LVAC Paper No. 14/2009

LOCAL VESSELS ADVISORY COMMITTEE

REVIEW OF AIR QUALITY OBJECTIVES

PURPOSE

This paper consults Members about the proposals to update the Air Quality Objectives (the AQOs) and the proposed emission control measures for attaining the proposed AQOs, for which a public consultation is being conducted from 23 July 2009 to 30 November 2009 based on the consultation document at **Annex A**.

BACKGROUND

Existing AQOs

2. In Hong Kong, the AQOs are set out in a Technical Memorandum issued under section 7 of the Air Pollution Control Ordinance (APCO) (Chapter 311) for promoting the conservation and the best use of air in the public interest. The APCO also requires the Authority (i.e. the Director of Environmental Protection) to aim to achieve the AQOs as soon as is reasonably practicable and thereafter to maintain the quality so achieved. The AQOs stipulate concentration targets for selected air pollutants, which serve as the references to the Authority in deciding on the levels of emissions permitted for specified process licences granted under the APCO and assessing whether the air quality impact of designated projects is acceptable for approval under the Environmental Impact Assessment Ordinance (EIAO) (Chapter 499). The AQOs also provide the key references for determining the Air Pollution Index.

3. The current AQOs, which cover seven major air pollutants, were established in 1987 without any update thereafter. In recent years, the World Health Organisation (WHO) and a number of overseas countries/economies such as the United States, the European Union and Australia have updated their air quality guidelines or standards in the light of new scientific evidence and data on health

effects of air pollution. **Annex B** gives a comparison between Hong Kong's existing AQOs, the air quality standards being adopted by advanced countries and the latest Air Quality Guidelines (AQGs) issued by WHO. Our AQOs are lagging behind those being pursued by the more developed countries in at least two aspects –

(a) we allow for much higher concentration levels of key pollutants; and

(b) we do not provide for the assessment of fine particulate matters (PM2.5) which has been scientifically proven to have greater adverse impact on human health than respirable suspended particulates (PM10).

THE PROPOSAL

4. In response to the release of the WHO AQGs and strong public demand to review the appropriateness of the current AQOs, we commissioned a consultancy study in June 2007 to recommend a new set of AQOs for Hong Kong and an air quality management strategy to achieve the new AQOs. The Final Report of the Study is now available at the Environmental Protection Department's website [www.epd.gov.hk]

5. In light of the objectives of the WHO AQGs and the practices of other advanced countries/economies in revising their air quality standards, we propose to apply the following guiding principles in setting the new AQOs -

- Protection of public health
- Benchmarking against WHO Guidelines
- A staged approach for updating the AQOs

6. Taking into account these principles, the air quality standards being pursued in other countries and the local situations, the Review of AQOs (the Review) recommends that –

(a) the WHO AQGs should be deemed as a long-term policy goal, the pursuit of which will be considered with reference to the international practices, the latest technological developments and local circumstances;

(b) a progressive, forward-looking approach with an explicit reference to protection of public health as a key parameter on the one hand, and to be

commensurate with social and economic development as other important parameters on the other, should be adopted in revising the AQOs;

(c) as the first step, the AQOs should be updated with reference to the WHO AQGs and Interim Targets (ITs). Specifically, the proposed new AQOs are as follows –

(i) adopting the concentration targets set out under WHO AQGs for sulphur dioxide (SO_2; 10-minute), nitrogen dioxide (NO2; 1-hour and annual); carbon monoxide (CO; 1-hour and 8-hour) and lead (Pb; annual);

(ii) adopting the concentration targets set out under WHO IT2 for PM10 (24-hour and annual); and

(iii) adopting the concentration targets set out under WHO IT1 for SO_2 (24-hour) and PM 2.5 (24-hour and annual), and the IT for ozone (8-hour).

A comparison of the proposed new AQOs with WHO AQGs, our current AQOs and those of other international cities is at **Annex C**.

7. The Review recommends the proposed emission control measures at **Annex D** be taken forward for further consideration. To attain the proposed new AQOs, the Review has identified under the Phase I stage a host of 19 emission control measures which can be grouped into four main categories. The first category is emission capping and control, notably increasing the ratio of natural gas in local electricity generation to 50% and early retirement of aged and heavily polluting vehicles. The second category comprises transport management measures such as the establishment of low emission zones and bus route rationalization. The third category is related to infrastructure development and planning, such as expanding rail network to reduce the use of vehicles. The fourth category includes energy efficiency enhancement measures, such as mandatory implementation of Building Energy Codes. These proposed Phase I control measures are considered technically feasible and more ready for implementation over the short to medium term.

8. As the Guangdong side continues to align itself with the best practices in the world to curb emissions in tandem with its economic growth, the consultant's

modelling results show that implementation of the proposed Phase I control measures could help deliver the proposed new AQOs with allowance of certain exceedences in line with international practices.

9. To deliver progressively the long-term target of achieving the ultimate WHO AQGs, the Review recommends establishing a review mechanism for updating the AQOs in no less than five years so as to ascertain the extent to which the new AQOs have been achieved, as well as the need and practicality of further tightening the AQOs..

COSTS AND BENEFITS

10. In the study, the consultant has undertaken a cost-benefit analysis to provide an indication of the relative cost effectiveness of the proposed emission control measures. As the proposed measures are at a conceptual stage, the estimates on costs and benefits are subject to a great deal of uncertainties and variations depending on the timing and details of implementation. According to the estimates of the consultant, implementation of the proposed Phase I emission control measures would bring about an anticipated benefit of $1,228 million per year mainly due to improvement of public health and savings in energy costs, which are significantly higher than the estimated annualized cost of about $596 million to be incurred by the society. The consultant also estimates that some 4,200 hospital admissions would be avoided. The average life expectancy of the population would be increased by about one month or around 7,400 life years saved per year. Findings of the cost-benefit analysis however should not be taken as the only criterion for consideration of the priority of the proposed emission control measures as other factors such as emission reduction potential, acceptance by the stakeholders are relevant considerations as well.

PUBLIC CONSULTATION

11. We are now conducting a full-scale public consultation exercise from 23 July 2009 to 30 November 2009 to ascertain the public's acceptance of the recommendations of the Review and the associated implications. In the course of the consultation, we will solicit the views of the community via a public forum and meetings with the stakeholders, industry and business groups, professional bodies, political parties and the District Councils. Early implementation of the proposed air quality improvement measures would bring us closer to the proposed new AQOs and

deliver cleaner air. On the other hand, the proposed emission control measures involve various degree of complexity, and their implementation is subject to the extent of support of the stakeholders. During the consultation period, the public would be asked to express their views on the pace of taking the proposed measures to implementation in order to deliver improvements in air quality and the price they are willing to pay for the measures including the higher electricity tariff, bus fares as well as adjustments in the way of life.

ADVICE SOUGHT

12. Members are invited to offer their views on the proposals of the Review in the public consultation document at Annex A.

