2016 Hong Kong Air Pollutant Emission Inventory Report

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Environmental Protection Department

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The Government of the Hong Kong Special Administrative Region

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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 2016 Hong Kong Emission Inventory. It covers:

(i) the emission inventory by source category in 2016 (Chapter 3);
(ii) the emission trends from 1997 to 2016 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 the 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. Starting from 2016, emissions from cigarette smoking have been included under this category to improve the coverage of the emission inventory.

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 can produce a large amount 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 2016 EMISSION INVENTORY

3.1. The table below shows a breakdown of air pollutant emissions by source category in 2016, while Annex 1 shows the changes in emissions between 2015 and 2016.

Breakdown of 2016 Emission Inventory

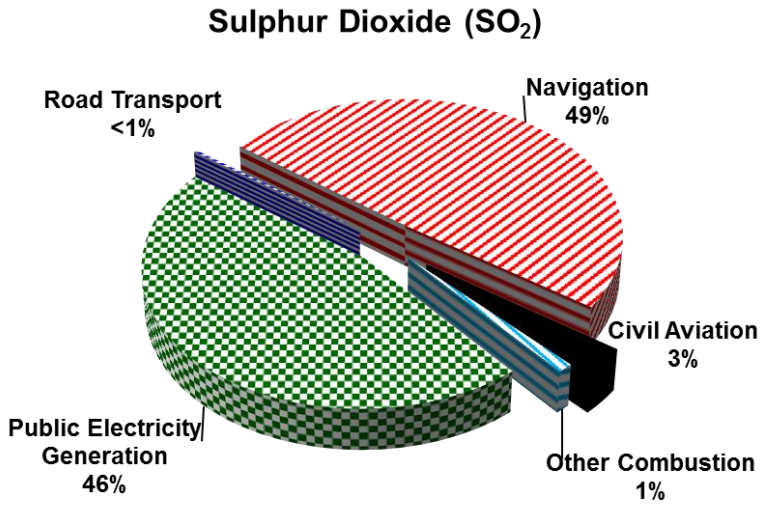
Pollution Sources	Emissions (Tonnes)					
	SO_2	**NOx**	**RSP**	**FSP**	**VOC**	**CO**
Public Electricity Generation	8,020	25,620	610	310	430	3,690
Road Transport	40	16,200	420	380	4,700	31,500
Navigation	8,540	32,900	1,640	1,480	4,510	13,940
Civil Aviation	530	6,060	50	50	530	3,960
Other Combustion	180	8,850	740	690	870	5,520
Non-combustion	N/A	N/A	890	480	15,200	N/A
Total Emissions (without Hill Fires)	17,310	89,640	4,350	3,380	26,240	58,600
Hill Fires	10	30	370	300	80	850
Total Emissions (with Hill Fires)	17,310	89,670	4,720	3,680	26,310	59,450

Note: - All figures are rounded to the nearest ten.
- "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.

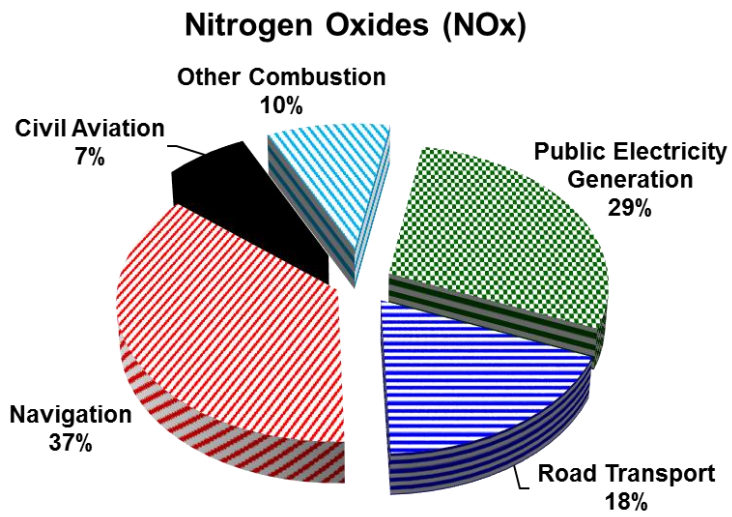
3.2. A summary of updates to the emission inventories is appended at Annex 2.

3.3. The following pie charts show the percentage share of emissions by source category (excluding hill fires) for each pollutant in 2016.

