2019 Hong Kong Emission Inventory Report

Report Number	:	EPD/TR/1/21
Report Prepared by	:	Claudie Wong, Hilda Huang, Carmen Chan
Work Done by	:	Air Science Group
Checked by	:	Sonia Lo
Approved by	:	Kenneth Leung
Security Classification	:	Unrestricted

Air Science Group

•

Environmental Protection Department

•

The Government of the Hong Kong Special Administrative Region

August 2021

CONTENT

Annexes

1 INTRODUCTION

1.1. The Environmental Protection Department (EPD) compiles the Hong Kong Air Pollutant Emission Inventory annually to analyze the quantity of local air pollutant emissions and their major emission sources for supporting the formulation of effective air quality management strategies in Hong Kong. It also provides necessary data for carrying out air quality impact assessments. The emission inventory for Hong Kong was first published on EPD's website in March 2000.

1.2. This report presents the 2019 Hong Kong Emission Inventory. It covers:

(i) the emission inventory by source category in 2019 (Chapter 3);
(ii) the emission trends from 2001 to 2019 for six major air pollutants (Chapter 4);
(iii) the sectoral analyses for six emission source categories (Chapter 5); and
(iv) the emissions from hill fires (Chapter 6).

2 SCOPE OF EMISSION INVENTORY

2.1. The emission inventory comprises estimates of emissions from seven source categories for six major air pollutants, namely: sulphur dioxide (SO_2), nitrogen oxides (NOx), respirable suspended particulates (RSP or PM_{10}), fine suspended particulates (FSP or $PM_{2.5}$), volatile organic compounds (VOC), and carbon monoxide (CO). The emission sources include public electricity generation, road transport, navigation, civil aviation, other combustion sources, non-combustion sources, and hill fires.

2.2. Other combustion sources are defined as sources involving combustion, other than public electricity generation, road transport, navigation and civil aviation. Major contributing sources in this sector include non-road mobile machineries operating in construction sites and container terminals.

2.3. Non-combustion sources are defined as those remaining sources that do not involve combustion, from which only VOC, RSP and FSP emissions are significant. In this category, the major emission sources for VOC include paints and associated solvents, consumer products and printing, whereas those for RSP and FSP include paved road dust, cooking fumes, construction dust and quarry production.

2.4. In Hong Kong, hill fires are one of the sources of particulates. As most of the hill fires in Hong Kong are caused by human negligence or accidents and are sporadic in nature, their emissions cannot be reduced through emission control measures like other pollution sources. In order to enable more meaningful comparison on the emission trends of controllable pollution sources and the effectiveness of local emission control measures, hill fires are reported separately in Chapter 6. The total emissions of air pollutants in Section 3.1 and Annex I are presented into two total emission figures, one with hill fires and the other without.

3 2019 EMISSION INVENTORY

3.1. The table below shows a breakdown of air pollutant emissions by source category in 2019, while Annex 1 shows the changes in emissions between 2018 and 2019.

Breakdown of 2019 Emission Inventory

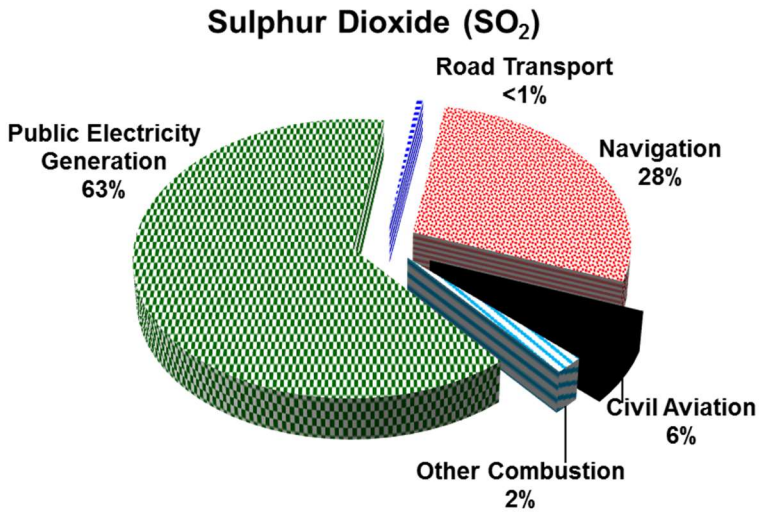
Pollution Sources	Emissions (Tonnes)					
	SO_2	**NOx**	**RSP**	**FSP**	**VOC**	**CO**
Public Electricity Generation	5,340	23,160	570	300	400	3,350
Road Transport	40	12,700	330	300	4,900	30,100
Navigation	2,360	27,550	990	920	2,610	17,360
Civil Aviation	520	6,310	60	60	590	4,260
Other Combustion	170	7,900	640	590	720	5,360
Non-combustion	N/A	N/A	900	470	11,910	N/A
Total Emissions (without Hill Fires)	8,430	77,620	3,480	2,630	21,130	60,440
Hill Fires	10	40	450	360	100	1,040
Total Emissions (with Hill Fires)	8,440	77,660	3,930	2,990	21,230	61,470

Notes:
- All figures, except those for Road Transport, are rounded to the nearest ten. For Road Transport, the figures smaller than 1,000 are rounded to the nearest ten and the remaining figures are rounded to the nearest hundred.
- "N/A" denotes not applicable.
- There may be slight discrepancies between the sums of individual items and the total emissions shown in the table because of rounding.

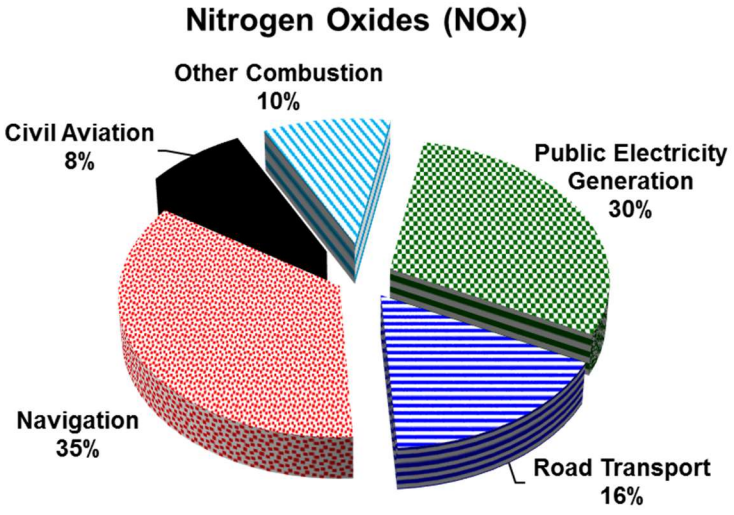
3.2. A summary of updates to the emission inventories is appended at Annex 2.

3.3. The following pie charts show the percentage share of emissions by source category (excluding hill fires) for each pollutant in 2019.

