CHAPTER 2

Environment Bureau
Environmental Protection Department
Transport and Housing Bureau
Transport Department
Marine Department

Implementation of air-quality improvement measures

Audit Commission
Hong Kong
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IMPLEMENTATION OF AIR-QUALITY IMPROVEMENT MEASURES

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Executive Summary

1. Air pollution is one of the major problems in Hong Kong. The Environment Bureau (ENB) and the Environmental Protection Department (EPD) are responsible for formulating and implementing environmental policies, including those on air quality. In 2012-13, the EPD's estimated expenditure on managing air quality is $627 million.

2. The existing air quality objectives (AQOs) in Hong Kong were set in 1987, some 25 years ago. The AQOs stipulate the concentration levels for seven major air pollutants, of which sulphur dioxide (SO_2), nitrogen dioxide, and particulate matters with a diameter of 10 micrometres or less (PM_{10}) are the most relevant and significant ones in Hong Kong. The major sources of air pollution in Hong Kong are motor vehicles, marine vessels and power plants as well as emissions from the Pearl River Delta (PRD) region.

3. Under the Air Pollution Control Ordinance, the EPD, as the Air Pollution Control Authority, is tasked to aim to achieve the AQOs as soon as is reasonably practicable and thereafter to maintain the quality so achieved. In the past decade, through the EPD's efforts, concentrations of SO_2, PM_{10} and carbon monoxide have been reduced in Hong Kong. In January 2012, the Government announced that, based on the Air Quality Guidelines issued in 2006 by the World Health Organisation, the AQOs in Hong Kong would be revised to more stringent levels with effect from 2014 (2014 AQOs). To meet the 2014 AQOs, the Government would, subject to resource availability, implement 22 air-quality improvement measures.

Emission control of vehicles

4. In 2010, emissions from vehicles accounted for 30% of nitrogen oxides (NOx) and 21% of PM_{10} of the total emissions in Hong Kong. In 2011, five of the 13 roadside AQO measurements had exceeded the AQO limits and there were 172 days with the roadside air pollution index exceeding the very high air pollution level of 100, ranging from 101 to 192. According to the EPD, diesel commercial vehicles were the main source of roadside pollution.

5. ***A significant number of high-polluting vehicles still in service.*** As of March 2012, there were 131,490 diesel vehicles, including 120,990 commercial vehicles (e.g. goods vehicles, non-franchised buses and light buses) and 5,800 franchised buses. Diesel vehicles registered before October 2001 (known as pre-Euro, Euro I and Euro II vehicles) are far more polluting than those registered since October 2006 (known as Euro IV and Euro V vehicles). To replace the high-polluting diesel vehicles, the EPD has launched since 2000 four one-off grant schemes. Whilst the 2000 Taxi Grant Scheme and the 2002 Public Light Bus Grant Scheme had replaced 99.8% and 54% respectively of the diesel taxis and diesel public light buses, the 2007 Grant Scheme for replacing the pre-Euro and Euro I diesel commercial vehicles was less than effective as it had only replaced 29% of the pertinent vehicles. Similarly, as of March 2012, the 2010 Grant Scheme (which will take place until June 2013) had only replaced 11% of the Euro II diesel commercial vehicles. As a result, 44% of the 120,990 diesel commercial vehicles running on the street were high-polluting ones (pre-Euro, Euro I and Euro II vehicles). Audit considers that the EPD needs to formulate better strategies for reducing the number of high-polluting vehicles running on the street.

6. ***Slow progress in implementing bus-route rationalisation.*** According to the EPD, franchised buses could account for up to 40% of the total vehicular emissions at busy traffic locations, causing health risks. The EPD consultant also estimated that a 10% reduction of bus trips could help reduce 156 tonnes of roadside NOx emissions, and the rationalisation of bus services was the most cost-effective air-quality improvement measure as it did not involve significant additional costs for implementation. However, Audit has found that from 2009 to 2011, only 1.1% of bus trips had been reduced in three busy locations.

Emission control of marine vessels

7. In 2010, emissions from marine vessels accounted for 48% of SO_2, 36% of PM_{10}, and 32% of NOx of the total emissions in Hong Kong. According to the International Maritime Organisation (IMO), air pollution from vessels is substantial and growing, causing serious and increasing public health and environmental impacts. Due to increased maritime activities in Hong Kong and the PRD region, emissions from vessels have substantially increased and become a significant source of air pollution in Hong Kong.

8. ***Delay in adopting the IMO 2010 standards.*** Legislative amendments were effected in June 2008 to adopt the IMO 2005 Standards which governed the sulphur content of vessel fuel and NOx emissions by vessel engines, but up to September 2012, similar amendments had not been made to adopt the more stringent IMO 2010 Standards which should have been adopted by consenting members of the IMO (including Hong Kong) with effect from July 2010. Owing to the lack of legal backing, the Marine Department cannot refrain ocean-going vessels from using high sulphur-content fuel and engines with high NOx emissions in Hong Kong waters.

9. ***Slow progress in requiring local and river-trade vessels to use ultra-low-sulphur diesel.*** Local and river-trade vessels in Hong Kong are normally fuelled by diesel with a sulphur limit of 0.5%. Although the EPD had once completed a trial scheme for local ferries to use ultra-low-sulphur diesel (with a sulphur limit of 0.005%), up to September 2012, local and river-trade vessels had still not been required to use ultra-low-sulphur diesel. Audit research has shown that some overseas countries have adopted more stringent standards for local vessels to use diesel with a sulphur content of 0.001% to 0.0015% and the Mainland will also adopt from July 2013 onwards a sulphur content of 0.035% for the purpose.

10. ***Slow progress in controlling dark-smoke emissions from vessels***. Vehicles suspected of emitting dark smoke are required under the Road Traffic Ordinance to undergo a smoke test to ascertain whether their dark-smoke emissions exceed the statutory limits. However, vessels will only be prosecuted under the Shipping and Port Control Ordinance and the Merchant Shipping (Local Vessels) Ordinance if they emit smoke in such a quantity as to cause a nuisance. Although legislative amendments for adopting the Ringelmann Chart had been proposed for measuring dark-smoke emissions, up to September 2012, the amendments had not been introduced. As a result, from 2007 to 2011, only five prosecutions relating to smoky vessels had been successful.

Emission control of power plants

11. In 2010, emissions from local power plants accounted for 50% of SO_2, 25% of NOx and 16% of PM_{10} of the total emissions in Hong Kong. Two electricity companies are operating a total of four power plants which together supply 77% of electricity for local consumption. In 2011, these four power plants used coal or natural gas as fuel, with coal accounting for 71% of local electricity generation and natural gas 29%.

12. ***Room for reducing NOx emissions from local power plants.*** Audit has found that emissions of SO_2, NOx and PM_{10} per unit of electricity generated from local power plants by using natural gas are far lower than those generated by using coal. However, it is more costly to generate electricity using gas than coal. Audit has further found that the NOx emission allowances set for local power plants, to be effective from 2015 and 2017, would significantly exceed those proposed by the EPD consultant. This may affect the achievement of the 2014 AQOs.

Regional emission control

13. In April 2002, the Hong Kong Special Administrative Region Government and the Guangdong Provincial Government issued a joint statement setting targets for reducing emissions of various pollutants in the PRD region by 2010. In October 2012, the EPD announced that Hong Kong had met the targets set under the joint statement. However, Audit notes that, as of September 2012, the post-2010 emission-reduction targets and the arrangements for implementation had not yet been formulated.

Audit recommendations

14. **Audit recommendations are made in the respective sections in this Audit Report. Only the key ones are highlighted in this Executive Summary. Audit has *recommended* that the Administration should take on board the audit observations and recommendations in this Audit Report for implementing measures to improve the air quality of Hong Kong. Specifically, the Administration should:**

Emission control of vehicles

(a) **formulate better strategies for reducing the number of pre-Euro, Euro I and Euro II diesel commercial vehicles running on the street;**

(b) **step up efforts and formulate a better strategy for reducing franchised bus trips;**

Emission control of marine vessels

(c) **seek legislative support for adopting the IMO 2010 Standards in Hong Kong as early as possible;**

(d) **require local and river-trade vessels to use ultra-low-sulphur diesel in Hong Kong waters as early as possible;**

(e) **seek legislative support to give effect to adopting the Ringelmann Chart as a reference to measure dark-smoke emissions from vessels;**

Emission control of power plants

(f) **take further measures to reduce NOx emissions from local power plants and review the long-term fuel mix for local electricity generation; and**

Regional emission control

(g) **work closely with the Guangdong Provincial Government with a view to setting the post-2010 emission-reduction targets and related implementation arrangements at an early time.**

Response from the Administration

15. The Administration agrees with the audit recommendations. The Secretary for the Environment and the Director of Environmental Protection have said that both the ENB and the EPD will seriously take on board the audit observations and recommendations in this Audit Report, and will promote public understanding of the health, economic and social implications of introducing various air-quality improvement measures.

PART 1: INTRODUCTION

1.1 This PART describes the background to the audit and outlines the audit objectives and scope.

Background

1.2 Air pollution is one of the major problems in Hong Kong. According to the World Health Organisation (WHO — Note 1), air pollution poses health risks to humans, causing respiratory and heart diseases and lung cancer. These adverse health effects will increase medical costs, lower workforce's productivity and undermine people's quality of life. Therefore, good air-quality management is essential for safeguarding and promoting people's well being. A system of setting air-quality standards, implementing air-quality improvement measures, conducting periodic measurements of air quality against standards, and reporting and publishing the measurement results will help improve air quality and enhance public accountability.

1.3 The Environment Bureau (ENB — Note 2) and the Environmental Protection Department (EPD) are responsible for formulating and implementing environmental policies, including those on air quality. In 2010-11 and 2011-12, the EPD incurred $588 million and $567 million respectively on managing air quality. In 2012-13, the EPD's estimated expenditure on managing air quality is $627 million.

Note 1: *The WHO is the directing and coordinating authority for health of the United Nations. It provides advice on global health matters, sets norms and standards, and monitors and assesses health trends.*

Note 2: *In July 2007, the ENB was formed to take up the policy on environmental matters. Before July 2007, the policy responsibility had been taken up by the then Environment, Transport and Works Bureau (July 2002 to June 2007), the then Environment and Food Bureau (January 2000 to June 2002), and the then Planning, Environment and Lands Bureau (July 1997 to December 1999). For simplicity, all previous policy bureaux responsible for the policy on environmental matters are referred to as the ENB in this Audit Report.*

1.4 Controlling air pollution is a complex and sometimes controversial issue. The major tasks include:

(a) setting strategic direction and key measures;

(b) monitoring findings on health impacts of air pollution and formulating air-quality improvement measures having regard to technological, economic and social implications;

(c) informing, educating and securing the support and cooperation of the public and stakeholders;

(d) promulgating rules and regulations on limiting products and activities that generate and emit pollutants;

(e) coordinating the work plans and efforts of different government bureaux and departments; and

(f) working with neighbouring cities and provinces to achieve mutually agreed aims.

Air-quality standards and guidelines are important perimeters for formulating air-quality management strategies and measures.

Air pollution problems in Hong Kong

1.5 At present, Hong Kong faces two major air pollution problems, namely the local street-level pollution problem and the regional smog problem. Air pollution at the street level is mainly caused by emissions from motor vehicles, especially aged diesel commercial vehicles. Smog is caused by a combination of pollutants from motor vehicles, marine vessels, power plants and non-road mobile machinery (NRMM) in Hong Kong, and emissions in the Pearl River Delta (PRD — Note 3) region, as follows:

Note 3: *The PRD region comprises the Hong Kong Special Administrative Region, the Macao Special Administrative Region and the PRD Economic Zone of Guangdong Province which comprises nine municipalities, namely Guangzhou, Shenzhen, Dongguan, Zhongshan, Zhuhai, Jiangmen, Foshan, Zhaoqing and Huizhou.*

(a) ***Motor vehicles.*** As of December 2011, there were 630,000 licensed vehicles in Hong Kong, of which 209,000 (33%) were at the age of 10 or older;

(b) ***Marine vessels.*** As of December 2011, there were 16,300 local vessels, and there were 205,000 vessel arrivals in 2011, comprising 33,000 ocean-going and 172,000 river-trade vessel arrivals. In December 2011, the EPD informed the Legislative Council (LegCo) Panel on Environmental Affairs (EA Panel) that marine activities had become one of the major sources of air pollution in Hong Kong;

(c) ***Power plants.*** There are four power plants operated by two power companies. In 2011, 71% of local electricity generation was fuelled by coal, and the remaining 29% by natural gas. Coal burning causes serious air pollution;

(d) ***NRMM.*** Mobile machines, transportable industrial equipment and non-road vehicles are commonly referred to as NRMM. They are mainly used in construction sites, the airport and container terminals. As of December 2011, there were 13,500 units of NRMM. At present, NRMM is not required by any law to install an emission-control device; and

(e) ***PRD region.*** A joint study completed in 2002 by the EPD and the Environmental Protection Department of the Guangdong Provincial Government (Guangdong EPD) revealed that emissions from the PRD Economic Zone (see Note 3) accounted for 80% to 95% of the total emissions in the PRD region.

Smog can irritate human eyes, noses and throats, and affect heart and respiratory systems. It also impairs visibility.

Air quality objectives in Hong Kong

1.6 In Hong Kong, air quality objectives (AQOs) are set out in a Technical Memorandum issued under section 7 of the Air Pollution Control Ordinance (Cap. 311 — APCO). Under the APCO, the EPD is the Air Pollution Control Authority and is tasked to aim to achieve the AQOs as soon as is reasonably practicable and thereafter to maintain the quality so achieved. The AQOs stipulate concentration targets for selected air pollutants, which serve as the references to the EPD in assessing whether the air-quality impact of designated projects is acceptable

for approval under the Environmental Impact Assessment Ordinance (Cap. 499). The AQOs also provide the key references for determining the air pollution index (API).

1.7 The existing AQOs were established in 1987, which cover the following seven key air pollutants:

(a) sulphur dioxide (SO_2)

(b) nitrogen dioxide (NO_2)

(c) respirable suspended particulates (expressed as PM_{10} which are particulate matters with a diameter of 10 micrometres (μm) or less — one μm is one millionth of a metre)

(d) total suspended particulates (TSP — Note 4)

(e) ozone (O_3 — Note 5)

(f) carbon monoxide (CO)

(g) lead

The AQOs set out the upper concentration limits in terms of micrograms (one microgram is one millionth of a gram) per cubic metre ($\mu g/m^3$) for each of these seven air pollutants (details are at Appendix A). According to the ENB and the EPD, these air pollutants would have adverse effects on human health. The AQOs have not been revised since their establishment in 1987.