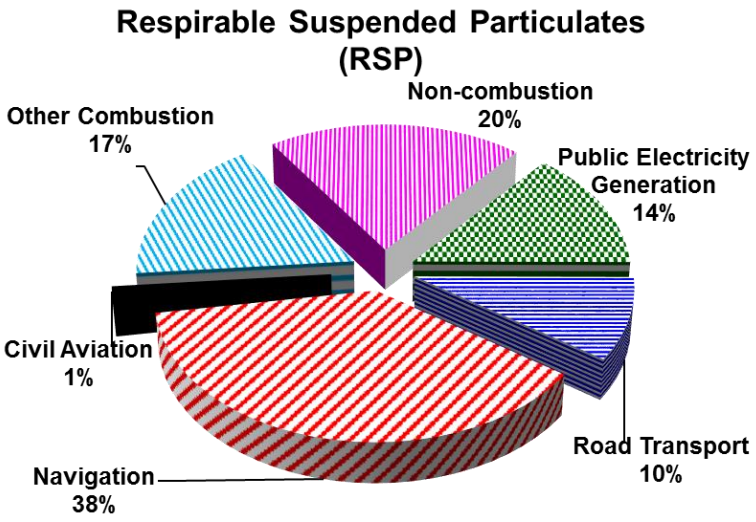
Total SO_2 emission = 17,310 Tonnes



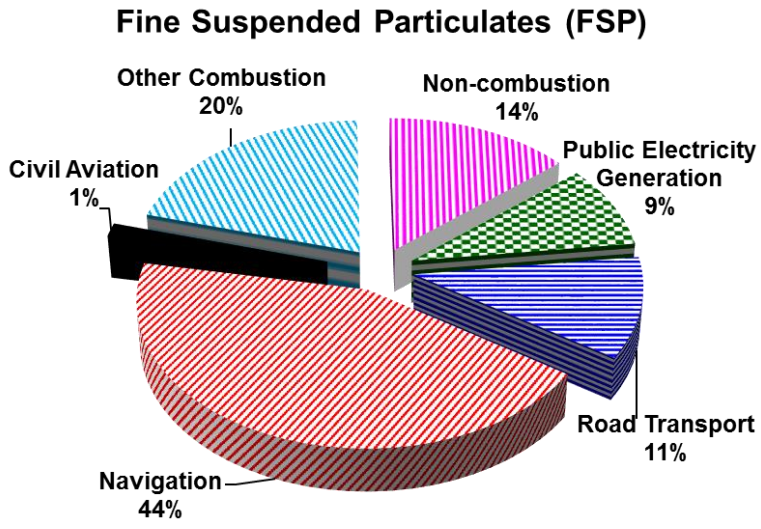
Total NOx emission = 89,640 Tonnes



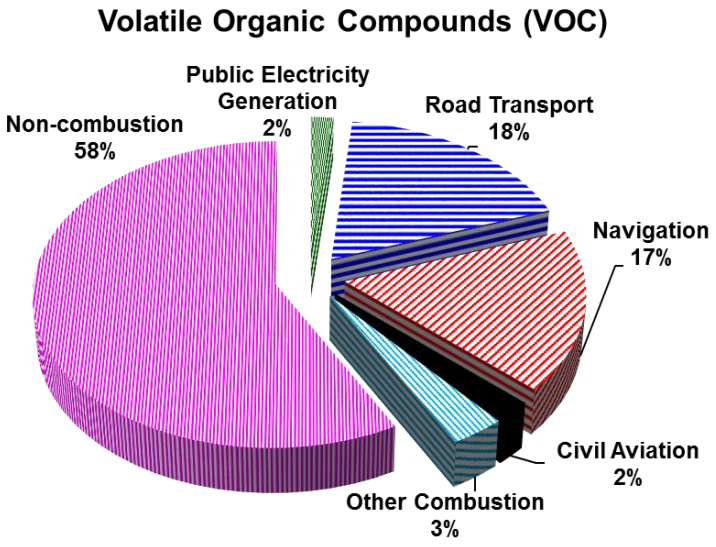
Total RSP emission = 4,350 Tonnes



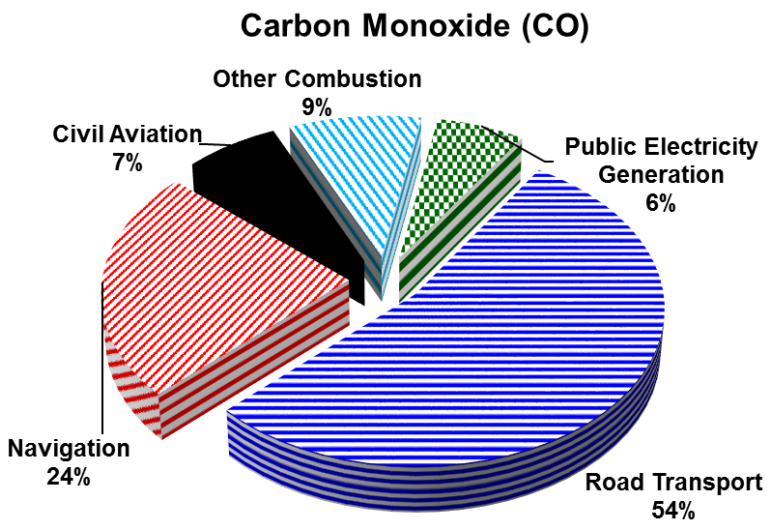
Total FSP emission = 3,380 Tonnes



Total VOC emission = 26,240 Tonnes

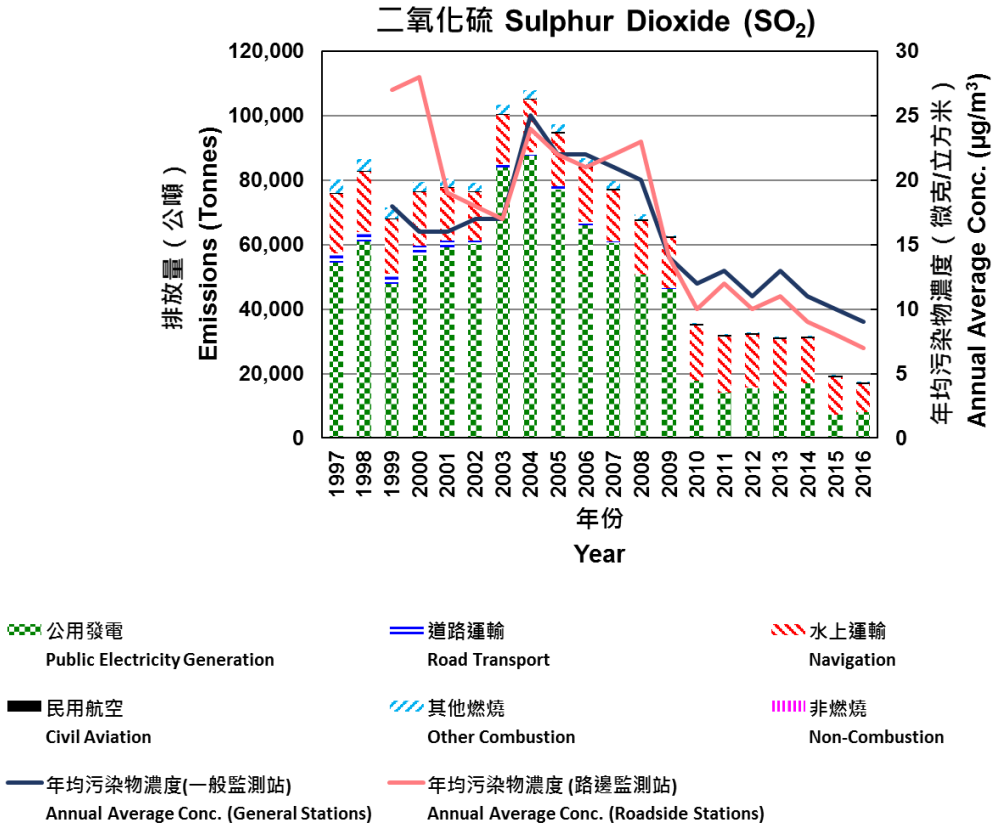


Total CO emission = 58,600 Tonnes



4 EMISSION TRENDS FROM 1997 TO 2016

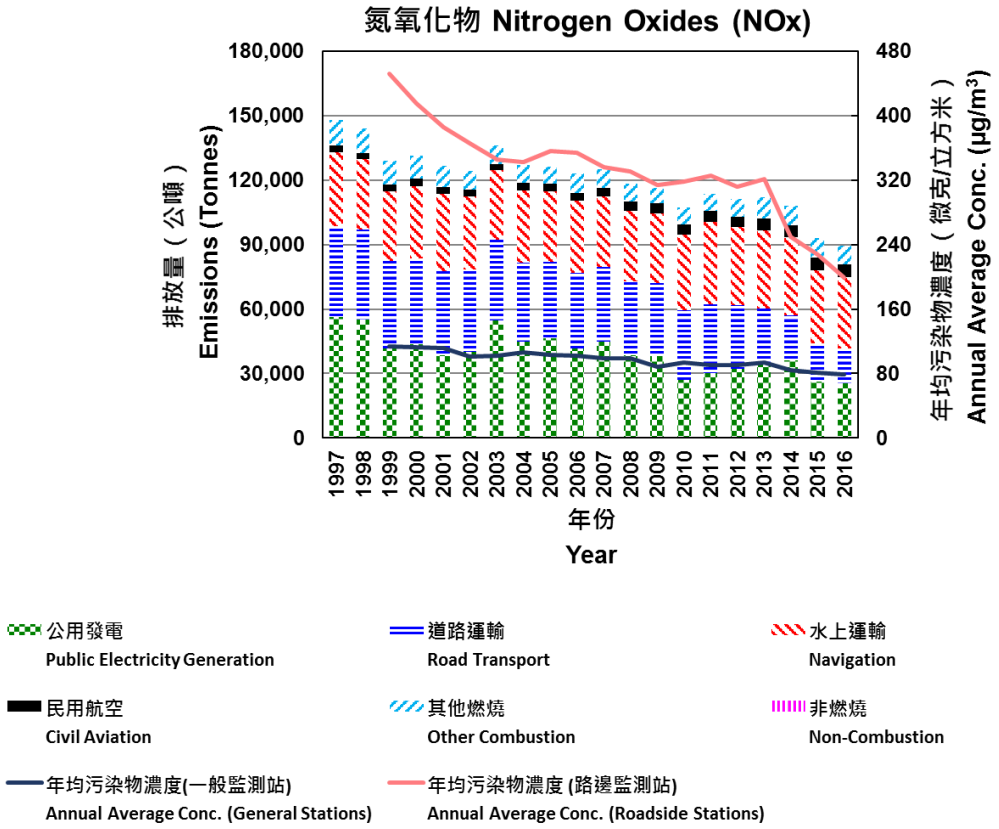
SO_2 Emissions and Air Quality Trends



4.1. Between 1997 and 2016, SO_2 emissions decreased by 78%, which was mainly caused by a decline in emissions from the public electricity generation sector. Navigation and public electricity generation sectors were the top two sources of SO_2 emissions, accounting for 49% and 46% of total SO_2 emissions in 2016, respectively.

4.2. During the same period, SO_2 levels measured at the EPD's general air quality monitoring stations by and large followed the SO_2 emission trend, indicating that the ambient SO_2 mainly originates from local emission sources, in addition to other factors such as meteorological conditions.

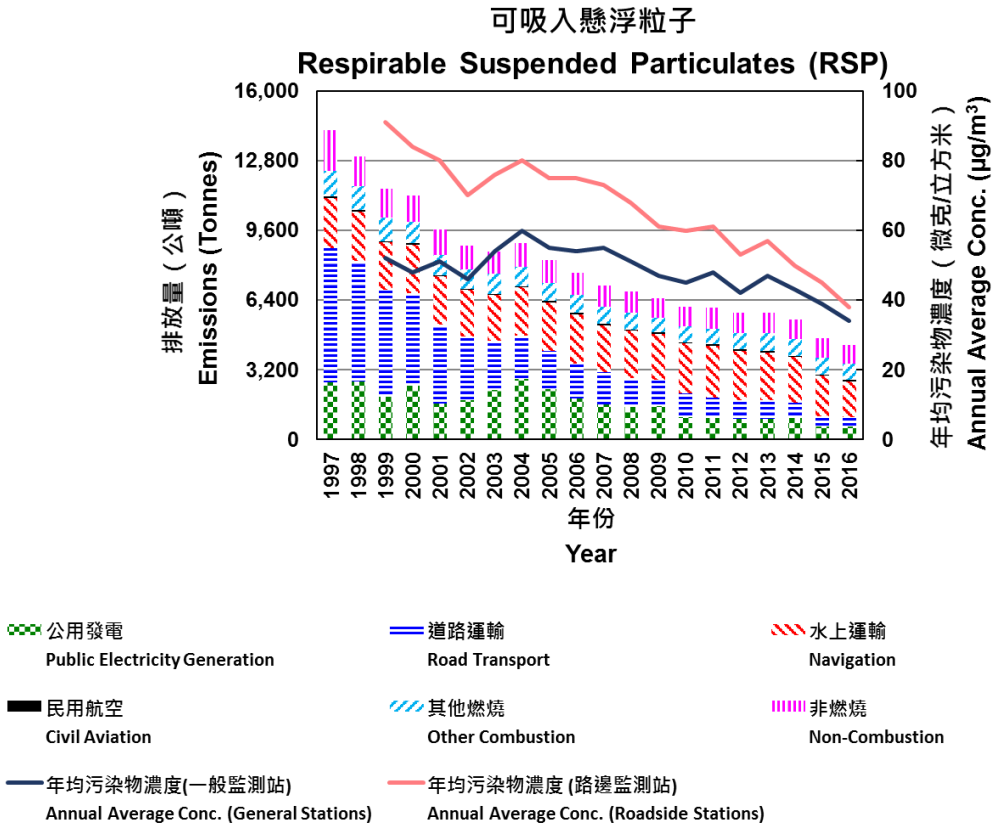
NOx Emissions and Air Quality Trends



4.3. Between 1997 and 2016, NOx emissions decreased by 39%. Navigation, public electricity generation and road transport sectors were the top three sources of NOx emissions, accounting for 37%, 29% and 18% of total NOx emissions in 2016, respectively.

4.4. During the same period, NOx levels measured at the EPD's roadside air quality monitoring stations by and large followed the NOx emission trend, indicating that the roadside NOx mainly originates from local emission sources.

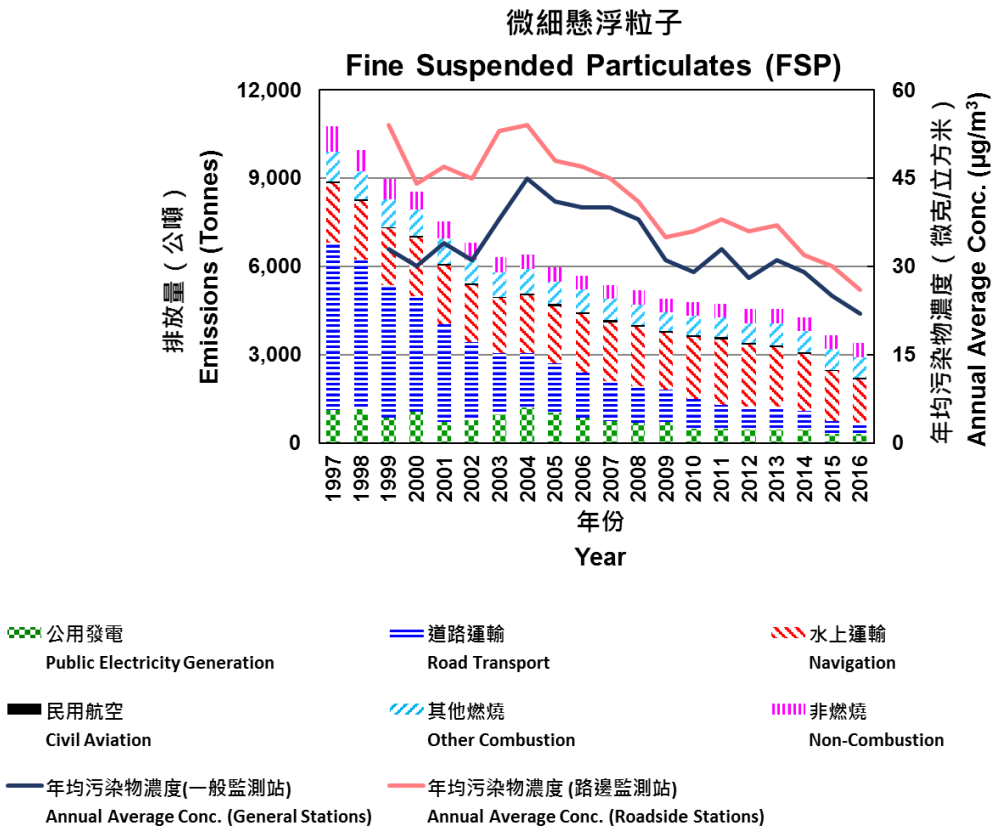
RSP Emissions and Air Quality Trends



4.5. Between 1997 and 2016, RSP emissions decreased by 69% which was mainly caused by a decline in emissions from the road transport and public electricity generation sectors. Navigation, non-combustion and other combustion sectors were the top three sources of RSP emissions, accounting for 38%, 20% and 17% of total RSP emissions in 2016, respectively.