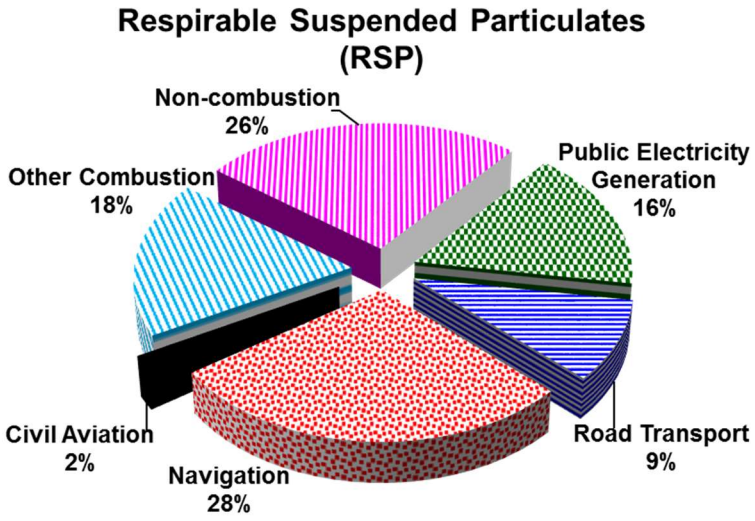
Total SO_2 emissions = 8,430 tonnes



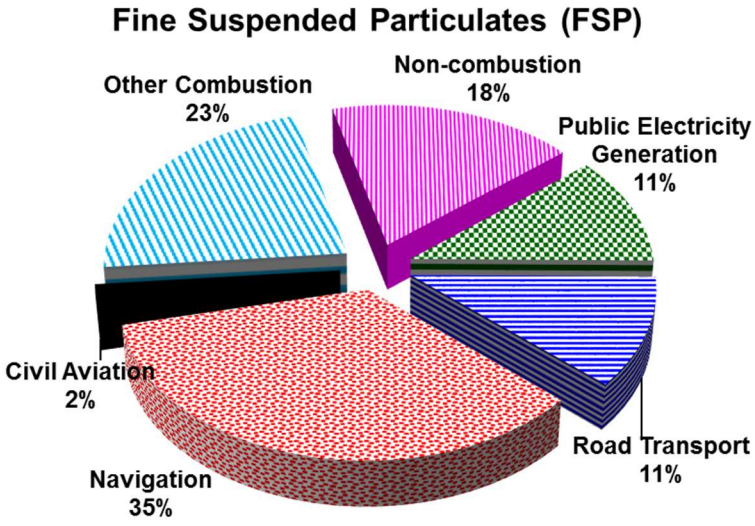
Total NOx emissions = 77,620 tonnes



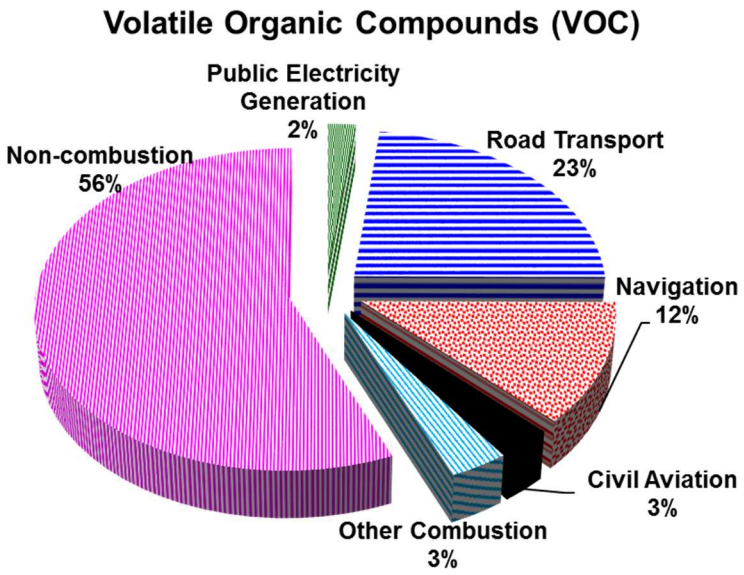
Total RSP emissions = 3,480 tonnes



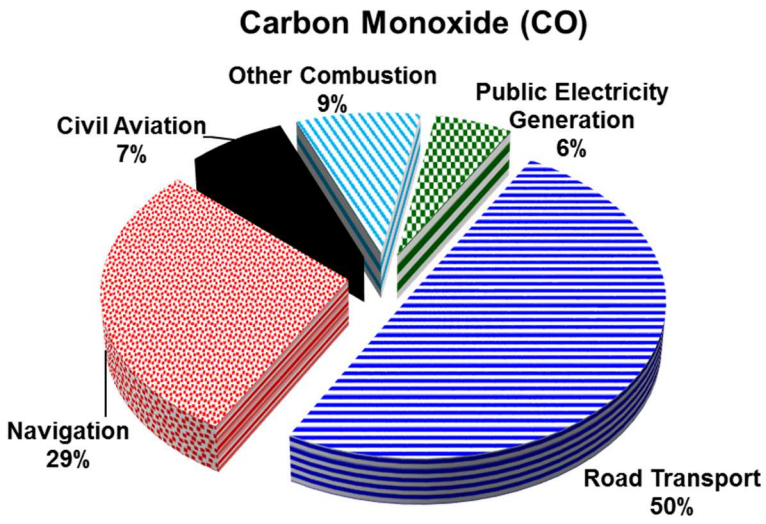
Total FSP emissions = 2,630 tonnes



Total VOC emissions = 21,130 tonnes

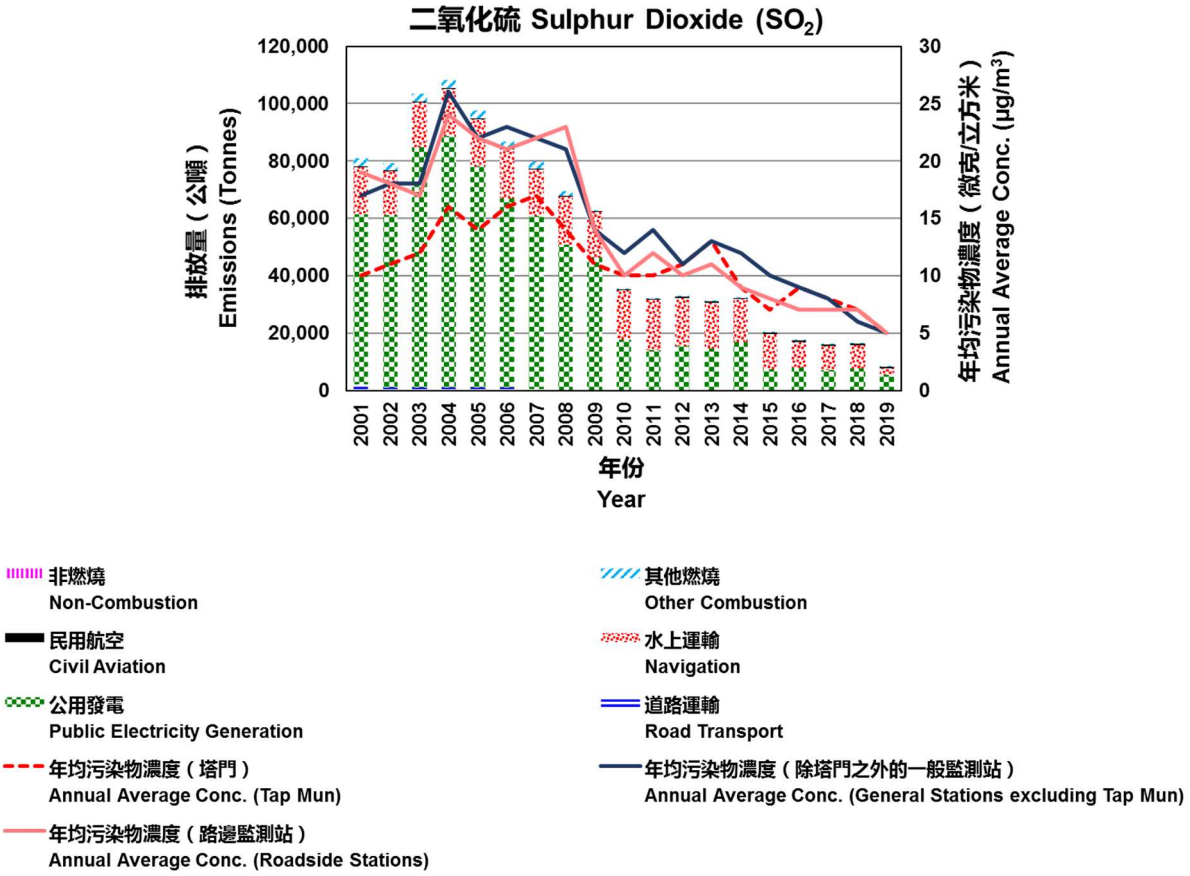


Total CO emissions = 60,440 tonnes



4 EMISSION TRENDS FROM 2001 TO 2019

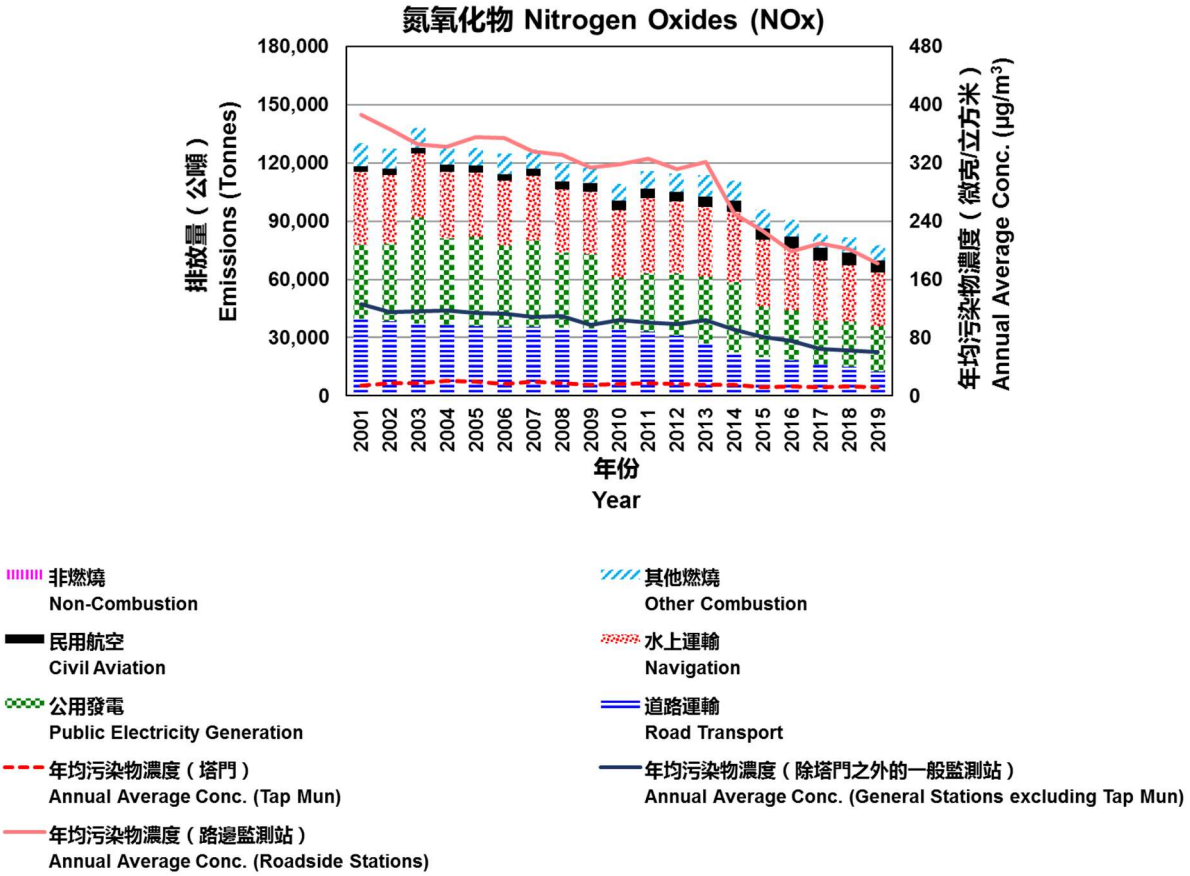
SO_2 Emissions and Air Quality Trends



4.1. Between 2001 and 2019, SO_2 emissions decreased by 90%, which were mainly caused by the decline in emissions from the public electricity generation and navigation sectors. Public electricity generation and navigation sectors were the top two sources of SO_2 emissions, accounting for 63% and 28% of total SO_2 emissions in 2019, respectively.

4.2. During the same period, SO_2 concentration levels measured at the EPD's general air quality monitoring stations by and large followed the SO_2 emission trend.

