City Synthesis Report on
Urban Air Quality Management

Hong Kong SAR

Discussion Draft, December 2006

ADB

CLEAN AIR INITIATIVE for Asian Cities

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 Published 2006 by the Asian Development Bank (ADB).
Printed in the Philippines.

ADB facilitated this study through its Regional Technical Assistance 6291: Rolling Out Air Quality Management in Asia.

The Study was led by the CAI-Asia Secretariat and the information contained in this report was developed by the CAI-Asia Secretariat with inputs by a range of organizations and air quality experts from across Asia and elsewhere.

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Abbreviations

ADB	Asian Development Bank
ACFA	Asian Clean Fuels Association
APCO	Air Pollution Control Ordinance
API	air pollution index
AQ	air quality
AQM	air quality management
AQO	air quality objective
CAI	Clean Air Initiative (for Asian Cities)
CO	Carbon monoxide
CSD	Census and Statistics Department
EPD	Environmental Protection Department
GDP	gross domestic product
GIC	Government Information Center
hr	hour
km	kilometer
km^2	square kilometer
LPG	liquefied petroleum gas
NMVOC	non-methane volatile organic compound
NO_X	Nitrogen oxide
O_3	ozone
Pb	lead
PM	particulate matter
$PM_{2.5}$	particulate matter with diameter equal or less than 2.5 micrometers
PM_{10}	particulate matter with diameter equal or less than 10 micrometers
RSP	respirable suspended particulate
SAR	Special Administrative Region (Hong Kong)
SO_2	Sulfur dioxide
SPM	suspended particulate matter
TSP	total suspended particulate
$\mu g/m^3$	microgram per cubic meter
USA	United States of America
US EPA	United States Environment Protection Agency
WHO	World Health Organization

Note: "$" means "US dollar" in this publication.

Acknowledgments

This series of country and city reports is the first time that a comprehensive overview of urban air quality management (AQM) at the country and city—in the case of Hong Kong Special Administrative Region of the People's Republic of China (PRC)—levels has been prepared in Asia. Research compilation for this country and city synthesis reports (CSR) on Urban Air Quality Management was led by the Clean Air Initiative for Asian Cities (CAI-Asia) Secretariat with inputs by a range of organizations and air quality experts from across Asia and elsewhere, and facilitated by the Asian Development Bank (ADB) through its Regional Technical Assistance No. 6291: Rolling Out Air Quality Management in Asia. The primary authors of the reports are Ms. Aurora Fe Ables, Ms. May Ajero, Mr. Herbert Fabian, and Ms. Ninette Ramirez, all from CAI-Asia with the supervision of Mr. Cornie Huizenga, Head of Secretariat, CAI-Asia.

The CSRs were prepared with assistance from volunteer authors from the different countries, and facilitated by CAI-Asia local networks in Nepal (Clean Air Network-Nepal), Pakistan (Pakistan Clean Air Network), Philippines (Partnership for Clean Air [PCA]), the People's Republic of China (PRC) (CAI-Asia Project Office), Sri Lanka (Clean Air Sri Lanka), and Viet Nam (Viet Nam Clean Air Partnership). CAI-Asia local networks have also organized a development partners meeting on clean air in the respective countries and city where initial drafts of the CSRs were presented to local AQM stakeholders.

For the Hong Kong SAR City Synthesis Report, CAI-Asia extends special thanks to Mr. Kong Ha, Mr. Sik-wing Pang, Mr. Joe W.Y. Fong, and Mr. Chin-wan Tse of the Hong Kong SAR Environmental Protection Department for providing data and comments to the report.

CAI-Asia would like to thank ADB for facilitating the research and Mr. Masami Tsuji, Senior Environment Specialist, Dr. David McCauley, Senior Environmental Economist, and Mr. Nessim Ahmad, Director—all from the Environment and Social Safeguard Division, Regional and Sustainable Development Department—for providing guidance. Ms. Glynda Bathan, Mr. Michael Co, Ms. Agatha Diaz, and Ms. Gianina Panopio of CAI-Asia are also acknowledged for their logistical and technical support for the CSR team.

CAI-Asia and the respective country and city Ministries of Environment reviewed the volume—with technical review inputs from Prof. Frank Murray of Murdoch University—which Ms. Agnes Adre and Ms. Theresa Castillo copyedited. Mr. Segundo dela Cruz, Jr. handled the graphic design and layout.

» Part One

General Information

Geography and Climate

The Hong Kong Special Administrative Region (Hong Kong SAR) of the People's Republic of China (PRC) is located southeast of the mainland PRC. Its total area of 1,104 square kilometers (km^2) includes Hong Kong Island, Kowloon peninsula, and the New Territories, which also includes 262 outlying islands (Government Information Center [GIC] 2006).

Hong Kong SAR has a subtropical climate, tending toward the temperate for about half the year. Its mean minimum and mean maximum temperatures ranged from 21.4–25.4°C in 2005 (Census and Statistics Department [CSD] 2006). Temperature falls to 10°C in winter and rises to an average maximum of 31.5°C in July. The mean annual precipitation reaches 2,200 millimeters (mm) most of which falls between May and August. In 2005, the total rainfall was 3,214.5 mm. Wind speeds are usually at 11 kilometers per hour (km/h) and reach an ever-recorded maximum of 260 km/h during tropical cyclones that usually come in the rainy months of April to September (GIC 2006, Hong Kong Observatory 2003).

Urbanization and Population

Hong Kong SAR's population reached 6.9359 million in 2005 (CSD 2006) and had a population density of 6,420 people per km^2 (Asian Development Bank [ADB] 2006). The population densities in the Kowloon peninsula and the New Territories continued to increase from its 2000 levels, but the reverse was true in Hong Kong Island where the figures went down from 16,960 in 2000 to 15,880 persons per km^2 in 2005. Hong Kong SAR hosted a large foreign population of about 524,200 in 2004 with 25% coming from the Philippines, 20% from Indonesia, and 6% from the United Sates of America (USA) (GIC 2006). It is highly urbanized, with 100% of the population living in urban areas (Asian Development Bank [ADB] 2006).

Economy and Industry

Hong Kong SAR is the world's 11th largest trading economy, 6th largest foreign exchange market, and 13th largest banking center, and Asia's 2nd biggest stock market (GIC 2006). The service sector continues to be the largest contributor to its gross domestic product (GDP). In 2005, the service sector contributed 87.4% of GDP, with the industry sector contributing 16.1% (GIC 2006). It is among the world's top exporters of garments, watches and clocks, toys, games, electronic products, and certain light industrial products (GIC 2006). Other industrial products include chemicals, metals, and glassworks.

Energy

Hong Kong SAR imports its energy requirements for coal, gas, or oil from the mainland PRC and other countries. It consumed 10,825 thousand metric tons of coal in 2005, 18.8% higher than 1995 (ADB 2006). Electricity consumption was 40,048 million kilowatt-hours (160,363 terajoules[1]) in which 58% was used commercially, 22% for domestic, 9% for industrial, and 10% exported to the mainland PRC (CSD 2006 and ADB 2006). Hong Kong SAR generates its electricity through two coal power generation plants and one gas plant.

Transportation

The number of licensed vehicles in Hong Kong SAR has been growing and this is due to personal transport vehicles such as private cars, motorcycles, and motor tricycles (Table 1.0). Measures have been introduced to dampen motorization's effect on local air quality. This would be discussed in the air quality management (AQM) chapter.

[1] 1 terajoule = 10^{12} joules

TABLE 1.1

Motor Vehicles Licensed by Type ('000)

Type	2000	2004	2005
Private cars	332	345	351
Motorcycles (including motor tricycles)	26	33	34
Taxis	18	18	18
Buses, public and private	13	13	13
Light buses, public and private	6	6	6
Goods vehicles	114	110	111
Special purpose vehicles	[a]	1	1
Government vehicles (excluding military vehicles)	7	6	6
Total	**517**	**533**	**541**

[a] Less than 500 vehicles

Source: Census and Statistics Department 2006. *Hong Kong in Figures. 2006 edition.* February. Available at: www.censtatd.gov.hk.