4.6. During the same period, RSP levels measured at the EPD's general air quality monitoring stations did not follow closely with the RSP emission trend. It indicated that the ambient RSP originates from both local and regional emission sources.

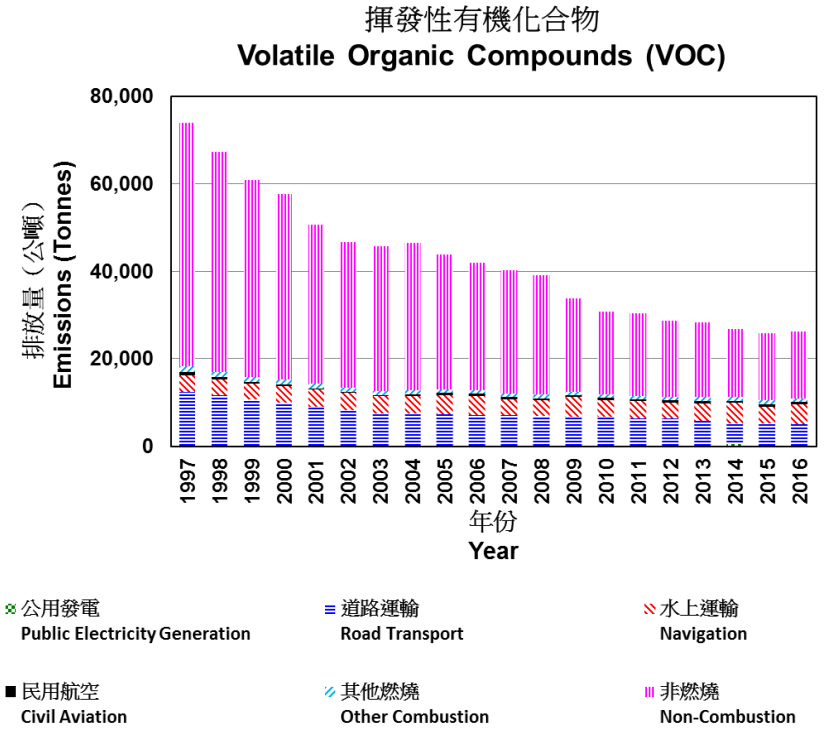
FSP Emissions and Air Quality Trends



4.7. As FSP is a fraction of RSP, they share similar emission sources and emission trends. Between 1997 and 2016, FSP emissions decreased by 69%. Navigation, other combustion and non-combustion sectors were the top three sources of FSP emissions, accounting for 44%, 20% and 14% of total FSP emissions in 2016, respectively.

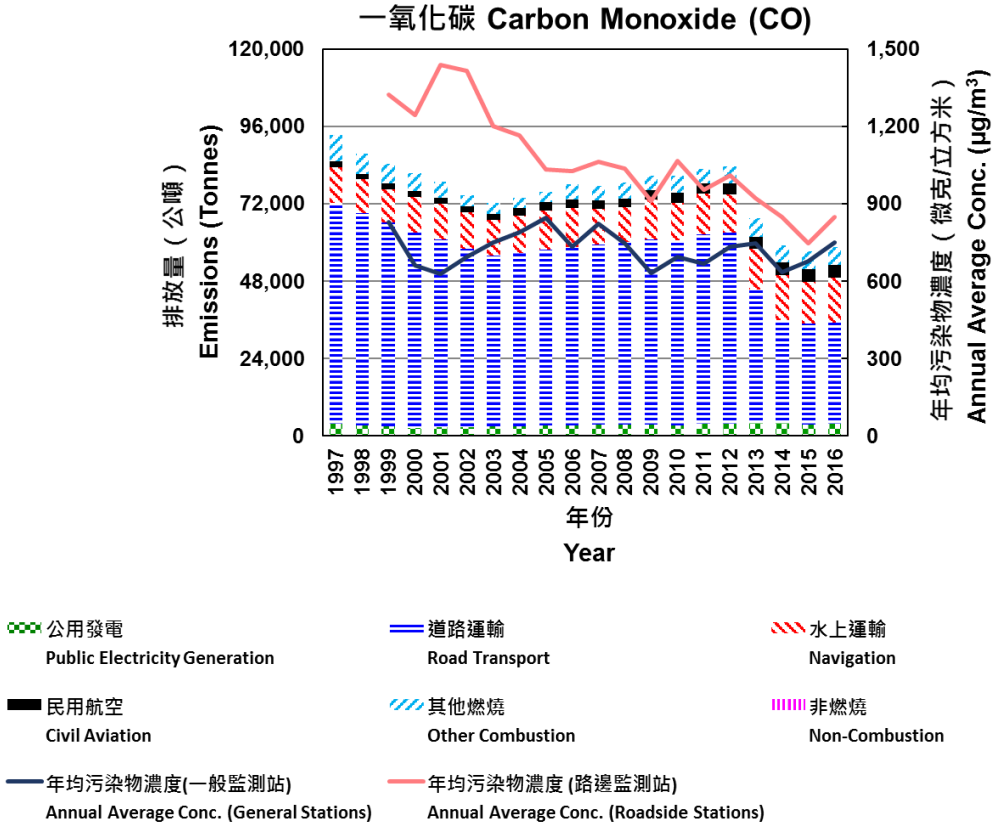
4.8. Similar to RSP, FSP levels measured at the EPD's general air quality monitoring stations did not follow closely with the FSP emission trend, indicating that the ambient FSP originates from both local and regional emission sources.

VOC Emissions Trend



4.9. Between 1997 and 2016, VOC emissions decreased by 65% which were mainly caused by the decline in emissions from non-combustion and road transport sectors. Non-combustion, road transport, and navigation sectors were the top three sources of VOC emissions, accounting for 58%, 18% and 17% of total VOC emissions in 2016, respectively.

CO Emissions and Air Quality Trends

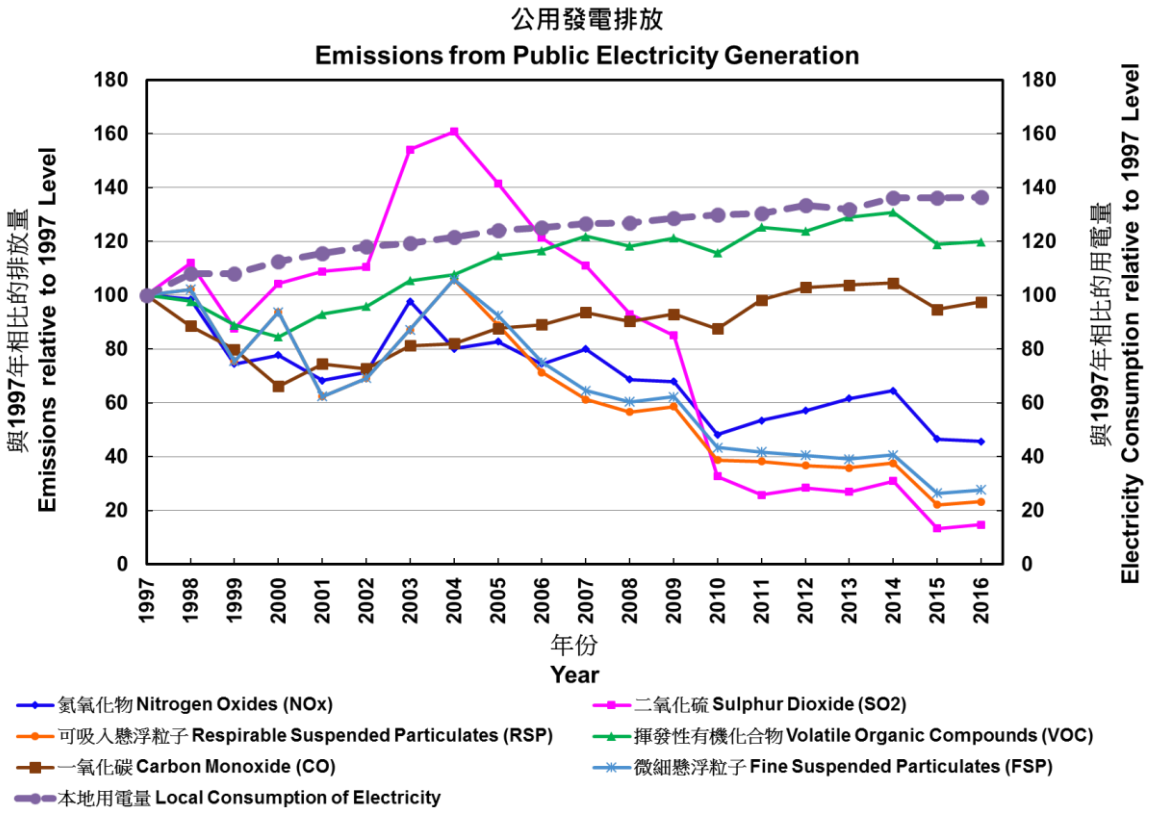


4.10. Between 1997 and 2016, CO emissions decreased by 37% which was mainly caused by a decline in emissions from the road transport sector. Road transport and navigation sectors were two major sources of CO emissions, accounting for 54% and 24% of the total CO emissions in 2016, respectively.

4.11. During the same period, CO levels measured at the EPD's ambient and roadside air quality monitoring stations were very low and did not follow closely with the CO emission trend, indicating that CO could originate from both local and regional sources.