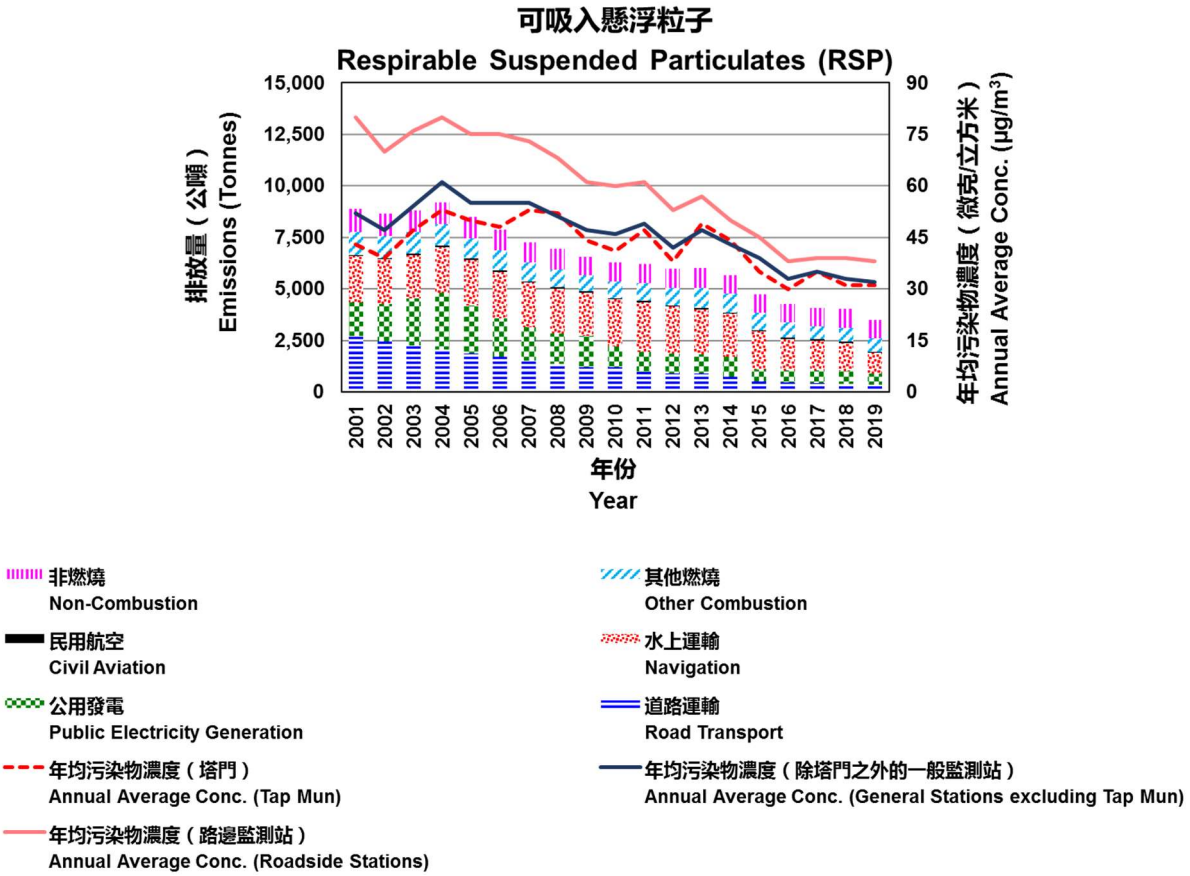
NOx Emissions and Air Quality Trends



4.3. Between 2001 and 2019, NOx emissions decreased by 40% that reduction from road transport played a significant role. Navigation, public electricity generation and road transport sectors were the top three sources of NOx emissions, accounting for 35%, 30% and 16% of total NOx emissions in 2019, respectively.

4.4. The background NOx concentration levels measured at the Tap Mun rural air quality monitoring station over the past years have been very low. Hence the NOx concentrations measured in Hong Kong are mainly due to local emission sources. During the same period, NOx concentration levels measured at the EPD's roadside air quality monitoring stations by and large followed the vehicular NOx emission trend.

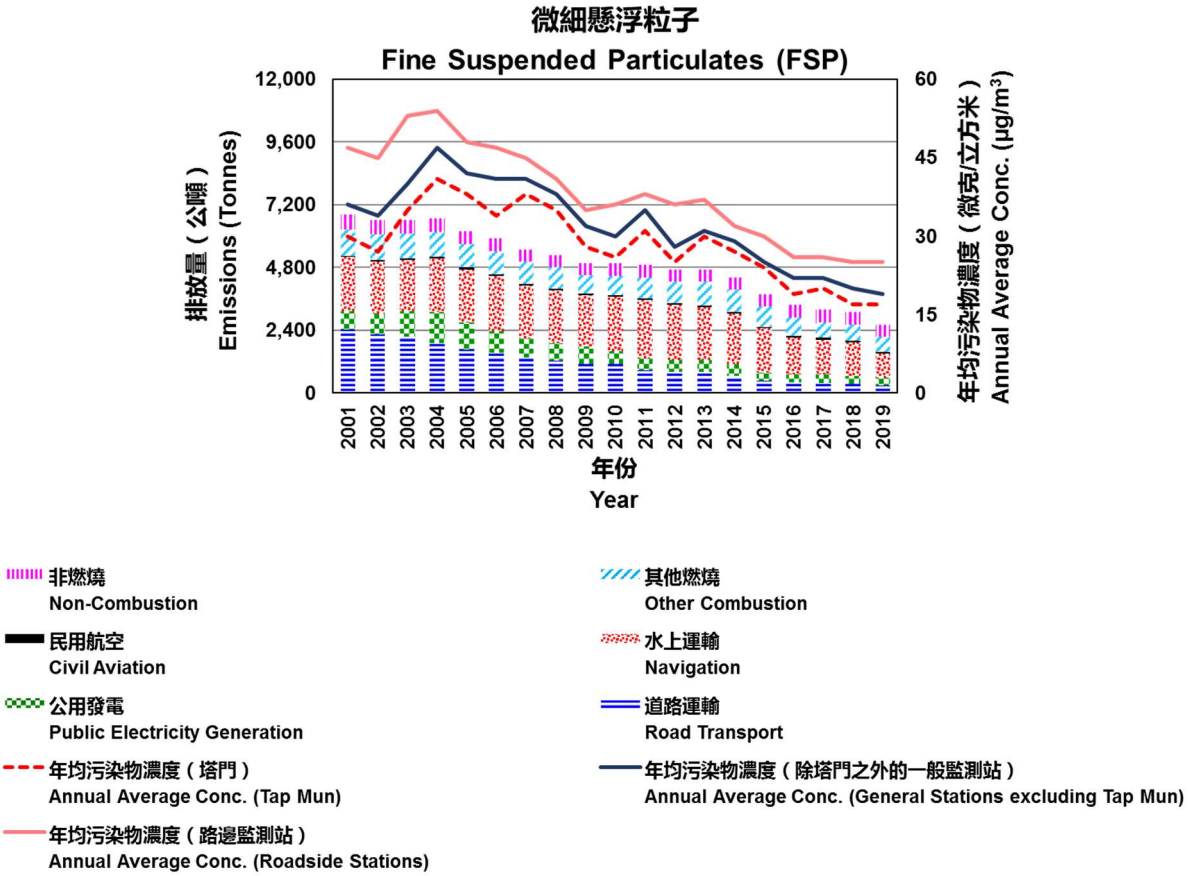
RSP Emissions and Air Quality Trends



4.5. Between 2001 and 2019, RSP emissions decreased by 61% which were mainly caused by the decline in emissions from the road transport, public electricity generation and navigation sectors. Navigation and non-combustion sectors were the top two sources of RSP emissions, accounting for 28% and 26% of total RSP emissions in 2019, respectively.

4.6. The background RSP concentration levels measured at the Tap Mun air quality monitoring station over the years have been close to those measured at the general air quality monitoring stations, reflecting that RSP concentrations in Hong Kong are not only affected by local sources but also subject to strong regional influence. The gap between roadside and general (ambient) RSP concentration levels have been narrowing, indicating that vehicular emissions have been significantly reduced over the years.

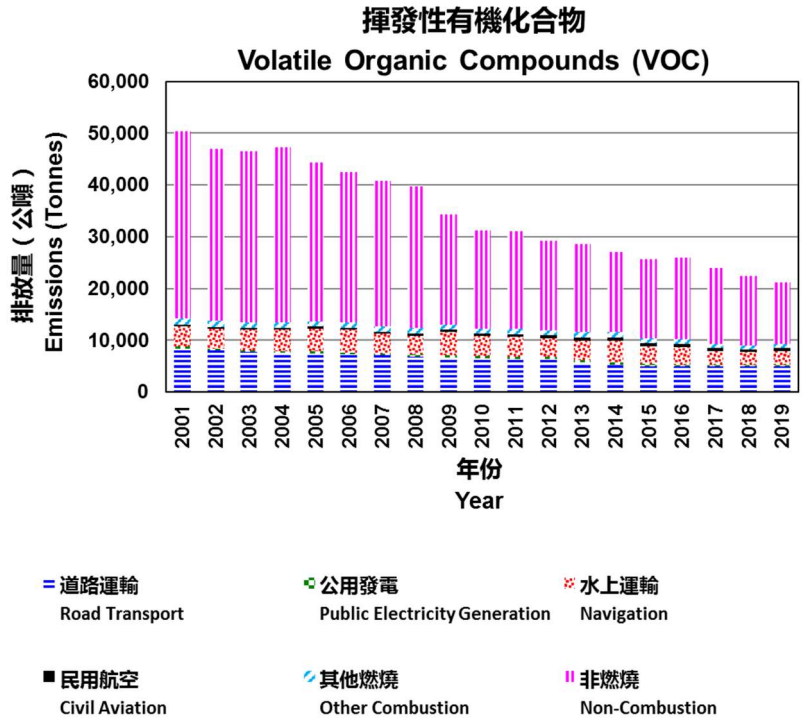
FSP Emissions and Air Quality Trends



4.7. As FSP is a fraction of RSP, they share similar emission sources and emission trends. Between 2001 and 2019, FSP emissions decreased by 62%. Navigation, other combustion and non-combustion sectors were the top three sources of FSP emissions, accounting for 35%, 23% and 18% of total FSP emissions in 2019, respectively.

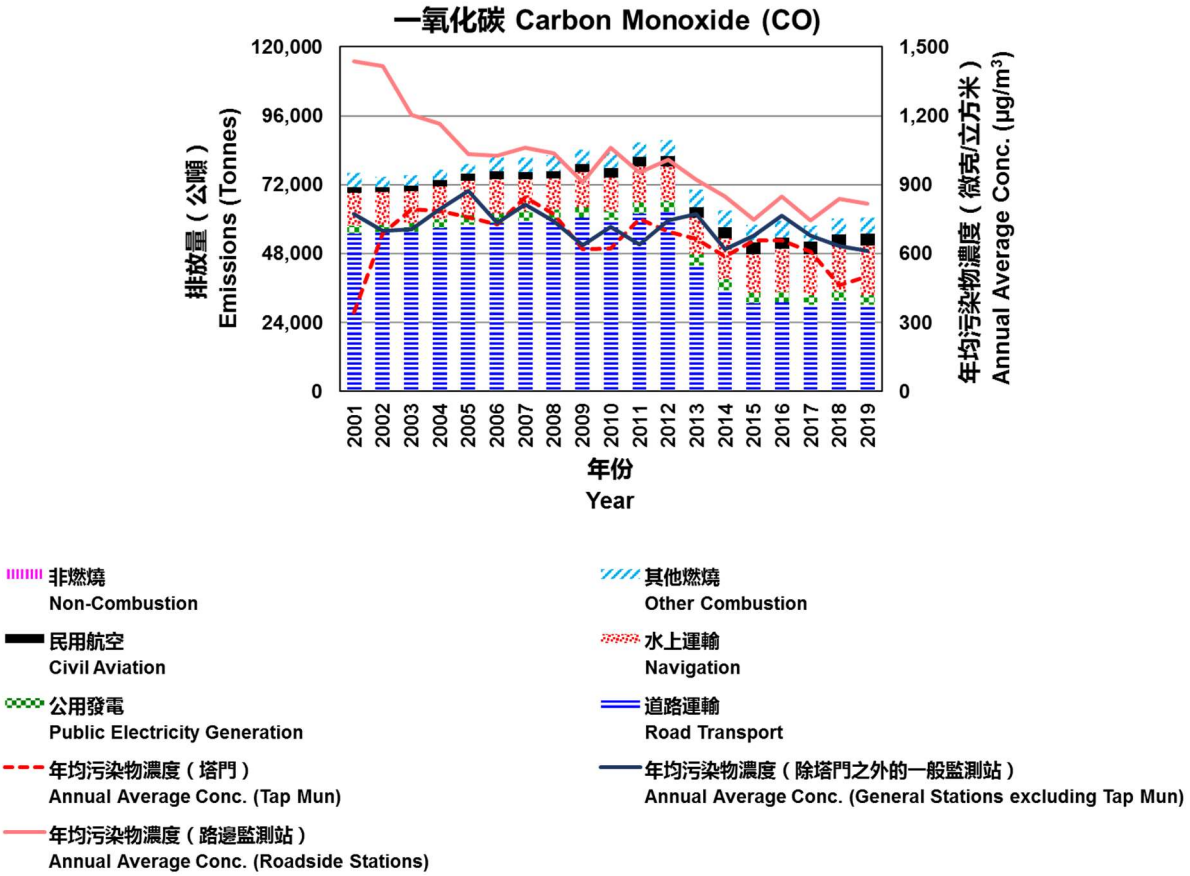
4.8. Similar to RSP, FSP originates from both local and regional emission sources and the roadside FSP emissions have been significantly reduced over the years.

