CHAPTER 1

Environment Bureau
Environmental Protection Department

Monitoring and reporting of air quality

Audit Commission
Hong Kong
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This audit review was carried out under a set of guidelines tabled in the Provisional Legislative Council by the Chairman of the Public Accounts Committee on 11 February 1998. The guidelines were agreed between the Public Accounts Committee and the Director of Audit and accepted by the Government of the Hong Kong Special Administrative Region.

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MONITORING AND REPORTING OF AIR QUALITY

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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, nitrogen dioxide (NO_2), and particulate matters with a diameter of 10 micrometres or less (PM_{10}) are the most relevant and significant ones in Hong Kong. Since 1999, the EPD has also compiled an hourly air pollution index (API) for each of the 11 general air-quality monitoring stations and three roadside stations.

3. In January 2012, the Government announced that, based on the Air Quality Guidelines (AQGs) issued in 2006 by the World Health Organisation (WHO), the AQOs in Hong Kong would be revised to more stringent levels with effect from 2014 (2014 AQOs).

Management of air quality objectives

AQOs not fully achieved

4. Under the Air Pollution Control Ordinance (Cap. 311), 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. However, the Audit Commission (Audit)'s examination has revealed that the existing AQOs have never been fully achieved since their adoption in 1987.

5. The achievement of AQOs at roadside is important. However, Audit notes that some AQO limits at roadside have been persistently and significantly exceeded. Hong Kong has never attained the roadside annual average AQO levels of NO_2 and PM_{10}. In 2011, the roadside annual average concentration levels of NO_2 and PM_{10} had exceeded the AQO limits by 53% and 11% respectively, and both had exceeded the WHO limits by 205%.

6. Air quality of Hong Kong is also unsatisfactory when compared with that of some world cities. For example, in 2011, the ambient annual average concentration level of NO_2 in Hong Kong was 279%, 47% and 36% higher than those in Sydney, London and New York respectively, and that of PM_{10} in Hong Kong was also 220%, 100% and 153% higher than those in the three cities respectively.

2014 AQOs not adequately protecting public health

7. The 2014 AQOs (see para. 3) for four major air pollutants are mostly set on the basis of WHO Interim Targets. As such, they do not provide adequate protection of public health when compared with the WHO AQG levels. Audit considers that the ENB and the EPD need to formulate an air-quality management strategy for achieving the WHO AQGs in the long term.

Administration of air pollution index

8. An API exceeding 100 reflects a very high air pollution level and is associated with high health risks. Audit notes that the EPD has never achieved its performance target on API (not exceeding 100 on any day in a year) since setting the target in 2006-07. In fact, the trend is worsening, caused by the vehicle emission problem and the worsening of roadside API. The number of days with API exceeding 100 had risen from 74 in 2007 to 175 in 2011.

Performance reporting

9. Audit examination of the Controlling Officer's Reports and Government websites has identified room for improvement in the Government's performance reporting of air quality. In particular, Audit found that some important information

was not readily accessible by the public. For example, the extents of achieving the existing AQOs and the EPD's performance target on API (not exceeding 100 on any day in a year) were not readily available on the EPD website.

Way forward

10. There is growing public concern over the worsening air pollution in Hong Kong and its adverse impacts on public health. According to the EPD's 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. Therefore, there is an imminent need for the Government to formulate and update strategies for implementing appropriate measures to achieve the AQOs as early as possible.

Audit recommendations

11. **Audit recommendations are made in the respective sections of this Audit Report. Only the key ones are highlighted in this Executive Summary. Audit has *recommended* that the Secretary for the Environment and the Director of Environmental Protection should:**

Management of air quality objectives

(a) **make vigorous efforts to formulate and implement strategies with time targets and milestones for achieving the AQOs as early as possible;**

(b) **take measures to ensure that the AQOs are regularly reviewed and revised, taking account of new WHO guidelines and overseas practices;**

(c) **set up a mechanism for effective monitoring of the extent of achieving the AQOs and for publicising the progress of achievement periodically;**

(d) **formulate an air-quality management strategy for achieving the WHO AQGs in the long term;**

Administration of air pollution index

(e) **consider providing the public with clearer and more specific precautionary advice when a roadside API exceeds 100; and**

Performance reporting

(f) **strengthen efforts in timely reporting and publishing measurement results of air quality.**

Response from the Administration

12. The Administration agrees with the audit recommendations. The Secretary for the Environment and the Director of Environmental Protection have said that protection of public health is the key guiding principle in the formulation of air-quality improvement measures, and the achievement of the WHO AQGs is a long-term goal of the EPD.

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. The work carried out by the EPD in seeking to achieve and maintain satisfactory air quality includes:

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.*

(a) development of air quality objectives (AQOs), standards and guidelines;

(b) enforcement of the requirements of the Air Pollution Control Ordinance (Cap. 311 — APCO) to control air pollution from factories, polluting processes and products, motor vehicles and other sources;

(c) operation of an air-quality monitoring network and laboratories to provide air quality information needed for evaluating the effectiveness of existing programmes and development of new policies; and

(d) provision of air quality information and air pollution index (API — see para. 1.11) to the public.

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.

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 (B/Ds); and

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

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

1.5 At present, Hong Kong faces two major air pollution problems, namely:

(a) ***Local street-level pollution problem.*** Air pollution at the street level is mainly caused by emissions from motor vehicles, especially aged diesel commercial vehicles; and

(b) ***Regional smog problem.*** Smog is caused by a combination of pollutants from motor vehicles, marine vessels, power plants and non-road mobile machinery in Hong Kong and emissions in the Pearl River Delta (PRD — Note 3) 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, AQOs are set out in a Technical Memorandum issued under section 7 of the APCO. 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 API.

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

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) 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.

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:

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.*

(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 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 (see Appendix B).

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 C) 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 the Legislative Council (LegCo), and having the new AQOs take effect in 2014 (2014 AQOs — see Appendix B); and

(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.

Appendix D provides a chronology of key events leading to the development of the 2014 AQOs.

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.*

Air-quality monitoring stations

1.10 To collect air-quality information for assessing the extent of achievement of AQOs and public exposure to air pollution, since 1983 the EPD has installed 14 fixed air-quality monitoring stations, 11 of which are general stations for measuring ambient air quality and three are roadside stations for measuring street-level air quality.

Air pollution index

1.11 To provide the public with information on local air-pollution levels, the EPD has compiled an API (see para. 1.3(d)) by comparing the concentration levels of five of the seven key air pollutants, namely SO_2, NO_2, PM_{10}, O_3 and CO, against the limits specified in the AQOs. Each hour, based on data collected at each air-quality monitoring station, the measured concentration level of each of the five air pollutants is converted into a numeric figure, ranging from 0 to 500, with the highest number taken as the API for that station. The EPD classifies APIs by five pollution levels (Low, Medium, High, Very high and Severe). When an API reaches the "Very high" (101 to 200) or the "Severe" (201 to 500) level, the EPD will advise the public, through the media and its website, of the health implications and precautionary actions to be taken.

Air-quality improvement measures

1.12 ***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 between 1997 and 2011 are shown at Appendix E. In 2009, the EPD said that the implementation of these measures had significantly reduced the local emissions of SO_2, nitrogen oxides (NOx — Note 7), PM_{10} and CO from their high levels in the 1990s by 55% to 83%.

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.*

1.13 ***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. 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.

1.14 ***Efforts made by other government B/Ds.*** Besides the EPD, a number of B/Ds 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;

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.*

(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

1.15 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.

1.16 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 (the subject matter of this Audit Report) and Implementation of air-quality improvement measures (see Chapter 2 of the Director of Audit's Report No. 59).

1.17 This Audit Report focuses on the following areas:

(a) management of AQOs (PART 2);

(b) administration of API (PART 3);

(c) performance reporting (PART 4); and

(d) way forward (PART 5).

In this Report, Audit has identified areas where improvements can be made by the Government in monitoring and reporting the air quality of Hong Kong, and has made recommendations to address the issues identified.

Acknowledgement

1.18 Audit would like to acknowledge with gratitude the full cooperation of the staff of the ENB, the THB, the EPD, the TD and the MD during the course of the audit review.

PART 2: MANAGEMENT OF AIR QUALITY OBJECTIVES

2.1 This PART examines the EPD's management of AQOs, focusing on the achievement and review of AQOs.

Achievement and revision of air quality objectives

Setting of AQOs

2.2 As mentioned in paragraph 1.3, the EPD is the Air Pollution Control Authority and is responsible for seeking to achieve AQOs as soon as is reasonably practicable and to maintain the quality so achieved. However, the existing AQOs have not been revised since their establishment in 1987 (Note 9). In January 2012, the Executive Council approved the adoption of the 2014 AQOs (see para. 1.9).

2.3 For benchmarking, the Mainland and some overseas countries, such as Australia, the United Kingdom (UK), the United States of America (USA) and member countries of the European Union (EU — Note 10), have also set air-quality standards which are revised from time to time with a view to protecting public health (see para. 2.19).

1997 Review

2.4 In March 1997 (ten years after the establishment in 1987 of the existing AQOs), the EPD formed the Working Group on the Health Effects of Air

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Note 9: *The EPD established the AQOs for seven air pollutants by making reference to research results of the Environmental Protection Agency of the United States Federal Government on the relationship between air-pollutant concentrations and their associated adverse effects on public health.*

Note 10: *EU member countries set their air-quality standards based on EU standards. An EU country may be fined by the EU if its air-quality standards are not met.*

Pollution (Note 11) to review and revise the AQOs in the light of overseas and local research findings (1997 Review). In the 1998 Policy Address, the Chief Executive announced that the Government aimed to complete assessing the adequacy of the AQOs by the end of 1998 and would make recommendations in 1999.

2.5 The 1997 Review was completed in August 1998. The Review concluded that tightening the AQOs would help provide better protection of public health. From 1999 to 2005, although the Chief Executive reported the progress of revising the AQOs in the Policy Addresses from 1999 to 2001, updates were no longer reported in his Policy Addresses from 2002 to 2005, and no recommendations were made to revise the AQOs during the same period. In his Policy Addresses from 2006 to 2008, the Chief Executive reported the commissioning and the progress of the 2007 Consultancy Review (see para. 1.9).

2.6 In September 2012, the EPD informed Audit that:

(a) from 1997 to 2005, it was awaiting the outcome of a lawsuit regarding introduction of $PM_{2.5}$ standards in the USA, which would have a significant impact on how the new AQOs should be established. The case was settled in 2005 and the WHO published a new set of AQGs in 2006; and

(b) after issue of the WHO AQGs in 2006, the EPD commenced the 2007 Consultancy Review.

2007 Consultancy Review

2.7 In July 2007, the EPD set up an Advisory Panel (Note 12) to oversee the 2007 Consultancy Review. The Review aimed to develop a new set of AQOs for

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Note 11: *The Working Group was chaired by an Assistant Director of the EPD, and its members comprised representatives from the EPD, the Department of Health and the Hospital Authority, and medical professionals.*

Note 12: *The Panel was chaired by the Director of Environmental Protection and comprised members from the fields of community health and air science, and representatives from the power sector, transport-related industries and relevant government B/Ds.*

Hong Kong and to formulate an air-quality management strategy to achieve the new AQOs.