5 SECTORAL ANALYSES

Sectoral analysis for "Public electricity generation"

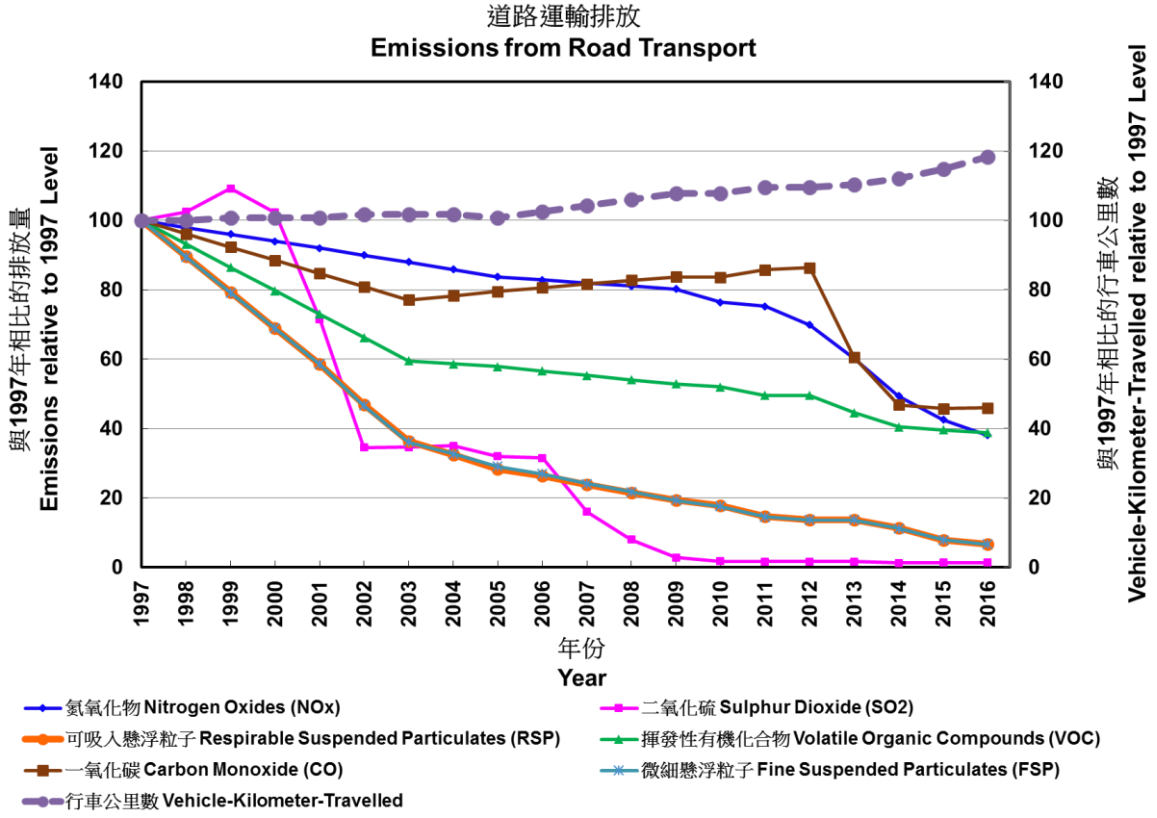


5.1. Electricity sector had been a major contributor to SO_2, NOx and RSP emissions. Subsequent to the imposition of statutory emission caps on power plants, its SO_2 emissions reduced substantially by 85%, NOx emissions by 54% and RSP emissions by 77% from 1997 to 2016, despite an increase in electricity consumption of 37%. In 2016, the emissions of SO_2, NOx and RSP accounted for 46%, 29% and 14% of the total emissions, respectively.

5.2. The emissions of SO_2, NOx and RSP from power sector continue to show a decreasing trend from 2010 to 2016, as power companies increased the use of natural gas for electricity generation in order to meet the emission caps set out in the Technical Memorandum (TM). The proportion of natural gas in the fuel mix would be increased to around 50% by 2020.

5.3. The EPD has progressively tightened the emission caps since 2005. In 2008, we stipulated the stringent emission caps for 2010 and beyond through the first TM for power plants. The seventh TM was issued in 2017 to further tighten the emissions of air pollutants from 2022 onwards. By 2022, the emission caps of SO_2, NOx and RSP would be reduced by 79%, 59% and 61% respectively, as compared to the emission caps for 2010.

Sectoral analysis for "Road transport"

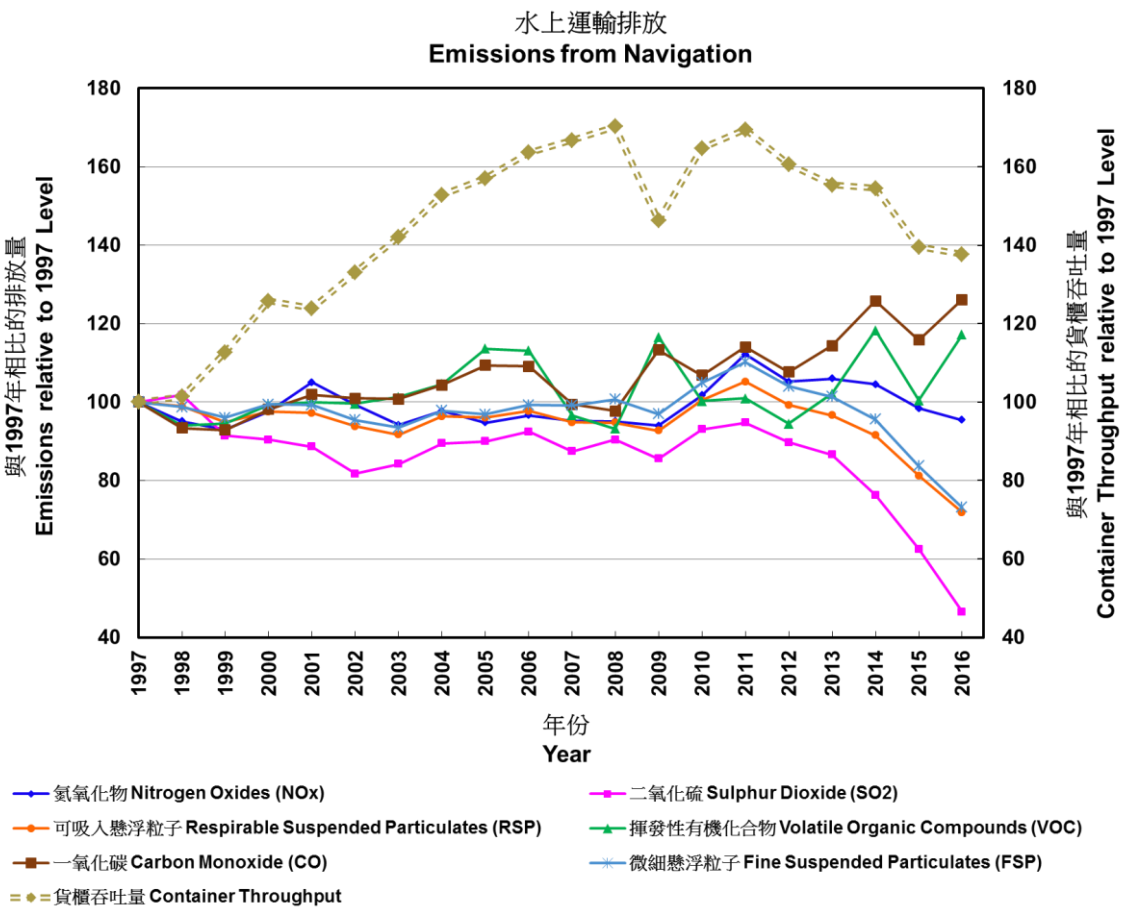


5.4. Road transport was a major emission source of NOx, VOC and CO, accounting for 18%, 18% and 54% of the total emissions in 2016, respectively. Overall, the emissions from road transport decreased by 54% to 99% from 1997 to 2016, despite an increase in vehicle-kilometer-travelled of 18% during the same period.

5.5. The substantial decreases in NOx, RSP, FSP, VOC and CO emissions from 2010 to 2016 could be attributed to a series of vehicle emission control programmes, which included the tightening of vehicle emission standards from Euro IV to Euro V in 2012; providing a one-off subsidy to vehicle owners for the replacement of the catalytic convertors and oxygen sensors of petrol/liquefied petroleum gas (LPG) taxis and light buses; strengthening the emissions control for petrol and LPG vehicles by deploying roadside remote sensing equipment to detect excessive emissions from petrol and LPG vehicles; retrofitting Euro II and Euro III franchised buses with selective catalytic reduction devices to upgrade their emission performance; and launching an incentive-cum-regulatory scheme to progressively phase out some 82 000 pre-Euro IV diesel commercial vehicles by end 2019.

5.6. 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%.

Sectoral analysis for "Navigation"

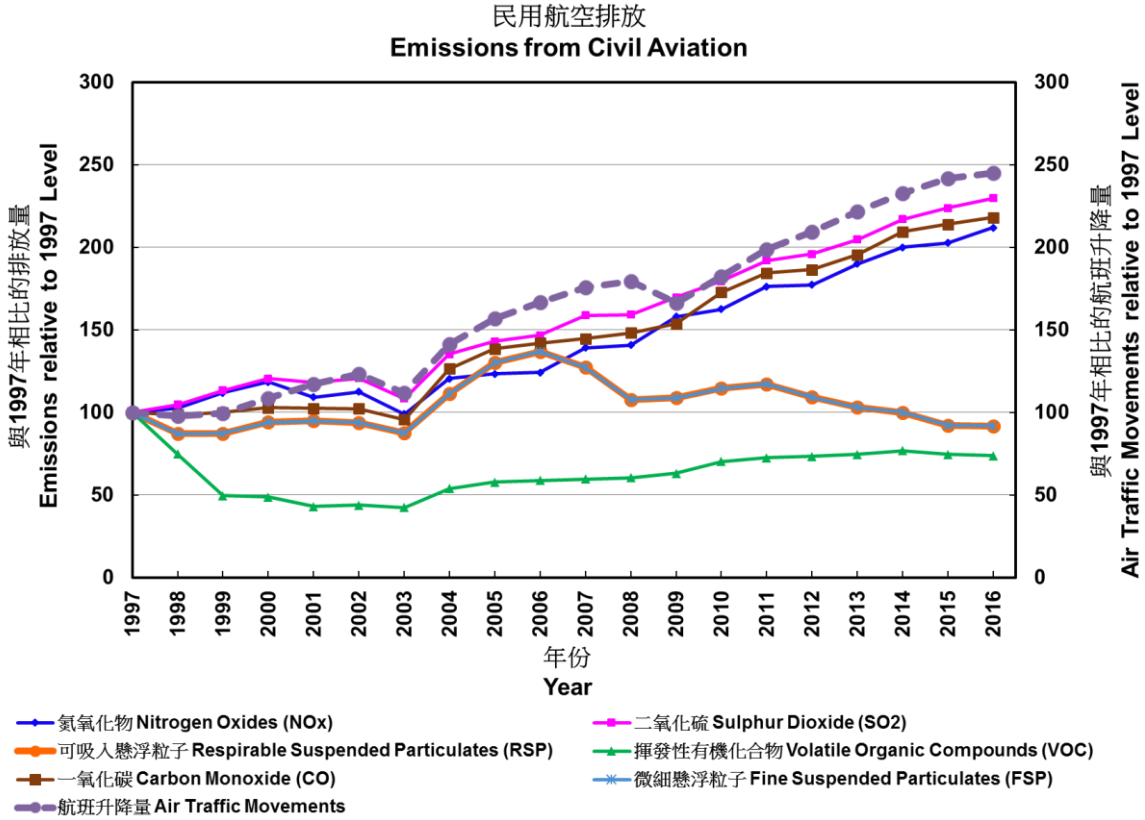


5.7. With the significant reduction in emissions from the electricity and road transport sectors over the past years, marine emissions have now become the major source in Hong Kong. Nonetheless, the emissions of SO_2, RSP, FSP substantially decreased between 2013 and 2016 by 26% to 46%. In 2016, the emissions of SO_2, NOx, RSP and FSP from marine vessels accounted for 49%, 37%, 38% and 44% of the total emissions, respectively.