Taxis, buses, and light buses account for a small fraction of the total licensed vehicles, but most of them use alternative fuel, ultra low sulfur diesel, and emissions control devices. Taxis in Hong Kong SAR used to operate on diesel but as of the end of 2004, almost all taxis (nearly 100%) are using liquid petroleum gas (LPG). Some public light buses run on LPG (2,420 units at the end of July 2006, representing 56% of 4,300 public light buses), one on electricity, while those remaining are on diesel of pre-Euro, Euro 1, 2 and 3 models (370 Euro 3 units at the end of 2004). Franchised bus companies have used ultra low sulfur diesel since February 2001 (Hong Kong Transport Department [HKTD] 2004).

More than 11 million passenger journeys are made daily on a public transport system that includes two high-capacity railways, trams, buses, minibuses, taxis, and ferries (HKTD 2006b). Octopus cards that use contact-less smart card systems can be used in paying transport services such as railways, buses, minibuses, coaches, ferries, and parking meters (HKTD 2006a). The smart card system has been in place since 1997 and the number of daily transactions has reached over eight million in 2005 (HKTD 2005). Walkways have been improved and traffic calming was implemented in over 25 streets to encourage pedestrianization in between motorized trips. Traffic information service is also available to help commuters and motorists alike to plan their journeys (HKTD 2006b).

» Part Two

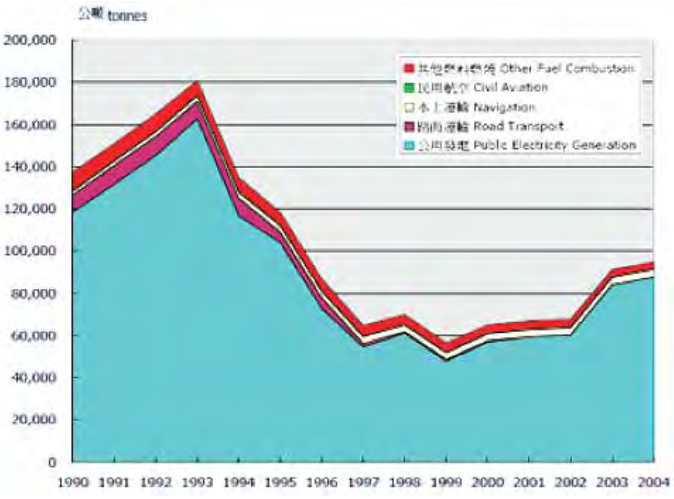
Sources of Air Pollution

The Environmental Protection Department (EPD) compiles emissions inventories annually for the following pollutants: Sulfur dioxide (SO_2), particulate matter (PM), Nitrogen oxides (NO_X), Carbon monoxide (CO), and non-methane volatile organic compounds (NMVOC). Figures 2.1–2.6 show the trends in emissions from 1990 to 2004 and the relative contributions from each of the sources.

Based on the graphs below, power plants continue to be the primary contributors of SO_2 (92%), NO_X (49%), and PM with diameter less than or equal to 10 micrometers (PM_{10}) (51%) emissions in Hong Kong SAR (Figures 2.1, 2.3, and 2.4). In 2005, electricity in Hong Kong SAR is generated mostly through the two coal power plants and only one plant runs on natural gas. In the early 1990s, a regulation that limited the sulfur content of industrial fuel significantly reduced SO_2 emission to very low levels. A downward tendency was observed until 1997, but recently, SO_2 emissions had increased (Figure 2.1).

FIGURE 2.1

Hong Kong SAR's SO_2 Emissions (tons)

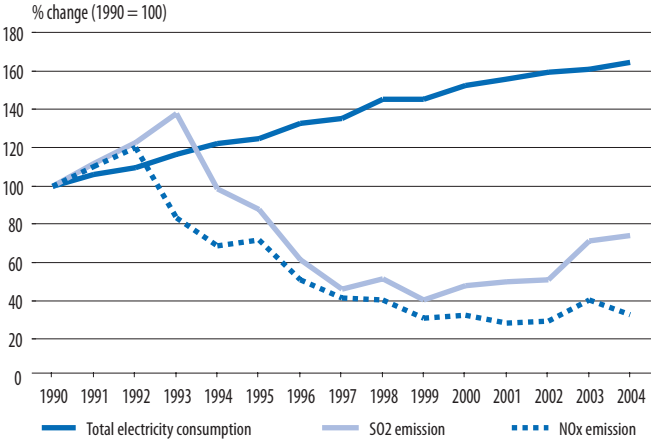


SO_2 = sulfur dioxide
Source: Environmental Protection Department 2006c. Air Pollutants and Greenhouse Gas Emission Inventory (1990-2004). May. Available at: www.epd.gov.hk/epd/english/environmentinhk/air/data/emission_inve.html.

SO_2 and NO_X emissions from power plants went down significantly over the years even if electricity demand had increased. This downward tendency was observed when the sulfur levels of industrial fuel were reduced (Figure 2.2).

FIGURE 2.2

Electricity Use and Corresponding Emissions from Power Plants



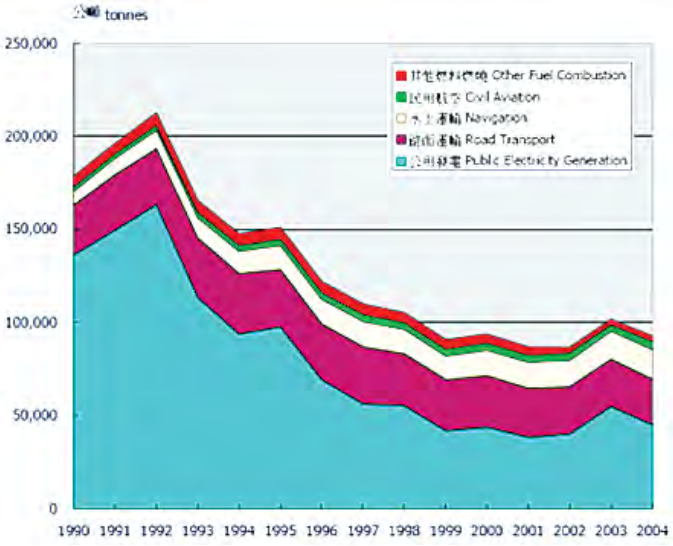
NO_X = Nitrogen oxide; SO_2 = Sulfur dioxide; % = percent
Source: Environmental Protection Department. 2006c. *An Overview on Air Quality and Air Pollution Control in Hong Kong.* June 8. Available at: www.epd.gov.hk/epd/english/environmentinhk/air/air_maincontent.html.

As mentioned previously, electricity generation is the primary contributor of NO_X emissions (49%), road transport (27%) comes second, followed by navigation (17%). The contributions of civil aviation and other fuel combustion sources are almost negligible at a combined 8%. (Figure 2.3)

The main sources of PM_{10} have been public electricity generation (51%) and road transport. The contributions of non-combustion sources, other fuel combustion, and navigation have been consistently lower when compared to the main two sources. Overall, PM_{10} emission levels had a downward tendency from 1992 to 2001. (Figure 2.4)

FIGURE 2.3

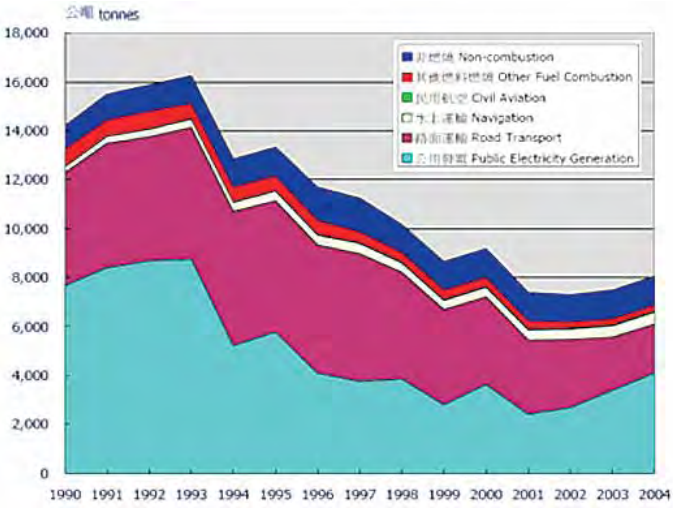
Hong Kong SAR's NO_x Emissions (tons)



NO_x = Nitrogen oxides; SAR = Special Administrative Region
Source: Environmental Protection Department 2006c. Air Pollutants and Greenhouse Gas Emission Inventory (1990-2004). May. Available at: www.epd.gov.hk/epd/english/environmentinhk/air/data/emission_inve.html.