Air Policy Division
Environmental Protection Department
October 2009

Annex A

綠色香港 我鍾意
I Love Hong Kong
I Love GREEN

Air Quality Objectives Review
Public Consultation

Environment Bureau
Hong Kong SAR Government

Contents

List of Annexes

"Join us in setting new benchmarks for Hong Kong's Air Quality Objectives. We need your participation in the pursuit for clean air and a green living environment"

Edward Yau
Secretary for the Environment

1 INTRODUCTION

1.1 We all like to breathe clean air. Fresh air is an essential part of a quality living environment. It is vital to the health of the people and plays an important role in maintaining the competitiveness of Hong Kong as an international business centre. In recent years, the Government has made tremendous effort to improve Hong Kong's air quality. Locally, we sought to tackle sources of pollution such as the emissions by power generation and the transportation sector. At the same time, we also stepped up cooperation with the mainland authorities over the monitoring, as well as the prevention and mitigation of air pollution problems. As a result of the concerted effort by all sectors of the community of Hong Kong, we have seen continuous improvement in our air quality. However, we must continue to strengthen our measures to improve air quality, so as to ensure a healthy and green living environment for this and future generations.

1.2 In the 2008/09 Policy Address, the Chief Executive announced that in reviewing our Air Quality Objectives (AQOs), Hong Kong will adopt targets in stages giving due regard to the World Health Organisation (WHO) Air Quality Guidelines (AQGs). The objective is clear, that we will continue to reinforce our effort to improve air quality. Building on the basis of the initiatives implemented in recent years, we shall introduce new measures to strengthen our work in this regard in line with the new AQOs that are currently being updated while taking into account the development needs of Hong Kong. Our AQOs, which set out the concentration targets of seven key air pollutants[1] in the ambient air, were promulgated in 1987 and are in need of updating. In 2006, the WHO took into account new scientific findings on the health implications of air pollution and updated its guidelines on air quality. To better protect the public from the adverse health effects of air pollution, the Government commissioned a consultancy study in 2007 to review the AQOs (the Review) taking into account the WHO AQGs and the practices of other advanced countries / economies. The consultant has completed the study, which recommends a new set of AQOs and a host of emission control measures required for delivering the proposed new AQOs[2].

1.3 This consultation paper sets out the main findings of the Review and seeks comments from interested parties on the proposed new AQOs and emission control measures. Specifically, we will also seek the views from the public on the package of proposed emission control measures, the pace under which they should be taken forward and the price that the community is willing to pay in return for better air quality. The views of the community will help us decide on how best the AQOs are to be updated and set an agenda for actions to deliver cleaner air.

[1] *The seven key air pollutants include sulphur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulates (TSP), respirable suspended particulates (RSP or PM_{10}), carbon monoxide (CO), ozone (O_3) and lead (Pb).*

[2] *The full report of the Review and its executive summary can be downloaded at the following website of the Environmental Protection Department – http://www.epd.gov.hk/epd/english/environmentinhk/air/air_quality_objectives/air_quality_objectives.html.*

2 AIR QUALITY IN HONG KONG

2.1 Like many other metropolitan cities in the world, Hong Kong is characterized by a high density of development. The huge demand for energy and transport services to support our economic activities has placed an enormous strain on our environment, not least on our air. The note at Annex A gives a brief account of the key emission sources in Hong Kong and health effects of air pollutants.

2.2 To improve our air quality, **we have put in place a series of stringent measures since 1990 to reduce emissions from key sources, including local power plants, transport sector and industrial activities**. These measures include in the main requiring local power plants to adopt the latest emission abatement technology and cleaner fuels for electricity generation, pursuing the best practices in the world to control emissions from vehicles and fuels, mandating the use of ultra low sulphur diesel (ULSD) in all industrial and commercial processes, and introducing legislation to limit the content of volatile organic compounds (VOCs) in a range of products, etc.

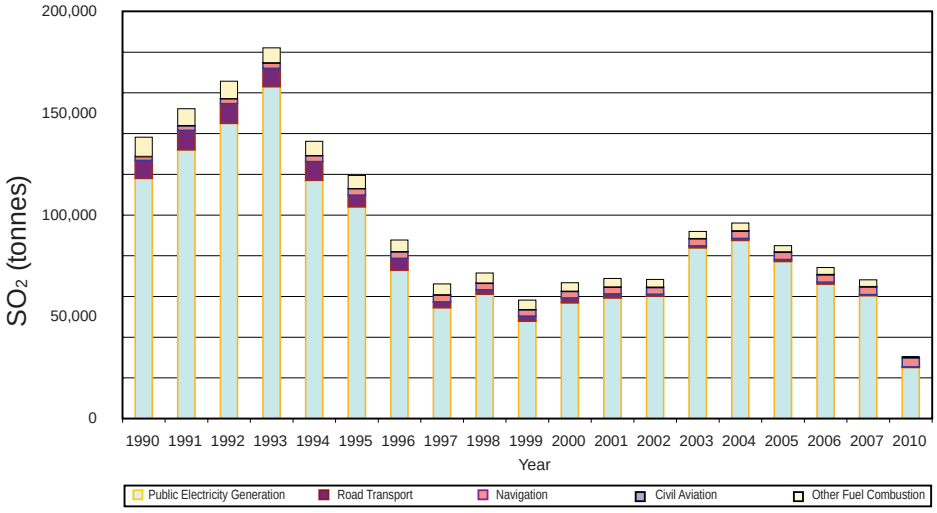
2.3 These efforts have borne fruits. The local emissions of SO_2, nitrogen oxides (NOx), RSP (or PM_{10}), non-methane VOCs and CO have significantly fallen by 55% to 83% from their peaks in 1990s. Figures 2.1(a) to (e) below show the trends of emissions of the key air pollutants from 1990 to 2007 and the projected emissions in 2010.

"Clean air, clean water and green countryside are the keys to quality living environment."