2.8 The 2007 Consultancy Review was completed in July 2009. The Review recommended promulgating new AQOs based on a combination of WHO AQG levels and WHO Interim Targets (see para. 1.8 and Appendix B). The Review also proposed 19 air-quality improvement measures (see items 1 to 19 of Appendix C) for achieving the new AQOs. Together with three additional improvement measures (see items 20 to 22 of Appendix C) later introduced by the EPD, as of September 2012, there were a total of 22 air-quality improvement measures.

Public consultation on recommendations of the 2007 Consultancy Review

2.9 In his Policy Address of October 2009, the Chief Executive said that he had tasked the Chief Secretary for Administration to coordinate with all the relevant B/Ds and stakeholders on implementing the air-quality improvement measures. In 2009, the EPD also launched a four-month public consultation on the recommendations of the 2007 Consultancy Review.

2.10 In June 2010, the EPD informed the LegCo Panel on Environmental Affairs (EA Panel) of the findings of the public consultation, as follows:

(a) the community had a strong aspiration for effective actions to improve the air quality of Hong Kong;

(b) the majority of the respondents supported in general the proposed set of new AQOs and the package of 19 air-quality improvement measures. Some respondents considered that the Government should adopt the WHO AQG levels as the new AQOs for Hong Kong;

(c) the public would like to see a clear timeline to implement the air-quality improvement measures for attaining the new AQOs; and

(d) the public called for strategic planning, effective prioritisation and integrated coordination among the various B/Ds under the steer of a high-power body to lead and oversee the implementation of the air-quality improvement measures.

The EPD also informed the EA Panel that, in conjunction with all the relevant B/Ds, the ENB and the EPD were looking for the best practicable way of taking forward the air-quality improvement measures and updating the AQOs.

Promulgation of 2014 AQOs

2.11 As mentioned in paragraph 1.9, in January 2012, the Government announced that:

(a) it would adopt a new set of AQOs (Note 13) together with a package of air-quality improvement measures, which would be implemented subject to resource availability; and

(b) it would start the preparatory work for amending the APCO with a view to implementing the new AQOs in 2014.

2.12 According to the ENB and the EPD, the delivery of the 2014 AQOs and the implementation of the air-quality improvement measures would help combat air pollution, thereby improving quality of life, reducing medical cost and indirectly raising labour productivity. It would also have the following economic implications:

(a) the EPD's consultant estimated that upon attainment in Hong Kong 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, such as less people contracting asthma or other respiratory diseases, would also be expected; and

(b) in addition, better air quality and visibility would help attract more tourists and foreign investments, and were conducive to attracting talents to stay and work in Hong Kong. These would contribute to reinforcing the position of Hong Kong as a world city and a leading international business hub.

Note 13: *The 2014 AQOs are more stringent than the existing ones. For example, the 24-hour AQO for PM_{10} would be tightened by 44% and the 1-hour AQO for NO_2 by 33%.*

Benchmarking against the standards of the WHO and world cities abroad

2.13 Hong Kong aspires to be Asia's world city. In positioning itself as Asia's world city, it compares itself with world cities like New York, London and Sydney. In this connection, Audit examination and research have revealed that, in 2011:

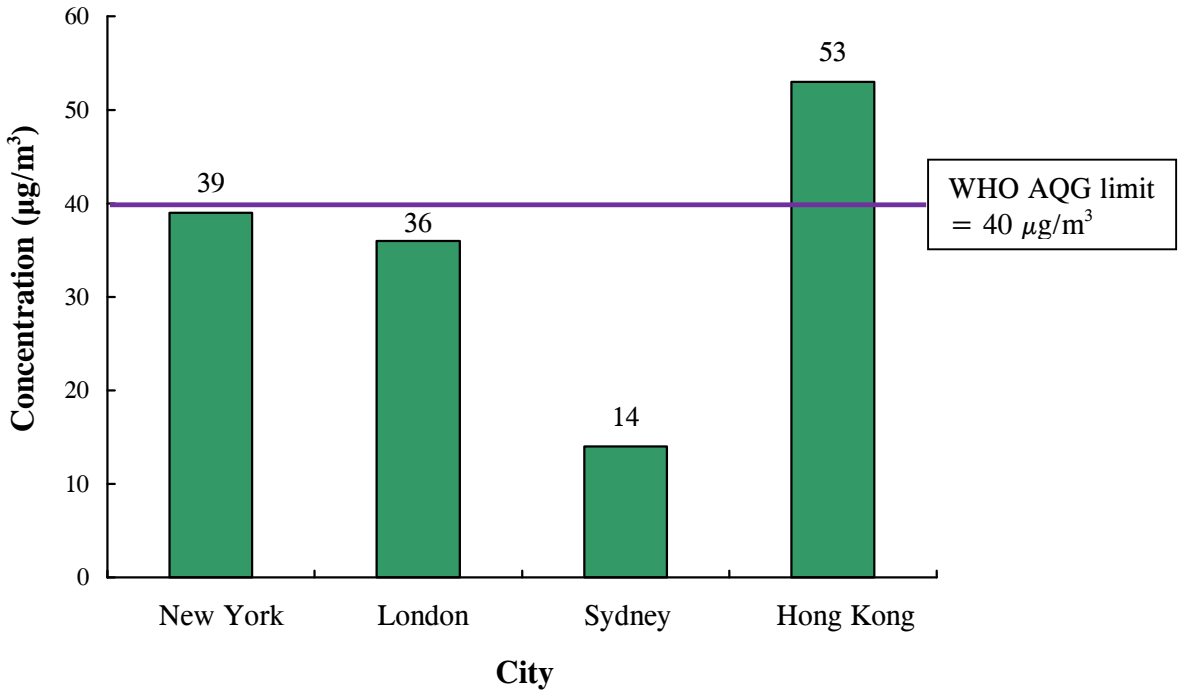
(a) the ambient annual average concentration levels of NO_2 and PM_{10} in Hong Kong had exceeded the limits specified in the WHO AQGs by 33% and 140% respectively; and

(b) the air quality of Hong Kong did not match with that of three world cities, namely New York, London and Sydney.

Figures 1 and 2 show the benchmarking results.

Figure 1

Ambient annual average concentration levels of NO_2 (2011)

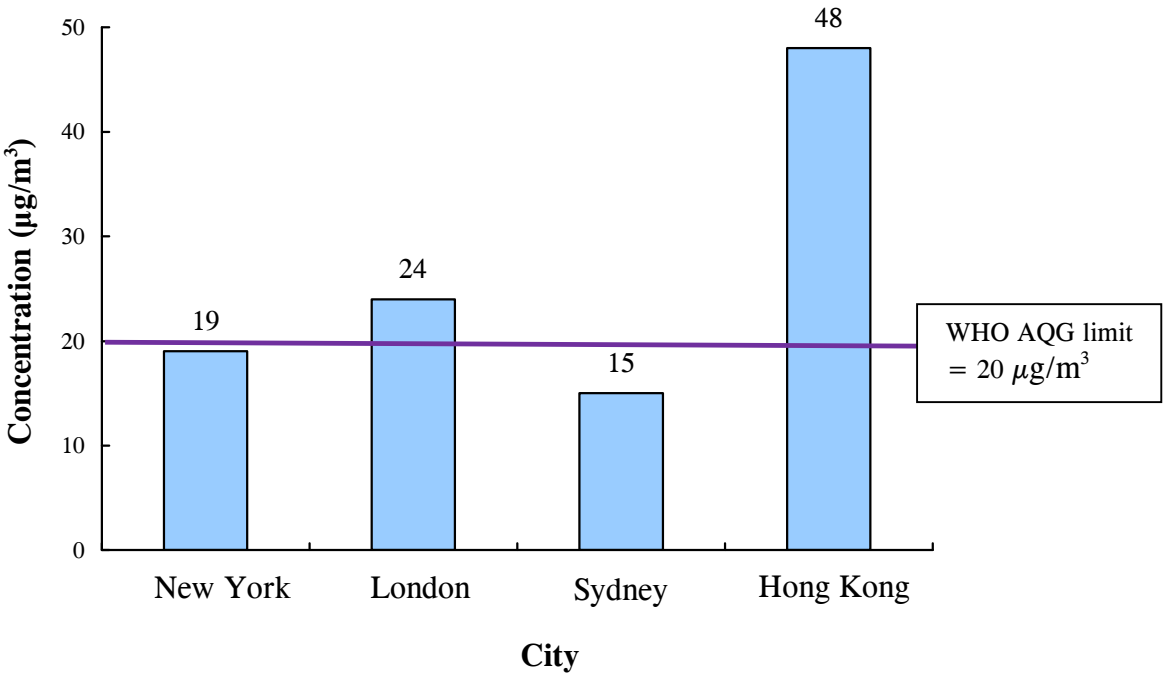


Source: *Audit analysis of EPD records and Audit research*

Remarks: *According to the EPD, different countries/cities might have adopted different methodologies in compiling the data.*

Figure 2

Ambient annual average concentration levels of PM_{10} (2011)



Source: *Audit analysis of EPD records and Audit research*

Remarks: *According to the EPD, different countries/cities might have adopted different methodologies in compiling the data.*

AQOs not fully achieved

2.14 The EPD is tasked under the APCO to implement appropriate measures to achieve the AQOs. However, Audit notes that the air quality of Hong Kong has not fully achieved the existing AQOs established in 1987 (which were set some 25 years ago). In particular, in 2011, for 8 of the 27 concentration measurements of the seven air pollutants, their concentration levels had exceeded the AQO limits, as follows:

(a) 4 measurements for NO_2, namely:

(i) the "one-hour measurement" recorded by all three roadside stations;

(ii) the "24-hour measurement" recorded by one general station;

(iii) the "24-hour measurement" recorded by all three roadside stations; and

(iv) the "annual measurement" recorded by all three roadside stations;

(b) the "annual measurement" for PM_{10} recorded by two roadside stations;

(c) the "annual measurement" for TSP recorded by one general station and that by one roadside station; and

(d) the "one-hour measurement" for O_3 recorded by four general stations.

Details are shown at Appendix F.

2.15 In August and September 2012, the EPD informed Audit that:

(a) with the exception of O_3 in the ambient level and NO_2 at the roadside, the concentrations of major pollutants had been reduced in recent years. For example, from 1999 to 2011:

(i) the ambient annual average concentrations of SO_2 had decreased by 28%, of NO_2 by 7%, of PM_{10} by 8% and of CO by 19%, but that of O_3 had increased by 21%;

(ii) the roadside annual average concentrations of SO_2 had decreased by 56%, of PM_{10} by 33% and of CO by 28%, but that of NO_2 had increased by 23%;

(iii) the number of general monitoring stations with excessive concentrations of NO_2 had decreased from 6 to 1, of PM_{10} from 5 to 0 and of TSP from 5 to 1;

(iv) the number of roadside monitoring stations with excessive concentrations of PM_{10} had decreased from 3 to 2; and

(v) the number of pollutant concentration measurements not complying with the AQO limits had decreased from 12 to 8. Owing to EPD efforts to reduce vehicle emissions, the "one-hour measurement" for NO_2 recorded by general stations, "24-hour measurement" and "annual measurement" for PM_{10} recorded by general stations, and "24-hour measurement" for PM_{10} recorded by roadside stations had met the AQO requirements; and

(b) in 2011, the ambient concentrations of SO_2, PM_{10}, CO and lead had met the AQO limits at the general stations, whereas those of NO_2 and TSP had not met the AQO limits at one general station, and that of O_3 had not met the AQO limits at four general stations.