Note 4: *TSP are airborne particles with a diameter of 100 μm or less. These particles include smoke, fumes and dust of various sizes, shapes and composition.*

Note 5: *Ozone is a primary ingredient of smog. It is a secondary pollutant formed by the reaction of nitrogen oxides and volatile organic compounds with oxygen in the air under strong sunlight.*

Air Quality Guidelines issued by the WHO

1.8 In the same year as Hong Kong established its AQOs (i.e. 1987), the WHO also released its Air Quality Guidelines (AQGs) to provide references for countries and cities to develop their air-quality standards. In 2000, the WHO updated its AQGs and, in 2006, published another new set of AQGs (WHO AQGs) which:

(a) introduced concentration limits for PM_{10} and $PM_{2.5}$ (particulate matters with a diameter of 2.5 μm or less — Note 6);

(b) revised the concentration limits for two air pollutants, namely SO_2 and O_3; and

(c) set WHO Interim Targets for four air pollutants (namely SO_2, PM_{10}, $PM_{2.5}$ and O_3) for progressive reduction in concentration limits to meet the WHO AQG levels.

2014 AQOs approved by Executive Council in January 2012

1.9 In 2007, the EPD commissioned a consultancy study to review the AQOs in Hong Kong (2007 Consultancy Review), which was completed in July 2009. The 2007 Consultancy Review recommended revising the AQOs and implementing a package of air-quality improvement measures. At a meeting of the Executive Council in January 2012, the Council advised and the Chief Executive of the Hong Kong Special Administrative Region (HKSAR) ordered, among other things, that:

(a) the Government should adopt a new set of AQOs together with a package of 22 air-quality improvement measures (see Appendix B) which would be implemented subject to resource availability;

(b) the Government should start the preparatory work for amending the APCO with a view to tabling the Amendment Bill in the 2012-13 session of LegCo, and having the new AQOs take effect in 2014 (2014 AQOs — see Appendix C); and

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Note 6: *According to the WHO, $PM_{2.5}$ are more harmful to health than PM_{10} as they can be inhaled deeply into the lungs of human bodies, thus increasing the risks of cardiovascular and respiratory illnesses, and reducing life expectancy.*

(c) government projects for which Environmental Impact Assessment studies had not yet commenced should endeavour to adopt the new AQOs as the benchmark for conducting the air-quality impact assessment under the studies.

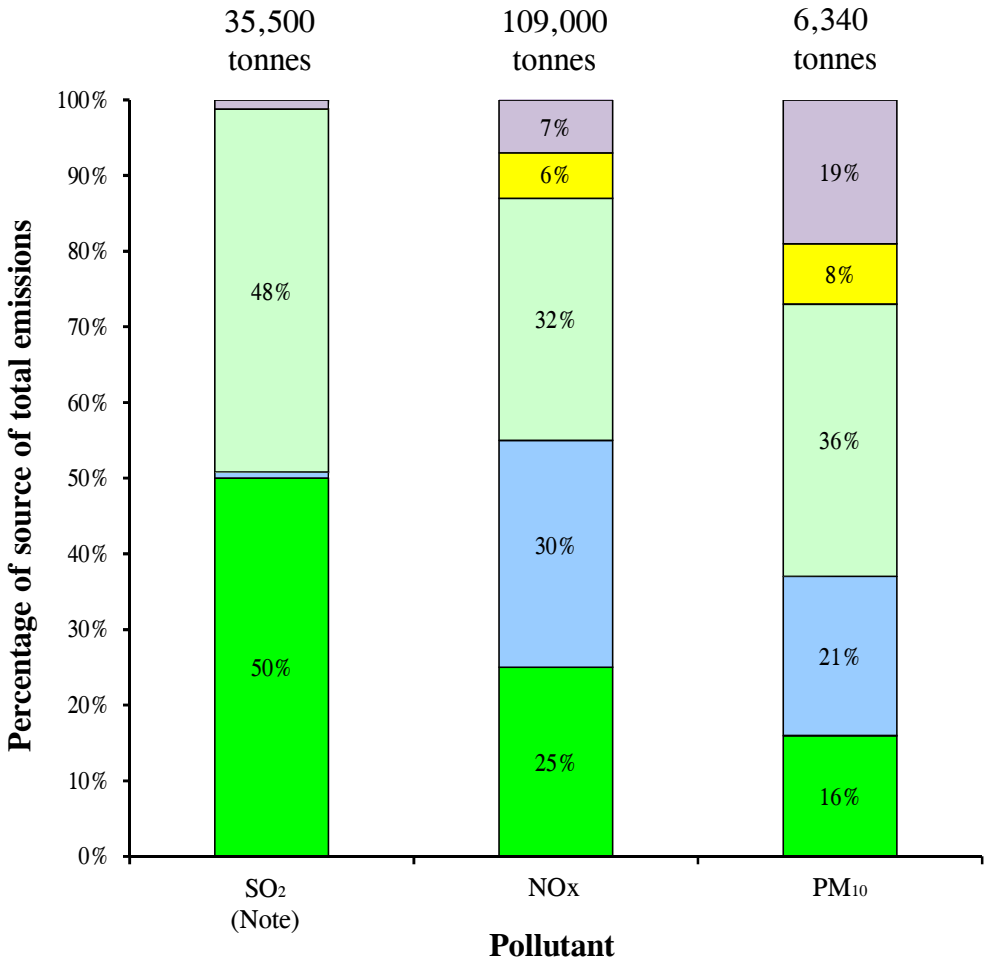
Sources of air pollutants

1.10 The EPD prepares an emission inventory which comprises emissions of major air pollutants, including SO_2, nitrogen oxides (NOx — Note 7) and PM_{10} from major sources, namely motor vehicles, marine vessels, power plants, NRMM and others (e.g. civil aviation, catering and industrial processes). In October 2012, the EPD published the 2010 emission inventory and uploaded it onto its website. Figure 1 shows an extract of the inventory.

Note 7: *NOx is a collective term for nitric oxide (NO) and NO_2 (NO_2 is formed after oxidation of NO). As most of the pollution sources emit both NO and NO_2, the EPD monitors and controls NOx emissions.*

Figure 1

Emission inventory (2010)



Legend:
- Power plants
- Motor vehicles
- Marine vessels
- NRMM
- Others (e.g. civil aviation, catering and industrial processes)

Source: *Audit analysis of EPD records*

Note: *Motor vehicles, NRMM and others accounted for the remaining 2% of total SO_2 emissions.*

Air-quality improvement measures

1.11 ***Local emission-control measures.*** Since early 1990s, the EPD has implemented various measures to control emissions for improving the air quality of Hong Kong. Major emission-control measures implemented from 1997 to 2011 are shown at Appendix D. In 2009, the EPD said that the implementation of these measures had significantly reduced the local emissions of SO_2, NOx, PM_{10} and CO from their high levels in the 1990s by 55% to 83%.

1.12 ***Regional emission-control measures.*** In April 2002, the HKSAR Government and the Guangdong Provincial Government issued a joint statement on improving the air quality in the PRD region (2002 Joint Statement). Using 1997 as the base year, the two Governments agreed to reduce by 2010 the emissions of four major pollutants, as follows:

- SO_2 by 40%
- NOx by 20%
- PM_{10} by 55%
- volatile organic compounds (VOCs — Note 8) by 55%

In December 2003, the two Governments further agreed to jointly implement the PRD Regional Air Quality Management Plan which introduced measures for the purpose of meeting the emission-reduction targets. In August 2009, with a view to further improving the regional air quality, the two Governments signed the Environmental Co-operation Agreement for formulating post-2010 emission-reduction targets and measures for the PRD region. In October 2012, the EPD published the emission-reduction results of Hong Kong which revealed that Hong Kong had met the 2010 emission-reduction targets.

Note 8: *VOCs are found in a wide variety of products such as solvent-based paints, printing inks, consumer products, organic solvents and petroleum products. The use of these products causes VOC emissions.*

1.13 ***Efforts made by other government bureaux and departments.*** Besides the EPD, a number of government bureaux and departments are also involved in addressing the air pollution problems within their respective purview. For example:

(a) the Transport Department (TD), under the policy responsibility of the Transport and Housing Bureau (THB), is responsible for providing a transport system which is safe, reliable, efficient, environmental friendly and satisfying to both users and operators. The TD provides assistance to the EPD to address air pollution problems by enforcing the control of smoke emissions by vehicles, conducting vehicle examination and monitoring the environmental performance of public transport operators;

(b) the Marine Department (MD), also under the policy responsibility of the THB, is responsible for enforcing the control of smoke emissions by marine vessels, and the compliance with international standards in respect of the use of low-sulphur-content diesel and engines with low NOx emissions by vessels navigating in Hong Kong waters; and

(c) works departments, under the policy responsibility of the Development Bureau, are responsible for ensuring that appropriate mitigation measures have been taken for works carried out under designated projects specified in the Environmental Impact Assessment Ordinance (see para. 1.6) to meet the environmental requirements.

Audit review

1.14 In 1997 and 2005, the Audit Commission (Audit) conducted two reviews on air pollution, namely:

(a) in 1997, a review of the monitoring and control of air pollution, the results of which were included in Chapter 5 of the Director of Audit's Report No. 29 of October 1997 and were examined by the Public Accounts Committee (PAC) of LegCo. In its Report of February 1998, the PAC made a number of recommendations for improvement in various areas; and

(b) in 2005, a review of the Government's efforts on reducing diesel vehicle emissions and concentrations of air pollutants at roadside level, the results of which were included in Chapter 2 of the Director of Audit's Report No. 44 of March 2005 and were also examined by the PAC. In its Report of July 2005, the PAC made a number of recommendations for improvement in various areas.

1.15 Audit has recently conducted a review of the Government's efforts in improving the air quality of Hong Kong. Two Audit Reports are issued, namely Monitoring and reporting of air quality (see Chapter 1 of the Director of Audit's Report No. 59) and Implementation of air-quality improvement measures (the subject matter of this Audit Report).

1.16 This Audit Report focuses on the following areas:

(a) emission control of vehicles (PART 2);

(b) emission control of marine vessels (PART 3);

(c) emission control of power plants (PART 4);

(d) emission control of NRMM (PART 5);

(e) regional emission control (PART 6); and

(f) way forward (PART 7).

In this Report, Audit has identified areas where improvements can be made by the Government in implementing air-quality improvement measures in Hong Kong, and has made recommendations to address the issues identified.

Acknowledgement

1.17 Audit would like to acknowledge with gratitude the full cooperation of the staff of the ENB, the THB, the Development Bureau, the EPD, the TD, the MD and the Government Logistics Department (GLD) during the course of the audit review.

PART 2: EMISSION CONTROL OF VEHICLES

2.1 This PART examines the actions taken by the EPD and the TD in controlling emissions from vehicles, focusing on:

(a) emissions from diesel vehicles (paras. 2.5 to 2.17); and

(b) emissions from franchised buses (paras. 2.18 to 2.33).

Roadside pollution caused by vehicles

2.2 As shown in Figure 1 in paragraph 1.10, emissions from vehicles accounted for 30% of NOx and 21% of PM_{10} of the total emissions in Hong Kong in 2010. In 2011, of the 13 roadside AQO measurements (Note 9), 5 had exceeded the AQO limits, as follows:

(a) one-hour NO_2 measurement (the highest concentration recorded in the year was 170% of the AQO limit);

(b) 24-hour NO_2 measurement (the highest concentration recorded in the year was 168% of the AQO limit);

(c) annual NO_2 measurement was 155% of the AQO limit;

(d) annual PM_{10} measurement was 120% of the AQO limit; and

(e) annual TSP measurement was 128% of the AQO limit.

In the same year, there were 172 days with the roadside API (Note 10) exceeding 100 (the very high air pollution level), ranging from 101 to 192.

Note 9: *There are 27 measurements (14 for ambient and 13 for roadside) of concentration levels of seven pollutants recorded at different time intervals.*

Note 10: *In addition to roadside API, there is a general API for measuring the ambient air quality. In 2011, there were 22 days with the general API exceeding 100.*

2.3 According to the EPD, roadside pollution is mainly caused by emissions from motor vehicles, particularly diesel vehicles. As of March 2012, there were 131,490 diesel vehicles, comprising:

- 120,990 (92%) commercial vehicles (Note 11)
- 5,800 (4%) franchised buses
- 2,000 (2%) private cars
- 1,600 (1%) government vehicles
- 1,100 (1%) special-purpose vehicles (Note 12)

WHO research has found that inhalation of emissions from diesel engines will increase the risk of lung cancer.

Emission standards

2.4 Under the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations (Cap. 311J), since April 1995, vehicles seeking first registration in Hong Kong have been required to meet the related European (Euro) emission standards (Note 13) depending on the date of registration. The Euro standards mainly regulate vehicle emissions of NOx, PM_{10} and CO. Since the introduction of Euro emission standards in 1993 in Europe, there have been five Euro emission

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Note 11: *Commercial vehicles include goods vehicles, non-franchised buses, light buses and taxis. With the exception of taxis and public light buses (see para. 2.8(a) and (b)), most commercial vehicles are fuelled by diesel.*

Note 12: *Special-purpose vehicles included mobile cranes and street-cleaning vehicles.*

Note 13: *Euro emission standards define the upper limits for exhaust emissions (including NOx, PM_{10} and CO) of vehicles newly registered in European Union member states in different times. Euro emission standards were introduced in Hong Kong either at the same time as in Europe or later (e.g. Euro V standard was introduced in Europe in 2009 but in Hong Kong in 2012).*

standards, namely Euro I, Euro II, Euro III, Euro IV and Euro V (Note 14). Vehicles registered before April 1995 are generally classified as pre-Euro vehicles. The standards are progressively becoming more stringent from Euro I to Euro V. Of the pollutants regulated by the Euro standards, NOx and PM_{10} are of major concern in the local environment (see para. 2.2). For illustration, Table 1 shows details of the emission limits of NOx and PM_{10} for diesel vehicles exceeding 3.5 tonnes in Hong Kong.

Table 1

Emission standards for diesel vehicles exceeding 3.5 tonnes in Hong Kong

Emission standard	Effective date of implementation (Note 1)	Pollutant limit (Gram per kilowatt-hour (g/kWh — Note 2))	
		NOx	PM_{10}
(a) Euro I	April 1995	8.0	0.36
(b) Euro II	April 1997 (for goods vehicles and buses) October 1998 (for light buses)	7.0	0.15
(c) Euro III	October 2001	5.0	0.10
(d) Euro IV	October 2006	3.5	0.02
(e) Euro V	June 2012	2.0	0.02

Source: EPD records

Note 1: Vehicles registered on or after the effective dates are required to meet the relevant emission standards. Pre-Euro vehicles emit an average of 9.0 g/kWh of NOx and 0.68 g/kWh of PM_{10}.

Note 2: kWh is a unit of engine power output.

Note 14: *There are two sets of Euro emission standards, one for vehicles of 3.5 tonnes or less (denoted by Euro 1 to Euro 5) and another for vehicles exceeding 3.5 tonnes (denoted by Euro I to Euro V). According to the EPD, Euro 1 to Euro 5 have been subsumed under Euro I to Euro V Standards in Hong Kong.*

Emissions from diesel vehicles

2.5 As shown in Table 1, diesel vehicles registered before October 2001 (pre-Euro, Euro I and Euro II vehicles) are far more polluting than those registered in later years. For example:

- pre-Euro diesel vehicles exceeding 3.5 tonnes emit an average of 0.68 g/kWh of PM_{10}, which is 34 times of the emission limit of 0.02 g/kWh of such Euro IV and Euro V vehicles
- PM_{10} emissions from Euro I and Euro II diesel vehicles exceeding 3.5 tonnes could be up to 18 and 8 times respectively of those from such Euro IV and Euro V vehicles

According to the EPD, in 2009, diesel commercial vehicles were the main contributors to roadside pollution, accounting for 76% of roadside NOx and 88% of roadside PM_{10}. With a view to replacing high-polluting diesel vehicles (pre-Euro to Euro II vehicles) with less polluting ones, from 2000 to 2010, the EPD launched four one-off grant schemes, namely:

(a) 2000 Taxi Grant Scheme;

(b) 2002 Public Light Bus Grant Scheme;

(c) 2007 pre-Euro and Euro I Diesel Commercial Vehicle Grant Scheme (2007 Grant Scheme); and

(d) 2010 Euro II Diesel Commercial Vehicle Grant Scheme (2010 Grant Scheme).