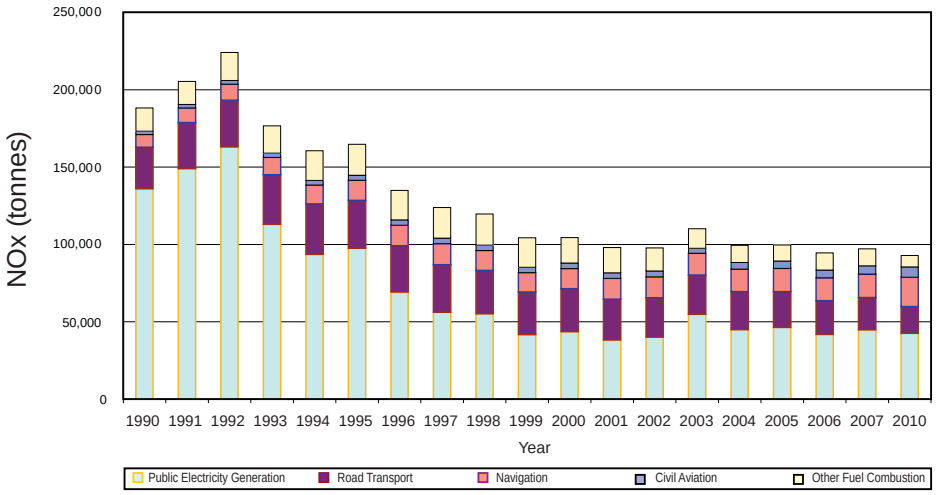
— Prof. Lam Kin-che
Chairman of Advisory Council on the Environment

Figure 2.1 : Emission Trends of Hong Kong

(a) SO_2



(b) NOx



(c) RSP (or PM_{10})

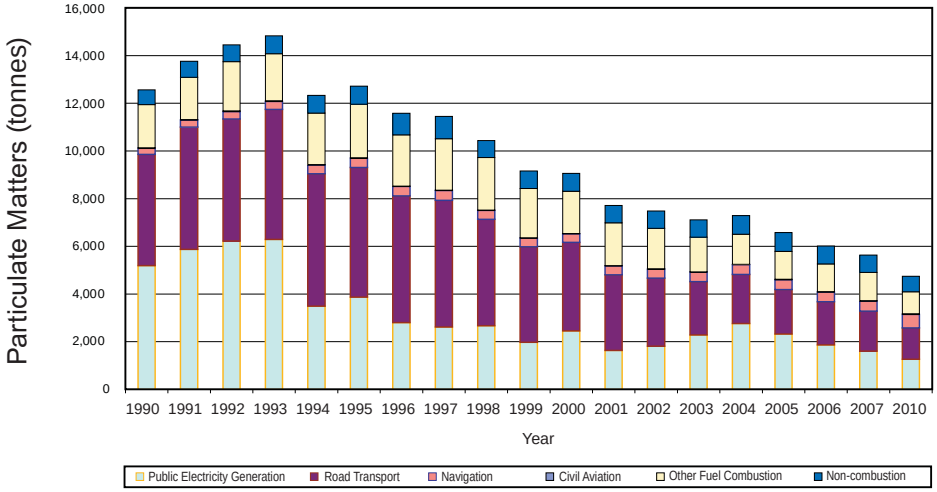
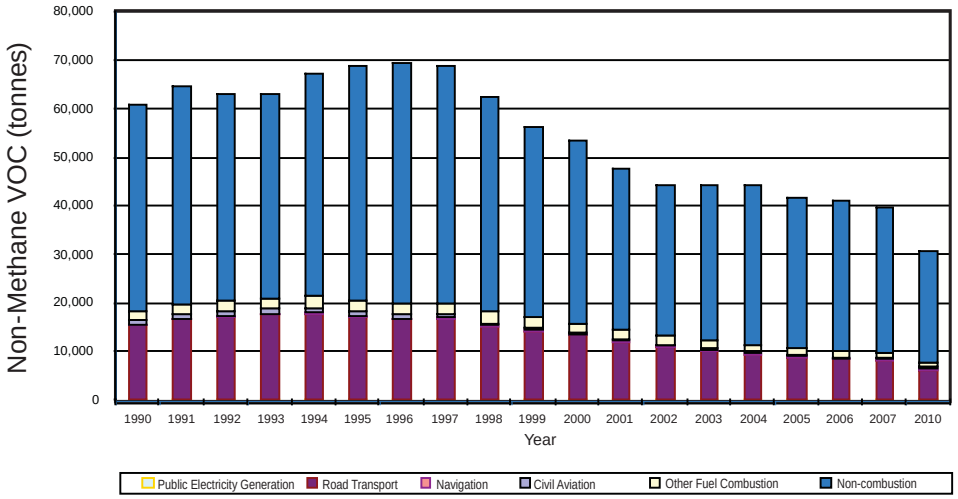
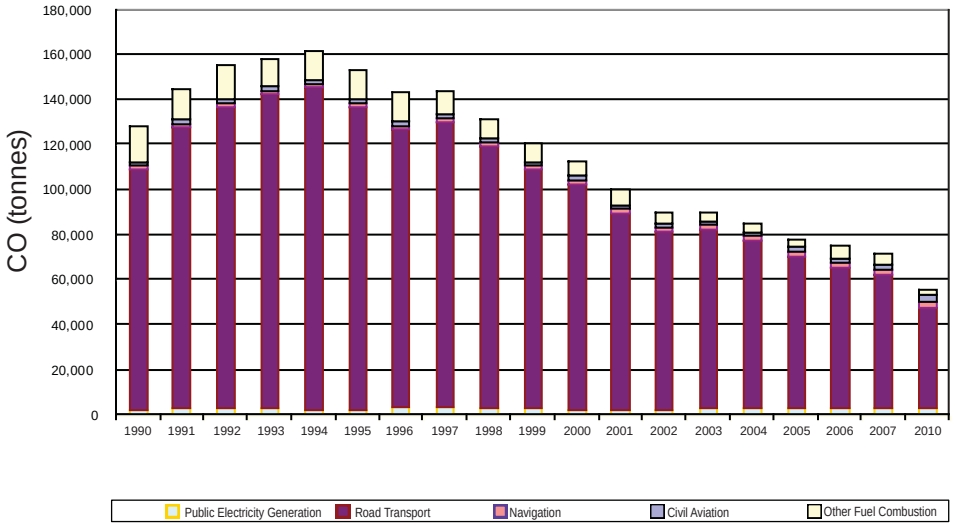


Figure 2.1 : Emission Trends of Hong Kong *(Continue)*

(d) VOCs



(e) CO



Note:

[1] *Emissions in 2010 are projected figures.*

[2] *The main source of Pb emissions in Hong Kong used to be from leaded petrol. Following the introduction of unleaded petrol in April 1991 and the ban on leaded petrol in April 1999, the amount of Pb emissions in Hong Kong has been maintained at very low levels. We have therefore not compiled the emission inventory for Pb.*

2.4 It is apparent that the extent of air quality improvement is not commensurate with the extent of emission reduction achieved over the past two decades as set out in Figures 2.1 (a) to (e) above. Figures 2.2(a) to (f) below present the air quality trends of Hong Kong in terms of the concentration levels of the key air pollutants.

