	(mPD)	(mAG)	(K)	(m/s)	(m)	(g/s)	(g/s)	(g/s)	(Hours)
North District Hospital ^(a)	NDHC01	POINT	830849.00	839680.00	15.2	64.52	333	7	0.60	0.0892	0.0047	0.0047	24-Hour
	NDHC02	POINT	830850.00	839681.00	15.2	64.52	333	7	0.60	0.0892	0.0047	0.0047	24-Hour
	NDHC03	POINT	830851.00	839682.00	15.2	64.52	333	7	0.60	0.0892	0.0047	0.0047	24-Hour
Expansion of North District Hospital ^(b)	NDHEW1	POINT	830884.45	839818.87	11.0	122.10	333	7	1.00	0.1192	0.0062	0.0062	24-Hour
	NDHEW2	POINT	830884.74	839820.39	11.0	122.10	333	7	1.00	0.1192	0.0062	0.0062	24-Hour
	NDHEW3	POINT	830885.00	839821.94	11.0	122.10	333	7	1.00	0.1192	0.0062	0.0062	24-Hour
	NDHEW4	POINT	830885.29	839823.43	11.0	122.10	333	7	1.00	0.1192	0.0062	0.0062	24-Hour
	NDHEW5	POINT	830885.53	839824.95	11.0	122.10	333	7	1.00	0.1192	0.0062	0.0062	24-Hour
	NDHEW6	POINT	830885.81	839826.42	11.0	122.10	333	7	1.00	0.1192	0.0062	0.0062	24-Hour
	NDHES1	POINT	830808.11	839922.95	11.0	129.10	333	7	1.00	0.2986	0.0156	0.0156	24-Hour
	NDHES2	POINT	830808.42	839924.52	11.0	129.10	333	7	1.00	0.2986	0.0156	0.0156	24-Hour
	NDHES3	POINT	830808.76	839926.18	11.0	129.10	333	7	1.00	0.2986	0.0156	0.0156	24-Hour
	NDHES4	POINT	830808.98	839927.64	11.0	129.10	333	7	1.00	0.2986	0.0156	0.0156	24-Hour
NDHEC1	POINT	830807.70	839921.14	11.0	116.10	333	7	1.00	0.3548	0.1183	0.1183	24-Hour	

Notes:

(a) Information provided by North District Hospital.

(b) Information provided by Hospital Authority.

(c) For those chimneys where the operators did not provide any information, their exit velocities and temperatures are assumed to be 7m/s and 333K as advised by EPD.

(d) An assumption of PM = RSP = FSP was made in a conservative approach.

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Calculation on Industrial Emissions in North District Hospital

North District Hospital - Boilers (NDHC01-03)

Monthly Energy Consumption	=	5,863,104 MJ		Note (a)
	=	1,628,640 kWh		(1kWh=3.6MJ)
Energy Consumption per Boiler	=	1,954,368 MJ		(Divided by 3 boilers)
	=	542,880 kWh		(Divided by 3 boilers)
Energy Consumption Rate per Boiler	=	0.2027 kWh/s	...(1)	Note (b)
	=	2,626.8 MJ/hr	...(2)	
NOx Emission Factor	=	220 mg/kWh		Note (c)
	=	0.22 g/kWh	...(3)	
Calculated NOx Emission Rate	=	0.0446 g/s	...(4)=(3)*(1)	
Adopted NOx Emission Rate	=	0.0892 g/s	...(4)*2	Note (d)
Calorific Value of Towngas	=	17.27 MJ/m ³	...(5)	Note (e)
	=	463.51 BTU/scf	...(6)	(1MJ/m ³ =26.84BTU/scf)
Average Gross Heating Value (Calorific Value) of Natural Gas	=	1,020 BTU/scf	...(7)	Note (f)
Conversion Ratio on Calorific Value (Towngas in Natural gas form)	=	0.4544	...(8)=(6)/(7)	
PM Emission Factor from Table 1.4-2 of AP-42	=	7.6 lb/10 ⁶ scf	...(9)	Note (g)
PM Emission Factor with Conversion Ratio on Calorific Value	=	3.4536 lb/10 ⁶ scf	...(10)=(9)*(8)	
	=	55.2580 kg/10 ⁶ m ³	...(11)	(1lb/10 ⁶ scf=16kg/10 ⁶ m ³)
Calculated PM (RSP/FSP) Emission Rate	=	8405.0 kg/10 ⁶ hr	...(12)=(2)/(5)*(11)	
	=	0.0023 g/s	...(13)	(1kg=1000g; 1hr=3600s)
Adopted PM (RSP/FSP) Emission Rate	=	0.0047 g/s	...(13)*2	Note (d)