Details of the four schemes and the number of vehicles replaced under the schemes are shown in Table 2.

Table 2

Four schemes for replacing high-polluting diesel vehicles (August 2000 to March 2012)

Scheme	Target vehicle to be replaced	Grant per vehicle	New vehicle after replacement	Vehicles replaced	
				(Number)	(%)
(a) 2000 Taxi Grant Scheme (August 2000 to December 2003)	Diesel taxi	$40,000 (Total grants: $724 million)	Liquefied-petroleum-gas (LPG) taxi	18,100 of 18,138 taxis	99.8%
(b) 2002 Public Light Bus Grant Scheme (August 2002 to December 2005)	Diesel public light bus	$60,000 (Total grants: $142 million)	LPG public light bus	2,370 of 4,350 public light buses	54%
(c) 2007 Grant Scheme (April 2007 to March 2010)	Pre-Euro and Euro I diesel commercial vehicle	12% (for pre-Euro vehicle) or 18% (for Euro I vehicle) of average taxable value (Note 1) (Total grants: $772 million)	Euro IV vehicle	11,265 of 38,600 pre-Euro vehicles	29%
				5,838 of 20,200 Euro I vehicles	29%
(d) 2010 Grant Scheme (July 2010 to June 2013)	Euro II diesel commercial vehicle	18% of average taxable value (Note 1) (Total grants: $261 million — up to March 2012)	Euro IV or Euro V vehicle (Note 2)	2,973 of 27,300 Euro II vehicles (up to March 2012)	11%

Source: Audit analysis of EPD records

Note 1: The taxable value of a vehicle is the sum of the published retail price, the brokerage/agency fee and other related fees.

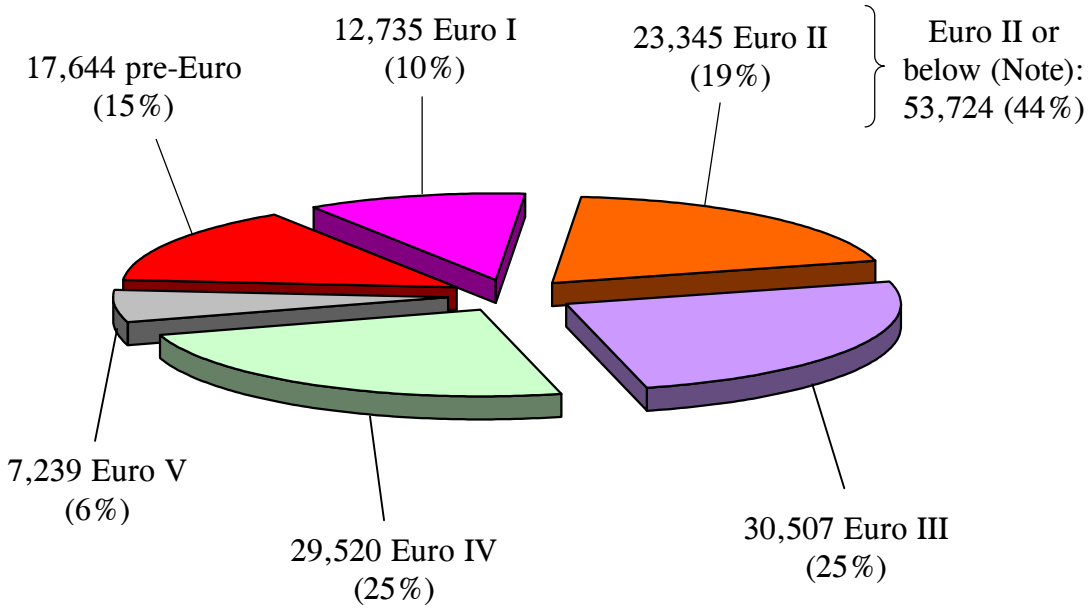
Note 2: A new vehicle has to comply with prevailing statutory emission standards, i.e. Euro IV or Euro V depending on the date of replacement (see Table 1 in para. 2.4).

Significant number of high-polluting vehicles

2.6 According to the 2007 Consultancy Review (see para. 1.9), in order to achieve the 2014 AQOs, it would require early retirement of pre-Euro, Euro I and Euro II diesel commercial vehicles. However, notwithstanding the implementation of two grant schemes in recent years to replace such vehicles (see items (c) and (d) in Table 2), as of March 2012, 53,724 pre-Euro, Euro I and Euro II diesel commercial vehicles were still running on the street, which accounted for 44% of the total 120,990 diesel commercial vehicles (see Figure 2). Of these 53,724 vehicles, one third (17,644) were pre-Euro ones.

Figure 2

120,990 diesel commercial vehicles in service (March 2012)



Source: *Audit analysis of EPD records*

Note: *From April 2007 to March 2012, some pre-Euro and Euro I vehicles had ceased service.*

2.7 According to TD records, as of December 2011, the average age of the pre-Euro, Euro I and Euro II diesel commercial vehicles running on the street was 20, 16 and 13 years respectively. If the EPD does not take action to reduce the

number of these vehicles, they will continue to cause serious air pollution for a number of years before retiring from service. Therefore, the EPD needs to formulate better strategies for reducing the number of such high-polluting vehicles running on the street.

Less than effective grant schemes to replace high-polluting vehicles

2.8 Audit examination of the four grant schemes in paragraph 2.5 has revealed various extents of effectiveness in replacing diesel commercial vehicles, as follows:

(a) ***Very effective 2000 Taxi Grant Scheme.*** The Scheme was very effective as it attracted nearly all taxi owners to replace their diesel taxis by LPG ones upon completion of the Scheme in December 2003 (see item (a) in Table 2 in para. 2.5). As of March 2012, 18,131 of the total 18,138 taxis were fuelled by LPG (Note 15). Under the Air Pollution Control (Vehicle Design Standards) (Emission) Regulations, taxis registered since August 2001 have been required to be fuelled by LPG or petrol. According to the EPD, the replacement of all diesel taxis by LPG ones contributed to an estimated reduction of 6% of roadside NOx and 25% of roadside PM_{10} emissions;

(b) ***Partially effective 2002 Public Light Bus Grant Scheme.*** The Scheme was partially effective as it only replaced 54% of diesel public light buses by LPG ones upon completion of the Scheme in December 2005 (see item (b) in Table 2 in para. 2.5). As of March 2012, 66% of the 4,350 public light buses were fuelled by LPG. According to the EPD, the replacement of diesel public light buses by LPG ones contributed to an estimated reduction of 1.6% of roadside NOx and 3.2% of roadside PM_{10} emissions;

(c) ***Less than effective 2007 Grant Scheme.*** The 2007 Grant Scheme was less than effective. In February 2007, when seeking funding of $3,176 million (which would be sufficient for replacing all the 58,800 pre-Euro and Euro I vehicles at that time), the Administration informed the Finance Committee (FC) of LegCo that it expected a participation rate of 70% under the scheme, and if all the related vehicles were replaced,

Note 15: *Seven taxis remained to be fuelled by petrol or diesel.*

the vehicular emissions of NOx and PM_{10} would be reduced by 38% and 74% respectively. However, as it transpired, only 17,103 vehicles (29% of the 58,800 vehicles — see item (c) in Table 2 in para. 2.5) joined the scheme (expired in March 2010), and total grants amounted to only $772 million (24% of $3,176 million). As of March 2012, taking account of 11,318 related vehicles which had ceased service between April 2007 and March 2012, there were still 17,644 pre-Euro and 12,735 Euro I diesel commercial vehicles (see Figure 2 in para. 2.6) running on the street and emitting substantial pollutants; and

(d) ***Less than effective 2010 Grant Scheme.*** Similar to the 2007 Grant Scheme in (c) above, Audit considers the 2010 Grant Scheme less than effective. In May 2010, when seeking funding of $540 million for the scheme, the Administration informed the FC that it expected that 6,450 of the 27,300 Euro II diesel commercial vehicles at that time would join the scheme (a participation rate of 24% — Note 16). Up to March 2012, 2,973 related vehicles (11% of the 27,300 related vehicles — see item (d) in Table 2 in para. 2.5) had joined the scheme, and the total grants amounted to $261 million (48% of $540 million). As of March 2012, there were still 23,345 Euro II diesel commercial vehicles running on the street (see Figure 2 in para. 2.6). Based on the EPD's estimate, upon expiry of the 2010 Grant Scheme in June 2013, assuming all the target 6,450 Euro II diesel commercial vehicles would join the scheme, there would still be a large number of related diesel commercial vehicles (Note 17) running on the street, emitting substantial pollutants. Audit considers that the EPD needs to strengthen publicity efforts to encourage Euro II diesel commercial vehicle owners to participate in the 2010 Grant Scheme.

2.9 In 2008 and 2010, the EPD's reviews of the 2007 Grant Scheme revealed that relying on a subsidy scheme alone to speed up vehicle replacement would not be effective, and suitable disincentives (such as higher licence fees for older commercial vehicles) should be introduced to motivate vehicles owners to replace

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Note 16: *This was based on the actual percentage of the approved funding used in the 2007 Grant Scheme (see item (c) above).*

Note 17: *Without taking account of the number of related vehicles that ceased/would cease service from July 2010 to June 2013, some 20,000 Euro II diesel commercial vehicles would still be running on the street (27,300 vehicles less 6,450 target vehicles joining the 2010 Grant Scheme).*

their aged vehicles. In November 2008, the EPD informed the EA Panel of a proposal to explore raising the licence fees for aged commercial vehicles but the proposal was not supported by the Panel.

2.10 Although the 2007 Grant Scheme aimed at replacing all the 58,800 pre-Euro and Euro I vehicles at that time, the outturn participation rate was only 29%. Furthermore, the replacement of an estimated 24% of Euro II vehicles under the 2010 Grant Scheme is far from satisfactory, as a large number of high-polluting diesel commercial vehicles are still running on the street and causing serious air pollution. In implementing a similar subsidy scheme in future, the EPD needs to draw lessons for implementation, taking into account the findings in paragraph 2.8, and estimate the participation rate more accurately before seeking funding from LegCo, such as by consulting the stakeholders.

High emissions from LPG vehicles

2.11 As stated in paragraph 2.8(a) and (b), as of March 2012, nearly all taxis and 66% of public light buses were fuelled by LPG. Audit notes that these LPG vehicles are installed with emission-reduction devices which will wear out within a certain period of time (about 18 months for taxis and light buses) and need to be replaced. According to the EPD:

(a) if worn-out emission-reduction devices are not timely replaced, emissions of NOx by LPG vehicles will increase by at least ten times; and

(b) in 2012, emissions from LPG taxis and light buses accounted for about 40% of total vehicular NOx emissions on heavy-traffic roads.

In April 2012, the FC approved $150 million for implementing a scheme to provide a one-off grant to fully subsidise the replacement of emission-reduction devices installed in LPG taxis and light buses. The Government has planned to tighten the control over emissions from LPG vehicles by using remote sensing equipment and conducting dynamometer tests (see item 21 at Appendix B).

2.12 In Audit's view, in view of the high NOx emissions from LPG taxis and light buses with worn-out emission-reduction devices, the EPD needs to expedite action to implement measures to prevent excessive emissions from LPG vehicles after implementation of the emission-reduction-device replacement scheme.

Euro II diesel government vehicles not yet replaced

2.13 Audit notes that, as of December 2011, 1,594 (26%) of the 6,099 government vehicles monitored by the GLD were diesel vehicles. Of these 1,594 diesel vehicles, 243 (15%) were of Euro II standard. They included goods vehicles, refuse-collection vehicles and special-purpose vehicles. Given the low emission standards of Euro II diesel vehicles vis-à-vis those of Euro IV and V ones (see Table 1 in para. 2.4), the GLD needs to consider replacing these Euro II diesel government vehicles with new ones earlier.

Audit recommendations

2.14 **Audit has *recommended* that the Secretary for the Environment and the Director of Environmental Protection should:**

(a) **formulate better strategies for reducing the number of pre-Euro, Euro I and Euro II diesel commercial vehicles running on the street;**

(b) **in implementing a subsidy scheme for replacing high-polluting vehicles in future:**

  (i) **draw lessons from the implementation of similar previous grant schemes; and**

  (ii) **estimate the participation rate more accurately before seeking funding from LegCo;**

(c) **strengthen publicity efforts to encourage Euro II diesel commercial vehicle owners to participate in the 2010 Grant Scheme; and**

(d) **expedite action to implement measures to prevent excessive emissions from LPG vehicles after implementation of the emission-reduction-device replacement scheme.**

2.15 **Audit has also *recommended* that the Director of Government Logistics should, in collaboration with the Director of Environmental Protection, consider replacing Euro II diesel government vehicles with new ones earlier.**

Response from the Administration

2.16 The Secretary for the Environment and the Director of Environmental Protection agree with the audit recommendations in paragraph 2.14. They have said that:

(a) the EPD will continue to formulate strategies for reducing the number of old and highly polluting diesel commercial vehicles running on the street. Given the relatively lukewarm response towards the voluntary vehicle replacement programmes, the EPD will reconsider launching disincentive schemes to expedite the early retirement of these highly polluting diesel vehicles. In this connection, in 2008, the EA Panel did not support a proposal to raise the licence fees for aged commercial vehicles (see para. 2.9);

(b) in order to phase out the highly polluting diesel vehicles more effectively, the EPD considers it necessary to adopt both incentives and disincentives. Introducing disincentives for the continued ownership of highly polluting vehicles will need the consensus of the community, relevant stakeholders and LegCo. When new schemes are rolled out in future, the EPD will endeavour to provide the best estimation of the participation rate as far as possible on the basis of available information;

(c) regarding the 2010 Grant Scheme, the ENB and the EPD have sent out letters to all eligible owners and broadcast Announcement of Public Interest on television and radio from time to time to encourage relevant vehicle owners to participate in the Scheme. The ENB and the EPD will strengthen publicity programmes by sending out reminder letters to vehicle owners and trade associations as well as stepping up general publicity in the near future; and

(d) regarding the emission-reduction-device replacement scheme for LPG and petrol taxis and public light buses, the ENB and the EPD are finalising the tendering procedures (for the supply of the devices and provision of related services) with a view to launching the scheme in 2013. The ENB and the EPD will start deploying remote sensors to detect high-emitting petrol and LPG vehicles upon completion of the replacement scheme.