FIGURE 2.4

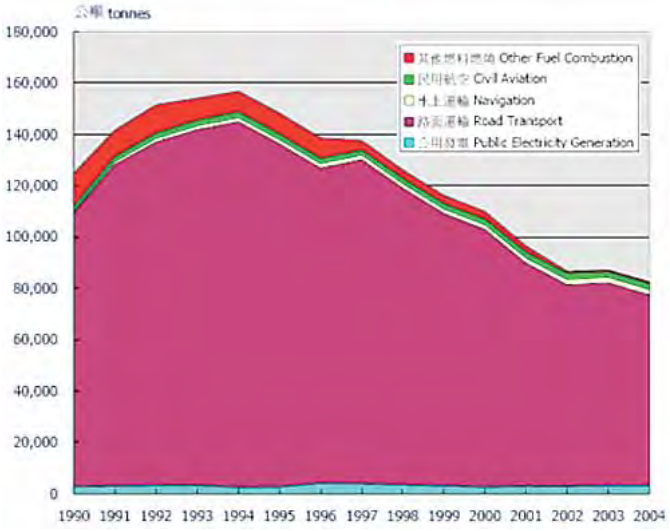
Hong Kong SAR PM Emissions (tons)



PM = particulate matter; SAR = Special Administrative Region
Source: Environmental Protection Department 2005. Air Pollutants and Greenhouse Gas Emission Inventory (1990-2004). December. Available at: www.epd.gov.hk/epd/english/environmentinhk/air/data/emission_inve.html.

FIGURE 2.5

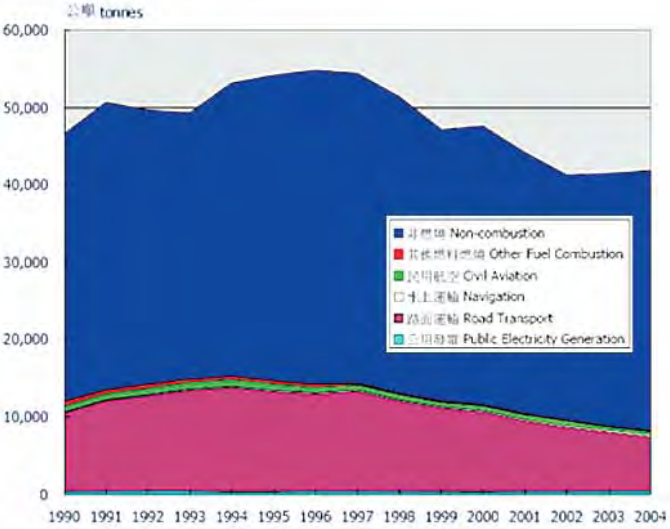
Hong Kong SAR CO Emissions (tons)



CO = Carbon monoxide; SAR = Special Administrative Region
Source: Environmental Protection Department 2005. Air Pollutants and Greenhouse Gas Emission Inventory (1990-2004). December. Available at: www.epd.gov.hk/epd/english/environmentinhk/air/data/emission_inve.html.

FIGURE 2.6

Hong Kong SAR's NMVOC Emissions (tons)



NMVOC = Non-methane volatile organic compound; SAR = Special Administrative Region
Source: Environmental Protection Department 2005. Air Pollutants and Greenhouse Gas Emission Inventory (1990-2004). December. Available at: www.epd.gov.hk/epd/english/environmentinhk/air/data/emission_inve.html.

Road transport emits the bulk of CO emissions (90%) and comes 2nd to power generation as source of PM_{10} and NO_X emissions. (Figure 2.5)

Non-combustion sources contribute most NMVOC emissions (80%), followed by road transport. Contributions of public electricity generation, civil aviation, and other fuel combustion to NMVOC are not as significant (Figure 2.6).

» Part Three

Status of Air Quality

Air Quality Monitoring

Hong Kong SAR has 14 fixed stations that continuously monitor pollutants. Eleven stations monitor ambient air and three stations monitor air from the roadside (Figure 3.1). The Air Science Group of EPD is responsible for the operation, maintenance, and management of these 14 fixed stations. The continuously monitored pollutants are SO_2, NO_X, NO_2, O_3, CO, lead (Pb), PM_{10}, and total suspended particulates (TSP).[1] Hong Kong SAR likewise uses reduced visibility as an indicator of air quality. Aside from criteria air pollutants, EPD also regularly monitors toxic air pollutants—volatile organic compounds (e.g., benzene, perchloroethylene and 1,3-butadiene), dioxins and furans (e.g., 2,3,7,8-Tetrachlorodibenzo-p-furan (2,3,7,8-TCDF), and 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), carbonyl compounds (e.g., formaldehyde), polycyclic aromatic hydrocarbons (e.g., benzo(a)pyrene), and hexavalent chromium.

Ad hoc monitoring is also done as a component of research studies by nongovernment institutions and the academe.

Hong Kong SAR works closely with Guangdong province to monitor air pollution in the Pearl River Delta region. The stations at Tung Chung, Tap Mun, and Tsuen Wan are included in both local and regional monitoring activities (Guangdong Provincial Environmental Protection Monitoring Centre and EPD, HKSAR 2005).

Local and regional air quality (AQ) monitoring activities undergo regular quality control and quality assurance checks to ensure accuracy and precision.

[1] Reported as particulate matter (PM) with diameter less than or equal to 10 micrometers, PM_{10}.

FIGURE 3.1

Location of EPD's Air Quality Monitoring Stations, 2005

EPD = Environmental Protection Department

Sources: Environmental Protection Department. 2006j. *Environmental Performance Report 2006.* Available: www.epd.gov.hk/epd/misc/er/er2006/english/contents.html.

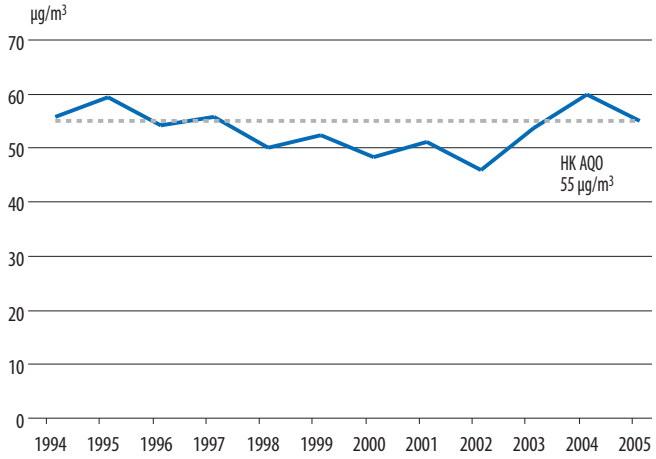
Air Quality Data

The primary pollutants of concern in Hong Kong SAR are particulates, both PM_{10} and TSP, which are proving difficult to control. Data from both general (ambient) and roadside stations show no clear trend. In general, the average annual concentrations of NO_2, CO, and SO_2 comply with their Air Quality Objectives (AQO) and are not problematic, except for roadside NO_2 levels that do not meet the AQO.

PM_{10} concentrations continue to fluctuate and show an overall decreasing tendency from 1994 to 2002, but start to increase afterward (Figure 3.2). Despite fluctuations between years, one may see an overall decrease in roadside PM_{10} levels between 1999 and 2005 due to the implementation of vehicle emission control measures in recent years. On the other hand, increases in PM_{10} concentrations in the ambient stations from 2000 indicate a rise in the regional background PM_{10} levels over the last few years. Current levels (2003 to 2005) of PM_{10} show non-attainment with respect to Hong Kong SAR's AQOs.

FIGURE 3.2

Annual Average PM_{10} Concentration

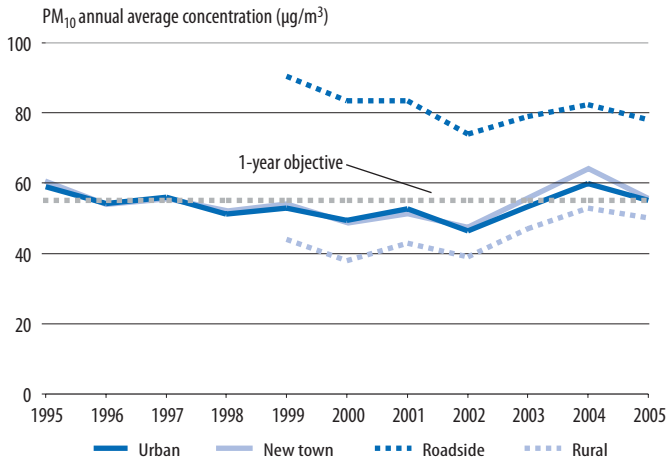


AQO = air quality objective; PM_{10} = particulate matter with diameter equal or less than 10 micrometers; µg/m³ = micrograms per cubic meter
Source: Environmental Protection Department. 2006a. Hong Kong Air Quality Trends. Unpublished data. Last updated 27 February.