Notes:

- Monthly fuel consumption is provided by North District Hospital. Highest monthly fuel consumption in 2019 is adopted.
- 24-hour operation per day, provided by North District Hospital.
- NOx Emission Factor is referenced from Section 3.5.1 of Approved EIA - "Provision of a Poultry Slaughtering Centre in Sheung Shui" (AEIAR142/2009).
- The emission rate is multiplied by 2 times as a conservative approach.
- Calorific Value is referenced from Town Gas Characteristics in Towngas Website. (<https://www.towngas.com/en/About-Us/Hong-Kong-Gas-Business/Gas-Production>)
- The emission factor is converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to the average natural gas heating value (i.e. 1,020Btu/scf).
- The PM emission factor is referenced from Table 1.4-2 of Chapter 1.4, USEPA AP42, Fifth Edition, Volume I. Emission factor is based on an average natural gas heating value of 1,020Btu/scf.

Appendix 3.5 – Emission Inventory of Industrial Emissions

Calculation on Industrial Emissions in Expansion of North District Hospital

Expansion of North District Hospital - Hot Water Boiler (NDHEW1-6)

Power Rate per Hot Water Boiler	=	1,950 kW		Note (a)
Energy Consumption per Hot Water Boiler per hour	=	1,950 kWh		(1kWh=1kW*1hr)
Energy Consumption Rate per Hot Water Boiler	=	0.5417 kWh/s	...(1)	(1hr=3600s)
	=	7,020 MJ/hr	...(2)	(1kWh=3.6MJ)
NOx Emission Factor	=	220 mg/kWh		Note (b)
	=	0.22 g/kWh	...(3)	(1g=1000mg)
NOx Emission Rate	=	0.1192 g/s	...(4)=(3)*(1)	
Calorific Value of Towngas	=	17.27 MJ/m ³	...(5)	Note (c)
	=	463.51 BTU/scf	...(6)	(1MJ/m ³ =26.84BTU/scf)
Average Gross Heating Value (Calorific Value) of Natural Gas	=	1,020 BTU/scf	...(7)	Note (d)
Conversion Ratio on Calorific Value (Towngas in Natural gas form)	=	0.4544	...(8)=(6)/(7)	
PM Emission Factor from Table 1.4-2 of AP-42	=	7.6 lb/10 ⁶ scf	...(9)	Note (e)
PM Emission Factor with Conversion Ratio on Calorific Value	=	3.4536 lb/10 ⁶ scf	...(10)=(9)*(8)	
	=	55.2580 kg/10 ⁶ m ³	...(11)	(1lb/10 ⁶ scf=16kg/10 ⁶ m ³)
PM (RSP/FSP) Emission Rate	=	22461.6 kg/10⁶hr	...(12)=(2)/(5)*(11)	
	=	0.0062 g/s	...(13)	(1kg=1000g; 1hr=3600s)

Expansion of North District Hospital - Steam Boiler (NDHES1-4)

Power Rate per Steam Boiler	=	4,886 kW		Note (a)
Energy Consumption per Steam Boiler per hour	=	4,886 kWh		(1kWh=1kW*1hr)
Energy Consumption Rate per Steam Boiler	=	1.3572 kWh/s	...(1)	(1hr=3600s)
	=	17,589.60 MJ/hr	...(2)	(1kWh=3.6MJ)
NOx Emission Factor	=	220 mg/kWh		Note (b)
	=	0.22 g/kWh	...(3)	(1g=1000mg)
NOx Emission Rate	=	0.2986 g/s	...(4)=(3)*(1)	
Calorific Value of Towngas	=	17.27 MJ/m ³	...(5)	Note (c)
	=	463.51 BTU/scf	...(6)	(1MJ/m ³ =26.84BTU/scf)
Average Gross Heating Value (Calorific Value) of Natural Gas	=	1,020 BTU/scf	...(7)	Note (d)
Conversion Ratio on Calorific Value (Towngas in Natural gas form)	=	0.4544	...(8)=(6)/(7)	
PM Emission Factor from Table 1.4-2 of AP-42	=	7.6 lb/10 ⁶ scf	...(9)	Note (e)
PM Emission Factor with Conversion Ratio on Calorific Value	=	3.4536 lb/10 ⁶ scf	...(10)=(9)*(8)	
	=	55.2580 kg/10 ⁶ m ³	...(11)	(1lb/10 ⁶ scf=16kg/10 ⁶ m ³)
PM (RSP/FSP) Emission Rate	=	56280.6 kg/10⁶hr	...(12)=(2)/(5)*(11)	
	=	0.0156 g/s	...(13)	(1kg=1000g; 1hr=3600s)