VOC Emissions Trend



4.9. Between 2001 and 2019, VOC emissions decreased by 58% which were mainly caused by the decline in emissions from the non-combustion sector. Non-combustion, road transport and navigation sectors were the top three sources of VOC emissions, accounting for 56%, 23% and 12% of total VOC emissions in 2019, respectively.

CO Emissions and Air Quality Trends

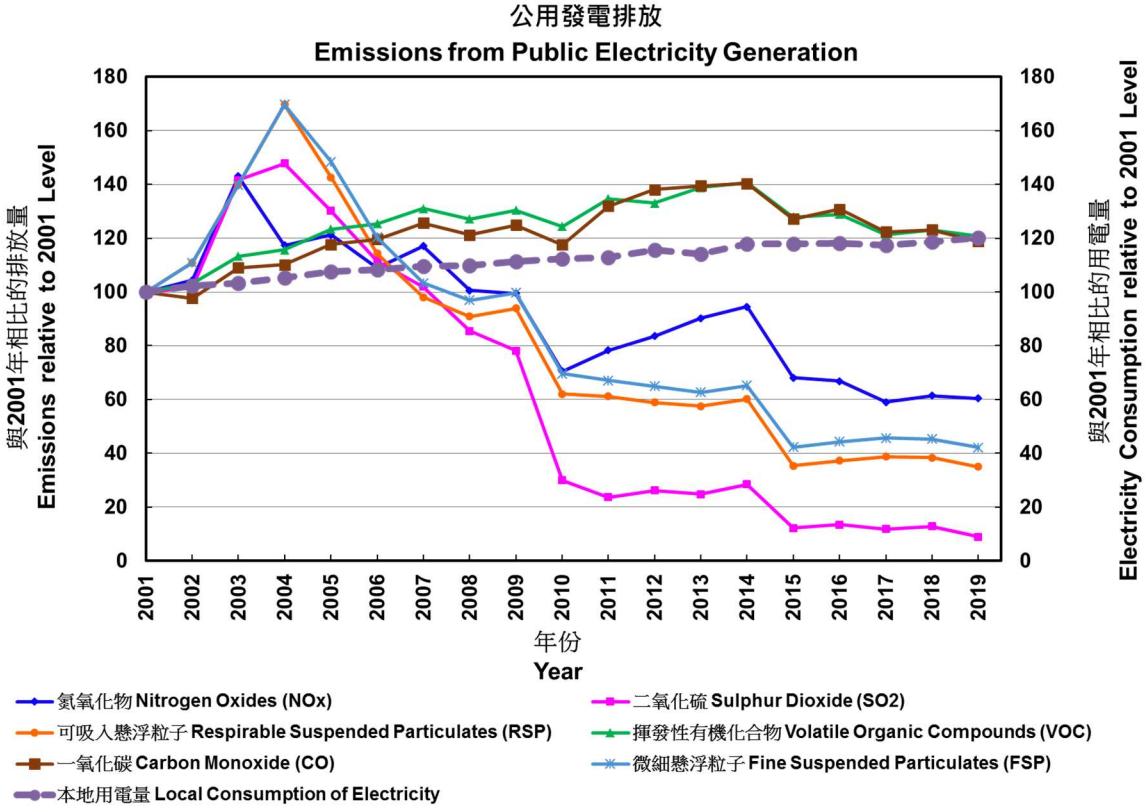


4.10. Between 2001 and 2019, CO emissions decreased by 21% which were mainly caused by the decline in emissions from the road transport sector. Road transport and navigation sectors were two major sources of CO emissions, accounting for 50% and 29% of the total CO emissions in 2019, respectively.

4.11. During the same period, the gap between the CO concentration levels measured at the EPD's roadside and ambient air quality monitoring stations have narrowed, indicating that vehicular CO emissions have been reduced.

5 SECTORAL ANALYSES

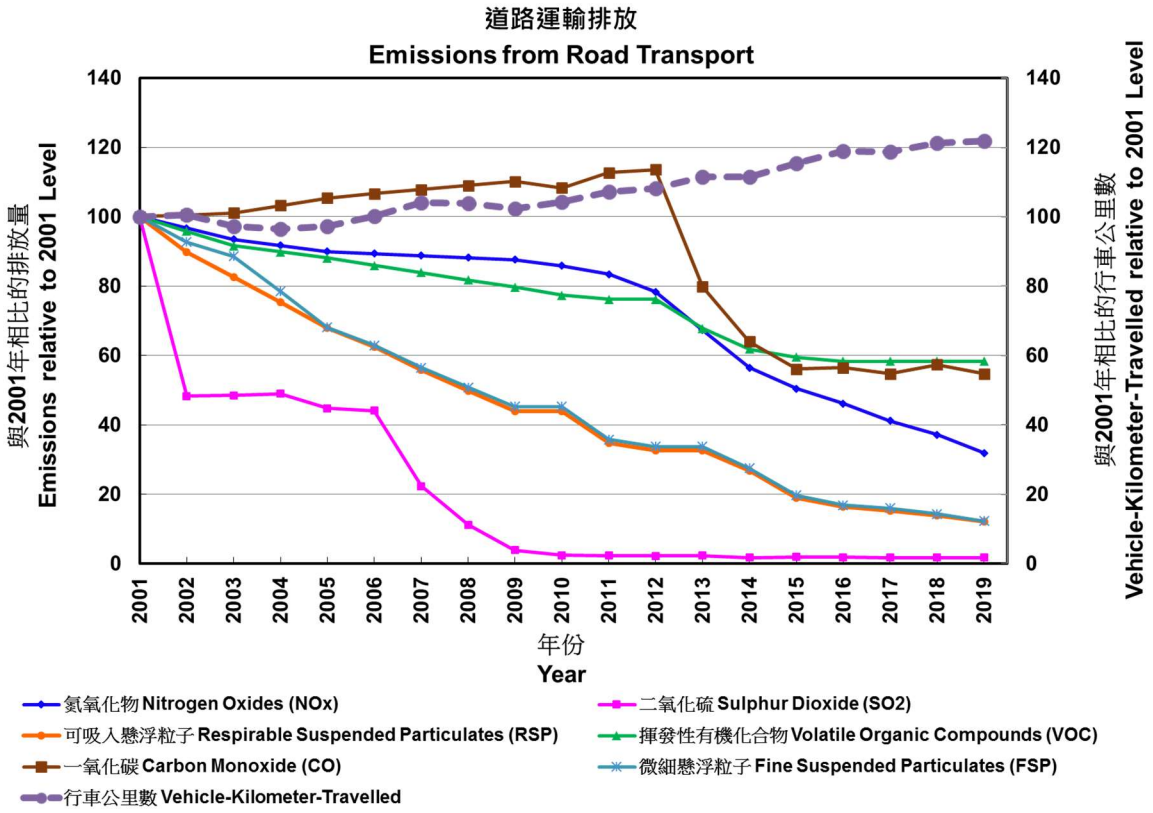
Sectoral analysis for "Public electricity generation"



5.1. Electricity sector had been a major contributor to SO_2, NOx and RSP emissions. Due to government's continuous efforts to control emissions from the power plants, including banning new coal-fired power generation units from 1997 and the imposition of statutory emission caps on power plants set out in the Technical Memorandum (TM) for Allocation of Emission Allowances in respect of Specified Licences, their SO_2 emissions reduced substantially by 91%, NOx emissions by 40% and RSP emissions by 65% from 2001 to 2019, despite an increase in electricity consumption of 20%. In 2019, the emissions of SO_2, NOx and RSP accounted for 63%, 30% and 16% of the total emissions, respectively.

5.2. The government has progressively tightened the emission caps. In 2008, EPD issued the first TM and stipulated emission caps for power plants for 2010 and beyond. So far, nine TMs have been issued and the latest one was issued in June 2021 to further tighten the emission caps for 2026 and onwards. By 2026, the emission caps of SO_2, NOx and RSP would be reduced by 89%, 74% and 71% respectively, as compared with the emission caps for 2010. To meet the emission caps, the power companies have retrofitted existing coal-fired generation units with emission reduction devices such as flue-gas desulphurization and denitrification systems where practicable, and increased the use of low-emission coal and natural gas. The proportion of natural gas in the fuel mix would be increased to around 54% by 2026.

Sectoral analysis for "Road transport"[§]