5.8. The reductions of SO_2, RSP and FSP emissions from marine vessels from 2010 to 2016 were primarily achieved through the marine control measures. The implementation of the Air Pollution Control (Marine Light Diesel) Regulation imposed a statutory sulphur limit of 0.05% on locally supplied marine light diesel since April 2014 (a 90% reduction from the previous limit of 0.5%). Besides, the Air Pollution Control (Ocean Going Vessels) (Fuel at Berth) Regulation implemented in July 2015 mandated ocean-going vessels to switch to low sulphur fuel not exceeding 0.5% (a reduction of around 80% from the previous average level of 2.7%) while at berth. The VOC emissions from the marine navigation sector were relatively low, hence a small fluctuation can make a big difference in percentage.

5.9. Among vessels, ocean going vessels (OGVs) were major emitters. As compared with 2010, the container throughput decreased by 16% in 2016.

Sectoral analysis for "Civil aviation"

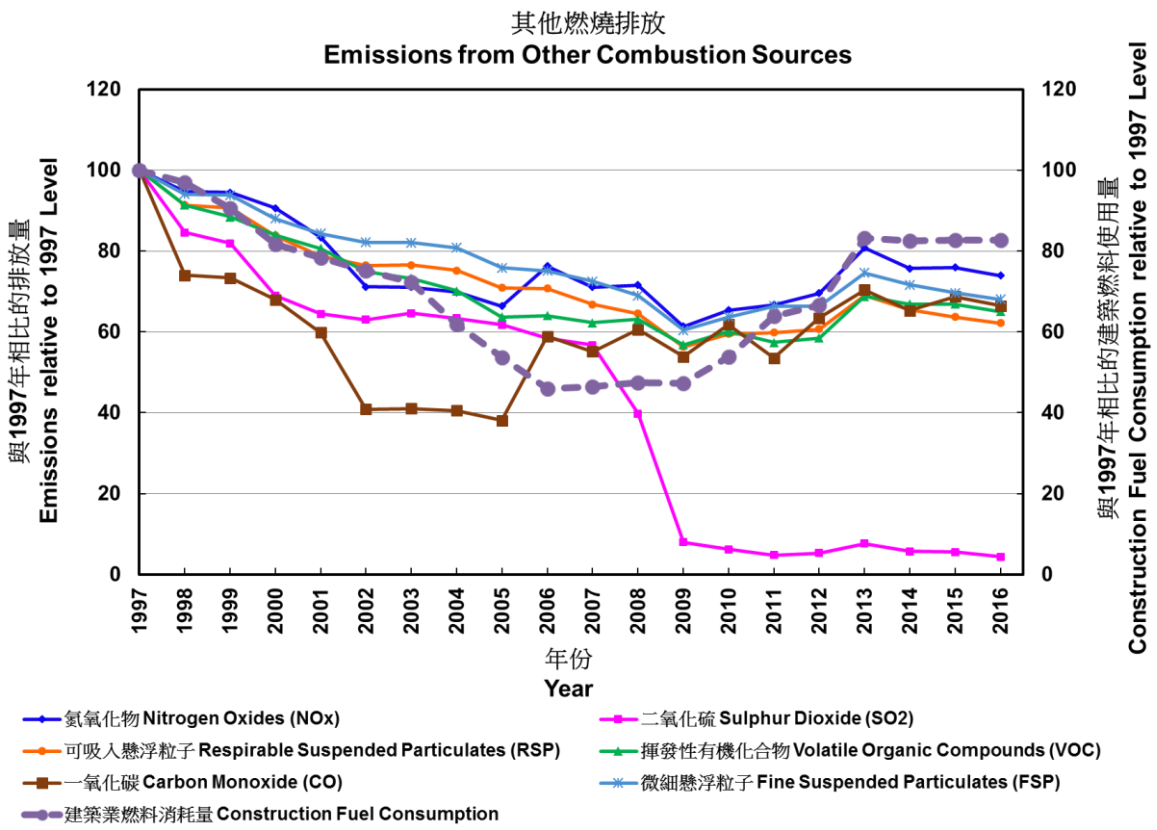


5.10. Emissions from civil aviation accounted for less than 8% of the total local emissions of air pollutants in 2016. From 1997 to 2016, the air traffic movements increased by 145%, while the emissions of NOx increased by 112%.

5.11. On the contrary, the emissions of RSP and FSP from civil aviation showed a decreasing trend from 2010 to 2016 due to the increased use of fixed ground power and pre-conditioned air systems for aircraft at parking stands of the Hong Kong International Airport (HKIA). Such measures reduced the operation time of onboard fuel combustion auxiliary power generation units (APU), and thereby reduce particulate emissions. Since December 2014, the use of APU at frontal stands was totally banned and hence its emissions were reduced to zero.

5.12. 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"

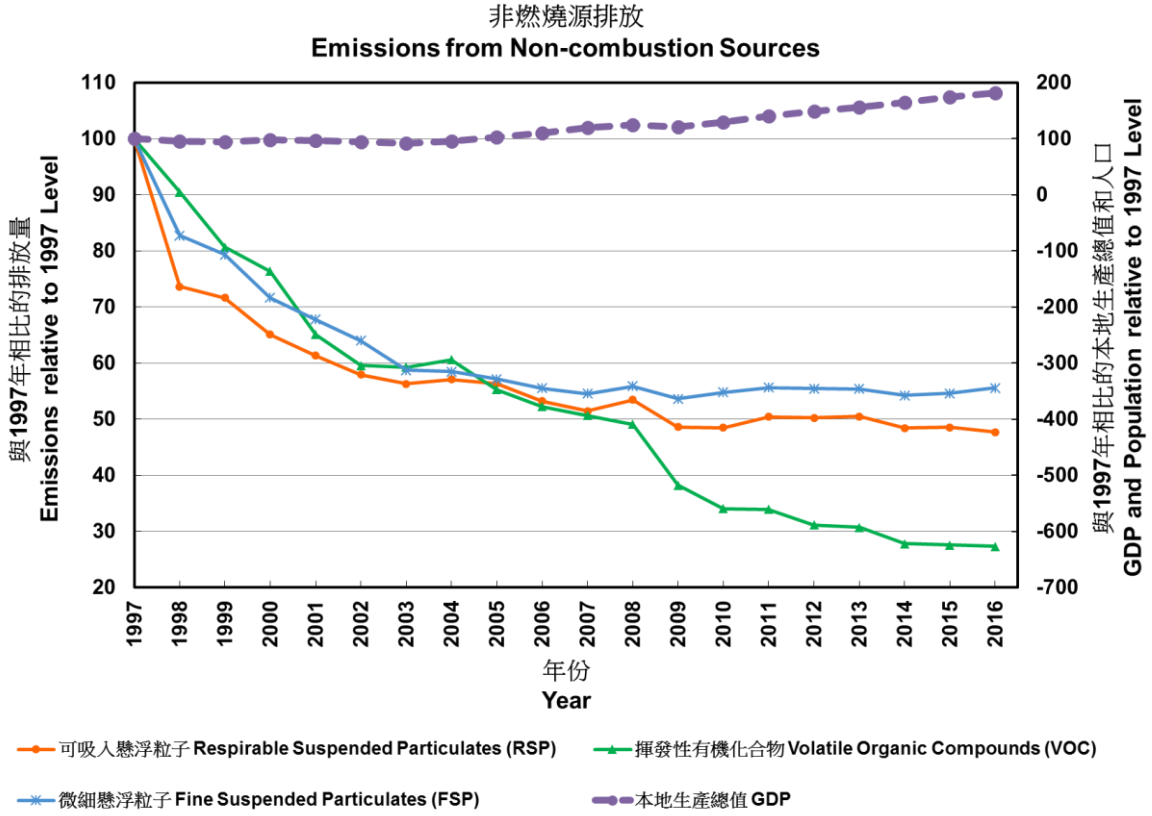


5.13. Other combustion sector is one of the important sources of RSP and FSP emissions, accounting for 17% and 20% of their total emissions in 2016 respectively. Overall, the emissions of various pollutants from other combustion sources decreased by 26% to 96% from 1997 to 2016.

5.14. Major contributing sources in this sector are non-road mobile machineries (NRMMs), especially construction machinery, which accounted for 56%, 59% and 62% of RSP, FSP and NOx emissions from other combustion sources respectively in 2016. The emission trends from other combustion sources from 2010 to 2016 by and large followed the fuel consumption growth in construction projects. On 1 June 2015, the Air Pollution Control (Non-road Mobile Machinery) (Emission) Regulation came into force, which controls the air pollutant emissions from NRMMs. Starting from 1 September 2015, any regulated machine to be sold or leased for local use must be an approved or exempted NRMM and must comply with the emission standards of Stage IIIA of the European Union or equivalent, while non-road vehicles must comply with Euro V emission standards.