2.16 As mentioned in paragraph 2.14, the AQOs have not been fully achieved since their adoption in 1987. In January 2012, the Government announced the 2014 AQOs and proposed 22 improvement measures with a view to attaining them. In order to better protect public health and properly discharge its statutory duty, Audit considers that the EPD needs to strive, in collaboration with other B/Ds and relevant stakeholders (including the public), to formulate and implement strategies for achieving the AQOs as early as possible.

AQOs not timely revised

2.17 The existing AQOs will be in force until 2013. In the past 25 years, the EPD have reviewed the AQOs twice, as detailed below, but have not timely revised the AQOs taking account of practices in other countries and cities:

(a) ***1997 Review (see paras. 2.4 to 2.6).*** Although the 1997 Review concluded that the AQOs should be tightened to provide greater protection of public health, Government action had not been taken over the years from 1999 to 2006 to revise the AQOs; and

(b) ***2007 Consultancy Review (see paras. 2.7 and 2.8).*** The EPD commenced the 2007 Consultancy Review after the issue of the WHO AQGs in 2006. Although the Review was completed in July 2009, the Government took some 30 months to announce in January 2012 the adoption of the 2014 AQOs.

Management of air quality objectives

2.18 In June and September 2012, the EPD informed Audit that:

(a) in updating the AQOs in Hong Kong, it was important to formulate additional measures for achieving the 2014 AQOs. The air-quality improvement measures encompassed a wide range of issues and straddled a number of policy areas;

(b) many improvement measures were controversial and complicated, and some might require legislative changes, and some could be resource demanding. The Government needed to analyse in detail the different views collected and assess their impacts on the relevant policy issues in order to fully consider and coordinate the implementation of the measures; and

(c) during the 19-month period from June 2010 (after the EA Panel was informed of the findings of public consultation — see para. 2.10) to January 2012, the Government had taken action on a number of key air-quality improvement measures (e.g. reducing emissions from power plants, introducing a trial scheme of retrofitting emission-reduction devices on franchised buses to reduce NOx emissions, and implementing a scheme to replace emission-reduction devices of liquefied-petroleum-gas (LPG) taxis and public light buses). Regular progress reports had been made to LegCo during the period.

2.19 Audit recognises that there are challenges ahead for Hong Kong to achieve the 2014 AQOs. Nonetheless, Audit notes that over the 13 years from 1997 to 2010, the USA, the UK and the EU had all tightened their air-quality standards and introduced new standards for their countries several times (see Appendix G). These countries have also set target dates for achieving their air-quality standards. Audit research has revealed the following:

(a) The UK and the EU set air-quality standards for $PM_{2.5}$ in 2007 and 2008 respectively. They have also set a target date of 2020 for attaining their specified standards for $PM_{2.5}$.

(b) In the USA, air-quality standards for $PM_{2.5}$ were introduced in 1997 (before issue of the WHO AQGs in 2006) and were tightened in 2006. The country has also set various target dates for attaining its specified standards for $PM_{2.5}$ and O_3. For example, it aims to achieve the 8-hour O_3 measurement for areas with serious pollution by June 2013.

(c) Singapore has set a target of lowering the ambient $PM_{2.5}$ level from 16 $\mu g/m^3$ in 2008 to 12 $\mu g/m^3$ by 2020, and to maintain it at this level until 2030.

(d) Over the past ten years, different countries and cities have taken various measures and introduced refinements to achieve their air-quality standards. For example, the Greater London Authority formulated an air-quality improvement strategy in 2010 introducing both transport and non-transport measures to reduce emissions. These included:

  (i) a scrappage scheme for polluting vehicles;

  (ii) a grant scheme for retrofitting vehicles with pollution abatement equipment; and

  (iii) imposing NOx emission limits for power plants.

Given the importance of good air quality to public health, Audit considers that the EPD needs to keep the AQOs in Hong Kong under regular review, and revise them in a timely manner, taking account of new WHO guidelines and overseas practices. The EPD also needs to set time targets with milestones for achieving the AQOs.

Review and monitoring mechanism

2.20 In January 2012, the Government announced that it aimed to implement the new AQOs in 2014. In April 2012, the EPD also informed the Subcommittee on Improving Air Quality (Note 14) of the EA Panel that it would put in place a review mechanism to regularly ascertain the extent of achievement of the 2014 AQOs, the progress of implementing the air-quality management strategy, and the need and practicality of further tightening the AQOs. The EPD undertook to conduct the reviews no less than once every five years.

2.21 Audit welcomes the EPD's initiative on the issue, but would like to urge the Government to put in place the proposed review and monitoring mechanism for achieving the 2014 AQOs as early as possible.

Less than effective measures to curb vehicle emission problem

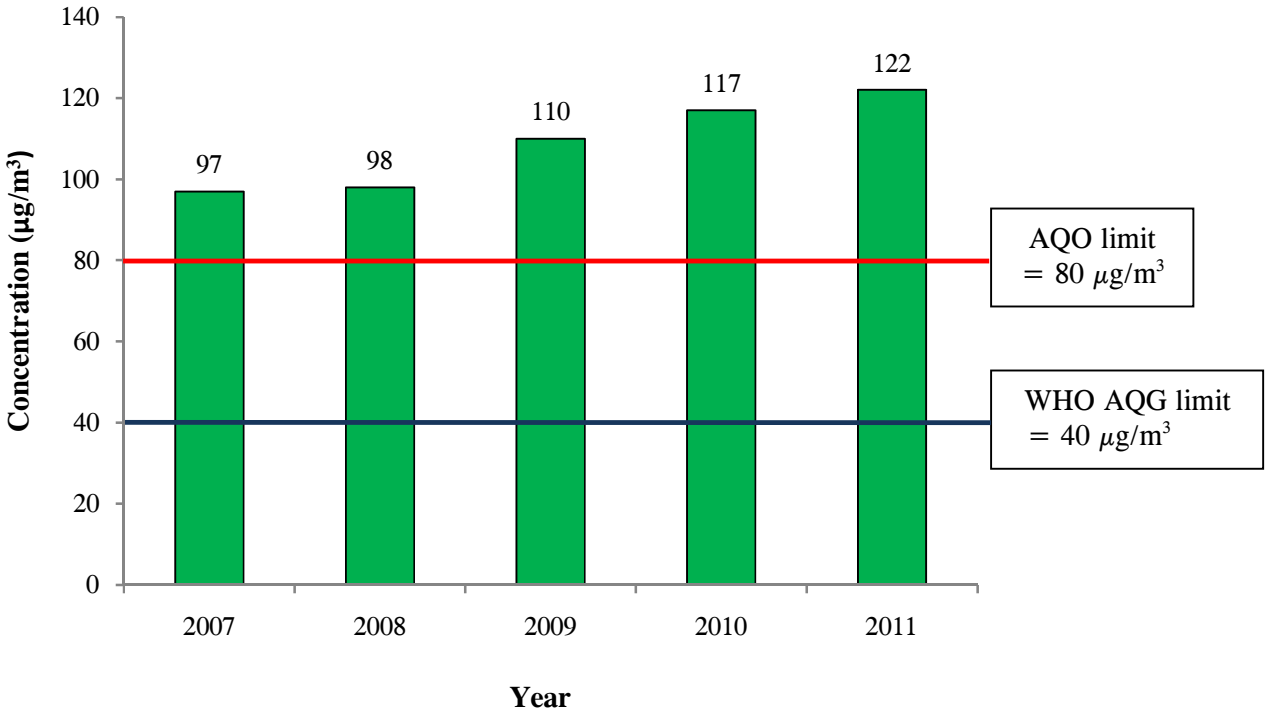
2.22 The achievement of AQOs at roadside is important. Aged motor vehicles, especially diesel vehicles, are the main causes of high concentrations of NO_2 and PM_{10} at street level in Hong Kong. According to the WHO, emissions from diesel engines are carcinogenic as there is sufficient evidence of an increased risk for lung cancer caused by such emissions.

2.23 The EPD has established three roadside stations to measure the concentrations of air pollutants. Audit however notes that in the recent five years, the air quality at roadside in terms of annual average NO_2 and PM_{10} measurements had persistently exceeded the AQO limits (see Figures 3 and 4).

Note 14: *The Subcommittee of the EA Panel was established in November 2008. Its terms of reference are to monitor and study policies and public concerns on improving air quality.*

Figure 3

Roadside annual average concentration levels of NO_2 (2007 to 2011)

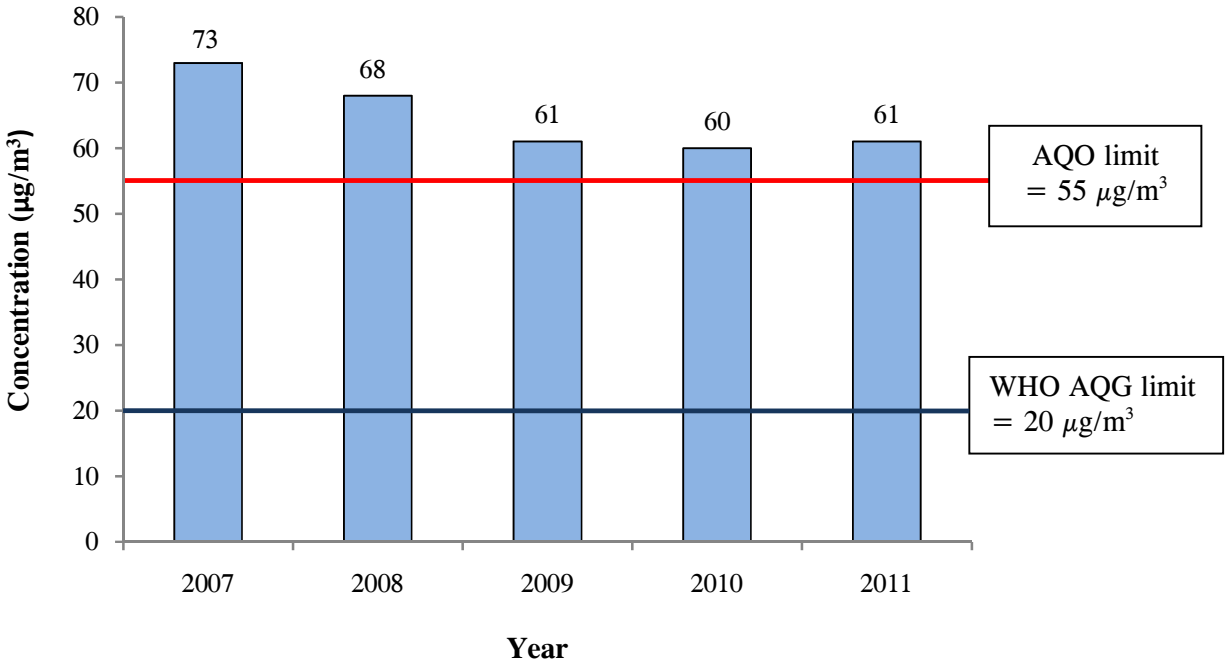


Source: *Audit analysis of EPD records*

Remarks: *From 2007 to 2011, the annual average concentration of NO_2 of the three roadside stations had increased by 26%.*

Figure 4

Roadside annual average concentration levels of PM_{10} (2007 to 2011)



Source: *Audit analysis of EPD records*

Remarks: *From 2007 to 2011, the annual average concentration of PM_{10} of the three roadside stations had decreased by 16%.*

2.24 Figures 3 and 4 show that, in 2011, the roadside annual average concentration level of 122 $\mu g/m^3$ for NO_2 and 61 $\mu g/m^3$ for PM_{10} had exceeded the existing AQO limits of 80 $\mu g/m^3$ and 55 $\mu g/m^3$ by 53% and 11% respectively. Both of them also had exceeded the WHO limits of 40 $\mu g/m^3$ for NO_2 and 20 $\mu g/m^3$ for PM_{10} by 205%. In this connection, Audit notes that from 2007 to 2011, the roadside annual average concentrations of:

(a) NO_2 had increased by 26%;

(b) PM_{10} had decreased by 16%;

(c) SO_2 had decreased by 45%; and

(d) CO had decreased by 10%.