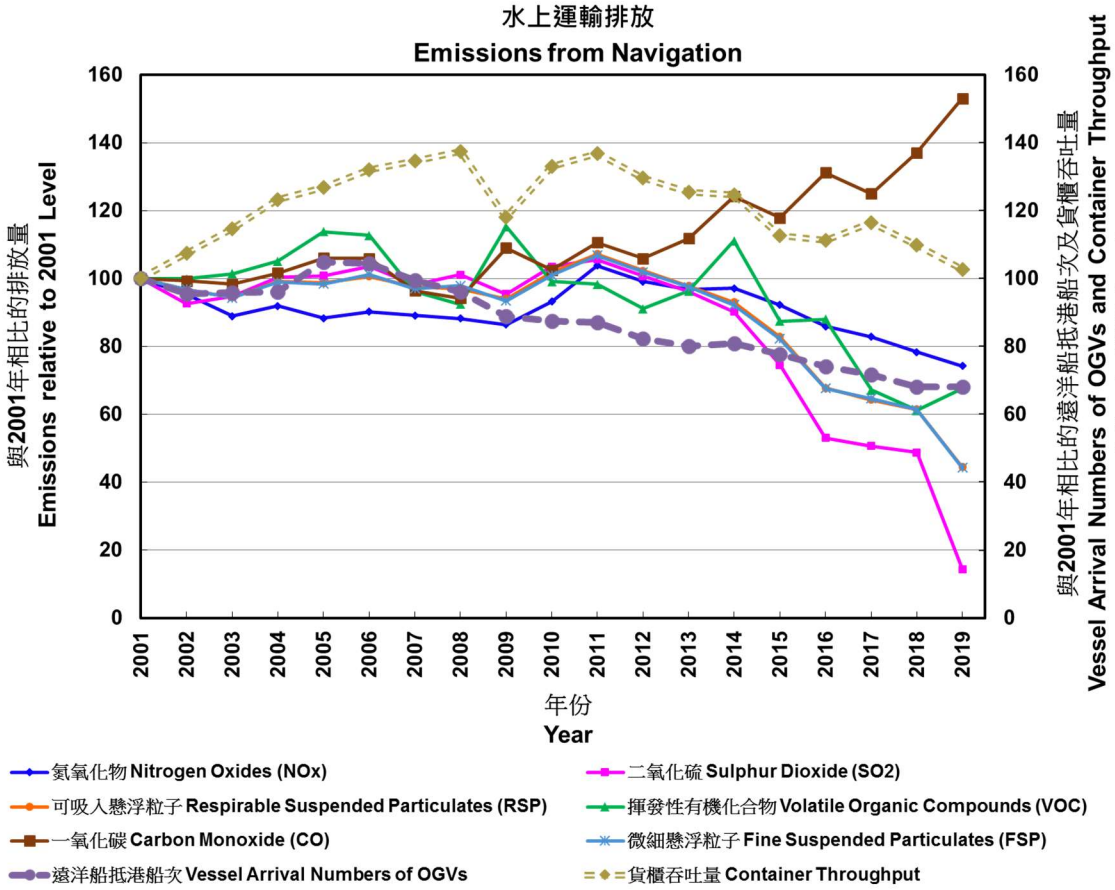
5.3. Road transport was a major emission source of NOx, VOC and CO, accounting for 16%, 23% and 50% of the total emissions in 2019, respectively. Overall, the emissions from road transport decreased by 42% to 98% from 2001 to 2019, despite an increase in vehicle-kilometer-travelled of 22% during the same period.

5.4. The substantial decreases in NOx, RSP, FSP, VOC and CO emissions from 2010 to 2019 could be attributed to a series of vehicle emission control programmes, which included strengthening the control of emissions from petrol and liquefied petroleum gas (LPG) vehicles by deploying roadside remote sensing equipment to identify vehicles emitting excessively; retrofitting Euro II and Euro III franchised buses with selective catalytic reduction (SCR) systems; progressively phasing out about 80,000 pre-Euro IV diesel commercial vehicles (DCVs) and tightening the emission standards for first registered vehicles to Euro VI in phases according to vehicle classes from 1 July 2017. It is anticipated that emissions from this sector will decrease further due to a further programme launched in October 2020 to progressively phase out about 40,000 Euro IV DCVs by the end of 2027; and tightened the vehicle emission standards of first registered motorcycles to Euro 4 from 1 October 2020 and the first registered light buses (design weight of more than 3.5 tonnes) and buses (design weight of not more than 9 tonnes) to Euro VI from 1 March 2021.

5.5. As for SO_2, the vehicle emissions stayed at a very low level in the past few years because of the introduction of Euro V diesel in December 2007, which has the sulphur content capped at 0.001%.

[§] Except SO_2, emissions of major air pollutants for 2001, 2003, 2005, 2009 and 2010-2019 were calculated based on actual data, while interpolated figures were used for the remaining years. Vehicle-Kilometer-Travelled was provided by the Transport Department.

Sectoral analysis for "Navigation"

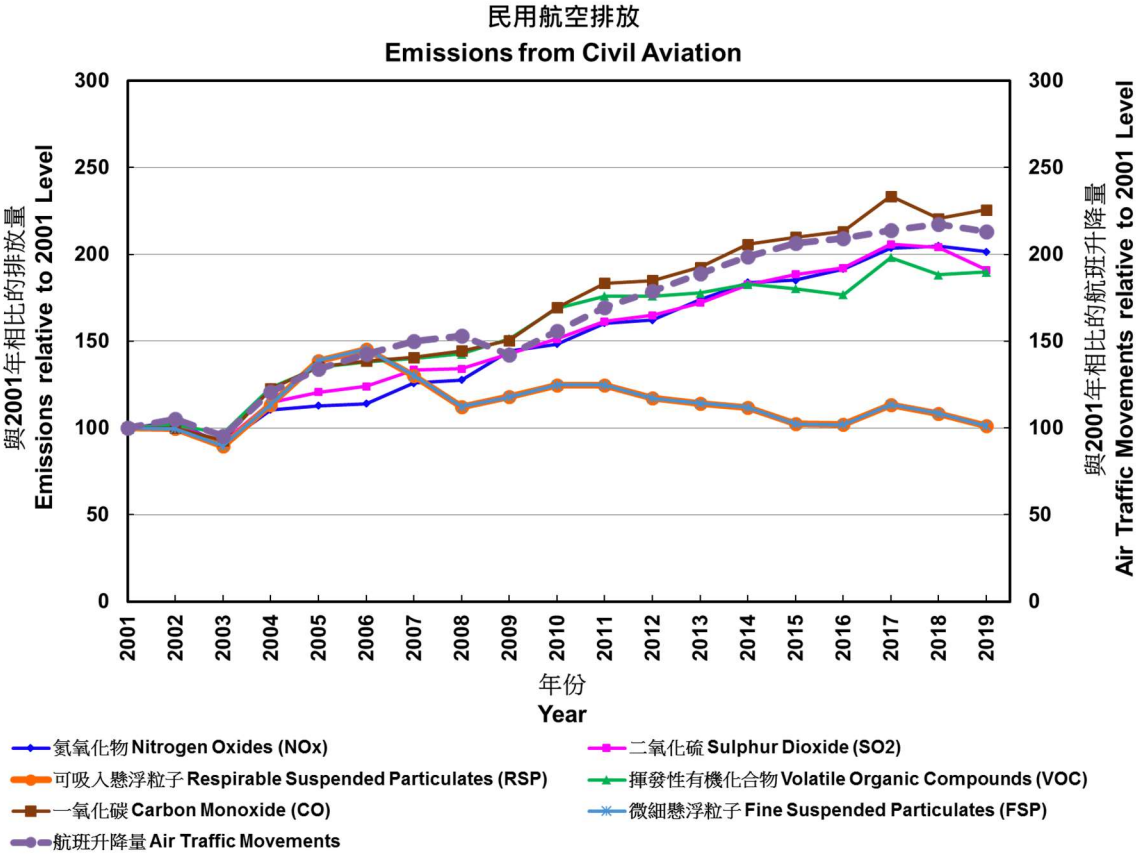


5.6. With the significant reduction in emissions from the electricity and road transport sectors over the past years, marine emissions have now become the major emission source in Hong Kong. Nonetheless, the emissions of SO_2, RSP and FSP from vessels decreased substantially by 55% to 85% from 2013 to 2019. In 2019, the emissions of SO_2, NOx, RSP and FSP from marine vessels accounted for 28%, 35%, 28% and 35% of the total emissions, respectively.

5.7. The reductions of SO_2, RSP and FSP emissions from marine vessels since 2014 were primarily achieved through a range of marine control measures over the years. The sulphur content of locally supplied marine light diesel has been capped at 0.05% since 1 April 2014. Since July 2015, ocean-going vessels (OGVs) were required to switch to use low sulphur fuel (with sulphur content not exceeding 0.5%) while berthing in Hong Kong waters. Starting from 1 January 2019, all vessels, irrespective of whether they are sailing or berthing in Hong Kong waters, are required to use compliant fuel, including low sulphur fuel or liquefied natural gas.

5.8. Among vessels, OGVs were the major emitters. As compared with 2010, the container throughput decreased by 23% in 2019, which also contributed to the reduction in emissions from marine vessels.

Sectoral analysis for "Civil aviation"

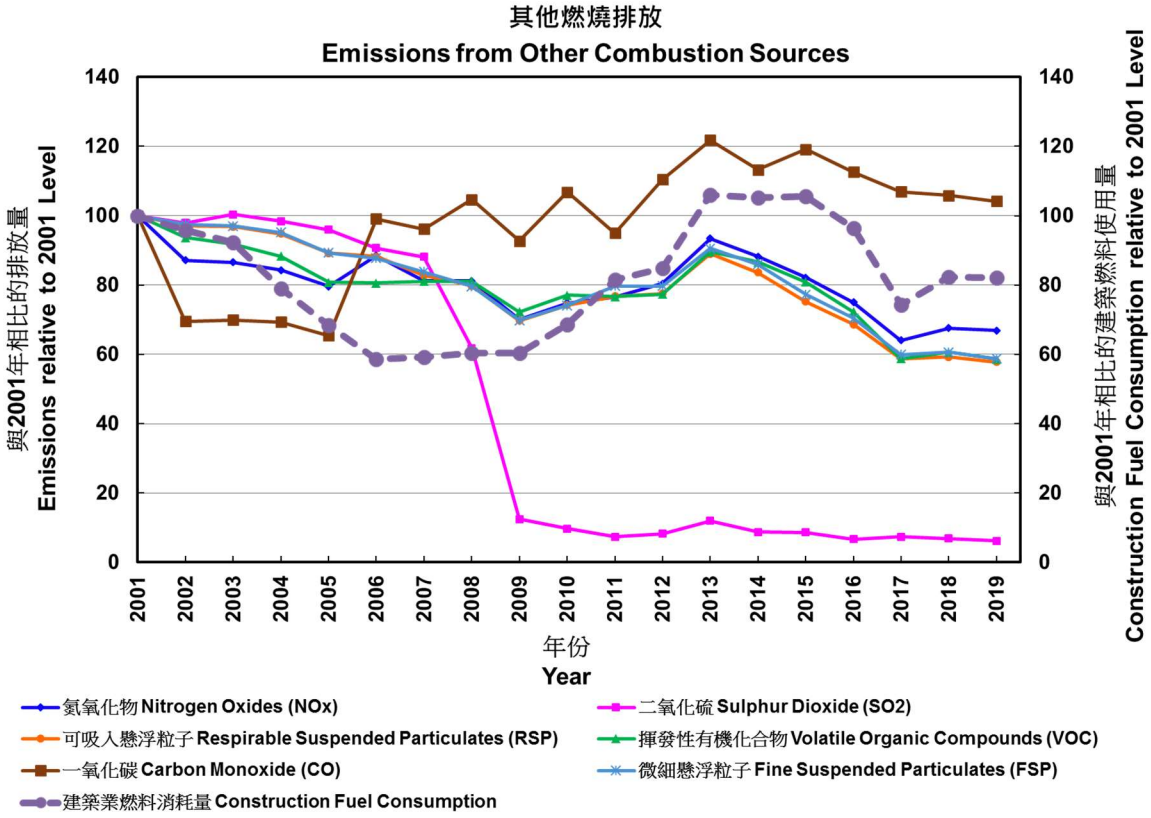


5.9. Emissions from civil aviation accounted for less than 9% of the total local emissions of air pollutants in 2019. From 2001 to 2019, the air traffic movements increased by 113%, leading to an increase of NOx emissions by 101%.