5.15. The SO_2 emissions from this sector have been reduced to a very low level since the Air Pollution Control (Fuel Restriction) Regulation tightened the cap on the sulphur content of diesel used in industrial and commercial sectors from 0.5% to 0.005% in October 2008. 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"

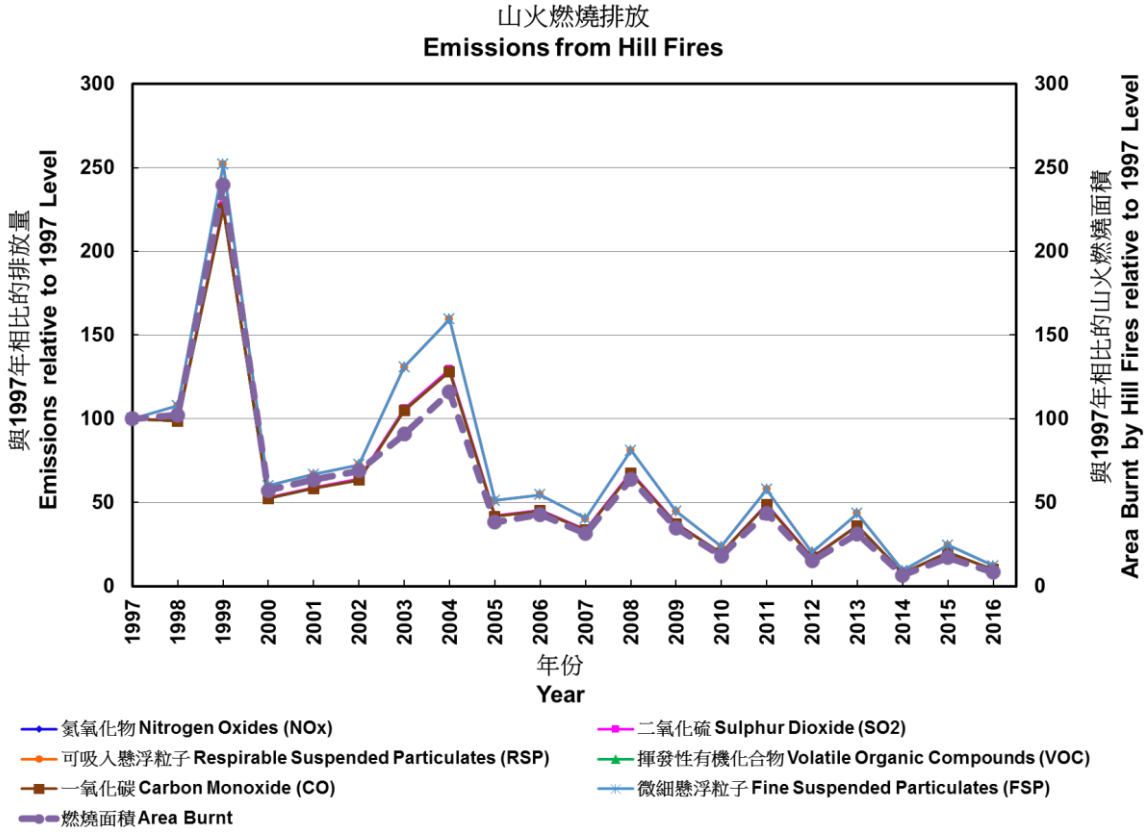


5.16. Non-combustion sources sector contributes considerably to local VOC emissions, accounting for 58% in 2016, whereas its contributions to local RSP and FSP emissions in 2016 were 20% and 14%, respectively. Overall, the emissions of the sector decreased by 44% to 73% from 1997 to 2016, despite the growth of Gross Domestic Product by 81%.

5.17. The use of paints, printing inks and associated solvents, consumer products, adhesive and sealants continued to be the major contributing sources, accounting for 88% of non-combustion sources VOC emissions in 2016. As compared with 2007, the VOC emissions from non-combustion sources decreased by 46% in 2016, as a result of the VOC control programme under the Air Pollution Control (Volatile Organic Compounds) Regulation since 2007.

5.18. The Regulation prohibits the import and local manufacture of regulated products with VOC contents exceeding the legal limits and controls emissions from lithographic heatset web printing machines. The regulated products include 6 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 has been extended to cover fountain solutions and printing machine cleaning agents starting from 2018.

6 EMISSIONS FROM HILL FIRES



6.1. Emissions from hill fires mainly contribute to particulate matters emissions, accounting for 8% of both total local RSP and FSP emissions in 2016. From 1997 to 2016, the area burnt due to hill fires substantially decreased by 92% and hence, the emissions of FSP and RSP from hill fires decreased by a similar extent over the same period.

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 been reduced substantially over the past 2 decades.

7 REGIONAL EMISSION REDUCTION COOPERATION

7.1. Over the past years, the Hong Kong and Guangdong governments have been working together to improve regional air quality in the Pearl River Delta (PRD) Region[1]. Both parties have been collaborating since 2002 to reduce emissions from major sources such as power plants, vehicles and industries. In 2012, the Hong Kong and Guangdong governments endorsed a set of 2015 emission reduction targets and 2020 emission reduction ranges of four major air pollutants, namely sulphur dioxide (SO_2), nitrogen oxides (NOx), respirable suspended particulates (RSP) and volatile organic compounds (VOC), for Hong Kong and Pearl River Delta Economic Zone (PRDEZ)[2], adopting 2010 as the base year. At the 17th meeting of Hong Kong-Guangdong Joint Working Group on Sustainable Development and Environmental Protection held in December 2017, the Hong Kong and Guangdong governments jointly announced the results of the mid-term review study which concluded the emission reduction results in 2015 and finalized the emission reduction targets for 2020.

Emission reduction results in 2015

7.2. Both Hong Kong and Guangdong have achieved their respective 2015 emission reduction targets for SO_2, NOx, RSP and VOC. According to 2015 Emission Inventory Report, the emission levels of major air pollutants in Hong Kong in 2015 decreased by 14% to 45% compared with 2010, while those in the PRDEZ dropped by 11% to 25% (as shown in Table 1). The emission reductions of SO_2, RSP and VOC in Hong Kong and that of SO_2 in the PRDEZ have far exceeded the targets.

Table 1: Emission reduction results for Pearl River Delta (PRD) Region in 2015

Pollutants	Region	2015 Emission Reduction Targets*	Actual Emission Reduction in 2015* based on 2015 Emission Inventory Report
SO_2	Hong Kong	-25%	-45%
	PRDEZ	-16%	-25%
NOx	Hong Kong	-10%	-14%
	PRDEZ	-18%	-22%
RSP	Hong Kong	-10%	-20%
	PRDEZ	-10%	-14%
VOC	Hong Kong	-5%	-14%
	PRDEZ	-10%	-11%

*Reductions are relative to 2010 emission levels

[1] PRD Region refers to the whole territory of HKSAR and the Pearl River Delta Economic Zone (PRDEZ).
[2] PRDEZ includes Guangzhou, Shenzhen, Zhuhai, Dongguan, Zhongshan, Foshan, Jiangmen, Huizhou and Zhaoqing.

Finalised emission reduction targets for 2020

7.3. Having taken into account the current and committed emission reduction measures, the mid-term review study finalised the emission reduction targets for 2020 for both sides (as shown in Table 2).

Table 2: 2020 Emission Reduction Targets for Pearl River Delta (PRD) Region

Pollutants	Region	2020 Emission Reduction Range released in 2012*	Established 2020 Emission Reduction Targets*
SO_2	Hong Kong	-35% ~ -75%	-55%
	PRDEZ	-20% ~ -35%	-28%
NOx	Hong Kong	-20% ~ -30%	-20%
	PRDEZ	-20% ~ -40%	-25%
RSP	Hong Kong	-15% ~ -40%	-25%
	PRDEZ	-15% ~ -25%	-17%
VOC	Hong Kong	-15%	-15%
	PRDEZ	-15% ~ -25%	-20%

*Reductions are relative to 2010 emission levels

7.4. Hong Kong will continue to co-operate with Guangdong Province to implement further control measures according to the Pearl River Delta Regional Air Quality Management Plan, in order to attain the emission reduction targets for 2020 and to meet broadly the existing Air Quality Objectives by 2020.

The key emission reduction measures implemented by Hong Kong include:

- requiring power plants to increase the use of natural gas in electricity generation;
- imposing and progressively tightening emission caps for power plants;
- tightening vehicle emission standards to Euro VI;
- continuing to phase out pre-Euro IV diesel commercial vehicles;
- collaborating with the Guangdong Provincial Government on the implementation of a domestic emission control area (DECA) in PRD waters as well as mandating vessels to use low-sulphur fuel in Hong Kong waters;
- controlling the VOC content of fountain solutions and printing machine cleaning agents; and
- aiming to tighten in phases the VOC content limits of architectural paints.

The key emission reduction measures implemented by Guangdong include:

- controlling the pollutant emissions of coal-fired thermal power plants and implementing ultra-low emission modifications of coal-fired generating units with power of 300 000 kilowatts or above;
- taking forward the comprehensive emission treatment of highly polluting boilers and strengthening emission monitoring of various industrial boilers and kilns to ensure stable and up-to-standard emissions;

- advancing the implementation of National VI emission standards for motor vehicles in the PRD;
- strongly promoting the use of new energy vehicles, which Shenzhen will use to fully electrify public transport by 2017, while Guangzhou and Foshan have already implemented electrification for newly acquired public vehicles from 2017 onwards. For newly acquired or replacement public vehicles in other regions of the PRD, the ratio of pure electric vehicles should not be less than 90 per cent;
- enhancing VOC control by regulating 13 major industries associated with sources of VOC including the petrochemical, furniture and printing industries;
- strengthening emission control at source including fugitive dust control for works and roads, enhancing the comprehensive utilisation of crop straw and forbidding straw burning in particular areas and at particular times, as well as stepping up cooking emission controls for the catering industry; and
- establishing a DECA in PRD waters and progressively implementing the use of low-sulphur fuel for vessels navigating, berthing and operating within the DECA in accordance with requirements.

7.5. As regards the next phase of the emission reduction plan, the two Governments will jointly form a scientific research team to discuss regional air pollution reduction co-operation beyond 2020, including the launch of a study on post-2020 air pollutant emission reduction targets and concentration levels for Hong Kong and Guangdong, in order to continuously improve regional air quality and protect public health.

- End -

Annex 1 – Breakdown of Emission Inventory by Source Categories from 2015 to 2016

Pollutant	Source Categories	Emissions (Tonnes)	
		2015	**2016**
SO_2	Public Electricity Generation	7,280	8,020
	Road Transport	40	40
	Navigation	11,460	8,540
	Civil Aviation	510	530
	Other Combustion	240	180
	Non-combustion	N/A	N/A
	Total (without Hill Fires)	19,530	17,310
	Hill Fires	10	10
	Total (with Hill Fires)	19,540	17,310
NOx	Public Electricity Generation	26,090	25,620
	Road Transport	18,100	16,200
	Navigation	33,940	32,900
	Civil Aviation	5,800	6,060
	Other Combustion	9,100	8,850
	Non-combustion	N/A	N/A
	Total (without Hill Fires)	93,020	89,640
	Hill Fires	60	30
	Total (with Hill Fires)	93,080	89,670
RSP	Public Electricity Generation	580	610
	Road Transport	490	420
	Navigation	1,860	1,640
	Civil Aviation	50	50
	Other Combustion	760	740
	Non-combustion	910	890
	Total (without Hill Fires)	4,640	4,350
	Hill Fires	740	370
	Total (with Hill Fires)	5,380	4,720
FSP	Public Electricity Generation	300	310
	Road Transport	450	380
	Navigation	1,690	1,480
	Civil Aviation	50	50
	Other Combustion	700	690

Pollutant	Source Categories	Emissions (Tonnes)	
		2015	**2016**
	Non-combustion	470	480
	Total (without Hill Fires)	3,660	3,380
	Hill Fires	600	300
	Total (with Hill Fires)	4,260	3,680
VOC	Public Electricity Generation	420	430
	Road Transport	4,800	4,700
	Navigation	3,870	4,510
	Civil Aviation	540	530
	Other Combustion	890	870
	Non-combustion	15,340	15,200
	Total (without Hill Fires)	25,860	26,240
	Hill Fires	160	80
	Total (with Hill Fires)	26,010	26,310
CO	Public Electricity Generation	3,580	3,690
	Road Transport	31,400	31,500
	Navigation	12,800	13,940
	Civil Aviation	3,880	3,960
	Other Combustion	5,710	5,520
	Non-combustion	N/A	N/A
	Total (without Hill Fires)	57,380	58,600
	Hill Fires	1,720	850
	Total (with Hill Fires)	59,090	59,450

Note:
- All figures are rounded to the nearest ten.
- “N/A” denotes not applicable.
- “0” denotes data less than 5.
- There may be slight discrepancies between the sums of individual items and the totals shown in the table because of rounding.