Figure 2.2 : Air Quality Trends of Hong Kong

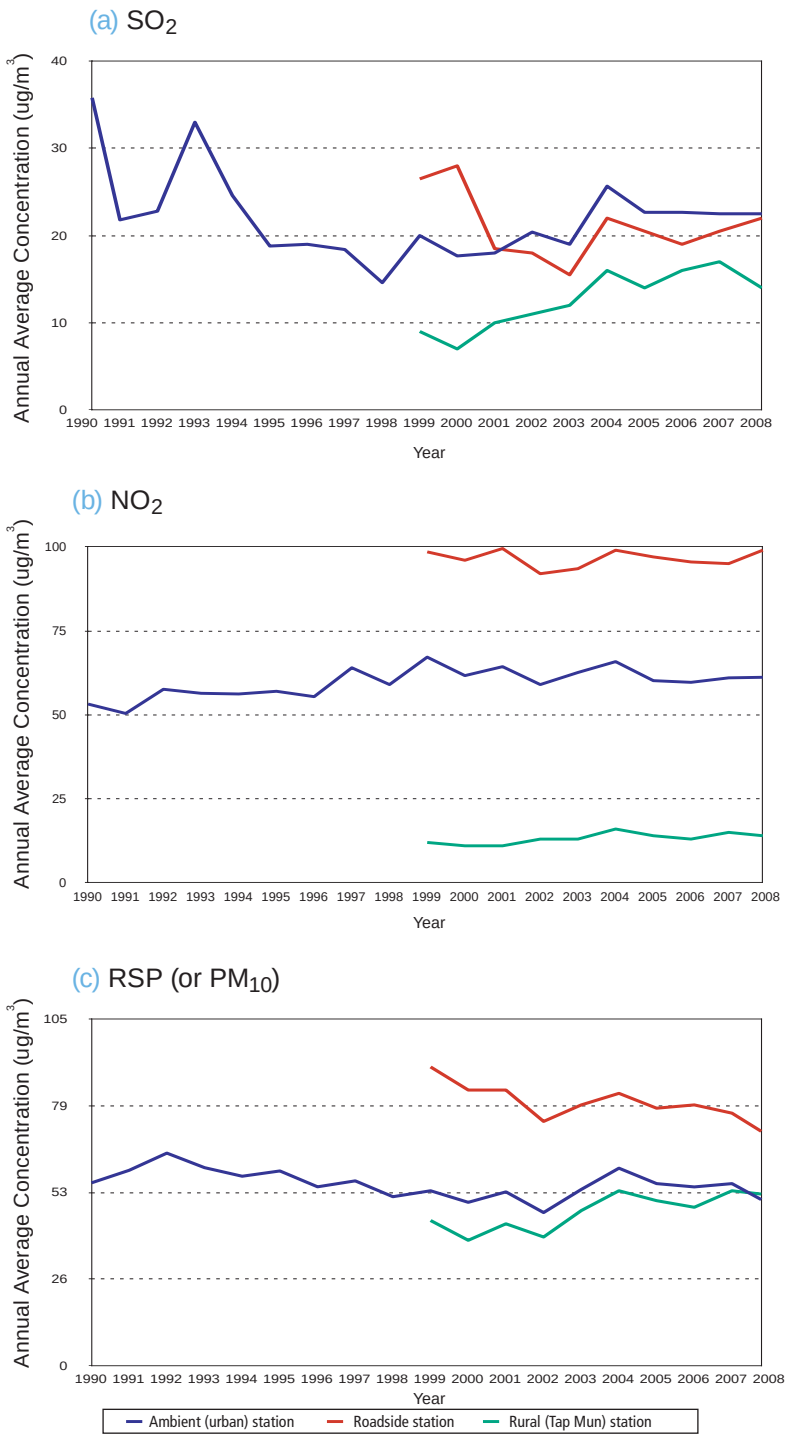
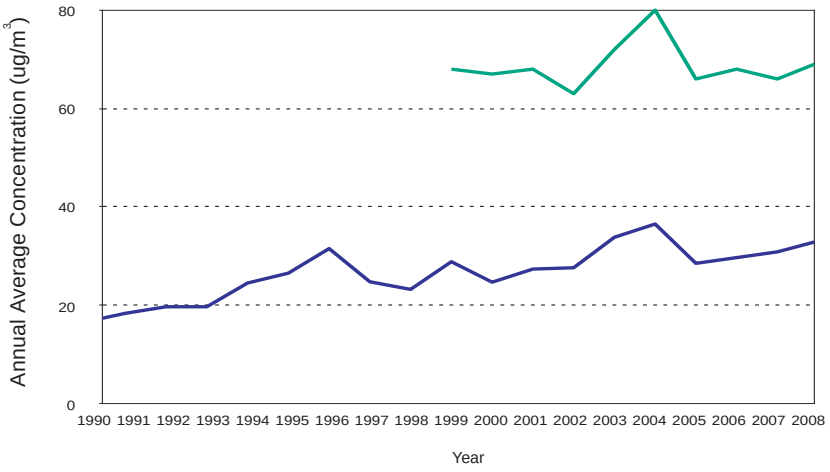
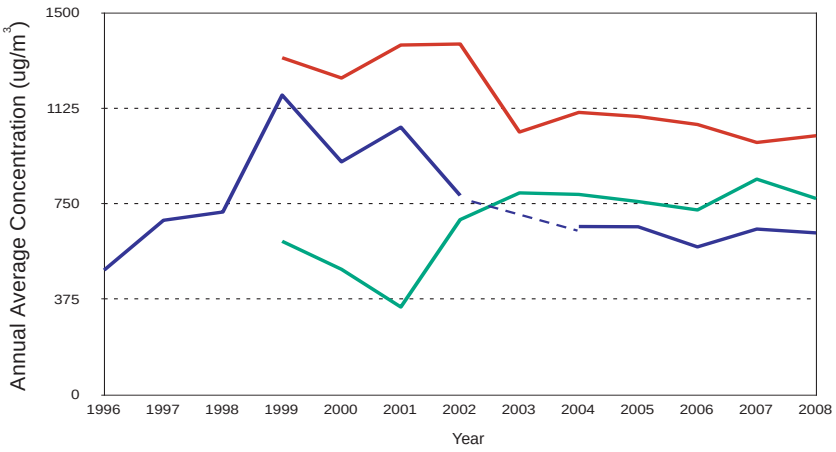


Figure 2.2 : Air Quality Trends of Hong Kong *(Continue)*

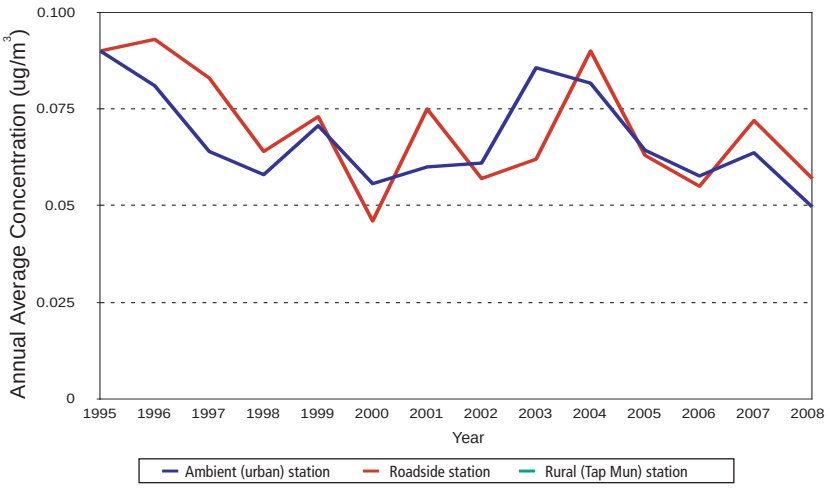
(d) O_3



(e) CO



(f) Pb



Note:

1 *Continuous measurement of CO at general and roadside air monitoring stations started from 1996 and 1999 respectively.*

2 *Measurement of Pb at general and roadside air monitoring stations started from 1995.*

2.5 In addition, as shown in Figure 2.3(a) and (b) below, our visibility has been deteriorating substantially despite the significant reduction in local emissions. **It underlines the impact of other pollution sources outside Hong Kong which play an important role in affecting both the local and regional air quality**. Indeed, smog has now become a common phenomenon for the entire Pearl River Delta (PRD) area.

Figure 2.3 : Emission and Reduced Visibility Trends in Hong Kong

(a) Air Pollutants Emission Trend in Hong Kong

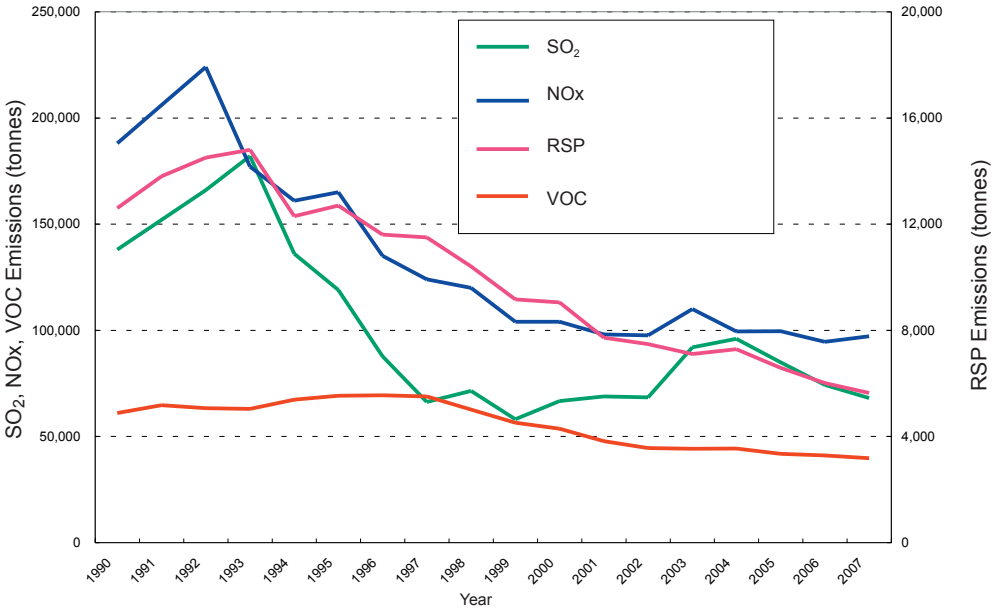
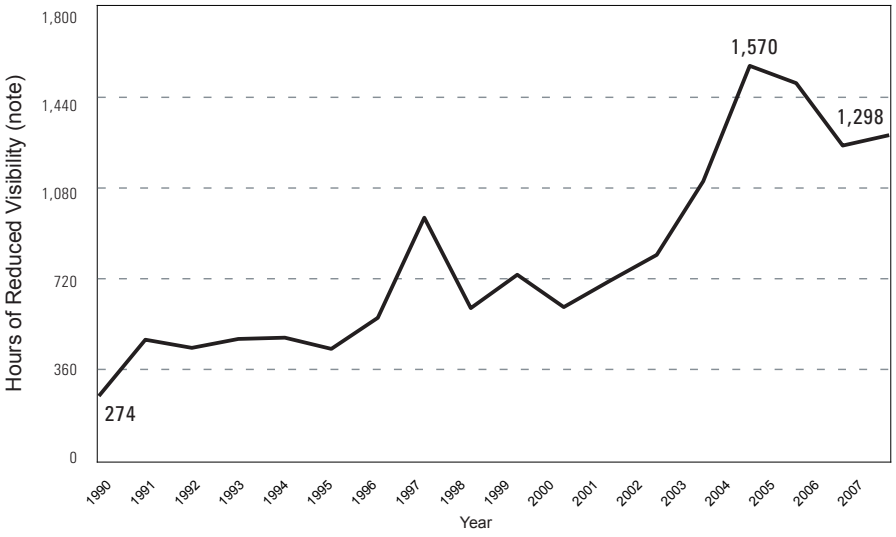


Figure 2.3

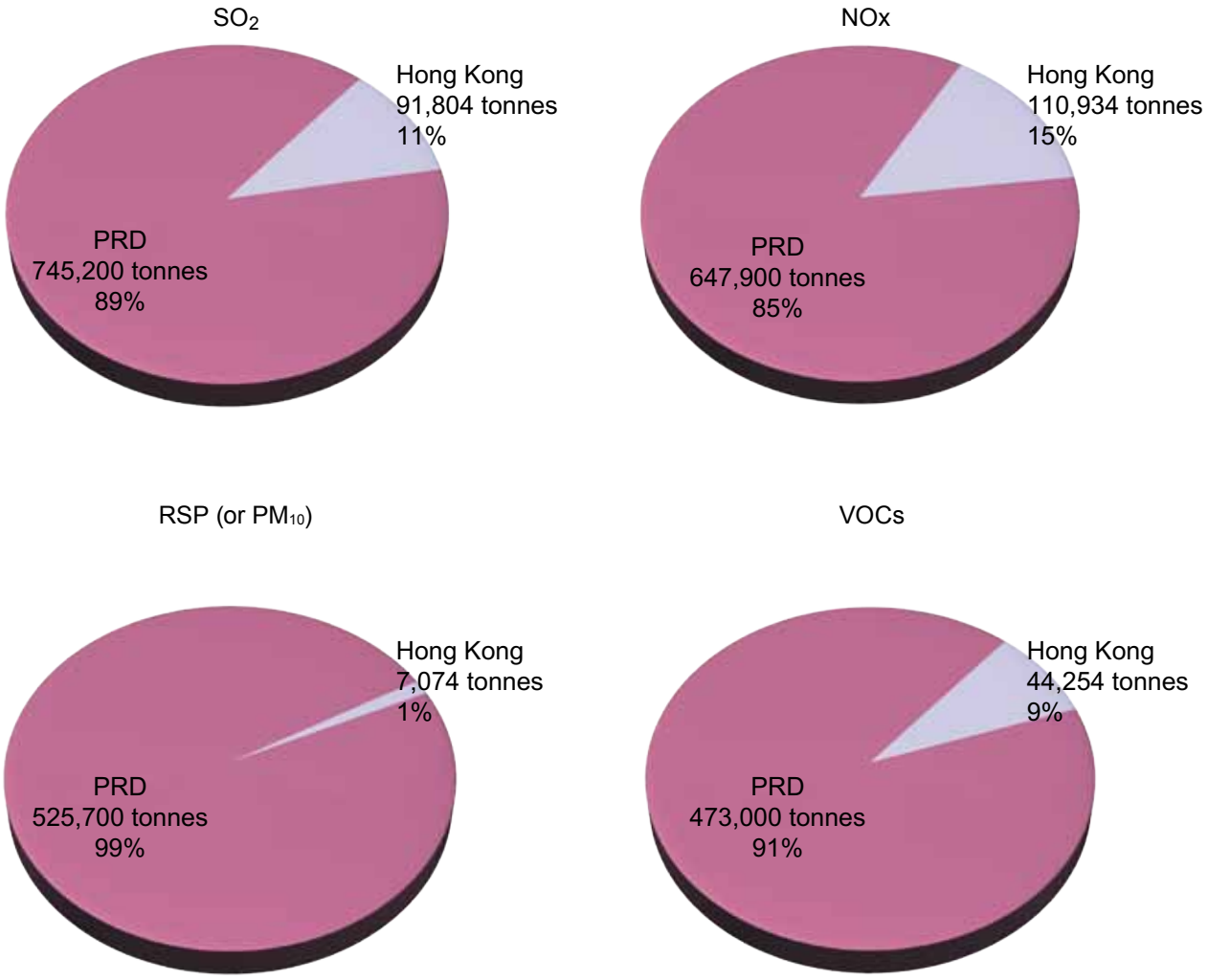
(b) Trend of Reduced Visibility in Hong Kong