2.25 Audit also notes that, since the EPD commenced monitoring roadside air quality at three roadside stations in 1999, Hong Kong has never attained the annual average AQO levels for NO_2 and PM_{10} at roadside. In particular, the roadside annual average NO_2 concentration levels had worsened over the five years from 2007 to 2011 (Note 15). The persistent high roadside concentration levels of NO_2 and PM_{10}, mainly caused by emissions from aged diesel vehicles, suggest that the measures taken by the EPD in recent years to curb vehicle emissions were less than effective for achieving the AQOs of these two pollutants.

2.26 In September 2012, the EPD informed Audit that:

(a) the persistent high roadside concentration level of NO_2 and PM_{10} were caused by a combination of factors, including emissions from aged diesel vehicles, and aged and poorly maintained LPG vehicles as well as the high regional pollution in O_3 and PM_{10}; and

(b) from 2007 to 2011, the regional O_3 concentration had increased by 14%, which accelerated the oxidisation of NOx from vehicles to become NO_2 at the roadside. During the period, the ambient PM_{10} level at Tap Mun, which was located far away from areas with roadside emissions, had recorded average annual concentrations of PM_{10} at 41 $\mu g/m^3$ to 53 $\mu g/m^3$. This reflected the high concentration of particulates in the regional air quality.

Note 15: *According to the EPD, during the period 1999 to 2011, the level of NOx (mainly arising from motor vehicles) had decreased by 28% while that of NO_2 (could be formed from the reaction of NOx and O_3) had increased by 23%.*

2.27 Given that Hong Kong has not been able to achieve the existing AQOs for NO_2 and PM_{10} at roadside, it will be a great challenge for it to achieve the more stringent 2014 AQOs (Note 16). In this connection, the ENB and the EPD, in collaboration with other B/Ds and stakeholders, need to make more vigorous efforts if Hong Kong is to achieve a breakthrough in resolving the vehicle emission problem.

2014 AQOs not adequately protecting public health

2.28 The WHO AQGs (see para. 1.8) are guidelines providing references for countries and cities to develop their air-quality standards to minimise health risks. The guidelines provide Interim Targets for SO_2, PM_{10}, $PM_{2.5}$ and O_3 as milestones to facilitate a progressive approach for achieving the WHO AQGs. The WHO has indicated that, if these Interim Targets are achieved, one could expect significant reduction of risks for acute and chronic health effects from air pollution. As of September 2012, although no country or city had fully adopted the WHO AQGs as its air-quality standards, many countries (such as the USA and the UK) had tightened their air-quality standards (see para. 2.19).

2.29 In Hong Kong, the Government has taken achieving the WHO AQGs as the long-term goal. According to the EPD, when setting the 2014 AQOs, the Government made reference to the WHO's recommendation that each country or city should consider its own characteristics (political, social, economic, health considerations and technological feasibility) in formulating air policy targets. In the event, the 2014 AQOs for SO_2, PM_{10}, $PM_{2.5}$ and O_3 are mostly set based on the WHO Interim Targets. However, these Interim Targets do not provide adequate protection of public health when compared with the AQG levels. Table 1 shows the health impact of the 2014 AQOs for not achieving the WHO AQG levels.

Note 16: *The annual average concentration limit for NO_2 under the 2014 AQO will be 40 $\mu g/m^3$ vis-à-vis the current limit of 80 $\mu g/m^3$, and that for PM_{10} will be 50 $\mu g/m^3$ vis-à-vis the current limit of 55 $\mu g/m^3$.*

Table 1

Health impact of 2014 AQOs

Pollutant	Average time measurement	2014 AQO level based on	Health impact for not achieving WHO AQG level
SO_2	24-hour	WHO Interim Target 1	Effects on mortality and on hospital emergency admissions for total respiratory and chronic obstructive pulmonary diseases consistently demonstrated
PM_{10}	24-hour	WHO Interim Target 2	About 2.5% increase in short-term mortality
	Annual	WHO Interim Target 2	A higher risk of premature mortality
$PM_{2.5}$	24-hour	WHO Interim Target 1	About 5% increase in short-term mortality
	Annual	WHO Interim Target 1	About 15% higher long-term mortality
O_3	8-hour	WHO Interim Target 1	Inadequate protection of public health and estimated 3% to 5% increase in normal daily mortality (compared with estimated 1% to 2% increase in normal daily mortality at the WHO AQG level)

Source: WHO website

2.30 During the public consultation in 2009, some respondents considered that the EPD should adopt the WHO AQG concentration levels as the new AQOs (see para. 2.10(b)). As the Government has taken achieving the WHO AQGs as the long-term goal (see para. 2.29), Audit considers that the ENB and the EPD need to formulate an air-quality management strategy for achieving the WHO AQGs in the long term.

2.31 In September 2012, the EPD informed Audit that:

(a) in setting AQOs for Hong Kong, the relevant factors should be considered. Hong Kong's air quality was subject to various factors including regional air quality, local emissions and weather conditions. Some of these factors were outside the control of the EPD, in particular the regional influence; and

(b) to further reduce the concentration levels of PM_{10} and $PM_{2.5}$ in Hong Kong, the EPD was working with the Guangdong Provincial Government to reach an agreement on regional collaboration to further reduce emissions of key pollutants including PM_{10}. Details of the reduction targets would be announced as soon as possible.

Audit recommendations

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

(a) **in collaboration with other B/Ds and stakeholders, make vigorous efforts to formulate and implement strategies for achieving the AQOs as early as possible;**

(b) **take measures to ensure that the AQOs are regularly reviewed and revised, taking account of new WHO guidelines and overseas practices;**

(c) **set time targets with milestones for achieving the AQOs;**

(d) **set up a mechanism for effective monitoring of the extent of achieving the AQOs and for publicising the progress of achievement periodically;**

(e) **accord a higher priority to resolve the vehicle emission problem in order to achieve the AQOs at roadside at an earlier time; and**

(f) **formulate an air-quality management strategy for achieving the WHO AQGs in the long term.**

Response from the Administration

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

(a) protection of public health is the key guiding principle in the formulation of air-quality improvement measures. The EPD will intensify efforts to reduce emissions to a level that minimises health risk to the public;

(b) in collaboration with the relevant B/Ds and stakeholders, the EPD is implementing a package of 22 air-quality improvement measures with a view to achieving the new AQOs as soon as practicable;

(c) the EPD has committed to reviewing the AQOs at a frequency no less than once every five years. This is in line with international practices. Subject to the approval of LegCo, the EPD will promulgate the new AQOs through the APCO Amendment Bill. The new AQOs, if enacted, will demonstrate the Government's commitment for continuous improvement in air-quality standards;

(d) the EPD has regularly reported the extent of achieving the AQOs in its annual reports and on its website. The EPD will continue to improve on the provision of air-quality data and information to the public, as well as to make the reports more reader-friendly;

(e) the ENB and the EPD have accorded top priority to reduce vehicle emissions and have put forward a series of vehicle emission-control measures. These measures target at major polluting sources, including franchised buses, LPG taxis and public light buses, and diesel commercial vehicles. They will formulate additional control measures to tackle roadside air-quality problems;

(f) the achievement of the WHO AQGs is a long-term goal of the EPD. The new AQOs represent the working target for formulating further control measures. The five-year periodic review mechanism will enable the EPD to progressively tighten the AQOs and forthcoming working targets; and

(g) the EPD has fully achieved the emission-reduction targets for 2010 in accordance with the agreement reached with the Guangdong Provincial Government in 2002. Discussion with the Guangdong Provincial Government on further regional collaboration in emission reduction is near completion and the reduction targets will be announced as soon as possible. Regional collaboration will help continuously improve air quality.

PART 3: ADMINISTRATION OF AIR POLLUTION INDEX

3.1 This PART examines the EPD's administration of the API reporting system.

Air pollution index

3.2 API is a simplified and generalised way for reporting air quality. Different countries have adopted different methodologies in compiling APIs. In Hong Kong, API informs the public of the air pollution at ambient levels and at roadside of busy urban areas, and the potential health risk it would associate with, particularly on vulnerable groups such as children, the elderly and those with heart and respiratory diseases.

Hong Kong air pollution index reporting system

API reporting system

3.3 In June 1995, the EPD established the Hong Kong API reporting system, similar to those established in major countries and cities. The system translates the air-quality measurements of the 11 general and three roadside air-quality monitoring stations of the monitoring network (see paras. 3.6 to 3.8) into easily understandable numeric units, namely the API. In 1999, the EPD commenced compiling hourly APIs for all monitoring stations. Under the system, the hourly concentration level of each of five air pollutants (namely SO_2, NO_2, PM_{10}, CO and O_3, which are commonly adopted in other API systems) measured at each station is compared with the corresponding AQO for compiling the API for each pollutant, which ranges from 0 to 500. The highest API among the APIs of the five pollutants (referred to as the contributing pollutant) is taken and reported as the hourly API of that station. The EPD publishes the hourly APIs of the 14 stations on its website and provides such information to the public through the media. At 4 p.m. every day, the EPD provides forecasts on the ranges of API for the next 24 hours (see an example in Table 2). The objectives of providing API information are to:

(a) provide timely air-quality information to the public in a simple manner;

(b) advise the public before the onset of high air pollution levels; and

(c) enhance public awareness of air pollution.