Annex 2 – Summary of Updates to the Emission Inventory

1. Making reference to international developments and technological advancement, we have been updating the methodologies to compile emission inventories including the collection of most updated data with an aim to provide a better support to the management of air quality. Whenever the compilation methodology is updated, new activity data are collated, or errors in the estimates are identified, we will follow international practice to update the emission inventory and to revise the emission inventories for past years as far as practicable based on the updated methods and data to enable consistent and reliable emission trend analysis to be made.

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 types 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. To compile VOC emissions for the regulated products, we also made reference to EPD's studies on printing industry, solvent usage for coatings and VOC-containing products, and survey data for marine paints to assess emissions from VOC-containing products.

5. Updates to the emission inventories since their first publication in March 2000 are summarized in the table below. Based on the latest updates, we have recalculated historical emission inventories from 1997 to 2015. Comparisons between the previous and recalculated inventories are shown in **Annex 3**.

Update Date	**Emission Inventory Revised**	**Revisions and Updates**
March 2000	1990-1998	• First publication of emission inventory for PM, SO_2, NOx, NMVOCs and CO from combustion sources at the EPD's website.
December 2000	1990-1999	• Amended emission inventory for Public Electricity Generation, Road Transport and Other Fuel Combustion sources.
December 2001	1990-2000	• Amended combustion sources emissions (including emission factors for VOC emissions from coal-fired electricity generation units, vehicle kilometer travel (VKT) for Road Transport, emission estimation methods for Navigation and Civil Aviation and surrogates for Other Fuel Combustion emissions).
February 2003	1990-2001	• Replaced Census and Statistics Department (C&SD) retained import data for fuel with Energy End-use data from Electrical and Mechanical Services Department (EMSD). • Amended VKT data.
June 2004	1990-2002	• Replaced emission estimated using emission factors with sophisticated EMFAC-HK model to estimate emissions from Road Transport. • Included additional emission sources for RSP and VOC. • Replaced 2000 to 2001 Public Electricity Generation emissions for SO_2, NOx and PM with data provided the power companies.
January to March 2005	1990-2003	• Amended 2000 to 2002 SO_2, NOx and PM emissions for Public Electricity Generation according to data provided by the power companies. • Updated emissions estimated using the EMFAC-HK model. • Amended 2001-02 emissions using Energy End-Use Data from EMSD. • Excluded Biogenic VOC emission sources from total VOC emission.
December 2005	1990-2004	• Amended 2002-03 emissions using Energy End-Use Data from EMSD. • Updated emission factors for VOC emissions from the printing industry.
December 2006	1990-2005	• Amended 2003 to 2004 SO_2, NOx and PM emissions for Public Electricity Generation according to data provided by the power companies. • Updated fuel use for vehicles to calculate 1998 to 2004 SO_2 emissions. • Updated emission factors for VOC emissions from the printing industry.

Update Date	Emission Inventory Revised	Revisions and Updates
January 2008	1990-2006	• Replaced Power Plant PM emissions with RSP emissions using emission factors from USEPA. • Updated emission factors for emission from non-road mobile equipment at the airport, container terminal and construction sites. • Included VOC emissions from evaporation of gasoline. • Included RSP emissions from tyre, brake and road wear. • Amended estimation method for VOC emissions from printing industry and fuel storage tanks. • Updated emission factors for Civil Aviation emission sources.
January 2009	1990-2007	• Used information collected from Government Departments and shipping industry to estimate emissions from local vessels. • Updated emission factors for emission from non-road mobile equipment at the airport and container terminal.
September 2012	1997-2010	• Based on the results from the Marine Emission Study report completed in 2012 to update emissions from Navigation. Additional information for fuel use and vessel activities were used to calculate the emission. • Used updated version of EMFAC-HK (version 2.1) for Road Transport emission estimation. • Used updated version of EDMS (version 5.1.3) for Civil Aviation emission estimation. • Included emissions from auxiliary power units of the aircrafts parking at the gates of the airport. • Used sales report data to calculate VOC emissions from products controlled under the VOC Regulation. • Used further local reported and survey data for VOC emission calculation. • Used new reported and survey results to calculate emissions from Other Fuel Combustion sources. • Included RSP emissions from construction sites and cooking; Included VOC emissions from storage of naphthalene, aviation fuel and use of cleaning solvents associated with paint use.
February 2013	1997-2011	• Used C&SD data to derive fuel consumption data for construction sector from 1997 to 2011. • Amended VOC emissions from architectural paints in 2010 due to a correction in the paint consumption data.

Update Date	Emission Inventory Revised	Revisions and Updates
January 2014	1997-2012	• We compiled the emission inventory of FSP as it is one of the major air pollutants stipulated in the new Air Quality Objectives (AQOs) which takes effect from 1 January 2014. • Emissions of OGVs during shifting between berthing locations were compiled since more detailed vessel activity data were collected from the Marine Department. • New surrogates for fuel consumption for the construction and industrial sectors were derived from C&SD data since the previously used Energy End-Use data from EMSD are no longer suitable after a major revision. • Having regard to the real world developments, the sulphur content of aviation fuel, duration of landing and take-off cycles of aircraft at Hong Kong International Airport and hence the air pollutant emissions from Civil Aviation sector have been updated. • Screen printing emissions were updated according to additional survey data to cover emissions in the application of screen printing inks on non-paper substrates, of which this type of inks was exempted from the VOC Regulation.
January 2015	2009-2012	• VOC emissions from architectural paints in 2012 were updated using VOC contents of the latest sales reports submitted by importers. • VOC emissions from screen printing from 2009 to 2012 were revised based on our latest survey which revealed a reduction in the local use of non-regulated screen printing ink.
January 2016	1997-2014	• 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	1997-2015	• A mixing height of 3000 ft (915 m), as recommended by ICAO, 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.

Update Date	Emission Inventory Revised	Revisions and Updates
January 2018	1997-2016	• 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.

Annex 3 – Comparison between the Previous and Recalculated Inventories (without Hill Fires) from 1997 to 2015

Table A3-1. Changes in SO_2 emission inventories from 1997 to 2015

Year	SO_2 (Tonnes)		
	Previous*	Recalculated*	% Changes
1997	82,280	80,150	-3%
1998	88,110	86,440	-2%
1999	73,230	71,440	-2%
2000	80,380	79,530	-1%
2001	81,860	80,560	-2%
2002	79,900	79,060	-1%
2003	104,990	103,310	-2%
2004	108,810	107,930	-1%
2005	98,290	97,420	-1%
2006	87,330	86,700	-1%
2007	79,830	79,620	0%
2008	69,430	69,440	0%
2009	62,560	62,820	0%
2010	35,470	35,560	0%
2011	32,120	32,070	0%
2012	32,700	32,660	0%
2013	31,420	31,400	0%
2014	31,650	31,640	0%
2015	19,530	19,530	0%

* Figures are rounded to the nearest ten.

Figure A3-1 SO_2 emissions trend from 1997 to 2015

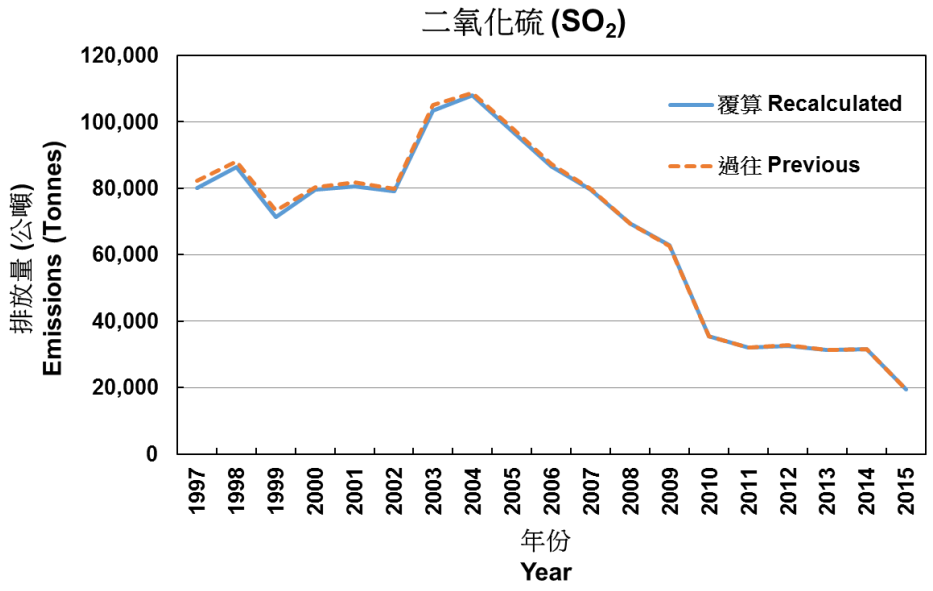


Table A3-2. Changes in NOx emission inventories from 1997 to 2015

Year	NOx (Tonnes)		
	Previous*	Recalculated*	% Changes
1997	152,000	147,900	-3%
1998	147,590	143,940	-2%
1999	132,880	129,140	-3%
2000	133,210	131,450	-1%
2001	129,570	126,730	-2%
2002	126,570	124,220	-2%
2003	140,580	136,010	-3%
2004	129,180	126,950	-2%
2005	128,130	126,170	-2%
2006	124,530	123,000	-1%
2007	126,120	125,020	-1%
2008	119,310	118,390	-1%
2009	116,550	116,480	0%
2010	107,090	107,080	0%
2011	114,610	113,730	-1%
2012	112,300	111,390	-1%
2013	112,460	111,830	-1%
2014	108,620	108,050	-1%
2015	91,640	93,020	2%

* Figures are rounded to the nearest ten.