Note: *Hours of reduced visibility observed at the Hong Kong Observatory. Visibility below 8 kilometres when there is no fog, mist or precipitation.*

2.6 Figure 2.4 below shows that emissions from Hong Kong account for about 1% to 15% of the total emissions in the PRD region. To improve our air quality, we need to tackle the problem in a regional context and work closely with the neighbouring Guangdong authorities. **In April 2002, we reached a consensus with the Guangdong Provincial Government to reduce, on a best endeavour basis, the emission of SO_2, NOx, RSP (or PM_{10}) and VOCs by 40%, 20%, 55% and 55% respectively in the region by 2010, using 1997 as the base year**. In December 2003, the two governments jointly drew up the PRD Regional Air Quality Management Plan (RAQMP) with a view to meeting the above emission reduction targets. Annex B provides a summary of the key emission control measures being pursued by both sides under the RAQMP. In addition, a PRD Regional Air Quality Monitoring Network has also been established to provide comprehensive and accurate air quality data of the region.

Figure 2.4 : Emissions of SO_2, NOx, RSP (or PM_{10}) and VOCs in PRD (2003)



3 AIR QUALITY OBJECTIVES

3.1 Hong Kong's AQOs are stipulated in a Technical Memorandum issued under the Air Pollution Control Ordinance (APCO) (Chapter 311) to promote the conservation and best use of air in the public interest. Under the law, the Authority (i.e. the Director of Environmental Protection) shall aim to achieve the relevant AQOs as soon as is reasonably practicable and thereafter to maintain the quality so achieved.

3.2 The existing AQOs were established in 1987, largely with reference to the health protection criteria established by the United States (US) Environmental Protection Agency at the time. Details of these AQOs are presented in Table 3.1 below.

Table 3.1 : The Existing AQOs

Pollutant	Averaging Time	Existing Hong Kong AQOs	No. of Exceedences Allowed
SO_2	1-hour	800	3
	24-hour	350	1
	Annual	80	N/A
TSP	24-hour	260	1
	Annual	80	N/A
RSP (or PM_{10})	24-hour	180	1
	Annual	55	N/A
NO_2	1-hour	300	3
	24-hour	150	1
	Annual	80	N/A
O_3	1-hour	240	3
CO	1-hour	30,000	3
	8-hour	10,000	1
Pb	3-month	1.5	N/A

3.3 The AQOs are applicable to non-occupational, outdoor locations where a person might reasonably be expected to be exposed over the relevant averaging period, including peak roadside sites. Our air quality would be deemed to be in compliance with the AQOs

" My two granddaughters often come to Wan Chai to visit me. Cleaner air will certainly make them healthier. "

— Mak Tuen Yeung
Wan Chai resident

if the sum of the number of non-overlapping exceedences observed at our air quality monitoring stations does not exceed the allowed number of exceedences. The same approach has been adopted in the United Kingdom (UK). In countries such as the US and Australia, their AQOs are only applicable to outdoor ambient air quality, excluding measurements from roadsides.

Statutory Roles of Air Quality Objectives

3.4 In line with the statutory requirements for the Authority to achieve the relevant AQOs as soon as is reasonably practicable, compliance with the statutory AQOs is a key consideration when the Authority decides on the licence applications of specified processes such as power plants under the APCO, and in assessing whether the air quality impacts of a designated project are acceptable for approval under the Environmental Impact Assessment Ordinance (Chapter 499). Any changes to the AQOs will therefore have major bearing on the operation of specified processes regulated under the APCO and major developments in Hong Kong.

Need for Review

3.5 In October 2006, the WHO released a new set of AQGs. A number of overseas countries / economies such as the US, the European Union (EU) and Australia have also updated their AQOs or air quality standards in the light of new scientific evidence and data on health effects of air pollution. Annex C gives a comparison between Hong Kong's existing AQOs, the air quality standards being adopted by other countries / economies and the latest AQGs issued by the WHO. The current AQOs are lagging behind those being pursued by other developed countries / economies in at least two aspects –

(a) they allow for much higher concentration levels of key pollutants; and

(b) they do not provide for the assessment of fine suspended particulates (FSP or $PM_{2.5}$), which has been scientifically proven to have greater adverse impact on human health than PM_{10}.[3]

[3] *PM_{10} and $PM_{2.5}$ refer to particulate matters (PM) with particle sizes of less than 10 microns and 2.5 microns respectively. Recent health studies show that $PM_{2.5}$ has greater association with adverse health effects and would pose a greater health risk to the public.*

3.6 In mid-2007, the Government commissioned a study to review and update our AQOs. The Review makes extensive reference to various international and local studies on the health impact of air pollution, the WHO AQGs and other air quality standards being adopted by advanced countries / economies. An Advisory Panel has been set up to provide steer to the Review. It comprises members from the Advisory Council on the Environment, experts from the fields of community health and air science, representatives from the power sector, transport-related industries and relevant Government bureaux and departments.