2.17 The Director of Government Logistics agrees with the audit recommendation in paragraph 2.15. He has said that:

(a) the GLD has been actively making arrangements for replacing Euro II diesel vehicles in the Government fleet and will continue to work with the user departments concerned in advancing the replacement programme as appropriate;

(b) the number of Euro II Government diesel vehicles had been reduced from 421 in February 2010 to 221 in June 2012; and

(c) by March 2013, the number of Euro II Government diesel vehicles will be further reduced to 129, of which 122 will be phased out in 2013-14 and the remaining seven will be replaced in 2014-15.

Emissions from franchised buses

2.18 In March 2012, 5,800 (4%) of the 131,490 diesel vehicles were franchised buses operated by five bus companies under 10-year franchises granted by the Government under the Public Bus Services Ordinance (Cap. 230). According to the EPD, at busy traffic locations such as Causeway Bay, Central (see Photograph 1) and Mong Kok, franchised buses could account for up to 40% of the total vehicular emissions, causing health risks. In recent years, the EPD and the TD have implemented measures to control emissions from franchised buses, such as revising planning guidelines for implementing bus route rationalisation proposals and installing emission-reduction devices on franchised buses.

Photograph 1

Franchised buses running on street

Source: Photograph taken by Audit at 9:45 a.m. on 21 August 2012 at Connaught Road Central, Central

Slow progress in implementing bus route rationalisation

2.19 According to the TD, rationalisation of franchised bus services includes:

(a) service reduction of bus routes through route cancellations, amalgamations, truncations and frequency reductions; and

(b) implementation of bus-bus interchange schemes at appropriate locations to reduce the need for new long-haul and direct point-to-point bus services and optimise the use of bus resources.

2.20 Rationalisation of franchised bus services is an on-going exercise conducted by the TD to achieve the objectives of enhancing bus operation efficiency and reducing traffic congestion and roadside emissions, having regard to the changes in passenger demand and the opening of new transport infrastructure. The 2007 Consultancy Review (see para. 1.9) estimated that, as one of the improvement measures to help achieve the 2014 AQOs, rationalisation of bus routes (mainly from non-peak services with excess capacity) by reducing 10% of the bus trips (Note 18) by 2015 could help reduce 156 tonnes of roadside NOx emissions. According to the Review, although bus route rationalisation would generate considerable environmental and health benefits, it would also cause inconvenience to commuters, and therefore its implementation would require support from the local communities.

2.21 In January 2010, the EPD and the TD informed the EA Panel that, as rationalisation of bus services did not involve significant additional costs for implementation, it was assessed in the 2007 Consultancy Review as the most cost-effective measure amongst other proposed improvement measures. In January 2012, the Executive Council advised and the Chief Executive ordered the adoption of a package of air-quality improvement measures, including bus-route rationalisation.

2.22 In the light of the 2007 Consultancy Review's (the Review was completed in July 2009) recommendation on implementing a 10% bus-trip reduction by 2015 (see para. 2.20), Audit conducted an examination on such reductions from 2009 to 2011. The results revealed that only 1.1% of bus trips had been reduced in three busy locations (see Table 3).

Note 18: *A bus trip is a complete journey of a bus route from a bus terminal to another.*

Table 3

Reductions in franchised bus trips
(2009 to 2011)

Location	Bus trips per day in 2009 (a) (No.)	Bus trips per day in 2011 (b) (No.)	Reduction (c) = (a) − (b) (No.)	Percentage reduction (d) = $\frac{(c)}{(a)} \times 100\%$
Causeway Bay	6,912	6,899	13	0.2%
Central	12,675	12,475	200	1.6%
Mong Kok	15,054	14,900	154	1.0%
Overall	34,641	34,274	367	1.1%

Source: Audit analysis of TD records

2.23 In September 2012, the TD informed Audit that:

(a) from 2002 to 2011, the TD had cancelled 64 bus routes, truncated 24 routes and reduced the frequency of 255 routes. Over the same period, the TD had also introduced 49 new routes and increased the frequency of 253 routes to enhance feeder bus services to rail stations and to meet new passenger demand. Despite the addition of these new routes, the total number of franchised buses in service had decreased from 6,378 by the end of 2002 to 5,798 by the end of 2011, representing a net reduction of 580 buses (or 9% reduction). In recent years, many proposals which the TD considered worth pursuing on transport grounds were not taken forward because of concerns raised by the local communities to the TD through District Councils; and

(b) as a result of implementing various bus rationalisation schemes over the last decade, the service level of many bus routes had reached a level with relatively little scope for further service rationalisation.

2.24 Audit notes the TD's views on bus-route rationalisation in paragraph 2.23. In this connection, Audit also notes that the Government has recently announced a policy on implementing bus-route rationalisation as one of the air-quality improvement measures (see para. 2.21). In Audit's view, in order to achieve the 2014 AQOs, the TD and the EPD need to step up efforts and formulate a better strategy for reducing franchised bus trips, in consultation with franchised bus companies and related District Councils.

Short remaining service life of some buses in a retrofit project

2.25 Given that the TD has required franchised buses to be withdrawn from service at the age of 18, all pre-Euro and Euro I franchised buses will be retired by 2012 and 2015 respectively. In August 2010, the EPD informed the EA Panel that it would launch a trial scheme jointly with three franchised bus companies providing bus services in the urban areas to examine the technical feasibility and environmental benefits of retrofitting their Euro II and Euro III buses with emission-reduction devices (Note 19).

2.26 In June and July 2012, the EPD further informed the EA Panel that:

(a) subject to satisfactory trial results, the Government would fund the full cost of retrofitting emission-reduction devices up to 3,700 Euro II and Euro III franchised buses. With an estimated cost of $150,000 for each device, the total estimated retrofit cost for all the 3,700 buses would be $555 million;

(b) it would seek funding approval from the FC in 2013; and

(c) it aimed to complete the retrofit project by end 2015 on a best endeavour basis, and would request the suppliers to provide a 3-year warranty on the emission-reduction devices.

Note 19: *According to the EPD, selective catalytic reduction devices will be retrofitted on franchised buses to reduce NOx emissions. For simplicity, these devices are referred to as emission-reduction devices in this Audit Report.*

2.27 According to the EPD:

(a) all Euro IV and Euro V buses had already been installed with emission-reduction devices before commencing operation;

(b) the design of an emission-reduction device was specific to each model of bus. The retrofitting of such devices on Euro II and Euro III buses could reduce their NOx emissions to Euro IV or above levels; and

(c) the tender exercise for retrofitting the buses with the devices would be conducted in the first quarter of 2014, and the retrofit project was expected to take place from mid-2014 to end 2015.

2.28 Audit welcomes the EPD's retrofit project. Nonetheless, given the TD's requirement for franchised buses to be withdrawn from service upon reaching 18 years of age, all Euro II buses will cease operation by 2019. Audit examination has further revealed that, of the 2,641 Euro II franchised buses in service as of March 2012, their years of withdrawal from service are as follows:

Year of withdrawal from service	Number of buses	Percentage
2013	8	1%
2014	21	1%
2015	526	20%
2016	1,010	38%
2017	511	19%
2018	387	14%
2019	178	7%
Total	2,641	100%

As the retrofit project will only take place from mid-2014, 21 buses may have less than 6-month service, 526 buses less than 18-month service and 1,010 buses less than 30-month service. Given that retrofitting a bus with an emission-reduction device will cost $150,000 each, Audit has reservation on whether it is justified to retrofit Euro II buses with a short service period.

2.29 In Audit's view, the EPD needs to set a minimum remaining service life for franchised buses participating in the retrofit project. In seeking funding for the project, the EPD also needs to inform the FC of the remaining service lives of the buses participating in the project.

Audit recommendations

2.30 **Audit has *recommended* that the Commissioner for Transport should:**

(a) **in collaboration with the Director of Environmental Protection, step up efforts in reducing franchised bus trips; and**

(b) **in consultation with franchised bus companies and related District Councils, formulate a better strategy for reducing franchised bus trips.**

2.31 **Regarding the implementation of the emission-reduction-device retrofit project, Audit has also *recommended* that the Director of Environmental Protection should:**

(a) **set a minimum remaining service life for franchised buses participating in the project; and**

(b) **inform the FC of the remaining service lives of the buses involved when seeking funding for the project.**

Response from the Administration

2.32 The Commissioner for Transport agrees with the audit recommendations in paragraph 2.30. She has said that:

(a) rationalisation of franchised bus services is an on-going exercise to achieve the objectives of enhancing bus operation efficiency and reducing traffic congestion, while at the same time achieving reduction in roadside emissions; and

(b) in support of achieving the transport objectives and the AQOs, the TD will take forward the audit recommendations and discuss with the EPD on the strategy for reducing franchised bus trips, in consultation with franchised bus companies and related District Councils.

2.33 The Director of Environmental Protection also agrees with the audit recommendations in paragraph 2.31. She has said that, when retrofitting franchised buses with emission-reduction devices, a minimum service life for the buses participating in the retrofit project will be set to ensure that the devices installed will have a reasonable serviceable life before their retirement.

PART 3: EMISSION CONTROL OF MARINE VESSELS

3.1 This PART examines the actions taken by the Administration in managing and reducing emissions from marine vessels, focusing on:

(a) enforcement of international standards (paras. 3.6 to 3.14);

(b) measures to lower emissions from vessels (paras. 3.15 to 3.25); and

(c) dark-smoke control of vessels (paras. 3.26 to 3.39).

Emissions from vessels

3.2 Generally, there are three types of vessels navigating in Hong Kong waters, namely:

- ocean-going vessels
- river-trade vessels (mainly registered in the Mainland)
- local vessels (such as ferries, pleasure boats and fishing boats)

In 2011, there were 33,000 ocean-going vessel and 172,000 river-trade vessel arrivals in Hong Kong. As of December 2011, there were 16,300 local vessels. According to the International Maritime Organisation (IMO — Note 20), air pollution from vessels is substantial and growing, causing serious and increasing public health and environmental impacts, and it would no longer be acceptable for the shipping industry to transfer the cost of its pollution to society at large. In December 2011, the EPD informed the EA Panel that, from 1990 to 2008, due to

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Note 20: *The IMO is an agency established in 1948 under the United Nations with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. As of August 2012, the IMO had 170 member states and 3 associate members. The Mainland has been a member state since 1973 and Hong Kong an associate member since 1967.*

increased maritime activities in Hong Kong and the PRD region, emissions from vessels had substantially increased and become a significant source of air pollution in Hong Kong. Photograph 2 shows an ocean-going vessel emitting dark smoke in Hong Kong waters.

Photograph 2

A vessel emitting dark smoke in Hong Kong waters

Source: MD records

3.3 In August 2008, the EPD commissioned a consultant to conduct a research study on emissions from vessels and to compile an updated emission inventory for vessels. According to the final study report issued in February 2012 (2012 Study Report), emissions from vessels navigating in Hong Kong waters were substantial (see Table 4).

Table 4

Emissions from vessels in Hong Kong waters (2010)

Pollutant	Emission from ocean-going vessels (a) (Tonne)	Emission from river-trade vessels (b) (Tonne)	Emission from local vessels (c) (Tonne)	Total emission from vessels (d) = (a) + (b) + (c) (Tonne)	Percentage of total vessel emission to total emission from all sources (see Figure 1 in para. 1.10)
SO_2	13,526	1,919	1,439	16,884	48%
NOx	15,385	8,618	10,970	34,973	32%
PM_{10}	1,578	295	388	2,261	36%

Source: *EPD records*

Remarks: *In 2010, there were 33,000 ocean-going vessel and 179,000 river-trade vessel arrivals in Hong Kong. As of December 2010, there were 15,400 local vessels.*

3.4 According to the 2012 Study Report, emissions of SO_2, NOx and PM_{10} from vessels would increase from 2010 to 2020. For example, SO_2 emissions from vessels are projected to increase to 19,200 tonnes in 2015 and 22,300 tonnes in 2020, representing 14% and 32% increases respectively over the 2010 level of 16,884 tonnes.

International standards of vessel fuel and emission

3.5 Table 4 shows that the main emissions from vessels are SO_2, NOx and PM_{10}. In this connection, in September 1997, the IMO promulgated a set of standards for adoption by the consenting member states with effect from May 2005 (IMO 2005 Standards — Note 21). The standards governed the sulphur content of vessel fuel (the lower the sulphur content, the fewer pollutant emissions) and NOx emissions by vessel engines. The IMO has also designated some sea areas as emission-control areas which are subject to tighter emission controls. In October 2008, the IMO revised the standards to more stringent levels, which should be adopted by the consenting member states with effect from 2010 onwards (IMO 2010 Standards). The two standards are shown in Table 5.

Note 21: *The IMO member states may indicate consent to adopting the IMO 2005 Standards and their subsequent amendments by informing the IMO. In March 2008, through the Central People's Government, the HKSAR Government informed the IMO that the IMO 2005 Standards and any subsequent amendments would apply to Hong Kong.*

Table 5

IMO vessel-emission standards

Particulars	IMO 2005 Standards (Note 1)	IMO 2010 Standards
(a) Sulphur limit of vessel fuel:		
(i) within emission-control areas designated by IMO (e.g. Baltic Sea and North Sea)	1.5% (effective from May 2005)	1.0% (effective from July 2010)
(ii) in other areas	4.5% (effective from May 2005)	3.5% (effective from January 2012)
(b) NOx emission standard (for marine diesel engine with power output greater than 130 kilowatt)	Tier I standards (for engines installed from January 2000 — Note 2)	Tier II standards (for engines installed from January 2011 — Note 2)

Source: *MD records and Audit research*

Note 1: *Under the Merchant Shipping (Prevention of Air Pollution) Regulation (Cap. 413M), any vessel registered in Hong Kong found not complying with the IMO 2005 Standards in any waters is liable to a maximum fine of $100,000.*

Note 2: *Under the IMO Standards, different NOx emission limits are set for diesel engines with different engine speeds. In general, Tier II standards are more stringent than the Tier I ones.*

Enforcement of international standards

3.6 In February 2006, the THB (Note 22) consulted the then Panel on Economic Services of LegCo (Note 23) on a proposal to implement the IMO 2005 Standards through enacting a regulation. The Panel supported the proposal. In November 2007, LegCo approved implementation of the IMO 2005 Standards under the Merchant Shipping (Prevention of Air Pollution) Regulation (Cap. 413M). The implementation of the standards took effect from June 2008. Under section 40 of the Merchant Shipping (Prevention of Air Pollution) Regulation, any vessel navigating in Hong Kong waters found not complying with the IMO 2005 Standards is liable to a maximum fine of $100,000.

3.7 The MD is responsible for port administration in Hong Kong, including overseeing the safe operation of vessels and regulating marine traffic in Hong Kong waters. In relation to marine emissions, in order to maintain Hong Kong's competitiveness and attractions as an international shipping centre, the MD participates in IMO meetings and takes measures to ensure that all relevant IMO standards are upheld in Hong Kong. In addition, the MD also provides technical support and assistance to the ENB and the EPD in formulating and implementing vessel-emission-reduction measures. In implementing the IMO requirements on environmental issues, the MD has also sought the EPD's views and comments on legislative amendment proposals.