Table 2

An example of APIs published on EPD website
(8:45 a.m. on 3 August 2012)

Forecast: Today's highest API

General station: 55 to 120/High to Very high
Roadside station: 130 to 180/Very high

Monitoring station	API at 8:00 a.m.	Air pollution level	Contributing pollutant
General station (Note)			
Central/Western	82	High	NO_2
Eastern	76	High	NO_2
Kwai Chung	90	High	NO_2
Kwun Tong	119	Very high	NO_2
Sha Tin	58	High	PM_{10}
Roadside station			
Causeway Bay	171	Very high	NO_2
Central	176	Very high	NO_2
Mong Kok	179	Very high	NO_2

Source: *EPD records*

Note: *For simplicity, air-quality information of only 5 of the 11 general stations (see Table 3 in para. 3.7) is shown in this example.*

3.4 There are two types of API, namely general API and roadside API, which are derived from concentration levels of pollutants measured by general stations and roadside stations respectively. The general API represents the air pollution level the general public exposes to at most of the time. The roadside API is more relevant to those who spend considerable time at roadside with heavy traffic.

3.5 The range of an API (0 to 500) is divided into five bands of air pollution level (Low, Medium, High, Very high and Severe). An API exceeding 100 reflects high health risks. For each band of air pollution level, the EPD provides precautionary advice to the general public (see Appendix H). For the two bands of "Very high" and "Severe" levels, the EPD provides additional advice to children, the elderly and outdoor workers.

Air-quality monitoring stations

3.6 To collect air-quality information, since 1983, the EPD has established a local network of air-quality monitoring stations to measure concentrations of major air pollutants in different parts of Hong Kong (Note 17).

3.7 From 1983 to 1999, the EPD had established 14 air-quality monitoring stations in various districts, comprising:

(a) 11 general stations, mostly located on roof tops at a height of four to six storeys above street level (see Photograph 1) for measuring ambient air quality; and

(b) three roadside stations, located at the street level (see Photograph 2) for measuring roadside air quality.

Table 3 shows details of the stations.

Note 17: *In November 2005, in addition to the local network, the HKSAR Government and the Guangdong Provincial Government jointly established a regional network to monitor the air quality of the PRD region. Details are shown in PART 6 of Chapter 2 of the Director of Audit's Report No. 59.*

Photograph 1

A general air-quality monitoring station in Tsuen Wan

Source: EPD records

Photograph 2

A roadside air-quality monitoring station in Central

Source: EPD records

Table 3

Air-quality monitoring stations
(2011)

District	Year of commencing operation	District population coverage ('000)
General station		
Kwun Tong	1983	622
Central/Western	1983	252
Sham Shui Po	1984	381
Kwai Chung	1988	511
Tsuen Wan	1988	305
Tai Po	1990	297
Sha Tin	1991	630
Yuen Long	1995	579
Tap Mun (Note 1)	1998	—
Eastern	1999	588
Tung Chung (Note 2)	1999	141
	Total	4,306
Roadside station (Note 3)		
Mong Kok	1991	—
Causeway Bay	1998	—
Central	1998	—

Source: *Records of the EPD and the Census and Statistics Department*

Note 1: *Tap Mun has minimal population, and the air-quality monitoring station is established to measure regional air quality. Therefore, the station does not provide district-based air-quality information.*

Note 2: *Tung Chung is part of the Islands District.*

Note 3: *Roadside stations do not have population coverage.*

3.8 According to the EPD, general stations are established to measure the ambient air quality of residential, industrial and rural areas, and roadside stations to assess the impact of vehicular emissions on road users. Roadside pollution levels are generally higher than the ambient pollution levels, because pollutants are often trapped by high-rise buildings and therefore become more concentrated at roadside.

Air-quality monitoring network assessment

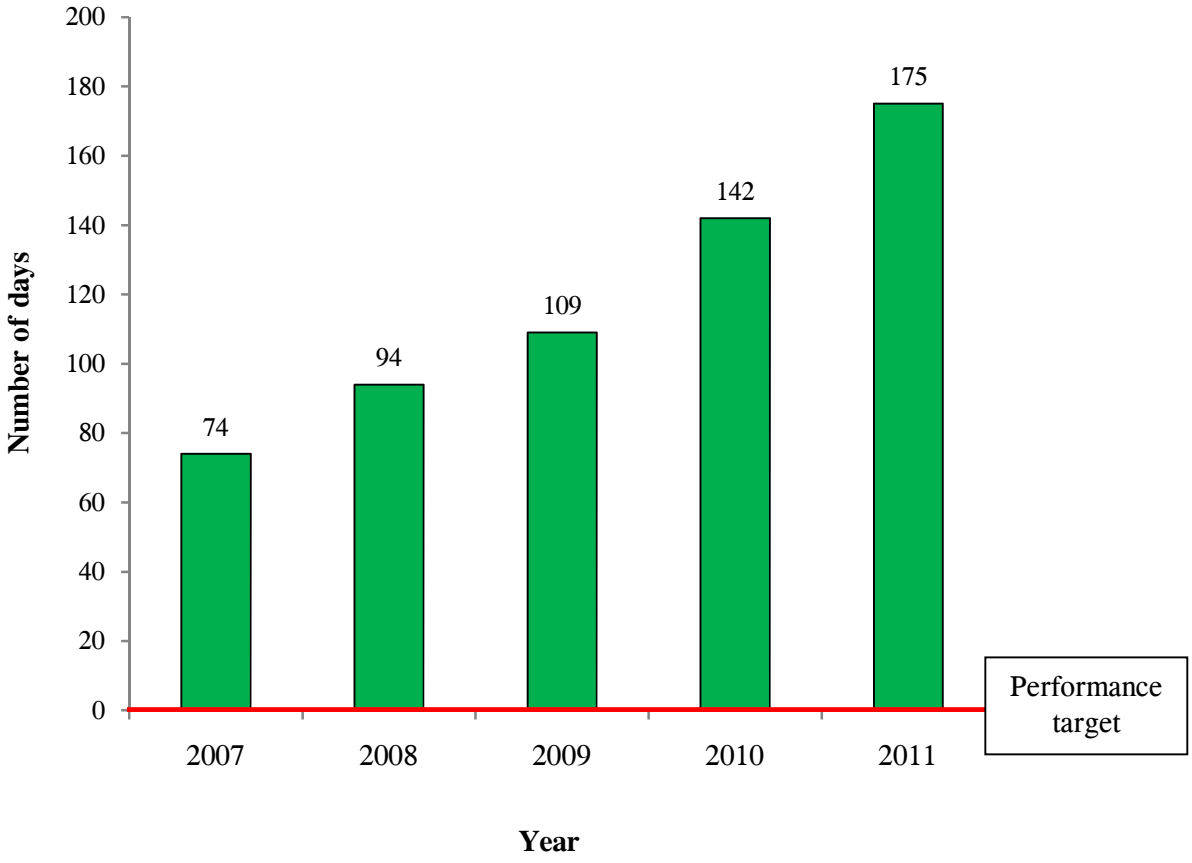
3.9 The EPD conducts annual assessments of the air-quality monitoring network to determine whether the network meets the monitoring objectives and whether it is necessary to terminate a station or establish a new one. It also conducts overall network assessments on a five-year basis. In May 2011, the EPD completed its first overall network assessment.

API performance target not achieved

3.10 An API exceeding 100 reflects very high air pollution and is associated with high health risks. Since 2006-07, the EPD has set a performance target that the number of days with API not exceeding 100 in a year should be 365 (or 366 in a leap year). In other words, the API should not exceed 100 on any day in a year. However, Figure 5 shows that there was an upward trend in the number of days with API exceeding 100 in the recent five years (2007 to 2011) from 74 in 2007 to 175 in 2011 (a 136% increase).

Figure 5

Number of days with API exceeding 100 in a year (2007 to 2011)



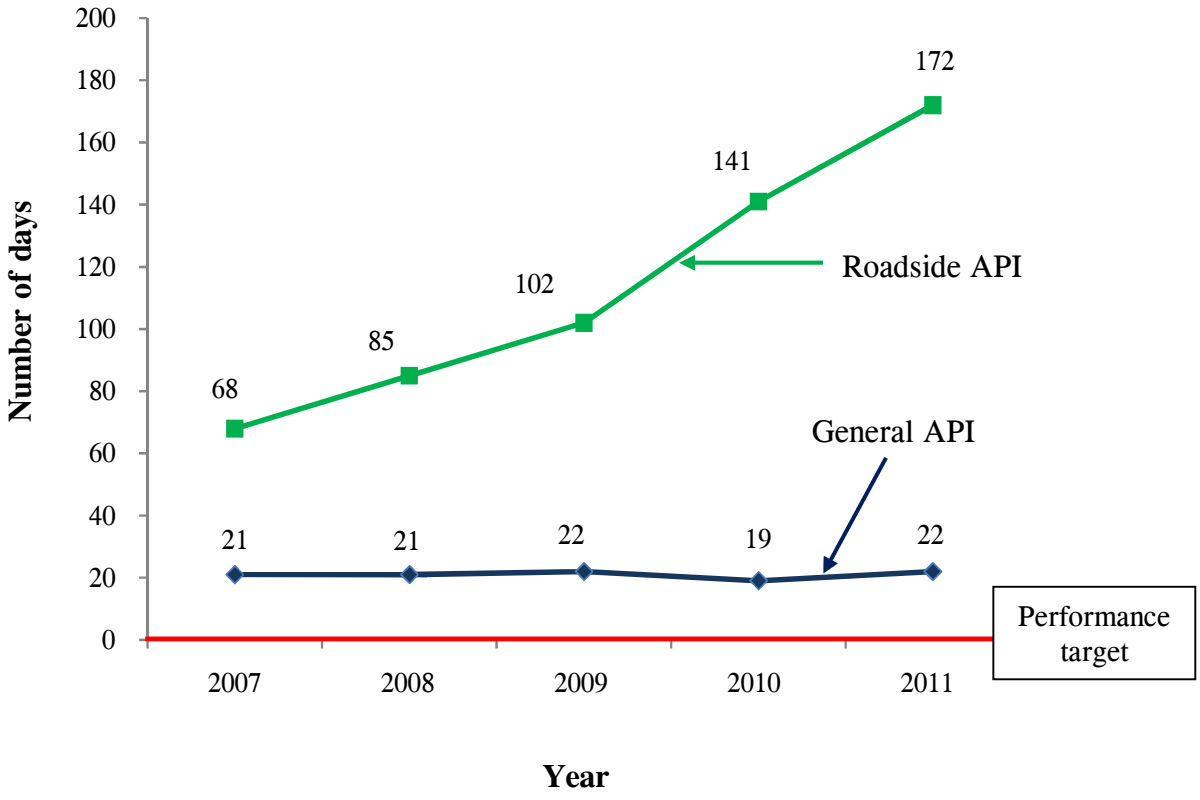
Source: *Audit analysis of EPD records*

Remarks: *According to the EPD's methodology, if any of the hourly APIs of the 14 stations exceeded 100 in a day, this day was regarded as a day with API exceeding 100.*

3.11 Audit notes that the worsening of the roadside API is a major factor contributing to the non-achievement of the API performance target, i.e. the API on any day in a year should not exceed 100. Figure 6 shows the trends of the number of days with general and roadside APIs exceeding 100 from 2007 to 2011.