Question (1): **Do you agree that the existing AQOs need updating?**

4. PRINCIPLES AND APPROACHES

4.1 Taking account of the objectives of the WHO AQGs and the practices of other advanced countries / economies in revising their air quality standards, we propose to apply the following guiding principles in setting the new AQOs.

Protection of Public Health

4.2 **The new AQOs should be set with a view to protecting public health**. This is essential to fulfill the requirement stipulated in the APCO that AQOs should be set to promote the conservation and best use of air in the public interest. To do otherwise will be against the public interest.

4.3 Other countries / economies also take the protection of public health as a key consideration in establishing their air quality standards. For example, the US and EU specify in their Acts or Directives the purpose of protecting public health, together with the other purposes including protection of welfare and environment. In the UK, its air quality strategy also provides that the primary objective is to ensure that all citizens should have access to outdoor air without significant risk to their health, where this is economically and technically feasible.

Benchmarking against World Health Organisation Guidelines

4.4 The WHO AQGs and the interim targets (ITs) have been drawn up based on a wealth of new studies on the health effects of air pollution and after extensive consultation with leading air scien-

“ Young people should be more concerned about air quality. Cleaner air makes us healthier. It also makes Hong Kong more prosperous. ”

— Cheris Ng Man Hei
Form 6 student

tists and health experts worldwide. The WHO AQGs and ITs are seen as the most authoritative set of guidelines that provides a good source of reference for all countries to build their air quality standards to minimize the risk of air pollution to public health. Many advanced countries / economies, particularly the EU, draw extensive reference to the WHO AQGs and ITs in setting their air quality standards. It is therefore proposed to update our AQOs by benchmarking against the target concentration values set out in the WHO AQGs and ITs.

A Staged Approach for Updating Air Quality Objectives

4.5 So far, there is no country in the world adopting the WHO AQGs in their entirety as legal standards. Among the developed countries / economies, the EU has one of the most stringent sets of air quality standards, which was updated in May 2008. As noted from Annex C, the standards adopted by the EU for SO_2, O_3, RSP (or PM_{10}) and FSP ($PM_{2.5}$) are still less stringent than those prescribed under the WHO AQGs.

4.6 The WHO AQGs are far tougher than the national standards being applied in many parts of the world. Achievement of the guidelines will be a challenge for many cities. The WHO accepts the need for governments to set national standards according to their own particular circumstances. The guidelines therefore also suggest ITs on SO_2, RSP (or PM_{10}), FSP (or $PM_{2.5}$) and O_3 to facilitate a progressive approach for achieving the ultimate AQGs and provide milestones in achieving better air quality. Specifically, the WHO AQGs provide that –

(a) "the standards set in each country will vary according to specific approaches to balancing risks to health, technological feasibility, economic considerations and other political and social factors"[4]. The WHO further recommends that "in formulating policy targets, governments should consider their own local circumstances carefully before using the guidelines directly as legal standards"[5]; and

(b) "given that air pollution levels in some countries often far exceed the recommended guideline levels, interim target levels are proposed, in excess of the guideline levels themselves, to promote steady progress towards meeting the WHO guidelines".[6]

4 *"WHO Air Quality Guidelines Global Update 2005" published in 2006, p.5.*
5 *"WHO Air Quality Guidelines Global Update 2005" published in 2006, p.6.*
6 *"WHO Air Quality Guidelines Global Update 2005" published in 2006, p.5.*

4.7 The current concentration levels of air pollutants in Hong Kong are much higher than the WHO AQGs, partly due to local emissions and partly due to regional air pollution. The regional impact on the air quality in Hong Kong could best be illustrated by Table 4.1 below showing the compliance status at Tap Mun air quality monitoring station, which is far away from local air pollution sources.

Table 4.1 : Compliance Status of Tap Mun Air Quality Monitoring Station with WHO AQGs from 2006 to 2008

Pollutant	Averaging Time	WHO AQGs ($\mu g/m^3$)	Highest Measured Concentration ($\mu g/m^3$)			No. of Exceedences of WHO AQGs		
			2006	2007	2008	2006	2007	2008
SO_2	10-minute	500	257	297	409	0	0	0
	24-hour	20	87	57	71	76	103	63
RSP (or PM_{10})	24-hour	50	138	159	147	151	158	167
	Annual	20	48	53	52	Not Met		
FSP (or $PM_{2.5}$)	24-hour	25	117	128	99	217	225	219
	Annual	10	34	38	35	Not Met		
NO_2	1-hour	200	123	107	119	0	0	0
	Annual	40	13	15	14	Met		
O_3	8-hour	100	337	248	320	169	163	184

4.8 The monitoring data show that even for such remote area as Tap Mun, which does not have any local emission sources, the WHO AQGs were breached to various extents for up to half of the time in a year. It underscores the transboundary nature of the air pollution problem facing Hong Kong. It is therefore proposed to adopt a staged approach in updating the AQOs to take account of the local situations and prevailing international practices. **The WHO AQGs will be taken as a long-term goal, the pursuit of which will be considered with reference to international practices, the latest technological developments and local circumstances.**

Question (2): **Do you agree that protection of public health should be the key consideration in updating the AQOs?**

Question (3): **Do you agree that the AQOs should be set with reference to the guidelines and ITs published by the WHO and that a staged approach be adopted to update the AQOs with a view to achieving the WHO AQGs as a long-term goal?**

5 PROPOSED NEW AIR QUALITY OBJECTIVES

5.1 Taking account of the guiding principles proposed in Chapter 4, the air quality standards being pursued in other countries / economies and the local situations, the Review proposes to update the existing AQOs by a combination of the WHO AQGs and ITs. The proposed new AQOs are highlighted in the yellow boxes of Table 5.1 below for easy comparison with the existing AQOs and the WHO AQGs or ITs.

Table 5.1 : Proposed New AQOs

Pollutant	Averaging Time	Existing AQOs ($\mu g/m^3$)	Proposed New AQOs vis-à-vis WHO AQGs / ITs ($\mu g/m^3$)			
			IT-1	IT-2	IT-3	AQGs
SO_2	10-minute	–	–			500
	24-hour	350	125	50		20
RSP (or PM_{10})	24-hour	180	150	100	75	50
	Annual	55	70	50	30	20
FSP (or $PM_{2.5}$)	24-hour	–	75	50	37.5	25
	Annual	–	35	25	15	10
NO_2	1-hour	300	–			200
	Annual	80	–			40
O_3	8-hour	240 (1-hour)	160			100
CO	15-minute	–	–			100,000
	30-minute	–	–			60,000
	1-hour	30,000	–			30,000
	8-hour	10,000	–			10,000
Pb	Annual	1.5 (3-month)	–			0.5

Proposed new AQOs

"I want to breathe in the street as easily as I can in Tokyo or New York. I want to see the mountains across the harbour more clearly, more often."