Note 22: *Before July 2002, the then Economic Services Bureau was responsible for overseeing the MD. From July 2002 to June 2007, the responsibility was transferred to the then Economic Development and Labour Bureau, and further transferred to the THB in July 2007. For simplicity, the Economic Services Bureau and the Economic Development and Labour Bureau are referred to as the THB in this Report.*

Note 23: *The then Panel on Economic Services was renamed as Panel on Economic Development in October 2007.*

3.8 The MD (or its authorised surveyors) conducts annual examination of local vessels to ensure that, among other things, they comply with the requirements under the Merchant Shipping (Prevention of Air Pollution) Regulation. The MD also conducts inspections of vessels within Hong Kong waters to ensure that they comply with the fuel sulphur limit and NOx emission standards under the Regulation. During inspections, the MD examines the fuel sulphur content of vessels on the basis of fuel delivery notes and NOx emissions on the basis of relevant compliance certificates. In 2009, 2010 and 2011, the MD conducted inspections of 776, 820 and 854 vessels respectively, and no non-compliance with the requirements under the Regulation was identified.

Delay in seeking legislative support for adopting IMO standards

3.9 In December 2008, the EPD and the MD informed the Advisory Council on the Environment (ACE — Note 24) that Hong Kong would implement the IMO 2010 Standards. In September 2009, the EPD informed the MD that, since NOx was one of the major air pollutants in Hong Kong, the tighter IMO Tier II NOx emission standards should be applied to new local vessels as soon as possible. Between March 2009 and April 2012, the MD informed the THB on five occasions on the need to introduce legislative amendments for adopting the IMO 2010 Standards, as follows:

Note 24: *The ACE is chaired by an academic with members comprising environmental and medical academics and professionals. It is responsible for keeping under review the state of the environment in Hong Kong, and advising the Government on appropriate measures to combat pollution and to protect and sustain the environment.*

Date	MD's views to THB
(a) March 2009	If administrative measures were adopted instead of legislative amendments, the IMO 2010 Standards might not be followed by the shipping industry without legal backing.
(b) October 2009	Legislative amendments were necessary to give effect to the IMO 2010 Standards in order to keep in line with international standards to tighten harmful emission limits from shipping.
(c) April 2011	The MD could not legally implement the IMO 2010 Standards since there was no legislation on such Standards.
(d) February 2012	Hong Kong, as an associate member of the IMO, had the obligation to apply the IMO 2010 Standards within Hong Kong waters. Without the necessary legislative amendments, there was no legislation to regulate the emissions from ocean-going vessels within Hong Kong waters.
(e) April 2012	Legislative amendments should be introduced to give effect that: (i) all ocean-going vessels should be required to comply with the IMO 2010 Standards; and (ii) river-trade and local vessels should be required to comply with the fuel sulphur limit of 3.5% under the IMO 2010 Standards, and with the Tier I NOx emission standards under the IMO 2005 Standards.

3.10 In August 2012, the MD informed Audit that:

(a) the IMO standards were mandatory and primarily set for and applied to ocean-going vessels navigating in the waters of signatory members. For ocean-going vessels, the IMO 2010 Standards had been implemented and upheld in Hong Kong since they came into force in July 2010 through:

  (i) advising Hong Kong registered ocean-going vessels by issuing guidelines to them about the latest international standards. Ocean-going vessels were self-motivated to comply with these guidelines; and

  (ii) conducting ship inspections within Hong Kong waters under section 39(2) of the Merchant Shipping (Prevention of Air Pollution) Regulation (Note 25); and

(b) for local and river-trade vessels, the IMO allowed flexibility for signatory members to determine whether to establish alternative emission-control measures on NOx emissions, and they were not required to notify the IMO of such alternative measures. The IMO 2010 Standards on fuel sulphur limit had in fact been practised in Hong Kong as local and river-trade vessels had used fuel with a sulphur content lower than 3.5%. For NOx emissions standards, these vessels were only required to comply with the IMO 2005 Standards.

3.11 The IMO 2005 Standards have applied to Hong Kong since June 2008 and the IMO 2010 Standards should also have applied to Hong Kong. However, up to September 2012, necessary legislative amendments had not been made to give effect to adopting the IMO 2010 Standards in Hong Kong. Although the MD has issued guidelines to Hong Kong registered ocean-going vessels for complying with the new standards, legal backing for enforcing the standards is required.

Note 25: *Under section 39(2) of the Merchant Shipping (Prevention of Air Pollution) Regulation, the MD may take appropriate steps to ensure that a vessel found with deficiencies does not proceed to sea until rectification of the deficiencies.*

3.12 In Audit's view, the delay in seeking legislative support for adopting the IMO 2010 Standards is unsatisfactory and is detrimental to the Hong Kong environment. In particular, the MD does not have the necessary legal backing to refrain ocean-going vessels from using high sulphur-content (up to 4.5%) fuel and engines with high NOx emissions in Hong Kong waters.

Audit recommendation

3.13 **Audit has *recommended* that the Secretary for Transport and Housing and the Director of Marine should seek legislative support for adopting the IMO 2010 Standards in Hong Kong as early as possible.**

Response from the Administration

3.14 The Secretary for Transport and Housing and the Director of Marine agree with the audit recommendation. They have said that:

(a) the THB recognises the need for legislative amendments to give legal backing to the latest IMO standards. While working with the MD on the legislative proposals, the THB notes that the MD has put in place administrative measures to promulgate the IMO 2010 Standards since their effective dates, and that in practice such standards have been complied with by ocean-going vessels navigating in Hong Kong waters; and

(b) the THB will work closely with the MD and the Department of Justice to expedite the legislative amendment process with a view to consulting the LegCo Panel on Economic Development on the amendment proposals in the 2012-13 legislative session for the purpose of incorporating the IMO 2010 Standards into the local legislation.

Measures to lower emissions from marine vessels

3.15 Apart from adopting the IMO 2005 Standards on vessel fuel and vessel engine emissions, the EPD has also taken various actions to further lower emissions from ocean-going, river-trade and local vessels navigating in Hong Kong waters (see paras. 3.16 to 3.22). However, progress has been slow.

Slow progress in requiring local and river-trade vessels to use ultra-low-sulphur diesel

3.16 Local and river-trade vessels are normally fuelled by light diesel (Note 26) with a sulphur limit of 0.5%. In October 2007, the ENB informed the EA Panel of the implementation of a trial scheme (2007 Trial Scheme) to explore the feasibility of using ultra-low-sulphur diesel (with a sulphur limit of 0.005%) on local ferries. In October 2009, the ENB informed the EA Panel that the trial scheme would end in 2010. In December 2011, the EPD further informed the EA Panel that although it was technically feasible for local ferries to use ultra-low-sulphur diesel with a sulphur limit of 0.005%, the fuel cost would increase by 21% due to additional handling costs for supplying ultra-low-sulphur diesel as the sulphur content of marine fuel being supplied in Hong Kong exceeded 0.005%.

3.17 In June 2012, after consulting the Working Group on Upgrading the Quality of Marine Light Diesel (Note 27), the EPD decided to conduct a trial on local vessels using diesel with a sulphur limit of 0.05% with a view to lowering the sulphur content of marine fuel. Subsequently, the EPD commissioned a local university to conduct a trial scheme to help local-vessel operators get first-hand experience of using diesel with a sulphur limit of 0.05%. The trial scheme was targeted for completion in the first quarter of 2013.

Note 26: *There are two types of marine fuel used by vessels, namely light diesel and residual oil. Light diesel is a distillate fuel which is used for fuelling engines of local and river-trade vessels and has a lower sulphur content. Residual oil is mostly used by ocean-going vessels and has a higher sulphur content.*

Note 27: *The Working Group included representatives from the EPD, the MD, the TD and the local vessel trades.*

3.18 As of September 2012, almost five years since the EA Panel was informed of the 2007 Trial Scheme in October 2007 (see para. 3.16), local and river-trade vessels had still not been required to use ultra-low-sulphur diesel. In order to reduce vessel emissions, Audit considers that the ENB and the EPD need to seek legislative support to introduce legislation as early as possible to require local and river-trade vessels to use ultra-low-sulphur diesel in Hong Kong waters.

3.19 Furthermore, Audit research has shown that some overseas countries have already adopted more stringent standards for local vessels to use diesel with a sulphur limit of 0.001% to 0.0015%, and the Mainland will also adopt from July 2013 a standard with a sulphur limit of 0.035% for diesel used by local vessels (see Table 6).

Table 6

Sulphur limits of diesel used by local vessels
(June 2012)

Country	Sulphur limit
(a) Australia (b) New Zealand (c) United Kingdom (UK)	0.001%
(d) Canada (e) United States of America (USA)	0.0015%
(f) Mainland of China	0.2% (0.035% from July 2013)

Source: Audit research

Comparing with the current 0.5% sulphur limit and the proposed 0.05% sulphur limit (see paras. 3.16 and 3.17) for diesel used by local vessels, the diesel standards of Hong Kong are falling far behind those of the Mainland and overseas countries. The EPD needs to explore measures to further reduce the sulphur limit of fuel used by local and river-trade vessels in Hong Kong.

Room for reducing emissions from ocean-going vessels and government vessels

3.20 ***Ocean-going vessels.*** In May 2012, the EPD informed the EA Panel that:

(a) the EPD and the MD would launch a three-year incentive scheme (by waiving half of the port facilities and light dues) to encourage ocean-going vessels to switch to using diesel with a sulphur limit of 0.5% when berthing in Hong Kong waters; and

(b) if all ocean-going vessels switched to using such fuel while at berth in Hong Kong waters:

  (i) the territory emissions of SO_2, NOx and PM_{10} would be reduced by 7%, 0.1% and 6% respectively; and

  (ii) the estimated revenue forgone would be $260 million for three years.

The incentive scheme was launched on 26 September 2012. Given the high emissions from ocean-going vessels, the EPD needs to monitor closely the implementation of the incentive scheme and assess its effectiveness.

3.21 ***Government vessels.*** As of December 2010, there were 791 government vessels and their emissions accounted for 8% of NOx and 6% of PM_{10} emissions from local vessels. Since 2011, all new government vessels with engine power output greater than 130 kilo-Watt have been required to meet the IMO Tier II standards. In April 2012, the EPD informed the EA Panel that it intended to conduct a trial scheme to replace the engines of some government vessels with a view to reducing their emissions, particularly NOx emissions. As of August 2012, of the 116 government vessels installed with engines with power output greater than 130 kilo-Watt, 56 (48%) had been replaced with engines meeting the IMO Tier I standards. The MD informed Audit in August 2012 that most of the engines of the remaining 60 (116 less 56) government vessels were more than 12 years old and it might be more cost-effective to replace them when they reached the end of their useful lives (i.e. 15 or 20 years depending on vessel types).

3.22 In Audit's view, the Government should take the lead to reduce emissions from government vessels. Therefore, the EPD should proceed with the proposed trial scheme and report to the EA Panel the results of the scheme in a timely manner. Based on the trial results, the EPD should also formulate appropriate strategies for replacing high-polluting engines of government vessels, where justified.

Audit recommendations

3.23 **Audit has *recommended* that the Secretary for the Environment and the Director of Environmental Protection should, in consultation with the Director of Marine:**

(a) **require local and river-trade vessels to use ultra-low-sulphur diesel in Hong Kong waters as early as possible;**

(b) **explore measures to further reduce the sulphur limit of fuel used by local and river-trade vessels, taking account of the more stringent fuel sulphur limits set in the Mainland and overseas countries;**

(c) **monitor closely the implementation of the incentive scheme to encourage ocean-going vessels to use diesel with a sulphur limit of 0.5% in Hong Kong waters, and assess its effectiveness; and**

(d) **proceed with the proposed trial scheme on replacing high-polluting engines of government vessels, report the results to the EA Panel and formulate appropriate replacement strategies in a timely manner.**

Response from the Administration

3.24 The Secretary for the Environment and the Director of Environmental Protection agree with the audit recommendations. They have said that:

(a) the EPD has been exploring with the marine trades on the feasibility of capping the sulphur content of local marine diesel at 0.05%, which is 90% less than that of the marine diesel presently available on the local market;

(b) the new sulphur limit of local marine diesel to be set by the EPD will make reference to fuel sulphur limits set in the Mainland and overseas countries;

(c) the EPD will closely monitor the incentive scheme for ocean-going vessels to switch to cleaner fuel, including the participation of the vessels and the effectiveness of the scheme; and

(d) with the assistance from the MD, the EPD is making preparation for commencing the proposed trial scheme on replacing high-polluting engines of government vessels in early 2013. The EPD will work out with the relevant bureaux/departments on the way forward for replacing these vessels in the light of the trial findings.

3.25 The Director of Marine has said that the MD will continue to provide technical support and assistance to the EPD in implementing the audit recommendations.

Dark-smoke control of vessels

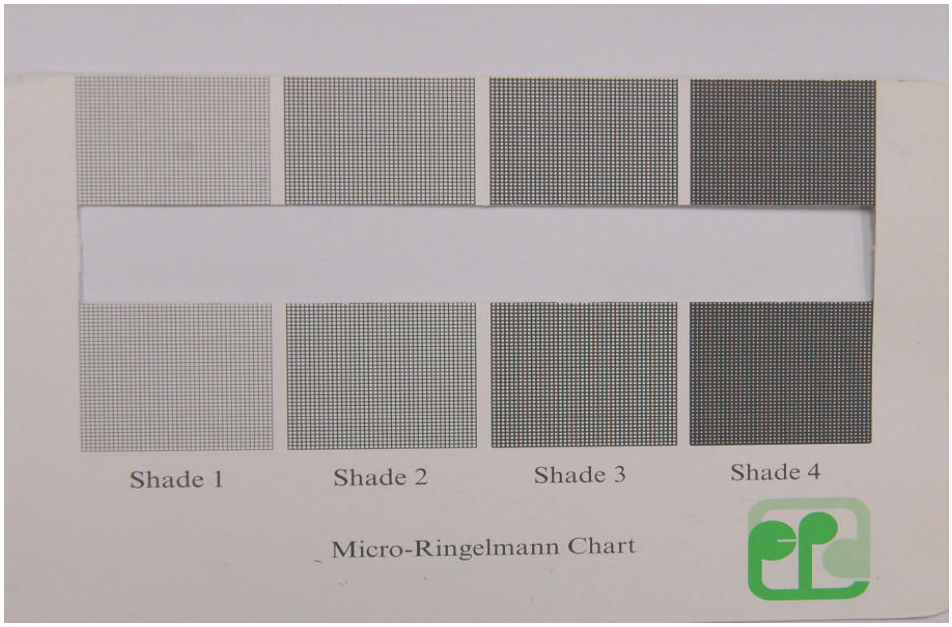
3.26 Vessels will emit dark smoke (mostly comprising unburnt carbon) if their engines are not properly maintained. Under the Shipping and Port Control Ordinance (Cap. 313) and the Merchant Shipping (Local Vessels) Ordinance (Cap. 548), no vessels in Hong Kong waters shall emit smoke in such a quantity as to cause a nuisance, and the owner and master/coxswain of any vessel in contravention of this requirement will commit an offence and will be liable to a fine of $10,000.

MD's work in controlling dark-smoke emissions from vessels

3.27 Since 2005, the MD has adopted the Ringelmann Chart (see Photograph 3) as a reference in conducting ship surveys. The Ringelmann Chart is a device with four shades of gray of different intensity (Shade 1 being the lightest and Shade 4 the darkest). In considering issuing a certificate of survey (which is required for applying for or renewing a vessel licence), the MD will ensure that the vessel's emissions do not exceed the acceptable level.