5.10. Since December 2014, the Airport Authority Hong Kong banned the use of onboard fuel combustion auxiliary power generation units in aircraft at frontal stands in the Hong Kong International Airport (HKIA). Such measures reduced the emissions from burning jet fuel.

5.11. The Civil Aviation Department (CAD) has adopted the standards set out at Annex 16 to the Convention on International Civil Aviation, Volume II, Part III, Chapter 2 to certify the engines installed on aircraft using the HKIA in order to reduce their emissions. This document specifies the standards for four types of emissions that an aircraft engine has to meet, including NOx and CO. Taking advantage of the latest development in satellite navigation technologies, CAD has conducted enhancements of the air route system which enabled shortened travelling distances and more aircraft to fly at optimum and fuel-efficient altitudes, thereby achieving fuel savings and a reduction of carbon dioxide emissions.

Sectoral analysis for "Other combustion"

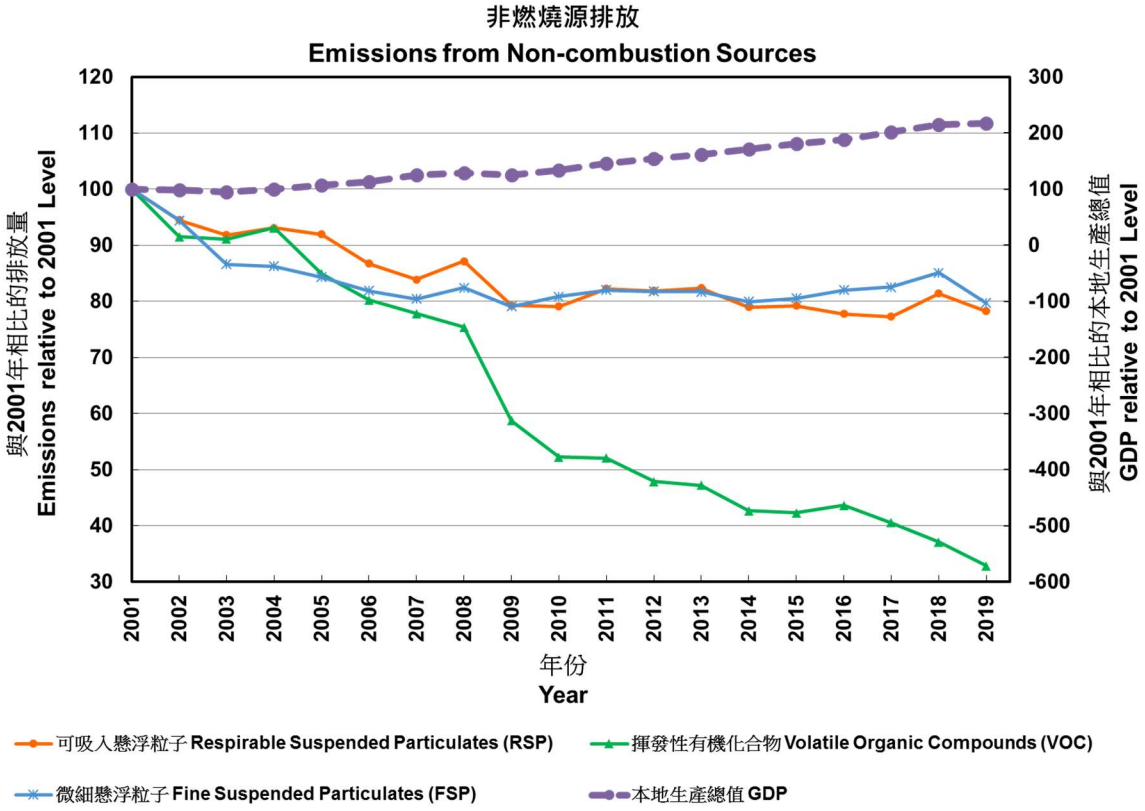


5.12. Other combustion sector is one of the important sources of RSP and FSP emissions, accounting for 18% and 23% of their total emissions in 2019 respectively. Overall, the emissions of various pollutants from other combustion sources decreased by 33% to 94% from 2001 to 2019.

5.13. Major contributing sources in this sector are non-road mobile machinery (NRMMs), especially construction machinery, which accounted for 52%, 54% and 53% of RSP, FSP and NOx emissions from other combustion sources respectively in 2019. The emission trends from other combustion sources from 2010 to 2019 by and large followed the fuel consumption change in construction projects. To reduce the emissions from NRMMs, prescribed emission standards for newly approved NRMMs have been stipulated in the Air Pollution Control (Non-road Mobile Machinery) (Emission) Regulation since 1 June 2015. Starting from 1 January 2019, the emission standards for newly registered non-road vehicles (including goods vehicles, petrol private cars, buses with design weight of more than 9 tonnes and light buses with design weight not exceeding 3.5 tonnes) and non-road diesel private cars were tightened to Euro VI and California LEV III respectively.

5.14. The SO_2 emissions from this sector have been reduced to a very low level since the implementation of the Air Pollution Control (Fuel Restriction) Regulation in October 2008, which tightened the cap on the sulphur content of diesel used in industrial and commercial sectors from 0.5% to 0.005%. Since January 2009, Euro V diesel (with sulphur content not exceeding 0.001%) has been imported for industrial and construction use.

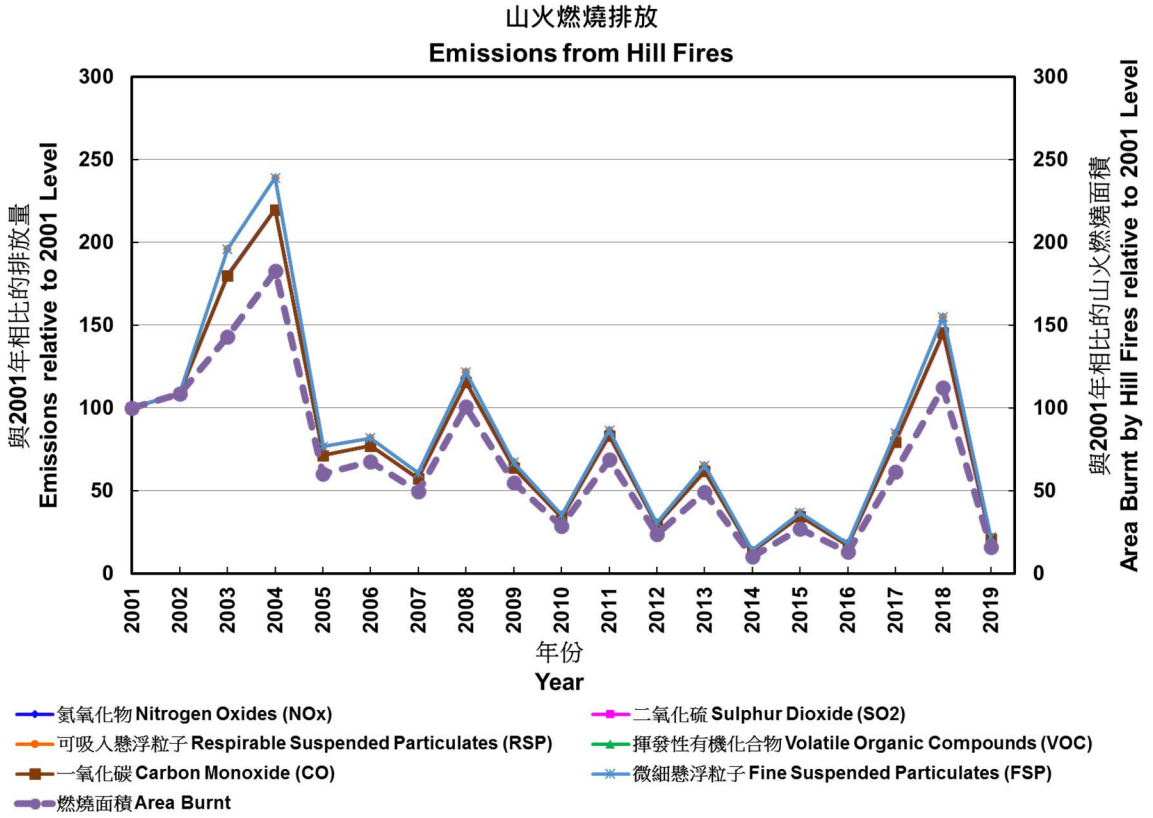
Sectoral analysis for "Non-combustion sources"



5.15. Non-combustion sources sector contributes considerably to local VOC emissions, accounting for 56% in 2019, whereas its contributions to local RSP and FSP emissions in 2019 were 26% and 18%, respectively. Overall, the emissions of the sector decreased by 20% to 67% from 2001 to 2019, despite the growth of Gross Domestic Product by 117%.

5.16. The use of paints, printing inks and associated solvents, consumer products, adhesive and sealants continued to be the major contributing sources, accounting for 85% of non-combustion sources VOC emissions in 2019. As compared with 2006, the VOC emissions from non-combustion sources decreased by 59% in 2019 as a result of the introduction of the VOC control programme under the Air Pollution Control (Volatile Organic Compounds) Regulation since 2007. The Regulation prohibits the import and local manufacture of regulated products with VOC contents exceeding the prescribed limits and controls emissions from lithographic heatset web printing machines. The regulated products include 6 broad categories of consumer products, 51 types of architectural paints, 7 types of printing inks, 14 types of vehicle refinishing paints, 36 types of vessel and pleasure craft paints and 47 types of adhesives and sealants. The Regulation was extended to cover fountain solutions and printing machine cleaning agents in 2018.

6 EMISSIONS FROM HILL FIRES



6.1. Emissions from hill fires mainly contribute to RSP and FSP emissions, accounting for 11% and 12% of total local RSP and FSP emissions in 2019, respectively.

6.2. The Agriculture, Fisheries and Conservation Department attaches great importance to the management of country parks and the publicity and education on the prevention of hill fires. With the collaboration of the public, the number of hill fires and their emissions have generally been reduced over the past 2 decades, except a rebound in 2018.