Roadside PM_{10} levels are high, especially when compared against those of urban, new town, and rural PM_{10} levels (Figure 3.3). This might be attributed to vehicular emissions and re-suspended road dust. Nevertheless, between 1999 and 2005, roadside PM_{10} level has been reduced by 14% because of the comprehensive vehicle emission control program implemented in recent years. Urban and new town PM_{10} levels fluctuate and have shown noncompliance for the last 2 years. Rural PM_{10} levels currently meet the AQO but have started getting close to the annual limit.

FIGURE 3.3

PM_{10} Long-term Trends

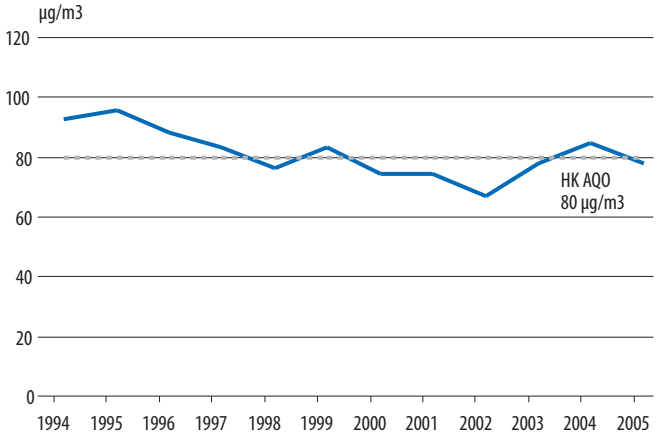


AQO = air quality objective; PM_{10} = particulate matter with diameter equal or less than 10 micrometers; µg/m³ = micrograms per cubic meter; AQO for annual average PM_{10} is 55 µg/m³
Source: Environmental Protection Department. 2006i. Hong Kong Air Quality Trends 2005. Available: www.epd-asg.gov.hk/english/report/files/aqt05e.pdf.

TSP concentrations are still being monitored in addition to PM_{10} monitoring. Annual average TSP concentrations have a downward tendency, but still fluctuate between compliance and noncompliance with AQO.

FIGURE 3.4

Annual Average TSP Concentration

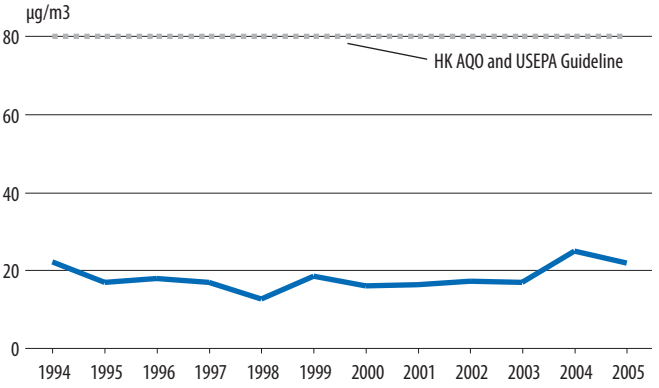


AQO = air quality objective; SPM = suspended particulate matter; SAR = Special Administrative Region; TSP = total suspended particulate matter; µg/m³ = micrograms per cubic meter; Hong Kong SAR AQO for annual average SPM is 80 µg/m³
Source: Environmental Protection Department. 2006a. Hong Kong Air Quality Trends. Unpublished data. Last updated 27 February.

SO_2 annual average concentrations have remained below AQO for the past 10 years (Figure 3.5).

FIGURE 3.5

Annual Average SO_2 Concentration

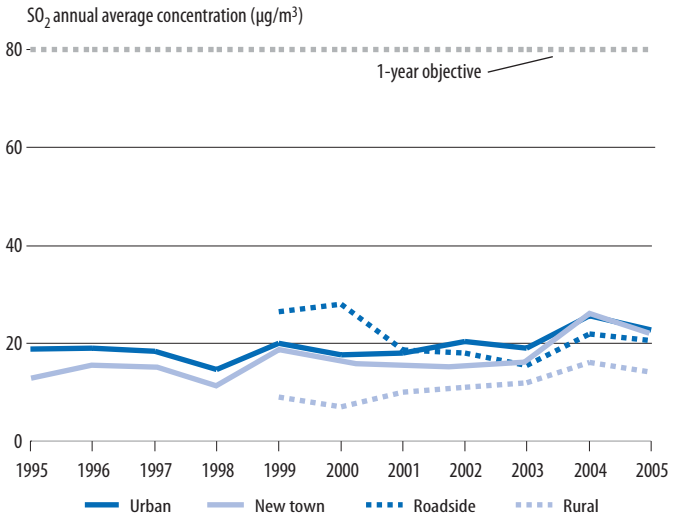


AQO = air quality objective; SAR = Special Administrative Region; SO_2 = sulfur dioxide; US EPA = United States Environment Protection Agency; µg/m³ = micrograms per cubic meter Hong Kong SAR's AQO for annual average SO_2 concentration is 80 µg/m³
Source: Environmental Protection Department. 2006a. Hong Kong Air Quality Trends. Unpublished data. Last updated 27 February.

Roadside SO_2 concentrations improved with the introduction of ultra low sulfur diesel in 2000 (Figure 3.6). Urban, new town, and rural SO_2 concentrations continue to comply with the annual AQO.

FIGURE 3.6

SO_2 Long-term Trends



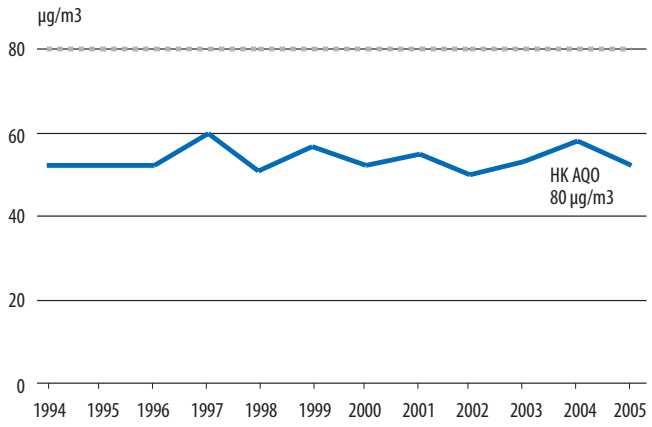
AQO = air quality objective; SAR = Special Administrative Region; SO_2 = sulfur dioxide; US EPA = United States Environment Protection Agency; µg/m³ = micrograms per cubic meter; Hong Kong SAR AQO for annual average SO_2 concentration is 80 µg/m³; equal to US EPA limit

Source: Environmental Protection Department. 2006i. Hong Kong Air Quality Trends 2005. Available: www.epd-asg.gov.hk/english/report/files/aqt05e.pdf.

NO_2 overall annual average concentrations fluctuate but still meet the AQO.

FIGURE 3.7

Annual Average NO_2 Concentration



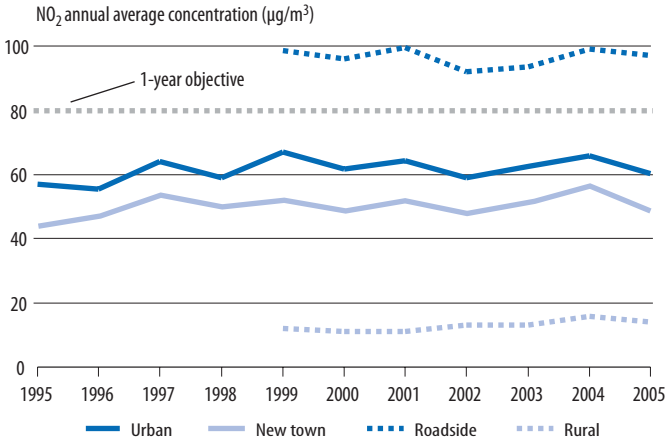
NO_2 = nitrogen dioxide; US EPA = United States Environment Protection Agency; µg/m³ = micrograms per cubic meter; US EPA Guideline value for annual average NO_2 concentration is 100 µg/m³

Source: Environmental Protection Department. 2006a. Hong Kong Air Quality Trends. Unpublished data. Last updated 27 February.