Photograph 3

Ringelmann Chart



Source: EPD records

3.28 According to the MD, its officers will issue an advisory letter if a vessel is found emitting dark smoke of an intensity of Shade 1 of the Ringelmann Chart (see Photograph 3) for three minutes or more, or of Shade 2 for less than three minutes. A warning letter will be issued if the related dark smoke is found of an intensity of Shade 2 lasting for three minutes or more. Prosecution action will be taken when there is sufficient evidence to prove the cause of a nuisance.

3.29 Since January 2006, the MD has distributed educational leaflets to masters/coxswains of vessels, advising them of the ways to prevent excessive smoke emissions and the penalties stipulated under the relevant Ordinances. Up to August 2012, 31,000 copies of such leaflets had been distributed. Moreover, from 2007 to August 2012, the MD had conducted eight dark-smoke visual surveys of vessels. Details are shown in Table 7.

Table 7

Dark-smoke visual surveys of vessels conducted by MD
(2007 to August 2012)

Year	Number of surveys conducted (No.)	Number of vessels surveyed (a) (No.)	Number of vessels with visible emission (b) (No.)	Percentage of vessels with visible emission (c) = $\frac{(b)}{(a)} \times 100\%$
2007	1	973	397	40.8%
2008	1	620	167	26.9%
2009	1	706	151	21.4%
2010	2	2,498	432	17.3%
2011	2	2,862	285	10.0%
2012 (Up to August)	1	1,442	17	1.2%
Overall	8	9,101	1,449	15.9%

Source: Audit analysis of MD records

3.30 As shown in Table 7, in 2010 and 2011, the MD conducted four dark-smoke visual surveys involving 5,360 (2,498 + 2,862) vessels navigating in Hong Kong waters. During the surveys, the MD took action on 80 vessels (1.5%) found emitting dark smoke. Of these 80 cases, the MD issued 75 advisory letters (for less severe cases) and 4 warning letters (for severe cases) to the owners and masters/coxswains of vessels, and took prosecution action in one case against the master of the vessel concerned, who was subsequently convicted and fined $2,500.

Slow progress in adopting Ringelmann Chart in controlling dark-smoke emissions from vessels

3.31 In June 2000, after considering standards adopted for controlling smoke emissions from vessels in overseas countries and for controlling smoke emissions from vehicles in Hong Kong, the MD proposed to the THB to introduce legislative amendments to give effect to adopting the Ringelmann Chart as a reference to measure dark-smoke emissions from vessels.

3.32 In April 2008, the MD consulted the shipping industry regarding introducing legislative amendments to give effect to adopting Shade 1 of the Ringelmann Chart as the benchmark for determining dark-smoke emissions by vessels. In the event, the shipping industry raised objection to the proposal. In October 2009, the THB informed the MD that, since there was other pressing legislative work to proceed with, the THB needed more time to consider details of introducing the proposed legislative amendments.

3.33 Under the Road Traffic Ordinance (Cap. 374), vehicles suspected of emitting dark smoke are required to undergo a smoke test to ascertain whether their dark-smoke emissions exceed the statutory limits. However, under the Shipping and Port Control Ordinance and the Merchant Shipping (Local Vessels) Ordinance, the owner and master/coxswain of a vessel will only be subject to prosecution if it emits smoke in such a quantity as to cause a nuisance. However, it is difficult to gather sufficient evidence to show that the dark-smoke emission has caused a nuisance for taking prosecution action. In fact, from 2007 to 2011, there had been only five successful prosecution cases relating to smoky vessels.

3.34 Under the Air Pollution Control (Smoke) Regulations (Cap. 311C), emissions of dark smoke by a chimney or a plant will be an offence if they appear to be as dark as or darker than Shade 1 of the Ringelmann Chart. Audit also notes that, in the UK, the Ringelmann Chart has been used as a tool for enforcement against dark-smoke emissions by vessels, as follows:

Practice in the UK

- It is an offence under the UK Clean Air Act 1993 for a vessel to emit dark smoke within the waters of the UK.
- Under the Act, "dark smoke" is defined as smoke which, if compared in the appropriate manner with the Ringelmann Chart, would appear to be as dark as or darker than Shade 2 of the Chart.
- The owner and the master of the vessel will be prosecuted and liable to a maximum fine of £5,000.

Source: Audit research

3.35 Dark smoke emitted by vessels comprises mainly suspended particulates which are harmful to health. Notwithstanding that the MD's visual surveys in recent years have shown decreased dark-smoke emissions from vessels (see Table 7 in para. 3.29), in order to provide an effective means to control such emissions, Audit considers that the THB needs to expedite action to seek legislative support to give effect to adopting the Ringelmann Chart as a reference to measure dark-smoke emissions from vessels.

Cessation of Smoky Vessels Spotter Programme

3.36 In November 2007, the MD launched the Smoky Vessels Spotter Programme, under which spotters were trained to assist in detecting dark-smoke emissions from vessels in Hong Kong waters. These spotters would report to the MD of suspected cases of dark-smoke emissions from vessels for the latter to take follow-up action. According to the MD, information provided by a spotter may not always be useful as a vessel is normally observed by a spotter from a far distance, and hence the vessel's name or licence number and the duration of emission of smoke may only be very brief for identifying the subject vessel for further action. As of December 2008, there were about 100 spotters who had reported three suspected smoky-vessel cases to the MD. After investigations, none of the suspected cases was substantiated and hence no prosecution action was taken. In December 2008, the Smoky Vessels Spotter Programme ceased operation.

3.37 Under the existing legislation, it is difficult to gather sufficient evidence to prosecute owners and masters/coxswains of vessels emitting dark smoke (see para. 3.33). Therefore, the Smoky Vessels Spotter Programme may not be useful under such a circumstance. However, if legislative changes are introduced to provide effective means for taking enforcement action against the owners and masters/coxswains of smoky vessels (see para. 3.35), the Spotter Programme may become useful and effective. The programme will, among other things, supplement the MD's resources in conducting related inspections and help raise public awareness of the smoky-vessel problem. Therefore, the MD needs to review whether the Smoky Vessels Spotter Programme should in future be re-launched after adoption of the Ringelmann Chart in detecting smoky vessels.

Audit recommendations

3.38 **Audit has *recommended* that the Secretary for Transport and Housing and the Director of Marine should:**

(a) **expedite action to seek legislative support to give effect to adopting the Ringelmann Chart as a reference to measure dark-smoke emissions from vessels; and**

(b) **review the desirability of re-launching the Smoky Vessels Spotter Programme after adoption of the Ringelmann Chart in detecting smoky vessels.**

Response from the Administration

3.39 The Secretary for Transport and Housing and the Director of Marine agree with the audit recommendations. They have said that:

(a) the THB and the MD will re-engage the shipping industry on the proposed setting of an objective standard for determining dark-smoke emissions from vessels by making reference to the Ringelmann Chart;

(b) in the light of the industry's feedback, the THB and the MD will formulate legislative proposals for consultation with the LegCo Panel on Economic Development within the 2012-13 legislative session; and

(c) subject to enactment of the legislative amendments, the MD will review whether to re-launch the Smoky Vessels Spotter Programme.

PART 4: EMISSION CONTROL OF POWER PLANTS

4.1 This PART examines the actions taken by the EPD in controlling emissions from power plants.

Emissions from power plants

4.2 Power generation is a major emission source in Hong Kong. In 2010, emissions from power plants accounted for 50% of SO_2, 25% of NOx and 16% of PM_{10} of the total emissions in Hong Kong (see Figure 1 in para. 1.10). There are two electricity companies operating a total of four power plants which together supply 77% of electricity for local consumption (the remaining 23% is supplied by a nuclear power plant on the Mainland). In 2011, the four power plants used coal or natural gas as fuel, with coal accounting for 71% of local electricity generation and natural gas 29%.

Emission allowances for power plants

4.3 In the 2007 Consultancy Review, the Consultant recommended reducing the emission allowances for local power plants for the purpose of achieving the 2014 AQOs. Furthermore, from November 2008 to October 2012, three technical memoranda were gazetted for allocating emission allowances for SO_2, NOx and PM_{10} among local power plants (Note 28), as follows:

	Date of gazette	**Effective from**
• First Technical Memorandum	November 2008	2010
• Second Technical Memorandum	October 2010	2015
• Third Technical Memorandum	October 2012	2017

Table 8 shows the proposed emission allowances in the 2007 Consultancy Review, the emission allowances effective from 2010, and those to be effective from 2015 and 2017, for achieving the 2014 AQOs.

Note 28: *The allocation is on a pro-rata basis according to the share of the total amount of electricity generated for local consumption.*

Table 8

Emission allowances for local power plants

Pollutant	Proposed emission allowance in 2007 Consultancy Review (Tonne)	Annual emission allowance		
		First Technical Memorandum (effective from 2010) (Tonne)	Second Technical Memorandum (effective from 2015) (Tonne)	Third Technical Memorandum (effective from 2017) (Tonne)
SO_2	11,718	25,120	12,482	10,399
NOx	17,375	42,600	27,552	25,950 (Note)
PM_{10}	737	1,260	831	750

Source: *EPD records*

Note: *EPD's proposed emission allowance of 25,950 tonnes (effective from 2017) will still exceed the consultant's proposal of 17,375 tonnes by 49% (see para. 4.6).*

Room for reducing NOx emissions from local power plants

4.4 According to the 2007 Consultancy Review:

(a) combustion of natural gas emits negligible amounts of SO_2 and PM_{10} and produces less NOx than those emitted by combustion of coal and diesel; and

(b) as one of the measures to achieve the 2014 AQOs, the percentage of natural gas in the fuel mix for local electricity generation should be increased.

Audit's comparison of the emissions of SO_2, NOx and PM_{10} from local power plants for electricity generation using coal with those using natural gas in 2011 also reveals that natural gas is much cleaner (see Table 9).

Table 9

Emissions from local power plants
(2011)

Fuel used	Electricity generated (Gigawatt-hour)	Emission		
		SO_2 (Tonne)	NOx (Tonne)	PM_{10} (Tonne)
Coal	27,651	13,881	27,244	923
Natural gas	11,367	129	2,758	73

Source: Audit analysis of EPD records

4.5 Table 9 shows that for electricity generated locally in 2011, emissions of SO_2, NOx and PM_{10} by using natural gas were far lower than those by using coal. As it transpires, emissions of SO_2, NOx and PM_{10} per unit of electricity generated by using natural gas were 98%, 75% and 82% respectively less than those generated by using coal. It is however more costly to generate electricity using gas than coal. According to information submitted by the ENB to the EA Panel in October 2010, the power companies' unit generation costs of coal-fired electricity were in the range of $0.4 to $0.6 per kWh, and those of gas-fired electricity in the range of $0.7 to $0.9 per kWh.

4.6 According to the EPD, in order to meet the EPD's proposed emission allowances effective from 2017 (see Table 8 in para. 4.3), the power companies need to raise the gas fuel mix in local electricity generation to 50%, and retrofit their coal-fired electricity-generation units with advanced emission-control equipment. However, Audit notes that, even if the EPD's proposed emission allowances effective from 2017 are accepted for implementation, the NOx emission allowance for local power plants of 25,950 tonnes will still exceed the Consultant's proposed emission allowance of 17,375 tonnes by 49% (see Table 8 in para. 4.3). As explained by the EPD, this situation is mainly attributable to the significantly higher NOx emissions from coal-fired power plants, which also emit other toxic substances such as mercury. In Audit's view, in order to achieve the 2014 AQOs, the EPD needs to:

(a) take further measures to reduce NOx emissions from local power plants; and

(b) review the long-term fuel mix for local electricity generation, taking account of the high emission of air pollutants by using coal vis-à-vis natural gas.

Emission allowances for $PM_{2.5}$ not yet set for local power plants

4.7 In April 2012, the EPD informed the EA Panel that the power sector was also a major source of $PM_{2.5}$. According to the ENB, comparing with PM_{10}, health studies have found that $PM_{2.5}$ have greater association with adverse health effects and will pose greater health risks to the general public. An EPD test in 2011 also indicated that $PM_{2.5}$ accounted for about 65% of PM_{10} emissions from local power plants.

4.8 In July 2012, the EPD informed Audit that:

(a) the existing SO_2, NOx and PM_{10} emission allowances were set to ensure the achievement of the 2010 emission-reduction targets under the 2002 Joint Statement issued with the Guangdong Authority (see para. 1.12);

(b) $PM_{2.5}$ were part of PM_{10}, such that the existing emission allowances and emission-control measures for PM_{10} would also be able to control $PM_{2.5}$ emissions; and

(c) $PM_{2.5}$ in the ambient environment were mainly the secondary product of chemical reactions of SO_2 and NOx, and it would be more beneficial to further reduce SO_2 and NOx emissions from power plants in order to reduce the $PM_{2.5}$ concentration in the ambient environment.

4.9 Audit notes that the EPD has accorded a high priority to the control of $PM_{2.5}$, and has included it as one of the air pollutants in the 2014 AQOs (see Appendix C). In this connection, Audit notes that power companies in Australia, Canada and the USA are required to report to the relevant authorities if $PM_{2.5}$ emissions from their power plants have exceeded specified quantities. In view of

the high potential risk of $PM_{2.5}$ emissions from power plants, the EPD needs to consider setting emission allowances for $PM_{2.5}$ for local power plants, taking account of good practices abroad.

Audit recommendations

4.10 **Audit has *recommended* that the Secretary for the Environment and the Director of Environmental Protection should:**

(a) **take further measures to reduce NOx emissions from local power plants;**

(b) **review the long-term fuel mix for local electricity generation, taking account of the high emission of air pollutants by using coal vis-à-vis natural gas; and**

(c) **consider setting emission allowances for $PM_{2.5}$ for local power plants, taking account of good practices abroad.**

Response from the Administration

4.11 The Secretary for the Environment and the Director of Environmental Protection agree with the audit recommendations. They have said that:

(a) the EPD will continue requiring the power plants to use best practicable measures to reduce their NOx emissions. Due to space constraints, the power plants might not be able to retrofit their electricity-generation units with emission-reduction devices for further emission reductions. The ENB and the EPD will look into the fuel mix for local electricity generation in the years ahead for substantially reducing its pollutant emissions. For example, the emission of NOx can be reduced by some 34% from the proposed 2017 emission allowances if the gas fuel mix in local electricity generation is raised to 75% or more by 2020;

(b) since 1997, the Government has required new electricity-generation plants to use natural gas. Upon the retirement of the old coal-firing electricity-generation units, they will be replaced by natural-gas units to further increase the proportion of electricity supply by gas-fired units so as to reduce the emission of key air pollutants; and

(c) most of the advanced countries have set ceilings for the emission of TSP by power plants but not the emission of $PM_{2.5}$. Notwithstanding this, the ENB and the EPD will explore the feasibility of setting ceilings for $PM_{2.5}$ emissions by local power plants in the next review, which will take place in 2014, having regard to the latest international practices on the issue.