Annex 1 – Breakdown of Emission Inventory by Source Category from 2018 to 2019

Pollutant	Source Category	Emissions (Tonnes)	
		2018	**2019**
SO_2	Public Electricity Generation	7,630	5,340
	Road Transport	40	40
	Navigation	8,030	2,360
	Civil Aviation	560	520
	Other Combustion	190	170
	Non-combustion	N/A	N/A
	Total (without Hill Fires)	16,440	8,430
	Hill Fires	50	10
	Total (with Hill Fires)	16,490	8,440
NOx	Public Electricity Generation	23,550	23,160
	Road Transport	14,800	12,700
	Navigation	29,050	27,550
	Civil Aviation	6,410	6,310
	Other Combustion	7,980	7,900
	Non-combustion	N/A	N/A
	Total (without Hill Fires)	81,800	77,620
	Hill Fires	250	40
	Total (with Hill Fires)	82,050	77,660
RSP	Public Electricity Generation	630	570
	Road Transport	380	330
	Navigation	1,370	990
	Civil Aviation	60	60
	Other Combustion	650	640
	Non-combustion	930	900
	Total (without Hill Fires)	4,020	3,480
	Hill Fires	3,100	450
	Total (with Hill Fires)	7,120	3,930
FSP	Public Electricity Generation	320	300
	Road Transport	350	300
	Navigation	1,270	920
	Civil Aviation	60	60

Pollutant	Source Category	Emissions (Tonnes)	
		2018	2019
	Other Combustion	610	590
	Non-combustion	500	470
	Total (without Hill Fires)	3,100	2,630
	Hill Fires	2,540	360
	Total (with Hill Fires)	5,640	2,990
VOC	Public Electricity Generation	410	400
	Road Transport	4,900	4,900
	Navigation	2,360	2,610
	Civil Aviation	590	590
	Other Combustion	750	720
	Non-combustion	13,460	11,910
	Total (without Hill Fires)	22,460	21,130
	Hill Fires	670	100
	Total (with Hill Fires)	23,130	21,230
CO	Public Electricity Generation	3,470	3,350
	Road Transport	31,600	30,100
	Navigation	15,550	17,360
	Civil Aviation	4,160	4,260
	Other Combustion	5,450	5,360
	Non-combustion	N/A	N/A
	Total (without Hill Fires)	60,230	60,440
	Hill Fires	7,240	1,040
	Total (with Hill Fires)	67,470	61,470

Notes:
- All figures, except those for Road Transport, are rounded to the nearest ten. For Road Transport, the figures smaller than 1,000 are rounded to the nearest ten and the remaining figures are rounded to the nearest hundred.
- "N/A" denotes not applicable.
- There may be slight discrepancies between the sums of individual items and the total emissions shown in the table because of rounding.

Annex 2 – Summary of Updates to the Emission Inventory

1. To provide more accurate emission data to facilitate the management of air quality, the EPD continuously updates the methodologies and emission factors to compile emission inventories. By making reference to the practices of international environmental agencies, we will recalculate historical emission inventories whenever emission estimation methods or emission factors are updated, and therefore the current data from 2001 to 2018 may be different from the estimates provided in the past.

2. Recalculation of historical emission inventories is widely adopted by environmental agencies such as European Environmental Agency of the European Community, California Air Resources Board (CARB), United Nations Environment Programme (UNEP), Intergovernmental Panel on Climate Change (IPCC), etc. when methods are changed or refined, when new sources categories are included in the inventory or when assumptions used in the estimates are revised.

3. Since the publication of the emission inventory on EPD's website in 2000, EPD have made a number of updates to the emission compilation and recalculated the historical emissions.

4. Major updates to the emission inventories in recent years are highlighted below.

i. EPD commissioned a comprehensive study on the marine emission inventory in 2008, which was completed in 2012. The study collected extensive local vessel activity data and reviewed the latest emission compilation methodologies of advanced places such as the Port of Los Angeles of the USA. The study concluded that these latest emission compilation methodologies can provide more realistic estimates of marine emissions. Based on the study findings, we updated the previous emission inventories for marine vessels. The updated emissions from vessels were higher than the previous ones.

ii. EPD have been conducting emission measurements for on-road vehicles by means of remote sensing equipment and advanced portable emission measurement systems (PEMS). The measurements have provided a more robust basis for us to estimate vehicle emissions. They have also found that vehicles with inadequate maintenance, e.g. LPG vehicles with worn-out catalytic converters, could emit considerably above their normal levels. We made use of the findings to update our vehicle emission estimation model and compile the vehicle emission inventory.

iii. Since the implementation of the Air Pollution Control (Volatile Organic Compounds) Regulation in April 2007, we have used the sales report data submitted by importers under the Regulation to compile VOC emissions of regulated products including six broad categories of consumer products (air fresheners, hairsprays, multi-purpose lubricants, floor wax strippers, insecticides and insect repellents), printing inks and architectural paints. In October 2009, we amended the Regulation to further regulate the VOC contents of vehicle refinishing paints, marine paints (vessels and pleasure craft paints), adhesive and sealants and started to compile the VOC emissions from these paints based on their sales report data. Emissions from cleansing solvents during the application of paints have also been estimated. The Regulation was extended to cover fountain solutions and printing machine cleaning agents in 2018. To compile VOC emissions for the non-regulated products, we also made reference to EPD's studies on printing industry, VOC-containing products and solvent usage for coatings, and survey data for marine paints to assess emissions from VOC-containing products.

5. Updates to the emission inventories over the past 5 years are summarized in the table below. Based on the latest updates, we have recalculated historical emission inventories from 2001 to 2018. Comparisons between the previous and recalculated inventories are shown in **Annex 3**.

Update Date	**Emission Inventory Revised**	**Revisions and Updates**
January 2016	2001-2014	• Emissions from asphalt production plants were estimated. • Emissions from Sludge Treatment Facility (STF) were estimated. • Emissions from landfill gas flaring were estimated. • Emissions from hill fires were estimated. • Other Fuel Combustion sector was renamed as Other Combustion sector to better reflect the nature of the sources covered. • Radar data from CAD and chock-on chock-off data from AAHK were obtained to refine the emission inventory for Civil Aviation sector. • Used updated version of EMFAC-HK (version 3.1.1) for estimating the emissions from Road Transport sector.
January 2017	2001-2015	• A mixing height of 3000 ft (915 m), as recommended by International Civil Aviation Organisation, was adopted to compile the emissions for Civil Aviation sector. • Used updated version of EMFAC-HK (version 3.3) for estimating the emissions from Road Transport sector.
January 2018	2001-2016	• Adopted updated version of EMFAC-HK (version 3.4) for estimating emissions from Road Transport sector. • Adopted the sulphur content of marine fuels obtained from Port Facilities and Light Dues Incentive Scheme for estimating emissions from ocean going vessels. • Adopted Aviation Environmental Design Tool (AEDT) version 2c for estimating emissions from Civil Aviation sector. • Adopted the emission factors from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016 for estimating emissions from non-road mobile machineries. • Emissions from cigarette smoking were estimated and included in Other Combustion sector.
January 2019	2001-2017	• Adopted updated version of EMFAC-HK (version 4.1) for estimating emissions from Road Transport sector. • Adopted the sulphur content of marine fuels obtained from Port Facilities and Light Dues Incentive Scheme for estimating emissions from ocean going vessels. • Updated power rating and age profiles of non-road mobile machines based on the registered information in the Non-Road Mobile Machinery database. • Updated the VOC emissions of unregulated VOC-containing consumer products based on the latest VOC study.

Update Date	Emission Inventory Revised	Revisions and Updates
February 2020	2001-2018	• Adopted updated version of EMFAC-HK (version 4.2) for estimating emissions from Road Transport sector. • Updated the emissions from local vessels equipped with outboard engines (OBE) based on the latest OBE study.
June 2021	2001-2019	• Adopted updated version of EMFAC-HK (version 4.3) for estimating emissions from Road Transport sector. • Adopted Aviation Environmental Design Tool (AEDT) version 3c for estimating emissions from Civil Aviation sector.

Annex 3 – Comparison between the Previous and Recalculated Inventories (without Hill Fires) from 2001 to 2018

Table A3-1. Changes in SO_2 emission inventories from 2001 to 2018

Year	SO_2 (Tonnes)		
	Previous*	Recalculated*	% Changes
2001	80,750	80,790	0%
2002	79,290	79,340	0%
2003	103,430	103,480	0%
2004	108,030	108,080	0%
2005	97,480	97,530	0%
2006	86,770	86,820	0%
2007	79,710	79,760	0%
2008	69,470	69,520	0%
2009	62,800	62,840	0%
2010	35,520	35,560	0%
2011	32,030	32,110	0%
2012	32,740	32,810	0%
2013	31,290	31,360	0%
2014	31,670	32,510	3%
2015	19,540	20,360	4%
2016	17,210	17,510	2%
2017	16,170	16,140	0%
2018	16,410	16,440	0%

* Figures are rounded to the nearest ten.

Figure A3-1 SO_2 emissions trend from 2001 to 2018

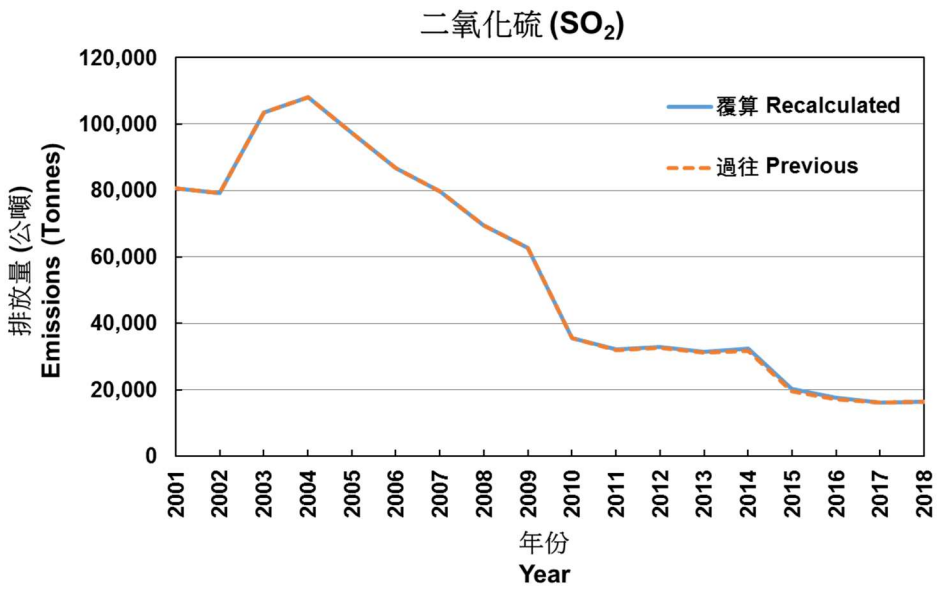


Table A3-2. Changes in NOx emission inventories from 2001 to 2018

Year	NOx (Tonnes)		
	Previous*	Recalculated*	% Changes
2001	130,260	130,170	0%
2002	127,500	127,420	0%
2003	138,170	138,070	0%
2004	129,060	128,970	0%
2005	128,050	127,930	0%
2006	124,930	124,830	0%
2007	126,950	126,800	0%
2008	120,140	119,970	0%
2009	117,930	117,860	0%
2010	108,770	109,290	0%
2011	115,680	115,790	0%
2012	114,330	114,560	0%
2013	113,580	113,780	0%
2014	110,500	110,920	0%
2015	95,430	95,920	1%
2016	91,320	90,760	-1%
2017	85,120	83,710	-2%
2018	83,580	81,800	-2%

* Figures are rounded to the nearest ten.