There is a big disparity with the roadside NO_2 levels when compared against the concentrations at the urban, new town, and rural areas (Figure 3.8). Roadside concentrations have not attained AQO since 1999. The reverse is true with the other areas.

FIGURE 3.8

NO_2 Long-term Trends



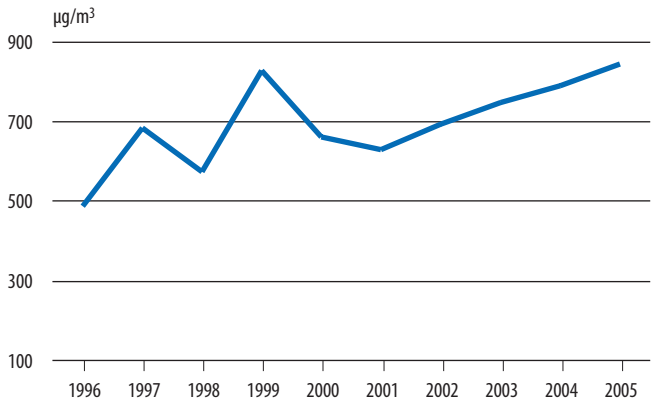
AQO = air quality objective; NO_2 = Nitrogen dioxide; µg/m³ = micrograms per cubic meter; AQO value for annual average NO_2 concentration is 80 µg/m³.

Source: Environmental Protection Department. 2006i. Hong Kong Air Quality Trends 2005. Available: www.epd-asg.gov.hk/english/report/files/aqt05e.pdf.

Figure 3.9 shows the long-term trend for 8-hour average concentrations of CO and Table 3.1 shows compliance details.

FIGURE 3.9

Annual Average CO Concentration



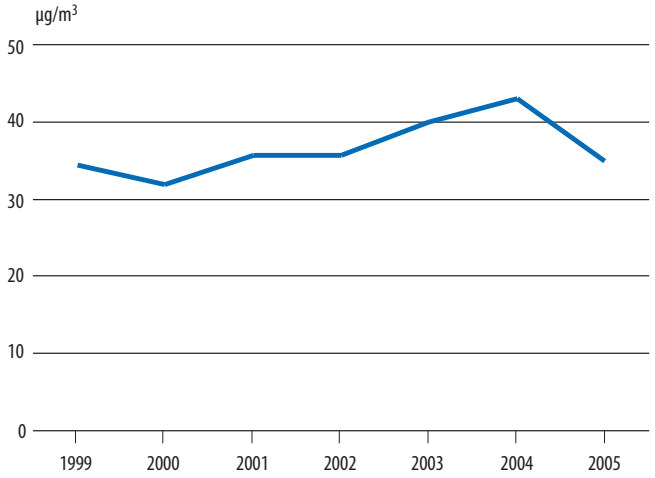
AQO = air quality objective; CO = carbon monoxide; µg/m³ = micrograms per cubic meter; Note that CO does not have an annual objective.

Source: Environmental Protection Department. 2006a. Hong Kong Air Quality Trends. Unpublished data. Last updated 27 February.

Figure 3.10 shows O_3 annual averages of 1-hour concentrations. Individual one-hour concentrations may exceed the standard, but are masked by the average. Peak concentrations of O_3 in excess of the AQO are shown in Table 3.1.

FIGURE 3.10

Annual 1-hour Average O_3 Concentration

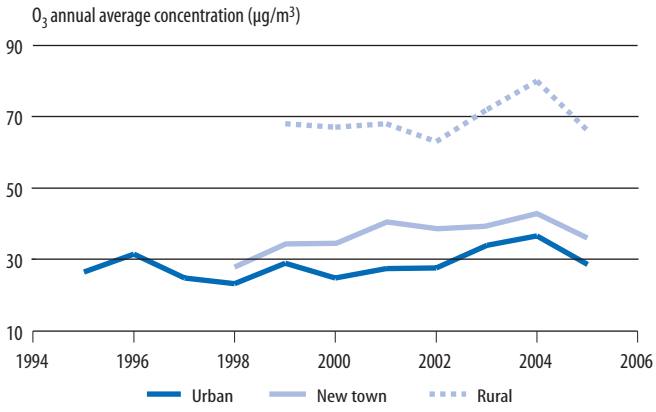


AQO = air quality objective; O_3 = ozone; µg/m³ = micrograms per cubic meter
Note: O_3 does not have an annual AQO. This graph shows the overall long-term trend.
Source: Environmental Protection Department. 2006a. Hong Kong Air Quality Trends. Unpublished data. Last updated 27 February.

The long-term trends of O_3 show that its concentrations in rural areas are higher than those in urban and in new town areas (Figure 3.11).

FIGURE 3.11

O_3 Long-term Trends



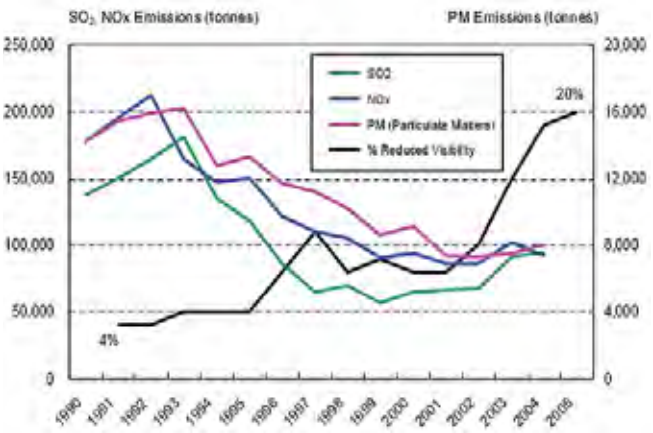
AQO = air quality objective; O_3 = ozone; SAR = Special Administrative Region; µg/m³ = micrograms per cubic meter; Hong Kong SAR AQO for 1-hr average O_3 is 240 µg/m³
Source: Environmental Protection Department. 2006i. Hong Kong Air Quality Trends 2005. Available: www.epd-asg.gov.hk/english/report/files/aqt05e.pdf.

For 2004, half of the parameters have complied with local AQOs. The stations with the most number of non-attainment were the stations in Yuen Long, Mong Kok, and Central.

Visibility in Hong Kong SAR is worsening and there seem to be no correlation between this parameter and the total emissions of NO_2, PM_{10}, and SO_2 in Hong Kong SAR. From 1993 to 1997, even though the emissions of the three pollutants generally decreased, visibility showed no sign of improvement. However, from 2001 to 2004, increased levels of PM_{10} and SO_2 were observed along with further reduction in visibility. The chart in Figure 3.12 illustrates the fact that despite substantial reductions in local emissions of various pollutants, visibility has dropped, indicating a deterioration of regional AQ over the years. The sources of the visibility-reducing particulates appear likely to include sources in the Pearl River Delta, as discussed later.

FIGURE 3.12

Air Pollutant Emissions and Reduced Visibility in Hong Kong SAR



NO_x = Nitrogen oxides; PM = particulate matter; SAR = Special Administrative Region; SO_2 = Sulfur dioxide; % = percent
Source: Environmental Protection Department. 2006h. Review of Hong Kong SAR's AQOs. Available: www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/files/Air_Quality_objectives_review.pdf.