PART 5: EMISSION CONTROL OF NON-ROAD MOBILE MACHINERY

5.1 This PART examines the actions taken by the EPD in controlling emissions from NRMM.

Emissions from non-road mobile machinery

5.2 Mobile machines, transportable industrial equipment and non-road vehicles are commonly referred to as NRMM. They are widely used in construction sites (e.g. excavators), the airport (e.g. catering trucks) and container terminals (e.g. loaders). Photographs 4 to 6 show some examples.

Photographs 4 to 6

Examples of NRMM

Photograph 4

Excavator at construction site

Photograph 5

Catering truck at airport

Photograph 6

Loader at container terminal

Source: EPD records

As shown in Figure 1 in paragraph 1.10, emissions from NRMM accounted for 6% of NOx and 8% of PM_{10} of the total emissions in Hong Kong in 2010.

5.3 According to the EPD, as of February 2012:

(a) there were 13,500 units of NRMM operating in Hong Kong (comprising 11,300 units at construction sites, 1,600 units at the airport and 600 units at container terminals);

(b) the estimated average age of the NRMM was 8 years old;

(c) the estimated average service life of the NRMM was 14 years; and

(d) if all the units of existing NRMM were replaced by those meeting emission standards of the European Union, the USA and Japan, 4% and 5% of the local emissions of NOx and PM_{10} could be reduced respectively.

5.4 At present, NRMM is not subject to any statutory air-pollutant-emission control, except that NRMM:

(a) must not cause air nuisances as regulated under the APCO;

(b) must not emit dark smoke over the restriction limits as regulated under the Air Pollution Control (Smoke) Regulations (see para. 3.34); and

(c) using diesel as fuel (such as NRMM used in construction sites or other non-domestic premises) must use diesel with a sulphur content not higher than 0.005% (i.e. ultra-low-sulphur content) as regulated under the Air Pollution Control (Fuel Restriction) Regulations (Cap. 311I). The Regulations aim to control the solid and liquid fuel quality of a wide range of fuel-burning equipment, including boilers, generators and engines located in non-domestic premises.

Proposal to control emissions from NRMM

5.5 In February 2012, the EPD informed the EA Panel of a plan to introduce emission controls over NRMM, as follows:

(a) all NRMM units (either new or second-hand) to be sold, leased or supplied for local use would have to meet specified emission standards (broadly in line with those of the European Union, the USA and Japan)

and be approved by the EPD. The approved NRMM units would be affixed with an approval label for identification;

(b) owners of all existing NRMM units in use before the introduction of the control system would have to notify the EPD of details of the NRMM, which would be exempted from the new emission-control requirements and would be affixed with an exemption label for identification. The EPD would keep a record of these NRMM units; and

(c) the EPD aimed to complete the related legislative procedures in the 2012-13 legislative session, and it would review the situation after implementation of the control system, and decide on the need for further control over existing NRMM at a later stage.

Insufficient control of emissions from NRMM

5.6 As stated in paragraph 5.5, the EPD has planned to complete in the 2012-13 legislative session the necessary legislative procedures for implementing the proposed NRMM emission-control system. However, the proposed NRMM emission standards are applicable only to NRMM units (either new or second-hand) to be sold, leased or supplied for local use after the new regulation comes into operation, but not the existing units already in use. As the estimated average service life of the NRMM units is as long as 14 years (see para. 5.3(c)), the existing NRMM units will continue to cause air pollution for a long period of time before they are decommissioned.

5.7 In the 2007 Consultancy Review, the Consultant recommended the installation of emission-reduction devices in existing NRMM units as a measure for reducing air pollution from this source. The Consultant's assessment revealed that this measure could bring about considerable health benefits at a relatively low cost to society. Furthermore, at its meeting in June 2010, the ACE suggested that the EPD should consider introducing emission-control measures for existing NRMM units such as providing incentives for their replacement or retrofitting.

5.8 Moreover, Audit notes that the State of California of the USA has implemented an emission-control system for existing NRMM units, as follows:

(a) owners of NRMM units are required to register details of their NRMM units with the relevant government authority, and update such details every year; and

(b) NRMM units are required to comply with the emission standards on NOx and PM_{10}. In order to meet the emission standards, the owner of an NRMM unit may replace the related engine or install an emission-control device in the machinery.

5.9 In view of the pollution caused by NRMM, in Audit's view, the EPD needs to introduce emission-control measures on existing NRMM, and complete the legislative procedures necessary for implementing the proposed NRMM emission-control system as early as possible.

Insufficient control of NRMM in government projects

5.10 In Audit's view, the Government should always take the lead to use only NRMM which meets specified environmental standards in its works projects. In this connection, the Development Bureau, in collaboration with the EPD and in consultation with the industry, needs to explore the feasibility of stipulating the use of such NRMM units in public works contracts.

Audit recommendations

5.11 **Audit has *recommended* that the Secretary for the Environment and the Director of Environmental Protection should:**

(a) **consider introducing emission-control measures on existing NRMM, taking into account the views of the ACE, the 2007 Consultancy Review recommendations and overseas practices; and**

(b) **complete the legislative procedures necessary for implementing the proposed NRMM emission-control system as early as possible.**

5.12 **Audit has also *recommended* that the Secretary for Development should, in collaboration with the Director of Environmental Protection and in consultation with the industry, consider exploring the feasibility of stipulating the use of NRMM units meeting specified environmental standards in public works contracts.**

Response from the Administration

5.13 The Secretary for the Environment and the Director of Environmental Protection agree with the audit recommendations in paragraph 5.11. They have said that:

(a) the EPD notes that it is not a common practice in overseas countries to control the emissions of in-use NRMM. The EPD will keep in view closely the overseas developments, both technical and regulatory, with a view to taking appropriate measures to introduce control requirements on existing NRMM in the future. In the meantime, the EPD will keep up its efforts to ensure that the operation of the existing NRMM units are in compliance with the existing requirements under the APCO; and

(b) the EPD plans to complete the legislative procedures for implementing the emission-control system for new NRMM in 2013. After imposing emission controls for new or second-hand NRMM units to be sold, leased or supplied for local use, the EPD will establish a registry to take stock of the existing NRMM units for issuing approval or exemption labels.

5.14 The Secretary for Development and the Director of Environmental Protection agree with the audit recommendation in paragraph 5.12. They have said that:

(a) at present, the Government does not have information on the availability of NRMM units meeting the specified environmental standards for local use. In the absence of this information, effective measures cannot be drawn up for controlling the use of NRMM units in public works projects; and

(b) the Development Bureau has reviewed the issue with the EPD and considers that, subject to the supply in the market and costs of different types of NRMM fulfilling the specified environmental standards, in consultation with the industry, it will explore with the EPD the appropriate scope and timing for using NRMM units in public works projects.

PART 6: REGIONAL EMISSION CONTROL

6.1 This PART examines the actions taken by the EPD, in collaboration with the Guangdong EPD, in controlling and monitoring emissions in the PRD region.

Management of regional air quality

PRD Regional Air Quality Management Plan

6.2 From 1999 to 2002, with a view to improving the air quality of the PRD region, the EPD and the Guangdong EPD conducted a joint study on regional air quality (1999 Joint Study). The objective was to analyse the relative significance of different industrial and commercial sources of pollution and their direct and indirect impacts on regional air quality so that air-pollution-control measures could be prioritised accordingly. According to the 1999 Joint Study:

(a) from 1997 to 2010, the economy in the PRD region would grow by 150%, population by 20%, electricity demand by 130%, and vehicle mileage by 180%; and

(b) in terms of total emissions, Hong Kong accounted for about 5% to 20% of regional air pollution while the PRD Economic Zone of Guangdong Province accounted for 80% to 95%.

6.3 In April 2002, the HKSAR Government and the Guangdong Provincial Government issued the 2002 Joint Statement. According to the Statement:

(a) the two Governments agreed to aim to reduce, on a best endeavour basis, the regional emissions of SO_2 by 40%, NOx by 20%, PM_{10} by 55% and VOCs by 55% by 2010, using 1997 as the base year;

(b) to achieve these targets, the two Governments would study and consider in detail the various improvement measures recommended in the 1999 Joint Study, determine work priorities and draw up action plans having regard to the feasibility of the proposed improvement measures;

(c) the two Governments aimed to strive to reduce the emissions from their own sources by the same levels in 2010;

(d) the two Governments would jointly draw up the PRD Regional Air Quality Management Plan and set up an expert group comprising representatives of the EPD and the Guangdong EPD to jointly monitor trends and changes in regional air quality and evaluate the effectiveness of the improvement measures; and

(e) the two Governments would make their best effort to strive to achieve the above emission-reduction targets in 2010 for the purposes of improving air quality in the PRD region, protecting public health and ensuring the sustainable development of the region.

6.4 In December 2003, the two Governments jointly drew up the PRD Regional Air Quality Management Plan with a view to meeting the emission-reduction targets, and set up the PRD Air Quality Management and Monitoring Special Panel (Note 29) to follow up the tasks under the Management Plan. The latest version of the Management Plan with enhanced control measures of the two Governments, as presented to the EA Panel in January 2012, is shown in Appendix E.

PRD Regional Air Quality Monitoring Network

6.5 In November 2005, the EPD and the Guangdong EPD jointly established the PRD Regional Air Quality Monitoring Network, comprising 16 air-quality monitoring stations, with 13 in the Guangdong Province and 3 in Hong Kong (Note 30). All stations are installed with equipment to measure the ambient concentrations of SO_2, NO_2, PM_{10} and O_3. The objectives of the Network are to:

Note 29: *The Panel was set up under the Hong Kong/Guangdong Joint Working Group on Sustainable Development and Environmental Protection, and comprised representatives of the EPD and the Guangdong EPD.*

Note 30: *The 16 stations are located in Luhu Park, Wanqingsha, Tianhu (all three in Guangzhou), Liyuan (in Shenzhen), Tangjia (in Zhuhai), Jinjuzui, Huijingcheng (both in Foshan), Donghu (in Jiangmen), Chengzhong (in Zhaoqing), Xiapu, Jinguowan (both in Huizhou), Haogang (in Dongguan), Zimaling Park (in Zhongshan), Tsuen Wan, Tap Mun and Tung Chung (all three in Hong Kong).*

(a) provide accurate air-quality data that can help the HKSAR Government and the Guangdong Provincial Government to appraise the air-quality situation and pollution problems in the PRD region for formulating appropriate control measures;

(b) evaluate the effectiveness of the air-pollution-control measures through long-term monitoring; and

(c) provide the public with information on the air quality of various places in the region.

6.6 The Guangdong EPD has published on its website the daily regional air-quality indices (Note 31) of 16 areas based on the air-quality data captured by the 16 monitoring stations, and the Guangdong EPD and the EPD have jointly prepared and published annual reports on the monitoring results, showing the extent of compliance with the national standards on the ambient concentrations of SO_2, NO_2, PM_{10} and O_3 in each of the 16 areas. The indices are as follows:

(a) 0 to 1: pollutant concentrations are well within the air-quality standards;

(b) 1 to 2: pollutant concentrations are generally within the air-quality standards;

(c) 2 to 3: concentrations of individual pollutants may approach or exceed the air-quality standards;

(d) 3 to 4: air-quality standards are generally exceeded; and

(e) $>$ 4: air-quality standards are significantly exceeded.

Note 31: *The regional air-quality index measures the aggregate level of four pollutants, namely SO_2, NO_2, PM_{10} and O_3, with reference to the national standards on air quality.*

Achievement of emission-reduction targets under 2002 Joint Statement

6.7 In September 2012, Audit made a recommendation to the EPD that it should expedite action on publishing the extent by the HKSAR Government of achieving the targets on reducing emissions as set out in the 2002 Joint Statement (see para. 6.3). In October 2012, the EPD announced that Hong Kong had met the 2010 emission-reduction targets, and the details of which had also been uploaded onto its website.

Slow progress in formulating post-2010 emission-reduction targets for PRD region

6.8 In August 2009, the HKSAR Government and the Guangdong Provincial Government signed the Environmental Co-operation Agreement. Under the Agreement, in order to improve the regional air quality further, a joint study group was set up in October 2009 to formulate post-2010 emission-reduction targets for the PRD region, and arrangements for implementation. In June 2012, the ENB informed the EA Panel that the two Governments were still discussing arrangements for the post-2010 emission-reduction targets. Audit considers that the EPD needs to work closely with the Guangdong EPD with a view to setting the post-2010 emission-reduction targets and related implementation arrangements at an early time.

Effective emission-control measures not yet implemented in the waters of Hong Kong and PRD region

6.9 In December 2011, the EPD informed the EA Panel that it was exploring with the Governments of the Guangdong Province and the Macao Special Administrative Region on:

(a) the feasibility of requiring ocean-going vessels to switch to use diesel with a sulphur limit of 0.5% while berthing at ports of Hong Kong and the PRD region; and

(b) over a longer term, setting up an emission-control area in PRD waters.

6.10 At present, under the IMO 2010 Standards, marine vessels are only required to use diesel with a sulphur limit of 3.5% in general waters, and a sulphur limit of 1.0% in designated emission-control areas (see Table 5 in para. 3.5). Therefore, the implementation of the two initiatives in paragraph 6.9 will significantly reduce emissions from ocean-going vessels in the waters of Hong Kong and the PRD region. In Audit's view, the EPD needs to, in collaboration with the THB and the MD, pursue expeditiously the two initiatives with the Governments of the Guangdong Province and the Macao Special Administrative Region.

Share of local air pollutants emitted from sources outside Hong Kong not yet estimated

6.11 In February 2012, a local university engaged by the EPD completed a comprehensive study on the contribution of regional and local sources to the suspended particulates in the air of Hong Kong. The study revealed that 67% of suspended particulates measured in Hong Kong came from non-local sources (i.e. from the PRD region and beyond), which was similar to the findings of a previous study conducted by the same university in 2005. However, apart from suspended particulates, Audit notes that the EPD has not conducted a study for estimating the share of other major local air pollutants emitted from sources outside Hong Kong. In Audit's view, the EPD needs to conduct a study for the purpose. This will provide useful information to support the implementation of various air-quality improvement measures.

Audit recommendations

6.12 **Audit has *recommended* that the Secretary for the Environment and the Director of Environmental Protection should:**

(a) **work closely with the Guangdong EPD with a view to setting the post-2010 emission-reduction targets and related implementation arrangements at an early time;**

(b) **in collaboration with the Secretary for Transport and Housing and the Director of Marine, continue to pursue with the Governments of the Guangdong Province and the Macao Special Administrative Region on:**

(i) **requiring ocean-going vessels to switch to use diesel with a sulphur limit of 0.5% while berthing at ports of Hong Kong and the PRD region; and**

(ii) **setting up an emission-control area in PRD waters; and**

(c) **conduct a study to estimate the share of major local air pollutants emitted from sources outside Hong Kong.**

Response from the Administration

6.13 The Secretary for the Environment and the Director of Environmental Protection agree with the audit recommendations. They have said that:

(a) the joint study with the Guangdong EPD on the post-2010 emission-reduction plan has basically been completed. The HKSAR Government and the Guangdong Provincial Government are finalising the emission targets and will announce the post-2010 emission-reduction targets as soon as practicable; and

(b) regarding emission-control requirements for marine vessels, the EPD, in collaboration with the THB and the MD, has been exploring with the relevant Mainland authorities on mandating ocean-going vessels to switch to use cleaner fuel while at berth and, in the long term, setting up an emission-control area in PRD waters. The Administration will continue to liaise with the Mainland authorities on the issue.