Appendix 3.5 – Emission Inventory of Industrial Emissions

Calculation on Industrial Emissions in Expansion of North District Hospital

Expansion of North District Hospital - Combined Cooling, Heat and Power (CCHP) Generator (NDHEC1)

Landfill Gas Input of CCHP Generator	=	3,709.00 kW		Note (a)
Energy Consumption per CCHP Generator per hour	=	3,709.00 kWh		(1kWh=1kW*1hr)
	=	13352.4 MJ/hr	...(1)	(1kWh=3.6MJ)
Calorific Value of Landfill Gas	=	18 MJ/m ³	...(2)	Note (f)
Fuel Consumption Rate as using Landfill Gas	=	741.8 m ³ /hr	...(3)=(1)/(2)	
	=	0.2061 m ³ /s	...(4)	(1hr=3600s)
Conversion from US Standard Condition to HK Condition		60 F		(US Standard Condition)
	=	288.71 K	...(5)	$K = (F - 32) \times 5/9 + 273.15$
		25 °C		(HK Condition)
	=	298.15 K	...(6)	$K = °C + 273.15$
Unit Conversion		1 MM scf		
(Temperature from 60F to 25°C)	=	1000000 scf		(1MM=1000000)
	=	28316.8 m ³	...(7)	(Temp. 60F; 1scf=0.028316847m ³)
	=	29243.2 m ³	...(8)=(7)*(6)/(5)	(Temperature 25°C; and Ideal Gas Law - $V1/V2 = T1/T2$)
		1 lb/MM scf		
	=	0.0155 g/m ³	...(9)	(Temperature 25°C; 1lb=453.59237g; and (8))
NOx Emission Factor from LFG Power Generator	=	111 lb/MM scf LFG	...(10)	Note (g)
	=	1.7217 g/m ³	...(11)=(10)*(9)	
NOx Emission Rate	=	0.3548 g/s	...(12)=(11)*(4)	
PM (RSP/FSP) Emission Factor	=	37 lb/MM scf LFG	...(13)	Note (g)
	=	0.5739 g/m ³	...(14)=(13)*(9)	
PM (RSP/FSP) Emission Rate	=	0.1183 g/s	...(15)=(14)*(4)	

Notes:

- (a) Information is provided by Hospital Authority.
- (b) NOx Emission Factor is reference from Section 3.5.1 of Approved EIA - "Provision of a Poultry Slaughtering Centre in Sheung Shui" (AEIAR142/2009).
- (c) Calorific Value is referenced from Town Gas Characteristics in Towngas Website. (<https://www.towngas.com/en/About-Us/Hong-Kong-Gas-Business/Gas-Production>)
- (d) The emission factor is converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to the average natural gas heating value (i.e. 1,020Btu/scf).
- (e) The PM emission factor is referenced from Table 1.4-2 of Chapter 1.4, USEPA AP42, Fifth Edition, Volume I. Emission factor is based on an average natural gas heating value of 1,020Btu/scf.
- (f) Heat value of landfill gas is referenced from EMSD Website. (https://re.emsd.gov.hk/english/energy/landfill/land_reso.html#:~:text=The%20heat%20value%20of%20landfill%20gas%20is%20approximately%2018%20MJ%2Fm3).
- (g) Emission Factors are referenced from "Secondary Air Emission" of Table 4-4 of Air Emission from Municipal Solid Waste Landfills - Background Information for Proposed Standards and Guidelines, USEPA, March 1991. Maximum emission factor of all listed control techniques in the table is adopted (i.e. 111 for NOx, 37 for PM).