TABLE 3.1

Hong Kong SAR's Air Quality Achievement Status

		Measured Highest Concentrations in 2004 (µg/m³)		Status of Achievement	
Pollutants	Averaging Time	Type of Station	Location	% of AQO at Highest Concentration	Evaluation of Achievement
SO_2	1-hour	Ambient	432 (Tung Chung)	54	Well achieved
		Roadside	494 (Central)	62	Well achieved
	24-hour	Ambient	171 (Yuen Long)	49	Well achieved
		Roadside	147 (Mong Kok)	42	Well achieved
	Annual	Ambient	32 (Kwai Chung)	40	Well achieved
		Roadside	28 (Central)	35	Well achieved
NO_2	1-hour	Ambient	317 (Yuen Long)	106	Not yet achieved
		Roadside	386 (Central)	129	Not yet achieved
	24-hour	Ambient	169 (Kwun Tong)	113	Not yet achieved
		Roadside	203 (Central)	135	Not yet achieved
	Annual	Ambient	70 (Kwai Chung and Sham Shui Po)	88	Achieved
		Roadside	105 (Central and Mong Kok)	131	Not yet achieved
Respirable	24-hour	Ambient	225 (Yuen Long)	125	Not yet achieved
suspended		Roadside	222 (Causeway Bay)	160	Not yet achieved
particulates	Annual	Ambient	71 (Yuen Long)	129	Not yet achieved
		Roadside	88 (Causeway Bay)	160	Not yet achieved
TSP	24-hour	Ambient	320 (Yuen Long)	123	Not yet achieved
		Roadside	220 (Mong Kok)	85	Achieved
	Annual	Ambient	113 (Yuen Long)	141	Not yet achieved
		Roadside	124 (Mong Kok)	155	Not yet achieved
O_3	1-hour	Ambient	403 (Tung Chung)	168	Not yet achieved
CO	1-hour	Ambient	3940 (Tung Chung)	13	Well achieved
		Roadside	4830 (Central)	16	Well achieved
	8-hour	Ambient	3385 (Tung Chung)	34	Well achieved
		Roadside	3423 (Mong Kok)	34	Well achieved
Pb	3-month		0.322	21	Well achieved

AQO = air quality objectives; CO = Carbon monoxide; NO_2 = Nitrogen dioxide; Pb = lead; O_3 = ozone; SAR = Special Administrative Region; SO_2 = Sulfur dioxide; TSP = total suspended particulates; µg/m³ = micrograms per cubic meter; % = percent

Source: Environmental Protection Department. 2006h. Review of Hong Kong SAR's AQOs. Available at: www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/files/Air_Quality_objectives_review.pdf.

Reporting of AQ Information

EPD reports Hong Kong SAR's AQ on its website (Environmental Protection Department 2006c), through its annual publications and through broadcast media such as TV and radio. AQ monitoring results—reported as air pollution indexes (API), hourly monitoring data from the 11 general and three roadside stations, emission inventories, and their corresponding archives—can be accessed on EPD's website.

API reports the air pollution levels that come with a corresponding health-related advisory for the public that depends on the nature of the originating AQ monitoring station. APIs are based on hourly monitoring data from its 14 stations and API readings are reflected hourly at the EPD website. Table 3.2 shows the API and the corresponding advisory for general and roadside APIs.

Progress reports on 2010 emission reduction targets set by Hong Kong SAR and Guangdong to address regional air pollution in the Pearl River Delta are released every 6 months. A regional air quality index (RAQI) that is a composite indicator of the aggregate level of four major regional pollutants PM_{10}, SO_2, NO_2, and O_3 is reported for each of the stations covered in the Pearl River Delta Regional Monitoring Network. The progress reports and the RAQI are available on their website (Pearl River Delta Regional Monitoring Network Website. Available at: http://61.144.36.8/equality2/raqi/eng.aspx),

TABLE 3.2

Hong Kong SAR's Air Pollution Index

Air Pollution Level		API	General API	Roadside API
Severe	Black	201–500	The general public are advised to reduce physical exertion and outdoor activities	The general public are advised to avoid prolonged stay in areas with heavy traffic. If it is necessary to stay in streets or roads with heavy traffic, they are advised to reduce physical exertion as far as possible.
Very High	Red	101–200	Persons with existing heart or respiratory illnesses (such as coronary heart and cardiovascular diseases, asthma, chronic bronchitis, and chronic obstructive airway diseases) are advised to reduce physical exertion and outdoor activities	Persons with existing heart or respiratory illnesses (such as coronary heart and cardiovascular diseases, asthma, chronic bronchitis, and chronic obstructive airway diseases) are advised to avoid prolonged stay in areas with heavy traffic. If it is necessary to stay in streets or roads with heavy traffic, they are advised to reduce physical exertion as far as possible.
High	Yellow	51–100	No immediate response action is suggested – Long-term effects may, however, be observed if exposed at this level persistently for months or years	
Medium	Turquoise	26–50	No response action is required.	
Low	Green	0–25	No response action is required.	

API = air pollution index; SAR = Special Administrative Region

Source: Environmental Protection Department. 2004. API: Advice to the public. November 2. Available at: www.epd-asg.gov.hk/english/advice/advice.php.

» Part Four

Impacts of Air Pollution

Reports of studies on impacts of air pollution on health and economics by academic institutions are available through EPD's website (EPD 2006b). Among those studies are about the short-term health effects (Wong et. al. 1999) of pollutants and their behavior against the frequency of hospital admissions due to cardiovascular and respiratory diseases and age bracket. The study reported that the relative risk for admissions for respiratory disease were from 1.013 (for SO_2) to 1.022 (for O_3), and for admissions for cardiovascular disease, from 1.006 (for PM_{10}) to 1.016 (for SO_2). There were positive correlations among the pollutants NO_2, O_3, and PM_{10}. O_3 levels and its positive correlation to hospital admissions were observed during winter months. Other studies correlating the behavior of pollutants against cardio-respiratory diseases and mortality include those of Hedley and others in 2002, which observed the effect of sulfur reduction; and Wong and others in 2002, which investigated the effects on daily mortality counts of air pollutants. In most of these studies, it was observed that residents 65 years old and over were found to be most at risk.

The American Chamber of Commerce through ACNielsen (American Chamber of Commerce 2006) recently facilitated a study on the impact of air pollution in Hong Kong SAR on its foreign investments. The results of the study showed that the business community had difficulties in recruiting professionals to work in Hong Kong SAR because of the quality of Hong Kong SAR's environment. Fifty-five percent of the respondents personally knew of professionals who declined job opportunities in Hong Kong SAR due to this factor. The quality of natural environment actually topped the list of factors in choosing their residence, where 94% of respondents ranked it as the most important or the 2nd most important factor. Fifty-six per cent believed that more investments would come to Hong Kong SAR if it had a cleaner environment and better air quality.

Synovate's survey findings released in January 2005 showed that air pollution adversely affected 96% of Hong Kong SAR residents. Sixty-nine percent of Hong Kong SAR respondents felt that their overall AQ worsened and that pollution was caused mainly by motor vehicles (72%). The survey also showed that Hong Kong SAR residents were willing to take individual responsibility to improve their environment (Synovate 2005).

» Part Five

Air Quality Management

Legislation and Mandate

Hong Kong was a British colony from 1841 until 30 June 1997 before it became a Special Administrative Region (SAR) of the People's Republic of China (PRC) under the Sino-British Joint Declaration of 1984. Most components of this declaration were adopted and implemented pursuant to the Basic Law—the basis of Hong Kong SAR's legal system that espouses the principle of "one country, two systems." In this regard, Hong Kong SAR has a separate environmental department from the PRC. Hong Kong SAR's EPD is responsible for both policy development and implementation to control local air pollution. However, there is still some ambiguity about engaging in external agreements with respect to the environment (GIC, no date).

Hong Kong SAR's 1st Clean Air Act of 1959 focused on controlling emissions from fuel combustion.

The 1983 Air Pollution Control Ordinance (APCO) provides the statutory framework that enables the establishment of AQO and subsidiary regulations to address emissions control from vehicle exhausts, construction dust, and major stationary sources. APCO divides Hong Kong SAR into 10 air control zones that target a uniform set of AQOs for the following air pollutants: SO_2; SPM—both respirable (PM_{10}) and total (TSP); NO_2; CO; photochemical oxidants, mostly O_3; and Pb. APCO operates through various technical memoranda, one of which establishes AQOs for each zone. Other memoranda also set out principles, procedures, guidelines, standards, and limits for prediction, measurement, assessment, and determination of air pollution and serving abatement notice (Mottershead, T. 2002). Important regulations for stationary, mobile, and area sources are listed in Table 5.1.

To address regional pollution, EPD works closely with Guangdong Environmental Protection Bureau (Mok Wai-chuen 2006). Their consensus with Guangdong in April 2002 (Guangdong Provincial Environmental Protection Monitoring Centre and EPD, HKSAR 2006) was to reduce on a best-endeavor basis the emission of four major air pollutants namely SO_2, NO_X, PM_{10}, and VOC by 40%, 20%, 55%, and 55% respectively in the region by 2010, using 1997 as the base year. Achieving these targets would enable Hong Kong SAR to meet its own AQOs, while improving the AQ of the Pearl River Delta, and alleviate the regional smog problem. The two governments jointly drew up the Pearl River Delta Regional AQM Plan ("Management Plan") in December 2003 with the goal of meeting the emission targets and set up the Pearl River Delta AQM and Monitoring Special Panel under the Hong Kong SAR/Guangdong Joint Working Group on Sustainable Development and Environmental Protection for this purpose.