Figure A3-2 NOx emission trend from 2001 to 2018

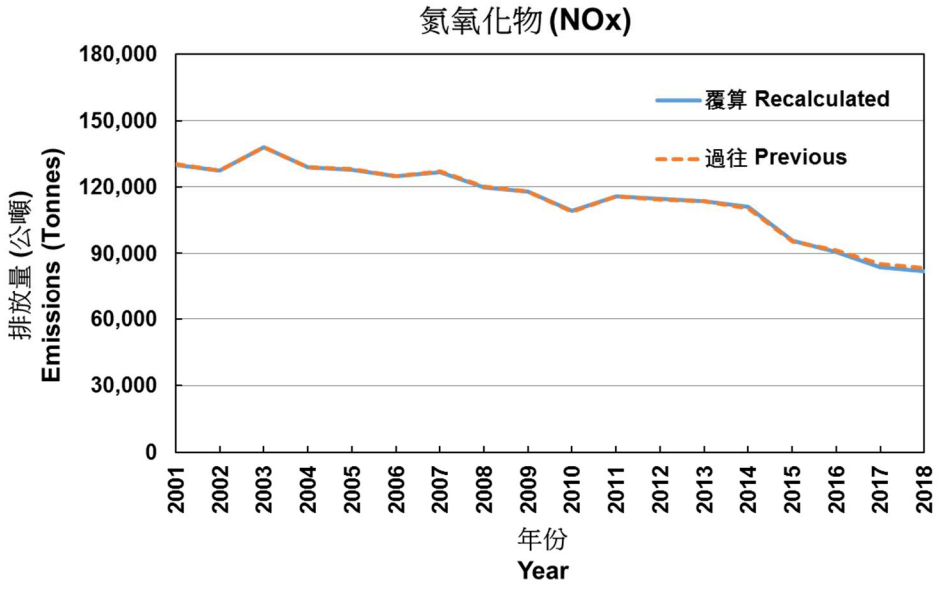


Table A3-3. Changes in RSP emission inventories from 2001 to 2018

Year	RSP (Tonnes)		
	Previous*	Recalculated*	% Changes
2001	8,890	8,890	0%
2002	8,620	8,630	0%
2003	8,800	8,810	0%
2004	9,200	9,200	0%
2005	8,480	8,490	0%
2006	7,850	7,860	0%
2007	7,240	7,240	0%
2008	6,950	6,940	0%
2009	6,570	6,570	0%
2010	6,270	6,270	0%
2011	6,180	6,200	0%
2012	5,970	5,990	0%
2013	5,970	6,000	0%
2014	5,660	5,670	0%
2015	4,700	4,740	1%
2016	4,300	4,270	-1%
2017	4,080	4,080	0%
2018	4,020	4,020	0%

* Figures are rounded to the nearest ten.

Figure A3-3 RSP emission trend from 2001 to 2018

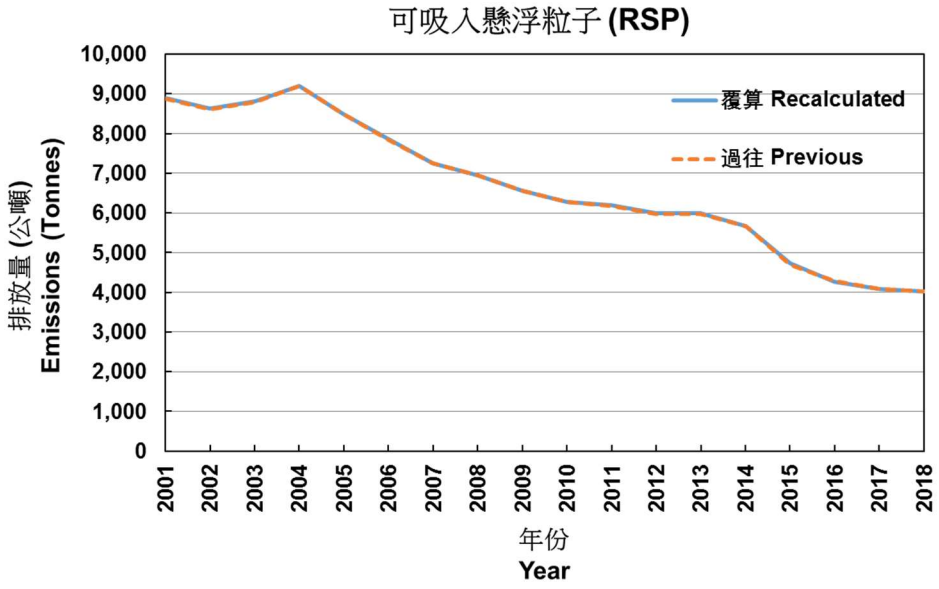


Table A3-4. Changes in FSP emission inventories from 2001 to 2018

Year	FSP (Tonnes)		
	Previous*	Recalculated*	% Changes
2001	6,840	6,850	0%
2002	6,620	6,620	0%
2003	6,610	6,620	0%
2004	6,660	6,670	0%
2005	6,190	6,200	0%
2006	5,900	5,910	0%
2007	5,490	5,490	0%
2008	5,290	5,290	0%
2009	4,960	4,960	0%
2010	4,960	4,970	0%
2011	4,880	4,900	0%
2012	4,710	4,730	0%
2013	4,700	4,730	1%
2014	4,410	4,430	0%
2015	3,740	3,780	1%
2016	3,380	3,360	-1%
2017	3,180	3,200	0%
2018	3,120	3,100	0%

* Figures are rounded to the nearest ten.

Figure A3-4 FSP emission trend from 2001 to 2018

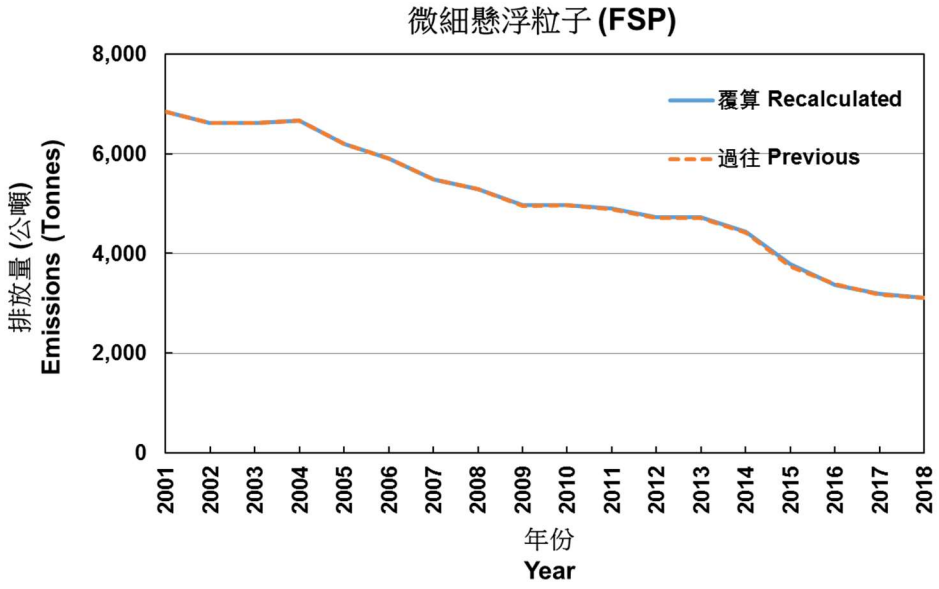


Table A3-5. Changes in VOC emission inventories from 2001 to 2018

Year	VOC (Tonnes)		
	Previous*	Recalculated*	% Changes
2001	49,970	50,380	1%
2002	46,540	46,900	1%
2003	46,130	46,440	1%
2004	46,960	47,220	1%
2005	44,180	44,400	0%
2006	42,310	42,500	0%
2007	40,680	40,840	0%
2008	39,490	39,630	0%
2009	34,130	34,250	0%
2010	31,130	31,160	0%
2011	30,780	31,020	1%
2012	29,070	29,210	0%
2013	28,410	28,650	1%
2014	26,920	27,060	1%
2015	25,520	25,690	1%
2016	26,000	25,990	0%
2017	23,910	23,930	0%
2018	22,330	22,460	1%

* Figures are rounded to the nearest ten.

Figure A3-5 VOC emission trend from 2001 to 2018

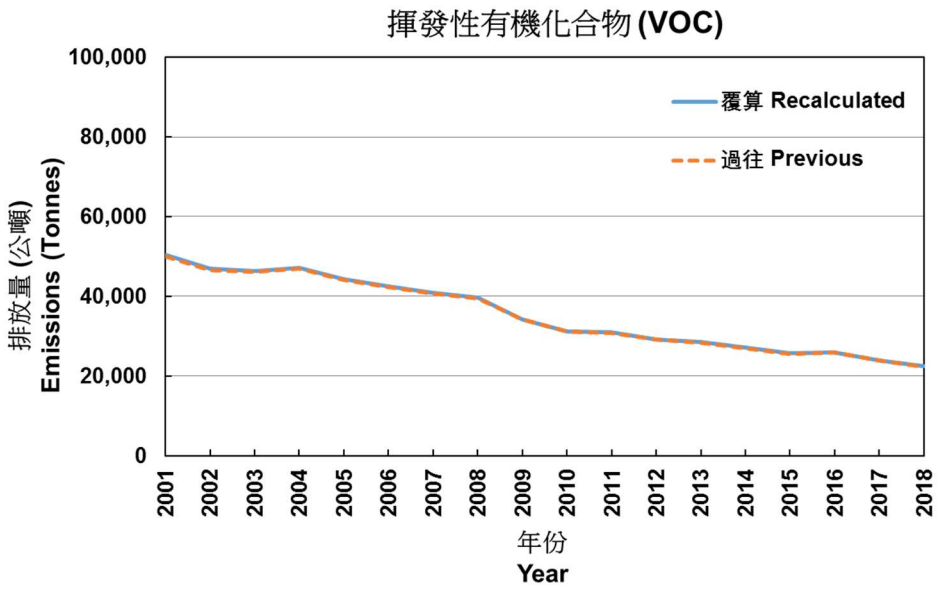


Table A3-6. Changes in CO emission inventories from 2001 to 2018

Year	CO (Tonnes)		
	Previous*	Recalculated*	% Changes
2001	75,190	76,200	1%
2002	73,830	74,790	1%
2003	74,280	75,180	1%
2004	76,520	77,320	1%
2005	78,540	79,260	1%
2006	81,070	81,750	1%
2007	80,770	81,390	1%
2008	81,600	82,170	1%
2009	83,550	84,100	1%
2010	83,580	83,230	0%
2011	85,960	86,610	1%
2012	86,930	87,580	1%
2013	69,890	70,410	1%
2014	62,550	62,960	1%
2015	57,530	57,960	1%
2016	59,200	59,490	0%
2017	57,590	57,640	0%
2018	57,100	60,230	5%

* Figures are rounded to the nearest ten.

Figure A3-6 CO emission trend from 2001 to 2018