Figure 6

Number of days with general and roadside APIs exceeding 100 in a year (2007 to 2011)



Source: *EPD records*

Remarks: *The roadside API and the general API might both exceed 100 in a particular day. This day is counted as one day in Figure 5.*

3.12 Figure 6 shows that the roadside API had worsened from 2007 to 2011. As mentioned in paragraph 2.27, in order to achieve the API performance target and to better protect public health, the EPD needs to make more vigorous efforts to resolve the vehicle emission problem. The audit recommendation in paragraph 2.32(e) is also relevant.

Provision of district APIs

3.13 The EPD publishes 14 APIs every hour based on the measurements of the 11 general stations (Note 18) and three roadside stations. Among the 18 administrative districts in Hong Kong, the EPD has not installed general stations in eight districts, namely Hong Kong Island Southern District, Wan Chai, Yau Tsim Mong, Kowloon City, Wong Tai Sin, Sai Kung, Tuen Mun, and New Territories North District. As a result, the EPD has not published any district-based APIs for these eight districts. As stated on EPD website, as of September 2012, residents in a district without district-based API should refer to the air-quality information of other districts with similar development characteristics. However, there was no information about the relevant districts that should be referred to. In this connection, the EPD informed Audit that, for example, people living in Tseung Kwan O of Sai Kung District might refer to the district-based API of Sha Tin.

3.14 The arrangement for informing the public of district-based API was not entirely satisfactory. Audit considers that the EPD needs to explore measures to provide district-based air-quality information for all 18 administrative districts as far as possible. For example, for each of the eight districts not yet installed with a general station, the EPD may inform the public on its website of the district-based air-quality information of the relevant district for reference.

Provision of general air-quality monitoring stations

3.15 Since 1999, no additional air-quality monitoring stations have been installed. In recent years, there have been deliberations on the adequacy of general air-quality monitoring stations on various occasions, as follows:

(a) ***2007, 2008 and 2010 LegCo meetings.*** Some LegCo Members expressed concerns about the adequacy of the monitoring network at different LegCo meetings, as follows:

  (i) despite the rapid increase in population and the traffic flow in Tseung Kwan O in the last decade, no monitoring station was installed in the district (May 2007 meeting);

Note 18: *Of these 11 general stations, 10 are installed in ten administrative districts in Hong Kong, and 1 in Tap Mun for measuring regional air quality.*

(ii) more monitoring stations should be set up to better grasp the state of air pollution in various districts (May 2008 meeting); and

(iii) the monitoring stations failed to comprehensively reflect the air pollution situation in Hong Kong as their number was inadequate, and the Government should consider providing air-quality data in all the 18 administrative districts (January 2010 meeting);

(b) ***2011 network assessment.*** The EPD's overall network assessment in May 2011 (see para. 3.9) found that the monitoring network in general conformed to international requirements and the EPD did not consider there was an immediate need for additional monitoring stations. Nevertheless, the assessment revealed that additional general stations might be required in Sai Kung/Tseung Kwan O, Kowloon City, Tuen Mun and North District when there was an increase in the population; and

(c) ***2012 LegCo Subcommittee meeting.*** At a meeting in April 2012, the Subcommittee on Improving Air Quality of the EA Panel requested the Government to consider increasing the number of monitoring stations from 11 to 18 using the 18 administrative districts as the basis. In June 2012, the EPD responded that the monitoring network had covered major areas in the territory with different types of land use such as residential areas, mixed residential/commercial areas, mixed residential/commercial/industrial areas, rural areas and busy urban roadside areas.

3.16 According to the EPD's guidelines, population growth and pollution sources in the vicinity of a district are key considerations in setting up a general air-quality monitoring station. In Audit's view, the EPD needs to consider setting up a general station each in Tseung Kwan O and Tuen Mun for the following reasons:

(a) Tseung Kwan O is projected to have a large population growth of 21% from 355,400 in 2010 to 430,100 in 2019. According to the 2007 Consultancy Review, Tseung Kwan O has different air-dispersion characteristics; and

(b) Tuen Mun is a highly populated new town. Furthermore, in March 2010, there were complaints lodged by Tuen Mun residents about the lack of a general station in the district. In this connection, Audit also notes that the

EPD will set up a sludge incinerator in Tuen Mun and has been working with the Tuen Mun District Council to set up a general station to monitor the air-quality impact of the sludge incinerator. In Audit's view, this station should be designed to serve as a general air-quality monitoring station for Tuen Mun which will provide a general API for the district.

Provision of roadside APIs

3.17 At LegCo meetings in May 2011 and May 2012, some LegCo Members requested the Government to consider setting up roadside stations in areas with high pedestrian flow, such as Sham Shui Po, Kwai Chung, Kwun Tong, Tsim Sha Tsui and Yau Ma Tei. The EPD responded that the existing three roadside stations were representative of roadside air quality of busy urban areas and no additional stations were required.

3.18 As of September 2012, when the roadside API of Central, Causeway Bay or Mong Kok exceeded 100, the EPD would inform the public of the district concerned and the recorded API, together with a precautionary advice that "persons with heart or respiratory illnesses are advised to avoid prolonged stay in areas with heavy traffic". In Audit's view, there is a risk that members of the public might interpret the advice as air quality at roadside of all districts other than the named district is satisfactory. Therefore, when a roadside API exceeds 100, the EPD needs to consider providing the public with clearer and more specific precautionary advice, such as avoiding prolonged stay in areas with heavy traffic and high pedestrian flow (such as Central, Causeway Bay, Mong Kok, Sham Shui Po, Kwai Chung, Kwun Tong, Tsim Sha Tsui and Yau Ma Tei).

Room for improvement in API reporting system

3.19 In April 2008, the EPD appointed a consultant to conduct a review of the API reporting system with a view to developing a new one for more accurate and timely communication of air-related health risks to the public. In July 2010, the EPD informed the Subcommittee on Improving Air Quality of the EA Panel that:

(a) the review report would be completed by the end of 2010;

(b) upon receipt of the report, the EPD would consider ways to improve the API reporting system; and

(c) the EPD undertook to provide the Subcommittee with the full review report which would also be uploaded onto EPD website for public reference.

In the event, the consultant only submitted its final review report to the EPD in June 2012, and up to September 2012, the EPD had not informed the Subcommittee about the progress of revamping the API reporting system.

3.20 The existing API in Hong Kong only reflects the concentration level and health impact of the contributing pollutant. Audit research has revealed that some overseas countries have adopted improved practices. For example, in Canada, the APIs have taken account of the combined health impact of a number of pollutants (Note 19), and the USA has included $PM_{2.5}$ in compiling their APIs (Note 20).

3.21 In Audit's view, to dovetail with the implementation of the 2014 AQOs, the EPD needs to set a time target for revamping the API reporting system, taking account of overseas practices in revamping the system.

Audit recommendations

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

(a) **provide on EPD website pertinent district-based air-quality information for each of the eight administrative districts not yet installed with a general air-quality monitoring station;**

(b) **set up a general air-quality monitoring station each in Tseung Kwan O and Tuen Mun, and compile a general API for each of the two districts;**

Note 19: *The APIs of Canada are based on health risks arising from combined effects of multiple pollutants, including NO_2, PM_{10}, $PM_{2.5}$ and O_3.*

Note 20: *In the USA, a separate API value (0 to 500) for each pollutant (NO_2, SO_2, O_3, $PM_{2.5}$, PM_{10} and CO) is calculated and the highest of these values is reported as the API.*

(c) **consider providing the public with clearer and more specific precautionary advice when a roadside API exceeds 100; and**

(d) **set a time target for revamping the API reporting system, taking account of overseas practices in revamping the system.**

Response from the Administration

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

(a) the EPD has provided additional information on its website showing the district-based coverage of the 11 general air-quality monitoring stations since October 2012. This will provide a better reference for understanding the air-quality situation of the 18 administrative districts;

(b) the coverage of current air-quality monitoring network is adequate as the stations have been set up with reference to the overall land use planning of the territory, population distribution and pollution sources. In view of the rapid development and the population growth in Tseung Kwan O, the EPD has envisaged that there will likely be a need to set up a new air-quality monitoring station in the district in a few years' time. In view of the lead time required for setting up the station, the EPD has commenced a preliminary site search for the purpose. For Tuen Mun, upon commissioning of the air-quality monitoring station in the district by 2013 for monitoring the air-quality impact of a sludge incinerator, the EPD will use the air-quality data from the station for compiling the API for the district. The EPD will continue to regularly review the air-quality monitoring network on an annual basis and monitor closely the need for setting up new stations;

(c) in October 2012, the EPD amended the precautionary advice for roadside API exceeding 100. This will provide more useful information to members of the public during incidents of high roadside air pollution; and

(d) the EPD is considering the recommendations of the API review for revamping the API reporting system (see para. 3.19). The EPD has planned to engage relevant stakeholders to explain to them the operation and implications of the proposed new air-quality reporting system, and to develop necessary guidelines in the coming months. The new system will be implemented after completion of the preparatory work and approval of the new AQOs by LegCo.

PART 4: PERFORMANCE REPORTING

4.1 This PART examines the Government's performance reporting of air quality, focusing on:

(a) the EPD's reporting of air-quality improvement or deterioration;

(b) the TD's reporting of emission control of vehicles; and

(c) the MD's reporting of emission control of marine vessels.

Performance information and targets

4.2 Each year, the Financial Services and the Treasury Bureau provides guidelines to B/Ds on reporting performance information and developing performance targets and indicators to be included in the Controlling Officer's Report (COR). Effective setting of performance targets and timely publishing of the extent of achievement of the targets help enhance public accountability and provide incentives for service improvements.

Performance targets in COR

4.3 In the 2012-13 COR, the EPD provided a brief description of its work carried out under the programme "Air" and reported the extent of achieving two performance targets on air quality (see Table 4).

Table 4

Performance targets on air quality
(2012-13)

Performance target	Target	2010 (Actual)	2011 (Actual)	2012 (Plan)
Number of days with API not exceeding 100	365/366	223	190	200
Annual average API	50	50	52	50

Source: EPD 2012-13 COR

4.4 In the 2012-13 COR, both the TD and the MD did not provide any performance targets on emission control of vehicles and marine vessels respectively.

Performance reporting on websites

4.5 ***EPD website.*** The EPD provides on its website an overview on air quality and air pollution control in Hong Kong. Information under different subsections including air pollution control strategies, AQOs, API and air quality, problems and solutions, data and statistics (see Figure 7) is provided for public reference. The EPD also publishes on its website Annual Reports of Air Quality providing comprehensive air-quality monitoring data and health impact information of major air pollutants.

Figure 7

EPD website on air pollution control
(August 2012)

Source: EPD website

4.6 ***TD website.*** The TD provides assistance to the EPD to address air pollution problems by enforcing control of smoke emissions by vehicles, conducting vehicle examination and monitoring the environmental performance of public transport operators (see para. 1.14(a)).

4.7 Since 2002, the TD has published an environmental report every year and uploaded the report onto its website. According to the environmental report of 2010 (as of September 2012, the 2011 report was not available), the environmental goal of the TD was to provide an environmental-friendly transport system in Hong Kong. To achieve this goal, the TD has set a number of environmental objectives, as follows:

(a) reduction of vehicular traffic, including rationalisation of bus routes and trips;

(b) tightening of vehicle emission control; and

(c) use of alternative-fuel vehicles to replace diesel vehicles.