6.14 The Secretary for Transport and Housing and the Director of Marine have said that the THB and the MD will continue to provide support to the ENB and the EPD in discussing with the Governments of the Guangdong Province and the Macao Special Administrative Region on regional emission-control proposals.

PART 7: WAY FORWARD

7.1 This PART summarises the areas for improvement and the way forward for implementing emission-control measures to improve the air quality of Hong Kong.

Areas for improvement

7.2 Since the promulgation of the seven AQOs under the APCO in 1987, the ENB and the EPD have implemented various measures to improve the air quality of Hong Kong. However, Audit examination has revealed that despite their efforts, up to December 2011, the AQOs had never been fully achieved, and in 2011, 24 years after promulgating the AQOs, 8 of the 27 concentration measurements had still exceeded the AQO limits. In particular, in 2011, the annual roadside concentration level for NO_2 and that for PM_{10} had exceeded the limits specified in the AQOs by 55% and 20% respectively. Furthermore, notwithstanding that the EPD has set a performance target that there should not be any day in a year with API exceeding 100, 175 (48%) in 365 days in 2011 had recorded high APIs exceeding 100, with the highest of 192 recorded at the Central roadside station on 29 May 2011.

7.3 In January 2012, the Government announced that, based on the WHO AQGs, the AQOs would be revised to stringent levels with effect from 2014. According to the EPD consultant, upon attainment of the 2014 AQOs, about 4,200 unnecessary hospital admissions and 7,400 statistical life years would be saved each year, or an improved average life expectancy of around one month for the entire population. Other health benefits include less people contracting asthma and other respiratory diseases.

7.4 Audit is concerned that the unsatisfactory air quality may cause detrimental health effects on members of the public, leading to an increased number of people contracting illnesses and hospital admissions. While Audit understands that the ambient air pollution is partly caused by the regional pollution which may not be fully under the control of the HKSAR Government, roadside pollution is mainly caused by vehicle emissions which is within its pursuit. In Audit's view, the Government needs to accord a high priority to implement measures for improving the air quality of Hong Kong, and work closely with the Guangdong Provincial

Government on ways and means to improve the regional air quality. In this connection, Audit has identified in earlier PARTs many areas that call for improvement.

Public support for implementing air-quality improvement measures required

7.5 With a view to achieving the 2014 AQOs, the Government has proposed 22 air-quality improvement measures. Audit believes that the full implementation of these 22 measures will help vastly improve the air quality and contribute to better health of the general public. However, Audit notes that there are challenges ahead in implementing these air-quality improvement measures. For example, the 2007 Grant Scheme for replacing high-polluting diesel commercial vehicles with new ones (which should comply with the prevailing statutory emission standards) only attracted 29% of the vehicle owners to join the scheme.

7.6 The implementation of the air-quality improvement measures may involve substantial financial resources. For example, the measures on earlier replacement of aged and high-polluting vehicles will involve additional costs to the vehicle owners. The Government needs to plan carefully on who should bear the financial costs of implementing each of the air-quality improvement measures: whether they should be borne totally by the Government (by means of providing subsidies), by the polluters (by means of introducing legislative requirements), or partly by the Government and partly by the polluters.

7.7 There are great challenges ahead for meeting the 2014 AQOs which are more stringent than the existing ones (established in 1987). In Audit's view, the Government needs to take on board the audit observations and recommendations in this Audit Report for implementing measures to improve the air quality of Hong Kong. The Government also needs to fully apprise the public and stakeholders through periodic promotion campaigns of the health, economic and social implications of introducing air-quality improvement measures. With improved public awareness of the implications (particularly those on health) of implementing the proposed air-quality improvement measures, the Government may be able to gain wider public support for introducing the measures, and the ways and means for implementation.

Audit recommendations

7.8 **Audit has *recommended* that the Secretary for the Environment and the Director of Environmental Protection should:**

(a) **take on board the audit observations and recommendations in this Audit Report for implementing measures to improve the air quality of Hong Kong; and**

(b) **fully apprise the public and stakeholders through periodic promotion campaigns of the health, economic and social implications of introducing air-quality improvement measures, with a view to gaining public support for implementing the measures, and the ways and means for implementation.**

Response from the Administration

7.9 The Secretary for the Environment and the Director of Environmental Protection agree with the audit recommendations. They have said that:

(a) both the ENB and the EPD will seriously take on board the audit observations and recommendations in this Audit Report. In collaboration with all relevant bureaux and departments, the ENB will coordinate and consolidate a detailed plan to implement various measures for improving the air quality of Hong Kong; and

(b) in close consultation with the relevant bureaux and departments, the ENB and the EPD will promote public understanding of the health, economic and social implications of introducing various air-quality improvement measures and enlist their support for the implementation of such measures.

Appendix A
(para. 1.7 refers)

Air quality objectives (1987 to 2013)

Pollutant	Average time measurement	Average concentration limit ($\mu g/m^3$)	Number of excesses allowed in a year (Note)	Associated health effects
SO_2	1-hour	800	3	Respiratory illness, reduced lung function, and increase in morbidity and mortality rates
	24-hour	350	1	
	Annual	80	N/A	
NO_2	1-hour	300	3	Respiratory irritation, increased respiratory infection, and lung development impairment
	24-hour	150	1	
	Annual	80	N/A	
PM_{10}	24-hour	180	1	Respiratory illness, reduced lung function, risk of cancer, and increase in morbidity and mortality rates
	Annual	55	N/A	
TSP	24-hour	260	1	Respiratory fraction of TSP has effects on health
	Annual	80	N/A	
O_3	1-hour	240	3	Eye irritation, cough, reduced athletic performance, and possible chromosome damage
CO	1-hour	30,000	3	Coordination impairment, and deleterious to pregnant women and those with heart and circulatory damage
	8-hour	10,000	1	
Lead	3-month	1.5	0	Body processes affected, likely neuro-psychological effects, likely effects on heart attacks, strokes, and hypertension

Source: *EPD records*

Note: *The number of excesses does not apply to annual measurements.*

Appendix B
(paras. 1.9(a) and 2.11 refer)

22 air-quality improvement measures (September 2012)

A. Emission capping and control

1. Increasing the ratio of natural gas in local electricity generation to 50% with additional emission-abatement measures
2. Early retirement of aged/heavily polluting vehicles
3. Earlier replacement of Euro III commercial diesel vehicles with models meeting latest Euro standards
4. Wider use of hybrid, electric vehicles or other environment-friendly vehicles with similar performance
5. Requiring the use of 0.1% sulphur diesel for local vessels subject to confirmation of technical feasibility
6. Government vessels adopting feasible measures to reduce NOx emissions
7. Electrification of aviation ground-support equipment
8. Emission control for off-road vehicles/equipment
9. Strengthening VOC control

B. Transport management

10. Designating low emission zones
11. Designating car-free zones and implementing pedestrianisation schemes
12. Implementing bus route rationalisation

C. Infrastructure development and planning

13. Expanding rail network
14. Developing cycle tracks in new development areas

D. Energy efficiency

15. Mandatory implementation of the Building Energy Codes

16. Promulgating energy efficiency standards for domestic electrical appliances

17. Adopting light-emitting diode or equivalent alternatives for traffic signals and street lighting

18. Implementing tree planting and roof-top greening

19. Developing district cooling system for Kai Tak Development

E. Other measures identified further to the 2007 Consultancy Review

20. Retrofitting Euro II and III franchised buses with selective catalytic reduction devices

21. Tightening the emission-control regime on emissions from LPG and petrol vehicles through remote sensing equipment and dynamometer tests

22. Seeking to collaborate with PRD governments in requiring ocean-going vessels to switch to cleaner fuel while berthing at PRD ports and setting up an emission-control area in PRD waters over the longer term

Source: EPD records

Appendix C
(paras. 1.9(b) and 4.9 refer)

Air quality objectives (2014 onwards)

Pollutant	Average time measurement	Average concentration limit ($\mu g/m^3$)	Number of excesses allowed in a year (Note)
SO_2	10-minute	500	3
	24-hour	125	3
NO_2	1-hour	200	18
	Annual	40	N/A
PM_{10}	24-hour	100	9
	Annual	50	N/A
$PM_{2.5}$	24-hour	75	9
	Annual	35	N/A
O_3	8-hour	160	9
CO	1-hour	30,000	0
	8-hour	10,000	0
Lead	Annual	0.5	N/A

Source: EPD records

Note: The EPD set such numbers based on the recommendations of the 2007 Consultancy Review to cater for local situations. The number of excesses does not apply to annual measurements.

Appendix D
(para. 1.11 refers)

Major emission-control measures (1997 to 2011)

Year	Measures
1997	• Ceasing the approval of new coal-fired electricity generation units
	• Introducing statutory specifications for motor-vehicle fuel of Euro II standards
1999	• Strengthening control for smoky vehicles
	• Banning the sale of leaded petrol
	• Requiring all newly registered vehicles to comply with Euro II emission standards
2000	• Launching an incentive scheme to encourage replacement of diesel taxis by LPG taxis
	• Providing incentives for the installation of particulate-reduction devices in pre-Euro diesel vehicles
	• Including an emission test in the roadworthiness test for petrol and LPG vehicles
	• Introducing a preferential fuel duty to promote the use of Euro IV diesel (ultra-low-sulphur diesel)
2001	• Requiring all newly registered taxis to be either LPG or petrol vehicles
	• Requiring all newly registered vehicles to comply with Euro III emission standards
	• Tightening the statutory specifications for motor-vehicle fuel to Euro III standards
2002	• Launching an incentive scheme to encourage the early replacement of diesel public light buses by LPG or electric vehicles
	• Tightening the statutory specifications for motor-vehicle fuel to Euro IV standards
2005	• Introducing emission caps on power plants
	• Tightening the statutory specifications for unleaded petrol to Euro IV standards

Year	Measures
2007	• Requiring all newly registered vehicles to comply with Euro IV emission standards
	• Launching an incentive scheme to replace pre-Euro and Euro I diesel commercial vehicles with new vehicles meeting the prevailing statutory emission standards
	• Launching a tax incentive scheme for environment-friendly petrol private cars
	• Requiring all pre-Euro diesel vehicles to be installed with particulate-reduction devices
	• Providing a two-year concessionary duty rate of $0.56 per litre for Euro V vehicle diesel
2008	• Launching a tax incentive scheme for environment-friendly commercial vehicles
	• Waiving the duty for Euro V motor-vehicle diesel
	• Gazettal of the First Technical Memorandum for the power sector, which allocated emission allowances to power plants from 2010 onwards
	• Tightening the statutory cap on the sulphur content of diesel fuel for commercial and industrial uses to 0.005%
2009	• Completion of the 2007 Consultancy Review, which recommended improvement measures for achieving the 2014 AQOs
2010	• Tightening motor-vehicle-fuel specifications to Euro V standards
	• Launching an incentive scheme to replace Euro II diesel commercial vehicles with new vehicles meeting the prevailing statutory emission standards
	• Gazettal of the Second Technical Memorandum for the power sector with effect from 2015 onwards to further tighten the emission allowances under the First Technical Memorandum
2011	• Setting up the $300 million Pilot Green Transport Fund to encourage the transport sector to try out green and innovative transport technologies
	• Commencement of the trial of retrofitting Euro II and III franchised buses with emission-reduction devices
	• Enacting the Motor Vehicle Idling (Fixed Penalty) Ordinance (Cap. 611)

Source: EPD records

Appendix E
(para. 6.4 refers)

Key initiatives under the Pearl River Delta Regional Air Quality Management Plan

A. To be implemented by the Guangdong Provincial Government

1. Establishing a diversified clean energy-production-and-supply system

2. Requiring all large-scale thermal-power generating units to carry out flue-gas desulphurisation

3. Requiring all thermal-power plants under construction, alteration or expansion to carry out flue-gas denitrification

4. Closing down small thermal-power plants and other serious-polluting industries

5. Implementing new pollutant-emission standards for thermal-power plants, boilers and polluting manufacturing industries

6. Stepping up annual inspections and on-road spot checks of vehicles

7. Restricting the growth of motorcycles in key cities

8. Implementing a vehicle labelling system

9. Constructing metro expressway systems and developing green transportation

10. Enhancing technological improvement at enterprises and promoting cleaner production

11. Requiring newly registered light-duty-petrol vehicles and gas vehicles in the PRD region to comply with the National IV standards (which are on a par with the Euro IV standards)

12. Supplying National III standard motor fuel in the whole province and starting to supply National IV standard petrol in Guangzhou

13. Implementing comprehensive vapour recovery systems in petrol filling stations, oil depots and tanker trucks in PRD cities

B. To be implemented by the HKSAR Government

1. Encouraging the replacement of diesel light buses with ones using cleaner fuel
2. Retrofitting particulate-removal devices installed on pre-Euro diesel vehicles
3. Retrofitting Euro II and III franchised buses with emission-reduction devices
4. Encouraging the replacement of pre-Euro, Euro I and Euro II commercial diesel vehicles with Euro IV models
5. Encouraging the use of environment-friendly private and commercial vehicles, and franchised buses
6. Encouraging testing of low-emission and low-carbon transport technologies
7. Requiring drivers to switch off idling vehicle engines
8. Strengthening control of emissions from petrol and LPG vehicles
9. Tightening emission standards for in-use diesel vehicles and newly registered vehicles
10. Enhancing vapour recovery systems in petrol filling stations
11. Designating pilot low-emission zones
12. Encouraging the use of cleaner fuel by ferries
13. Controlling emissions from non-road mobile sources
14. Reducing VOC emissions from printing processes and VOC content in regulated products
15. Reducing emissions from power plants

Source: EPD records

Appendix F

Acronyms and abbreviations

ACE	Advisory Council on the Environment
APCO	Air Pollution Control Ordinance
API	Air pollution index
AQGs	Air Quality Guidelines
AQO	Air quality objective
Audit	Audit Commission
CO	Carbon monoxide
EA Panel	Panel on Environmental Affairs
ENB	Environment Bureau
EPD	Environmental Protection Department
Euro	European
FC	Finance Committee
GLD	Government Logistics Department
Guangdong EPD	Environmental Protection Department of the Guangdong Provincial Government
g/kWh	Gram per kilowatt-hour
HKSAR	Hong Kong Special Administrative Region
IMO	International Maritime Organisation
LegCo	Legislative Council
LPG	Liquefied-petroleum gas
MD	Marine Department
$\mu g/m^3$	Microgram per cubic metre
μm	Micrometre

NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
NRMM	Non-road mobile machinery
O_3	Ozone
PAC	Public Accounts Committee
$PM_{2.5}$	Particulate matters with a diameter of 2.5 μm or less
PM_{10}	Particulate matters with a diameter of 10 μm or less
PRD	Pearl River Delta
SO_2	Sulphur dioxide
TD	Transport Department
THB	Transport and Housing Bureau
TSP	Total suspended particulates
UK	United Kingdom
USA	United States of America
VOC	Volatile organic compound
WHO	World Health Organisation