Ambient AQ Standards

Hong Kong SAR enforces its locally established AQOs, apart from the PRC's national AQ standards. Hong Kong SAR's AQO was developed mainly by referring to researches done in the United States (EPD 2006g). AQO is a set of target ambient levels for the pollutants SO_2, TSPs, respirable suspended particulates, NO_2, CO, Pb, and O_3.

Hong Kong SAR's AQOs are set for general ambient air, which are applicable to open places where people can gain access and normally stay for a period comparable with the averaging time of AQO. Since air-monitoring data collected at the roadside may reflect the air pollution source strength (i.e., road traffic emissions) only, it can hardly be used to represent the general ambient AQ. Also, as roadside is a hot spot and very few people stay at the roadside for such a prolonged period as a year, the annual AQO is less relevant to roadside air quality. The short-term (1-hour to 24-hour) AQOs are relevant as some people may stay near the street during daytime.

TABLE 5.1
Air Pollution Control Regulations in Hong Kong SAR

Source	Regulation	Year	Components
Stationary	Dust and grit emission	1974	Emission standards; assessment procedures; and requirements for particle emissions
	Specified processes	1987	Control of facility constructions, emissions, and processes
	Furnaces, ovens, and chimneys (installation and alternation)	1972	
	Smoke	1983	Control of emissions from combustion sources
	Fuel restriction	1990	For industrial uses, only diesel with less than 0.5% sulfur content is allowed
	Dry-cleaning machines	2001	Control of machine types; recovery of vapors (esp. perchloroethylene)
Mobile	Motor vehicle fuel	1991	Provides fuel specifications for vehicle use
	Vehicle design standards (Emission)	1992	Vehicle design standards for certain motor vehicles
	Motor vehicle fuel	1994	Ban of leaded petrol
	Vehicle emission standards	2001	Euro 3 standards for newly registered vehicles
	Motor vehicle fuel	2002	Maximum 50 ppm sulfur for diesel equivalent to Euro 4 standards
	Emission reduction devices	2003	Pre-Euro diesel vehicles are required to install approved emission reduction devices
	Motor vehicle fuel	2005	Maximum 50 ppm sulfur in petrol equivalent to Euro 4 standards
	Vehicle emission limit	2006	Euro 4 emission limits for petrol vehicles
	Motor vehicle fuel	Proposed for 2009	Maximum 10 ppm sulfur in diesel and petrol that are equivalent to Euro 5 standards
Area	Building regulations	1962	Control of pollution from demolition works
	Open burning	1996	Control of open burning of construction waste, disposal of tyres, and salvage metal
	Petrol filling stations (vapor recovery)	1999, amended 2004	Installation of vapor recovery equipment at petrol filling stations and petrol delivery vehicles and application of good practices in petrol unloading (1999), and extends the requirement for vehicle refuelling (2004)
	Construction dust	1997	Control of dust emitted from construction works
Asbestos	APCO, Parts VIII and IX	1993	Requiring employment of registered asbestos professionals to carry out work that involve asbestos-containing materials and banning of the import and sale of blue and brown asbestos
Refrigerants and Halons	Ozone layer protection (products containing scheduled substances)	1993	Prohibition of the import of portable fire extinguishers containing halons not complying with Montreal Protocol
	Ozone layer protection (controlled refrigerants)	1994	Conservation of controlled refrigerants from scale installations and motor vehicles

APCO = Air Pollution Control Ordinance; LPG = liquefied petroleum gas; ppm = parts per million; SAR = Special Administrative Region
Sources: Environmental Protection Department. 2006f. Personal correspondence of Tse Chin-Wan to Aurora Ables. 06 Nov.
Mottershead, T. Hong Kong. In: Mottershead, T. (Ed.) 2002. *Environmental Law and Enforcement in the Asia-Pacific Rim.* Chapter 5, pp.137–203. Sweet & Maxwell Asia, Hong Kong, Singapore, Malaysia.

These objectives (Table 5.2) are based on different averaging times that are locally specific. Their stringencies vary when compared to US and WHO standards. WHO has since amended its guidelines in 2000 and a global update was made in 2005. In light of these developments, the government has organized a forum (EPD 2006f) that is open to the public on reviewing the AQOs and will conduct a study to examine the local situation for deciding the suitable targets and strategies for revising the current AQOs (Tsang 2006).

TABLE 5.2

Current Hong Kong SAR's AQOs and WHO AQ Guidelines (μg/m³)

Pollutant	Averaging Time	HK SAR's AQO	WHO AQG for Europe (2000)	Updated WHO AQG (2005)	US EPA
SO_2	10-minute	–	500	500	
	1-hour	800[d]	–	–	
	24-hour	350[e]	125	20 (IT-1:125, IT-2:50)	365 (0.14 ppm)[a,e]
	Annual	80	50	–	80 (0.03 ppm)[a,e]
TSP	24-hour	260[e]	–	–	
	Annual	80	–	–	
Respirable Suspended Particulate (PM_{10})	24-hour	180[e]	No guideline values are recommended but provided the dose response relationships	50 (IT-1:150, IT-2:100, IT-3:75)	150[e]
	Annual	55	–	20 (IT-1:70, IT-2: 50, IT-3:30)	50[b]
Fine Suspended Particulate ($PM_{2.5}$)	24-hour	–	No guideline values are recommended but provided the dose response relationships	25 (IT-1:75, IT-2: 50, IT-3: 37.5)	65
	Annual	–	–	10 (IT-1:35, IT-2: 25, IT-3:15)	15[c]
NO_2	1-hour	300[d]	200	200	
	24-hour	150[e]	–	–	
	Annual	80	40	40	100 (0.053 ppm)
O_3	1-hour	240[d]	120	–	253 (0.12 ppm)[f]
	8-hour	–	–	100 (IT-1:160)	157 (0.08 ppm)
CO	15-minute	–	100,000	40	
	30-minute	–	60,000	–	
	1-hour	30,000[e]	30,000		40,000 (35 ppm)[e]
	8-hour	10,000[e]	10,000	–	10,000 (9 ppm)[e]
Pb	3-month	1.5	–	–	1.5
	Annual	–	0.5	–	

AQG = Air Quality Guidelines; AQO = air quality objectives; CO = Carbon monoxide; IT = interim target; NO_2 = Nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter with diameter equal or less than 2.5 micrometers; PM_{10} = particulate matter with diameter equal or less than 10 micrometers; ppm = parts per million; SAR = Special Administrative Region; SO_2 = Sulfur dioxide; TSP = total suspended particulate; WHO = World Health Organization; yr = year; μg/m³ = micrograms per cubic meter

[1] As Sulfur oxides.

[2] To attain this standard, the 3-yr average of the weighted annual mean PM_{10} concentration at each monitor within an area must not exceed 50 μg/m³.

[#] To attain this standard, the 3-yr average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15 μg/m³.

[4] Not to be exceeded more than thrice per year.

[5] Not to be exceeded more than once per yr; 6 = the standard is attained when the expected number of days per calendar yr with maximum hourly average concentrations above 0.12 ppm is ≤ 1, as determined by appendix H of US EPA National Ambient Air Quality Standards. As of 15 June 2005, US EPA revoked the 1-hr ozone standard in all areas, except the 14 8-hr ozone non-attainment early action compact areas.

Source: United States Environmental Protection Agency. National Ambient Air Quality Standards. Available: www.epa.gov.air/criteria.html.

World Health Organization. 2005. WHO Air Quality Guidelines Global Update 2005 Meeting Report. Bonn, Germany. 18-20 October. Available: www.euro.who.int/Document/E87950.pdf.

Management of Mobile Sources

Vehicles, especially diesel trucks, buses, and light buses, are regarded as one of the main sources of pollutants such as PM_{10} and NO_X. Hong Kong SAR controls emissions from mobile sources as written in the Air Pollution Control Ordinance and through subsidiary regulations on fuel quality, standard vehicle designs, and the use of emissions control devices (Table 5.1).