4.8 In October 2012, in relation to the environmental objectives in paragraph 4.7, the TD informed Audit that:

(a) regarding the reduction of vehicular traffic:

(i) over the years, the TD had developed a set of planning guidelines governing the rationalisation of bus routes while meeting passenger demand and matching local operating environment. Between 2002 and 2011, the TD had successfully reduced 9% of the franchised bus fleet;

(ii) the TD had set quantitative targets in the annual Route Development Programme for the purpose of consultation with the District Councils. However, because of strong local objection, it was not uncommon for route rationalisation proposals to be scaled down or dropped after consultation, even if the proposals were worth pursuing on transport grounds; and

(iii) the TD would continue to explore new opportunities for bus-route rationalisation and to plan bus services according to the planning principles and guidelines;

(b) regarding the tightening of vehicle emission control, the TD would follow the EPD's emission-standard requirements in approving the registration of new vehicles in Hong Kong, and in conducting smoke tests for vehicles during annual and ad hoc examinations; and

(c) in implementing environmental policies and initiatives on using alternative-fuel vehicles, the TD had provided support to the EPD. For example, the TD had encouraged taxi and public light bus operators to replace diesel taxis and public light buses with LPG vehicles, and the franchised bus operators to participate in the trial schemes for using hybrid buses and electric buses.

4.9 In its annual environmental reports, the TD has published targets for achieving various environmental objectives, including those in (a) to (c) of paragraph 4.7 above. Audit however notes that most of these targets are not quantifiable ones. For example, the targets for the reduction in vehicular traffic in 2011 were to continue the existing bus-rail interchange schemes, and to rationalise more bus routes in busy areas and on busy roads.

4.10 ***MD website.*** The MD is responsible for enforcing the control of smoke emissions and use of low-sulphur-content diesel and engines with low NOx emissions by vessels navigating in Hong Kong waters (see para. 1.14(b)). The MD conducts port-control inspections to ensure that the fuel-sulphur content and NOx emissions of ocean-going vessels are in compliance with the required international standards. The MD also conducts dark smoke surveys as part of its enforcement and monitoring efforts to curb excessive emissions from vessels operating in Hong Kong waters. However, Audit notes that the MD has not set any environmental objectives or quantifiable targets for these environmental tasks.

Room for improvement in performance reporting in CORs

4.11 The EPD has a statutory duty under the APCO to achieve the AQOs (see para. 1.3). Whilst Audit recognises that the EPD has made substantial efforts to reduce air pollution, Hong Kong however has not yet fully achieved the existing AQOs established as early as 1987 (see para. 2.14). In PART 2, Audit has recommended that the ENB and the EPD should set time targets with milestones for achieving the AQOs, and set up a mechanism for effective monitoring of the extent of achieving the AQOs and for publicising the progress of achievement periodically (see para. 2.32(c) and (d)). To enhance public accountability, Audit considers that the EPD also needs to include in the CORs time targets for achieving the AQOs and progress of achieving the targets. As revealed in paragraph 3.10, the API trend had worsened from 2007 to 2011. In this connection, the EPD also needs to report in its CORs any adverse trends in performance against targets and the remedial action to be taken.

4.12 In formulating performance targets for achieving the AQOs, the EPD needs to work in close partnership with other B/Ds, including the TD and the MD, and address inter-departmental issues that may straddle a number of B/Ds. Audit considers that the EPD needs to work in collaboration with other B/Ds to formulate joint targets on inter-departmental issues (such as emission control of vehicles and marine vessels — see paras. 4.7 and 4.10).

Room for improvement in performance reporting on websites

4.13 After formulating meaningful targets, the EPD needs to report on its website the progress of achieving the targets from time to time. Such progress reporting will apprise stakeholders (including LegCo Members and members of the public) of the up-to-date progress of achieving the targets. In this connection:

(a) both summary information and more detailed information should be provided to meet different needs;

(b) each performance target should be accompanied by a technical note, providing an explanation of how the target is measured and how success is defined, and the sources of the relevant data; and

(c) the performance targets should also be underpinned by existing data sources and where historical data exist, a recent account of performance should be shown. Appropriate links should be provided (e.g. easily accessible hyperlinks with the TD and the MD websites). These linked sites provide easy access to related areas which will help stakeholders better understand other related issues.

4.14 Audit examination in August 2012 revealed that, although the EPD provided comprehensive information on its website on air quality and air pollution control in Hong Kong, including the measures taken on reducing vehicle emissions, some important information was not readily accessible by the public. As of August 2012, inadequacies were found in the following areas:

(a) some important air-quality information (see examples below) was not readily available on the website:

Information was not readily available

(i) The EPD provided the levels of compliance with the existing AQOs for individual air pollutants and a summary of the compliance levels in the Annual Reports of Air Quality in a clear and user-friendly manner. The EPD also provided an annual AQO compliance table on its website. Audit however noted that the extent of achieving the existing AQOs since their establishment in 1987 (see para. 2.14) was not clearly reflected in the Overview and AQOs sub-sections.

(ii) The EPD provided the excess of the roadside NO_2 and PM_{10} in comparison with the existing AQOs in the Annual Reports of Air Quality. However, the persistent inability to achieve the AQOs in terms of annual NO_2 and PM_{10} measurements at the roadside was not explicitly stated in the Overview and Cleaning the air at roadside subsections. Besides, there was no reporting that the roadside NO_2 and PM_{10} measurements had persistently exceeded the WHO limits (see paras. 2.23 and 2.24).

(iii) The EPD provided comprehensive statistics of hourly APIs, breaking down by different bands including those exceeding and not exceeding 100. However, Audit noted that the extent of achievement against the EPD's performance target of "Number of days with API not exceeding 100 in a year should be 365 (or 366 in a leap year)" was not provided (see para. 3.10).

(iv) The increase in the number of days with API exceeding 100 from 74 in 2007 to 175 in 2011 was not shown (see para. 3.10).

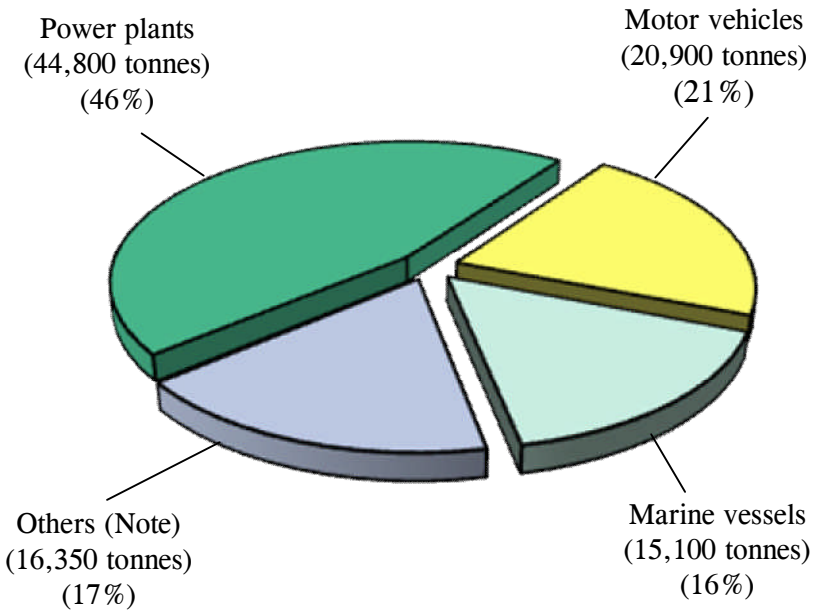
(v) The deterioration of the roadside API from 2007 to 2011 was not shown (see paras. 3.11 and 3.12).

(b) some of the data and statistics available on EPD website were not up-to-date. An example is given below:

Information was not up-to-date

1. In the "Data & Statistics" subsection, the EPD provided an air-pollutant-emission inventory of Hong Kong showing the volumes and percentages in 2007 of emissions of five major air pollutants, namely NOx (see below), SO_2, PM_{10}, CO and VOCs from major emission sources, including power plants, motor vehicles and marine vessels.

NOx emissions by various sources (2007)



Note: *Other sources include non-road mobile machinery, civil aviation, catering and industrial processes.*

Information was not up-to-date (Cont'd)

2. According to the EPD, the emission inventory is a fundamental building block in developing air-quality control strategies. It can be used for gauging changes in emission levels of air pollutants over the years, providing support in identifying major pollution sources and conducting air-quality modelling.

3. As informed by the EPD in August 2012, major studies on marine vessel and vehicle emissions had been conducted in recent years and the emission inventory would be updated upon completion and verification of the results of these studies. Given the importance of the emission inventory, the fact that the EPD had not updated it from 2007 to August 2012 is not satisfactory. Audit considers that the EPD needs to provide an updated emission inventory on its website as early as practicable.

Audit recommendations

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

(a) **include in the CORs time targets for achieving the AQOs and progress of achieving the targets;**

(b) **report in the CORs any adverse trends in performance against targets and remedial action to be taken; and**

(c) **in collaboration with the Commissioner for Transport and the Director of Marine:**

(i) **formulate joint targets on inter-departmental air-quality improvement issues (such as emission controls of vehicles and marine vessels) and regularly report the progress or gap in achieving such targets; and**

(ii) **improve performance reporting on websites, taking account of the audit observations in paragraph 4.14.**

Response from the Administration

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

(a) Hong Kong's air quality is subject to various factors including regional air quality, local emissions and weather conditions. Though some of these factors are outside the control of the EPD, the EPD will aim to achieve the new AQOs as soon as practicable. Subject to the conclusion of the agreement with the Guangdong Provincial Government on regional collaboration on emission-reduction targets and progress on implementation of the 22 emission-reduction measures, time targets for achieving the AQOs will be announced in early 2013;

(b) the EPD will report in the CORs if the performance targets are not met and the key reasons involved. Relevant follow-up measures will also be identified;

(c) regarding the audit recommendations in paragraph 4.15(c):

  (i) both the ENB and the EPD have been working closely with the THB, the TD and the MD to reduce the emissions from vehicles and vessels to enhance cross-bureau collaboration. For the emission-reduction measures targeting at vehicles and vessels, the EPD has been working on implementation of measures jointly with the B/Ds concerned, and will monitor the progress of meeting these targets and compile regular reports as appropriate in collaboration with these B/Ds; and

  (ii) the EPD has included performance reporting of the air-quality situation on its website and improved the presentation of the reports. In relation to the examples given in paragraph 4.14(a), the EPD will provide the relevant important air-quality information on its website; and

(d) the EPD has finalised the 2010 emission inventory, and the information was uploaded onto EPD website on 10 October 2012 (Note 21).

Note 21: *Audit notes that, as compared with the 2007 emission inventory, the 2010 inventory shows substantial increases in NOx emissions from motor vehicles and marine vessels.*

Performance reporting

4.17 The Commissioner for Transport agrees with the audit recommendations in paragraph 4.15(c). She has said that the TD will continue to provide assistance to the EPD on its air-quality improvement measures for controlling emissions from vehicles and ferries.