Figure A3-2 NOx emission trend from 1997 to 2015

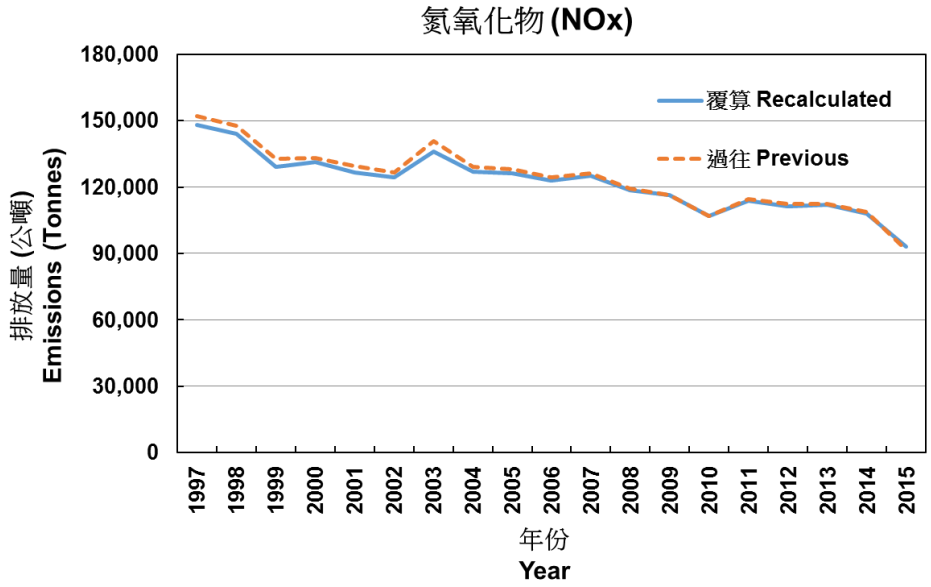


Table A3-3. Changes in RSP emission inventories from 1997 to 2015

Year	RSP (Tonnes)		
	Previous*	Recalculated*	% Changes
1997	14,280	14,200	-1%
1998	13,080	12,990	-1%
1999	11,580	11,510	-1%
2000	11,110	11,220	1%
2001	9,570	9,620	1%
2002	8,770	8,900	2%
2003	8,680	8,650	0%
2004	8,960	9,000	0%
2005	8,260	8,250	0%
2006	7,670	7,640	0%
2007	7,070	7,070	0%
2008	6,800	6,810	0%
2009	6,450	6,490	1%
2010	6,060	6,090	0%
2011	6,040	6,030	0%
2012	5,810	5,800	0%
2013	5,860	5,820	-1%
2014	5,560	5,510	-1%
2015	4,690	4,640	-1%

* Figures are rounded to the nearest ten.

Figure A3-3 RSP emission trend from 1997 to 2015

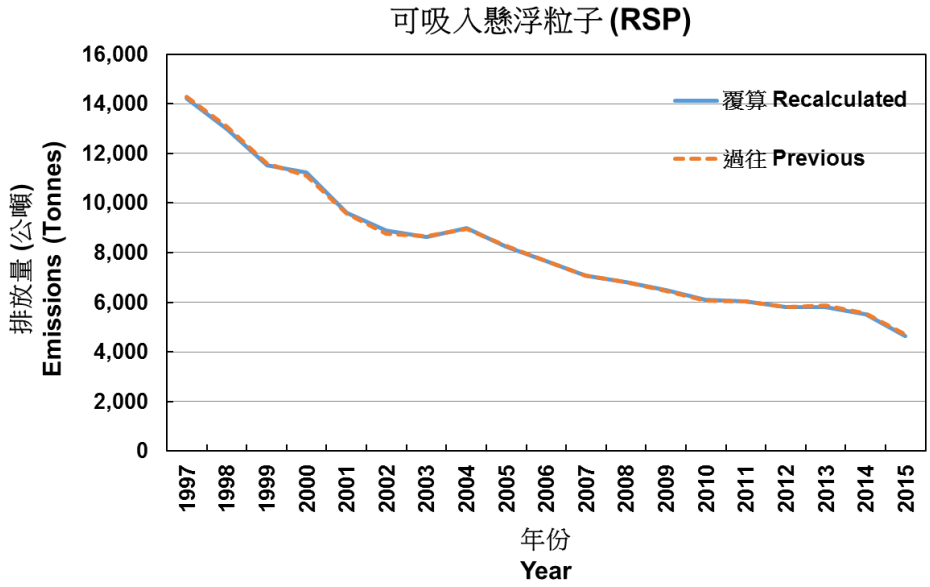


Table A3-4. Changes in FSP emission inventories from 1997 to 2015

Year	FSP (Tonnes)		
	Previous*	Recalculated*	% Changes
1997	10,860	10,760	-1%
1998	10,070	9,950	-1%
1999	9,050	8,970	-1%
2000	8,450	8,540	1%
2001	7,490	7,520	0%
2002	6,690	6,790	2%
2003	6,350	6,300	-1%
2004	6,400	6,400	0%
2005	6,040	5,980	-1%
2006	5,750	5,690	-1%
2007	5,350	5,370	0%
2008	5,150	5,180	1%
2009	4,830	4,890	1%
2010	4,740	4,780	1%
2011	4,730	4,740	0%
2012	4,540	4,540	0%
2013	4,580	4,550	-1%
2014	4,300	4,270	-1%
2015	3,700	3,660	-1%

* Figures are rounded to the nearest ten.

Figure A3-4 FSP emission trend from 1997 to 2015

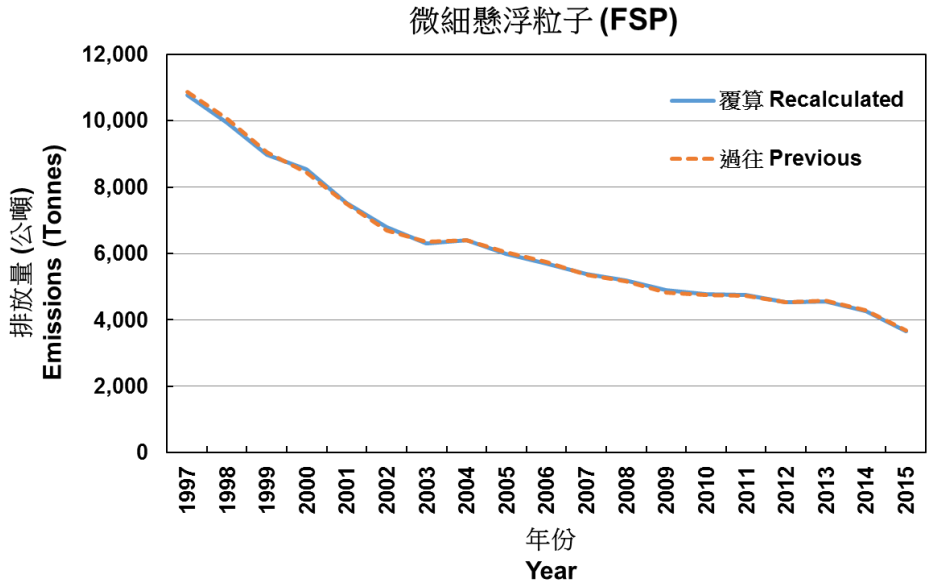


Table A3-5. Changes in VOC emission inventories from 1997 to 2015

Year	VOC (Tonnes)		
	Previous*	Recalculated*	% Changes
1997	75,730	74,040	-2%
1998	68,910	67,390	-2%
1999	62,260	60,860	-2%
2000	59,160	57,770	-2%
2001	51,900	50,650	-2%
2002	47,640	46,690	-2%
2003	46,320	45,770	-1%
2004	46,830	46,590	-1%
2005	43,910	43,830	0%
2006	41,990	41,990	0%
2007	40,730	40,320	-1%
2008	39,580	39,160	-1%
2009	33,640	33,830	1%
2010	30,870	30,830	0%
2011	30,400	30,500	0%
2012	28,730	28,740	0%
2013	28,290	28,360	0%
2014	26,490	26,840	1%
2015	26,450	25,860	-2%

* Figures are rounded to the nearest ten.

Figure A3-5 VOC emission trend from 1997 to 2015

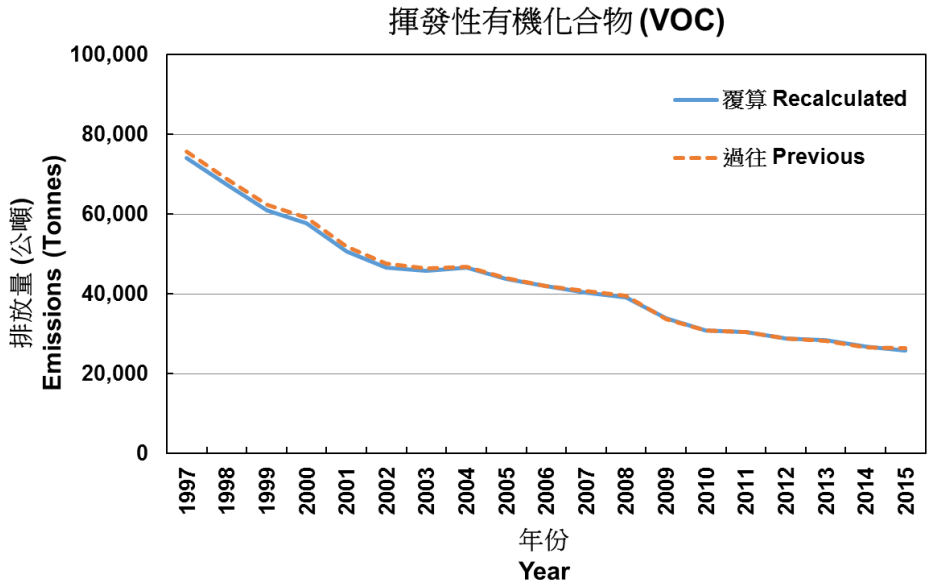


Table A3-6. Changes in CO emission inventories from 1997 to 2015

Year	CO (Tonnes)		
	Previous*	Recalculated*	% Changes
1997	96,600	93,460	-3%
1998	90,110	87,490	-3%
1999	86,710	84,460	-3%
2000	83,450	81,520	-2%
2001	80,500	78,940	-2%
2002	75,330	74,580	-1%
2003	72,100	72,160	0%
2004	72,710	73,950	2%
2005	73,650	75,580	3%
2006	75,790	78,130	3%
2007	75,890	77,680	2%
2008	76,320	78,610	3%
2009	76,940	80,700	5%
2010	76,800	80,690	5%
2011	79,100	82,920	5%
2012	79,390	83,650	5%
2013	65,050	67,470	4%
2014	56,670	59,190	4%
2015	56,440	57,380	2%

* Figures are rounded to the nearest ten.

Figure A3-6 CO emission trend from 1997 to 2015