Hong Kong SAR's EPD has developed fuel and vehicle emission standards as part of a comprehensive motor vehicle emission control program in 2000. These regulations are the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations (for newly registered vehicles) and the Air Pollution Control (Motor Vehicle Fuel) Regulation. These two sets of standards are at par with the most stringent ones adopted by the USA, the European Union, and Japan. For vehicles, noncompliance

would mean no registration from the Transport Department; while motor vehicle fuels that do not meet the specifications would not be supplied, distributed nor sold. In 2001, newly registered vehicles complied with Euro 3 emission standards. From January 2006, Euro 4 emission standards were introduced as part of the measures to achieve the 2010 emission targets with Guangdong. Ultra low sulfur diesel equivalent to Euro 4 requirements has been the minimum statutory standard for automotive diesel since April 2002. Starting in 2005, Euro 4 equivalent petrol requirements that reduce sulfur limits to a maximum of 50 ppm were implemented. Hong Kong SAR's Government is proposing to further reduce the limits to max 10 ppm sulfur in diesel (Euro 5 equivalent) at the same time as Europe, possibly in 2009 (Mok 2006).

The same comprehensive program in 2000 increased the penalty for smoky vehicles from HK$450–1,000. An advanced smoke test on a chassis dynamometer was introduced and this was included as part of obtaining a certificate of roadworthiness. Only licensed vehicles are allowed to operate in the city and such certificate is required to process the licenses. Private vehicles older than 6 years are required to get a certificate every year. Goods vehicles, special purpose vehicles, buses, and taxis must obtain this certificate each year. The certificate of roadworthiness is also required on an annual basis for private cars older than 6 years. Hong Kong SAR Government is preparing a proposal to extend the enhanced control of emissions from in-use petrol and LPG vehicles by testing their emissions using chassis dynamometer and remote sensing equipment. The government also will earmark HK$3.2 billion to help owners of 74,000 older diesel commercial vehicles convert to newer models that meet Euro 4 emission standards (Tsang 2006).

Over half of public light buses and nearly all taxis were switched from diesel to LPG through two separate one-off grant schemes (Mok 2006). Older pre-Euro diesel trucks and vans were fitted with particulate emission reduction devices through government assistance and mandatory retrofits. The Air Pollution Control (Emission Reduction Devices for Vehicles) Regulation that came into effect on 1 December 2003 required diesel light vehicles up to 4 tons and first registered on or before 31 March 1995 to be installed with particulate reduction devices. The installation requirements of this regulation were extended to pre-Euro heavy diesel vehicles that are over 4 tons, except long-idling vehicles, from 1 April 2006. Hence, with the exception of motorcycles, special purpose vehicles and long-idling vehicles, all vehicle classes listed in the regulation were required to have approved emission reduction devices and keep these devices in good working condition. The vehicle license renewal application might be refused or its vehicle license might be canceled if the vehicle was found contravening the requirements of the regulation while running on-road (EPD 2006e). In line with the policy of requiring pre-Euro diesel vehicles to be retrofitted with emission reduction devices, EPD plans to make the retrofit mandatory also for long-idling pre-Euro diesel vehicles such as concrete mixer, lorry crane, gully emptier, and pressure tanker in 2007 (EPD 2006g).

To promote the use of energy efficient products, the Hong Kong SAR Electrical and Mechanical Services Department operates a voluntary Energy Efficiency Labeling Scheme (EELS) for household and office appliances and vehicles (Electrical and Mechanical Services Department 2004). Under the scheme for petrol passenger cars, vehicles will carry an energy efficiency label that informs customers of their fuel efficiency under different road conditions. To encourage people to reduce pollution with the use of new technologies, a 30% reduction in first registration tax will be given to people who purchase vehicles with low emissions and high fuel efficiency (Tsang 2006).

The Hong Kong SAR Transport Department has prioritized efficient and environmentally friendly transport modes such as public transportation and interchange schemes that offer discounts to passengers when using the any combination of the two transport modes such as bus-rail, bus-bus, and (airport) taxi-rail. Rationalization of bus routes and stops, and park-and-ride schemes, pedestrian schemes in over 30 streets and traffic calming measures in more than 25 streets have been have been implemented since March 2000 to optimize trips, reduce vehicle/pedestrian conflicts, and encourage the use of public transportation (HKTD 2004).

Management of Stationary and Area Sources

Hong Kong SAR manages its stationary sources of air pollution by controlling the installations and equipment that produce emissions, directly monitoring emissions from the industries, and regulating fuel quality.

The Air Pollution Control Ordinance and its subsidiary regulations control emissions from power plants, industrial and commercial sources,[1] construction activities, open burning, asbestos, petrol filling stations, and dry-cleaning machines.

Certain industries that involve fuel combustion through furnaces, ovens, and boilers are required to submit the specifications of its fuel-burning equipment and undergo an environmental assessment of its design before they are allowed by EPD to erect installations or to alter. A permit to install or alter equipment is required if the projected fuel consumption capacity would exceed the following: 25 liters of conventional liquid fuel per hour, 35 kilograms of conventional solid fuel per hour, or 1,150 megajoules[2] of gaseous fuel per hour.

Sulfur levels in industrial fuel were reduced to not more than 0.5% by weight through a regulation passed in 1990.

Part of the measures to achieve the 2010 emission targets with Guangdong province were to require the installation of vapor recovery systems for vehicle refueling at petrol filling stations since 31 March 2005. They also required the power companies to take emission reduction measures and increase the use of natural gas in electricity generation. The government has imposed emission caps on power plants at Castle Peak, Black Point, and Lamma Island. These emission caps will be progressively tightened to meet the 2010 emission reduction targets. Also, the need to protect the environment will be the focus of negotiations with the power companies over their new schemes of control, and their permitted rate of return will be linked to their achievement of the emission caps. A regulation to restrict the VOC content in selected products will be introduced soon (Tsang 2006).

[1] The list of processes that are subject to more stringent emission control include: Acrylates Works, Aluminium Works, Cement Works, Ceramic Works, Chlorine Works, Copper Works, Electricity Works, Gas works, Iron and Steel Works, Metal Recovery Works, Mineral Works, Incinerators, Petrochemical Works, Sulfuric Acid Works, Tar and Bitumen Works, Frit Works, Lead Works,

[2] 1 Megajoule = $1x10^6$ joules

Public and Nongovernment Participation

In addition to these regulations, the government has mobilized initiatives such as Action Blue Sky Campaign in July 2006 to promote public participation in support of Hong Kong SAR's clean air objectives. The government has been encouraging motorists to switch off their vehicle engines while waiting, and will consult the public on whether legislation should be introduced to enforce this practice (Tsang 2006).

Public consultations and consultations with concerned parties on new laws and guidelines related to AQ are normally held before these laws and guidelines are finalized. The most recent forum was held in September 2006 to seek views from stakeholders on reviewing the current AQO with respect to the latest developments in international AQ guidelines set by the US, the European Council, and WHO. Volunteer societies such as Clear the Air[3] and Civic Exchange[4] act as watchdogs and provide a platform for the local community to address AQ issues in Hong Kong SAR.

Independent research and studies are done on an ad hoc basis by the academe and nongovernment institutions. The results from these studies are posted alongside official documents in the EPD website.

[3] Clear the Air was registered as a society in December 1997 as a response to Hong Kong SAR Legislative Council's (LegCo) refusal to pass the Hong Kong SAR Government's recommendation to increase fines for vehicles that emit black smoke from HK$450 (US$60) to HK$1,000 (US$130). Clear the Air has since discussed other air quality issues such as pollution from power plants, indoor smoking, and diesel engines among others. See: www.cleartheair.org.hk/about.htm.

[4] See Civic Exchange Website: www.civic-exchange.org/index.php?cat=88.

» Part Six

Conclusion

Hong Kong SAR has a high capacity of managing its air quality, including an advanced regulatory system, adequate financial resources, expert technical capacity, and strong public acceptance in support of the activities. This system has been relatively successful in bringing most air pollutants under control, but a number of issues remain—including control of particulate matter and ozone. To address these issues will require the successful implementation of measures both in Hong Kong SAR, and in neighboring regions, such as Guangdong province. The primary local source of air pollution is electricity generation, closely followed by road transport activities.

Hong Kong SAR's AQM is considered to be ahead of most of its Asian counterparts because it has come up with local measures and collaborated with Guangdong province under a consensus reached in 2002 to address regional air pollution in the Pearl River Delta.

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