4.18 The Director of Marine agrees with the audit recommendations in paragraph 4.15(c). He has said that the MD will continue to provide assistance to the EPD on the air-quality improvement initiatives for emission control of marine vessels, and will support and collaborate with the EPD in formulating necessary objectives and targets from the environmental perspective.

PART 5: WAY FORWARD

5.1 This PART summarises the areas for improvement and examines the way forward for monitoring and reporting air quality of Hong Kong.

Areas for improvement

5.2 Audit notes that, from 1999 to 2011, through the EPD's efforts, concentrations of SO_2, PM_{10} and CO had been reduced in Hong Kong. However, as reported in PART 2, the existing AQOs have never been fully achieved since their adoption in 1987. In particular, from 2007 to 2011, there had been an increasing trend in the roadside annual average concentration levels of NO_2 (a 26% increase), which had exceeded the AQO limit by 21% to 53%, and had exceeded the WHO AQG limit by 143% to 205%. During the same period, the roadside annual average concentration levels of PM_{10} had also exceeded the AQO limit by 9% to 33%, and had exceeded the WHO AQG limit by 200% to 265%.

5.3 Audit research has also shown that air quality of Hong Kong is unsatisfactory when compared with that of some world cities. For example, in 2011, the ambient annual average concentration level of NO_2 in Hong Kong was 279%, 47% and 36% higher than those in Sydney, London and New York respectively. In the same year, the ambient annual average concentration level of PM_{10} in Hong Kong was also 220%, 100% and 153% higher than those in Sydney, London and New York respectively.

5.4 PART 3 has revealed that the EPD's performance target on API (no single day in a year with API exceeding 100) has never been achieved since the adoption of this target in 2006-07, and there has been a rising trend of the API. For example, there was a 136% increase in the number of days with API exceeding 100 from 2007 to 2011.

5.5 In January 2012, the Government announced that, based on the WHO AQGs, the existing AQOs would be revised to stringent levels with effect from 2014. According to the EPD's 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.

5.6 This audit has revealed that the air quality of Hong Kong has not fully met the existing AQOs, and is falling short of the WHO standards. 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 (Note 22), roadside pollution is mainly caused by vehicle emissions which can be reduced through the vigorous efforts of the Government, and cooperation of vehicle owners and commuters. Furthermore, the Government needs to accord a higher priority to implement measures for improving the air quality of Hong Kong, and to work closely with the Guangdong Provincial Government on ways and means to improve the regional air quality. In this connection, Audit has identified in this review many areas that call for improvement (see paras. 2.32, 3.22 and 4.15).

Strategies for achieving AQOs

5.7 There is growing public concern over the worsening air pollution in Hong Kong and its adverse impacts on public health. The WHO and many researches have also confirmed the detrimental effects of high concentration of SO_2, NO_2 and PM_{10} on human health. In Audit's view, there is an imminent need for the Government to formulate and update strategies for implementing appropriate measures to achieve the AQOs as early as possible (the audit recommendation in para. 2.32(a) is relevant). In order to demonstrate the Government's determination to protect public health from worsening air quality, the Government needs to set time targets with milestones for achieving the 2014 AQOs, and establish a mechanism to monitor and publish the progress of achievement (the audit recommendations in para. 2.32(c) and (d) are relevant).

Note 22: *According to a recent EPD study completed in February 2012, 67% of suspended particulates in the air might come from regions outside Hong Kong.*

Reporting and publishing of measurement results

5.8 As stated in paragraph 1.2, 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. This audit has revealed areas for the EPD to improve its reporting and publishing of the measurement results of air quality (see paras. 4.11 to 4.15).

Audit recommendation

5.9 **To enhance public accountability, Audit has *recommended* that the Secretary for the Environment and the Director of Environmental Protection should strengthen efforts in timely reporting and publishing measurement results of air quality.**

Response from the Administration

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

(a) the Government has a firm commitment to improving air quality of Hong Kong for better protection of public health. The endorsement in January 2012 to adopt the new AQOs is a step forward to this;

(b) the ENB and the EPD have been implementing a package of 22 air-quality improvement measures together with the relevant B/Ds. They aim to achieve the new AQOs as soon as possible after completion of these measures; and

(c) the EPD will keep LegCo and the public informed of the progress of attaining the new AQOs and the implementation of the air-quality improvement measures from time to time and publish the relevant information on its website.

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 problems
	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. 1.8(c), 1.9(b) and 2.8 refer)

Air quality objectives (2014 onwards)

Pollutant	Average time measurement	Average concentration limit (Note 1)				Number of excesses allowed in a year (Note 2)
		WHO Interim Target 1 ($\mu g/m^3$)	WHO Interim Target 2 ($\mu g/m^3$)	WHO Interim Target 3 ($\mu g/m^3$)	WHO AQG level ($\mu g/m^3$)	
SO_2	10-minute	—	—	—	500*	3
	24-hour	125*	50	—	20	3
NO_2	1-hour	—	—	—	200*	18
	Annual	—	—	—	40*	N/A
PM_{10}	24-hour	150	100*	75	50	9
	Annual	70	50*	30	20	N/A
$PM_{2.5}$	24-hour	75*	50	37.5	25	9
	Annual	35*	25	15	10	N/A
O_3	8-hour	160*	—	—	100	9
CO	1-hour	—	—	—	30,000*	0
	8-hour	—	—	—	10,000*	0
Lead	Annual	—	—	—	0.5*	N/A

Source: EPD records

Note 1: The average concentration limits highlighted with an asterisk (*) are the 2014 AQOs. The WHO has suggested setting Interim Targets for SO_2, PM_{10}, $PM_{2.5}$ and O_3 to facilitate a progressive approach for achieving the AQG levels. The 2014 AQOs of these four pollutants are mostly set based on these Interim Targets.

Note 2: 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 C
(paras. 1.9(a) and 2.8 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 European (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 D
(para. 1.9 refers)

Chronology of key events
(1987 to 2012)

Year		Key event
(a)	1987	The EPD established the AQOs for Hong Kong. The WHO also published a set of AQGs providing references to countries and cities for them to develop their air-quality standards.
(b)	1997	The EPD formed the Working Group on the Health Effects of Air Pollution to review pertinent overseas and local research findings with a view to making recommendations on revising the AQOs.
(c)	1998	The 1997 Review was completed. The Review concluded that tightening the AQOs would help provide greater protection of public health. According to the Policy Address, the Administration aimed to complete assessing the adequacy of the AQOs by the end of 1998 and make recommendations in 1999.
(d)	1999 to 2001	According to the Policy Addresses, internal consultation was being carried out, the report of the Working Group on the Health Effects of Air Pollution was being considered and the EPD was awaiting the outcome of a lawsuit regarding the introduction of $PM_{2.5}$ standards in the USA before deciding on the way forward.
(e)	2002 to 2005	The Policy Addresses did not include updates on the progress of revising the AQOs. In the event, the EPD did not make any recommendations arising from the 1997 Review.
(f)	2006	The WHO AQGs were issued.
(g)	2007	The 2007 Consultancy Review on the AQOs commenced.
(h)	2009	The 2007 Consultancy Review was completed in July 2009. The Review recommended promulgating new AQOs based on a combination of WHO AQG levels and Interim Targets. The EPD launched a public consultation on the recommendations of the 2007 Consultancy Review.
(i)	2010	The EPD informed the EA Panel of findings of the public consultation.
(j)	2012	The EPD informed LegCo that it would adopt a set of proposed new AQOs together with a package of air-quality improvement measures, and it would start preparatory work for amending the APCO with a view to implementing the new AQOs in 2014.

Source: EPD records

Appendix E
(para. 1.12 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 F
(para. 2.14 refers)

Achievement of air quality objectives in 2011

Pollutant	Average time measurement	AQO ($\mu g/m^3$)	Highest concentration recorded ($\mu g/m^3$)		Achievement	
					% of AQO at highest concentration	Evaluation
SO_2	1-hour	800	General station	261	33%	Achieved
			Roadside station	177	22%	Achieved
	24-hour	350	General station	85	24%	Achieved
			Roadside station	64	18%	Achieved
	Annual	80	General station	21	26%	Achieved
			Roadside station	14	18%	Achieved
NO_2	1-hour	300	General station	296	99%	Achieved
			Roadside station	511	170%	Not achieved
	24-hour	150	General station	165	110%	Not achieved
			Roadside station	252	168%	Not achieved
	Annual	80	General station	70	88%	Achieved
			Roadside station	124	155%	Not achieved
PM_{10}	24-hour	180	General station	173	96%	Achieved
			Roadside station	135	75%	Achieved
	Annual	55	General station	54	98%	Achieved
			Roadside station	66	120%	Not achieved
TSP	24-hour	260	General station	196	75%	Achieved
			Roadside station	199	77%	Achieved
	Annual	80	General station	86	108%	Not achieved
			Roadside station	102	128%	Not achieved
O_3	1-hour	240	General station	316	132%	Not achieved
CO	1-hour	30,000	General station	3,210	11%	Achieved
			Roadside station	4,030	13%	Achieved
	8-hour	10,000	General station	2,610	26%	Achieved
			Roadside station	3,309	33%	Achieved
Lead	3-month	1.5	General station	0.104	7%	Achieved
			Roadside station	0.097	6%	Achieved

Source: EPD records

Appendix G
(para. 2.19 refers)

Revision of air-quality standards in overseas countries (1997 to 2010)

Country/Economy	Year of review	Pollutant	Revision particulars
USA	1997	$PM_{2.5}$	New standards introduced
		O_3	1-hour standard replaced by a newly introduced 8-hour standard
	2006	$PM_{2.5}$	Existing standards tightened
	2008	O_3	Existing standard tightened
		Lead	Existing standard tightened
	2010	SO_2	24-hour and annual standards replaced by a newly introduced 1-hour standard
		NO_2	New 1-hour standard introduced
EU	1999	SO_2	Annual standard replaced by newly introduced 1-hour and 24-hour standards
		NO_2	Existing annual standard tightened and a new 1-hour standard introduced
		PM_{10}	New standards introduced
		Lead	Existing standard tightened
	2000	CO	New standards introduced
	2008	$PM_{2.5}$	New standards introduced
UK	2000	SO_2	New standards introduced
		NO_2	Existing 1-hour standard tightened
		PM_{10}	New annual standard introduced
	2003	CO	Existing standard tightened
	2007	$PM_{2.5}$	New standards introduced

Source: Audit research

Appendix H
(para. 3.5 refers)

Air pollution index bands and precautionary advice to the public (September 2012)

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

Source: EPD records

Acronyms and abbreviations

APCO	Air Pollution Control Ordinance
API	Air pollution index
AQGs	Air Quality Guidelines
AQO	Air quality objective
Audit	Audit Commission
B/Ds	Bureaux and departments
CO	Carbon monoxide
COR	Controlling Officer's Report
EA Panel	Panel on Environmental Affairs
ENB	Environment Bureau
EPD	Environmental Protection Department
EU	European Union
Euro	European
HKSAR	Hong Kong Special Administrative Region
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
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
VOCs	Volatile organic compounds
WHO	World Health Organisation