— Mark Clifford
Executive Director, Asia Business Council

5.2 In deliberating the proposed new AQOs, the Review makes reference to the WHO AQGs and ITs on the major air pollutants, the local pollution concentration levels as well as the feasibility of achieving the respective WHO AQGs or ITs in the foreseeable future having regard to technological developments and local circumstances. **The Review shows that it is practicable to benchmark the proposed new AQOs of three out of the seven major air pollutants, viz. NO_2, CO and Pb, to the ultimate WHO AQGs**. For CO and Pb, the emissions and concentration levels of these two pollutants in Hong Kong have been maintained at very low levels. We are already in compliance with the concentration values prescribed under the WHO AQGs. As regards NO_2, its concentration in urban area is largely contributed by local sources. While delivering the WHO AQGs for NO_2 would present a major challenge to Hong Kong, modelling results show that this is achievable subject to implementation of stringent emission control measures, particularly those targeting at vehicular emissions (please refer to Chapter 6 for details).

5.3 As regards the other three air pollutants, i.e. SO_2, PM and O_3, it is proposed to set the proposed new AQOs against the most stringent and yet achievable WHO ITs.

5.4 For SO_2, among advanced countries / economies, the EU has adopted the most stringent standard which is equal to the WHO IT-1 of 125 $\mu g/m^3$. In Hong Kong, we have already taken very strong actions to cut SO_2 emissions, including the use of virtually sulphur free Euro V diesel as vehicular fuel, the use of ULSD across all industrial and commercial processes and retrofitting power plants with flue gas de-sulphurisation devices. The scope for further reducing drastically the emissions and concentration of SO_2 over the short to medium term is rather limited. It is therefore proposed that the 24-hour objective for SO_2 be tightened from the current 350 $\mu g/m^3$ to the WHO IT-1 of 125 $\mu g/m^3$. It would be feasible to have a new 10-minute SO_2 objective benchmarked against the WHO AQG of 500 $\mu g/m^3$.

5.5 For PM, there are currently only concentration targets for PM_{10} but not $PM_{2.5}$ under the existing AQOs. Evidence has accumulated in recent years to show that health risk attributable to exposure to PM is better represented by $PM_{2.5}$. It is proposed to introduce also a set of new AQOs for this air pollutant. **Based on the air quality monitoring data and the fact that Hong**

Kong's PM emissions account for only about 1% to 2% of the entire emissions in the PRD region, it is apparent that the PM concentration in Hong Kong is subject to very strong regional influence. **Widespread exceedences of the WHO AQGs for PM have been recorded even at Tap Mun where it is free of any local emission sources**. It would be difficult to significantly bring down PM concentration levels in Hong Kong without an overall reduction of the concentration levels in the region as a whole. Taking this into account, it is proposed that, as a start, the respective WHO IT-1 of 35 $\mu g/m^3$ and 75 $\mu g/m^3$ for annual and 24-hour $PM_{2.5}$ be adopted. With $PM_{2.5}$ accounts for about 70% of PM_{10} found in Hong Kong, it is proposed to tighten the annual and 24-hour PM_{10} objectives from 55 $\mu g/m^3$ and 180 $\mu g/m^3$ to the WHO IT-2 of 50 $\mu g/m^3$ and 100 $\mu g/m^3$ respectively.

5.6 Same as PM, O_3 in Hong Kong is also strongly affected by regional air pollution. O_3 is not a pollutant directly emitted from man-made sources but formed by photochemical reactions of other primary pollutants such as NOx and VOCs under sunlight. As it takes several hours for these photochemical reactions to take place, O_3 recorded locally could be attributed to VOC and NOx emissions from places afar. It is, therefore, proposed to adopt the WHO IT-1 of 160 $\mu g/m^3$ as the new AQO for O_3 to replace the existing 1-hour objective of 240 $\mu g/m^3$.

5.7 The WHO guidelines provide that "when the standards are set to be legally binding, criteria must be identified to determine compliance. This is quantified through the number of acceptable exceedences over a certain period of time….. Compliance criteria are defined in each country in order to compare the most representative data with the standards, and to minimize the designation of non-compliance owing to uncontrollable circumstances such as extreme weather. Such compliance criteria can be determined by evaluating historical data in the region as well as variability in weather and pollution patterns."[7] It is proposed that suitable number of exceedences be allowed for assessing the compliance status, which is in line with the WHO guidelines and international practices. Further details of the rationale behind the setting of the proposed new AQOs and number of exceedences are presented at Annex D. A comparison

[7] *"WHO Air Quality Guidelines Global Update 2005" published in 2006, p.183.*

between the proposed new AQOs and the air quality standards of the US and EU is set out in Table 5.2 below. Overall, the proposed new AQOs are comparable to those of the EU, which are one of the most stringent, and US, except for PM_{10} and $PM_{2.5}$ as explained in paragraph 5.5 above.

Table 5.2 : Comparison of Proposed New AQOs with those of US and EU

Pollutant	Averaging Time	Proposed New AQOs [1]		US[1]		EU[2]	
		µg/m³	No of Exceedences Allowed	µg/m³	No of Exceedences Allowed	µg/m³	No of Exceedences Allowed
SO_2	10-minute	500	3	-	-	-	-
	1-hour	-	-	-	-	350	24
	24-hour	125	3	365	1	125	3
	Annual	-	-	80	N/A	-	-
RSP (or PM_{10})	24-hour	100	9	150	[3]	50	35
	Annual	50	N/A	-	-	40	N/A
FSP (or $PM_{2.5}$)	24-hour	75	9	35	[4]	-	-
	Annual	35	N/A	15 [5]	N/A	25	N/A
NO_2	1-hour	200	18	-	-	200	18
	24-hour	-	-	-	-	-	-
	Annual	40	N/A	100	N/A	40	N/A
O_3	1-hour	-	-	-	-	-	-
	8-hour	160	9	147	[6]	120	25
CO	1-hour	30,000	0	40,000	1	-	-
	8-hour	10,000	0	10,000	1	10,000	0
Pb	3-month	-	-	1.5	N/A	-	-
	Annual	0.5	N/A	0.15	N/A	0.5	N/A

Note:
[1] *Reference condition: 25°C and 101.325 kPa.*
[2] *Reference condition: 20°C and 101.325 kPa.*
[3] *Three times in three years.*
[4] *3-year average of 98th percentile.*
[5] *3-year average of the weighted annual mean.*
[6] *3-year of fourth highest values.*

Regular Review Mechanism

5.8 **To deliver progressively the long-term target of achieving the ultimate WHO AQGs**, there should be a review mechanism to regularly ascertain the extent to which the new AQOs have been achieved, the progress of the air management strategy, as well as the need and practicality of further tightening the AQOs. The frequency of the review should be no less than every five years so as to strike a reasonable balance of maintaining momentum of updating the AQOs and allowing reasonable time to assess the impacts of the earlier emission control measures on air quality. A similar review frequency has been adopted in the US.

Question (4): **Do you agree to the proposed new AQOs which have been set with reference to a combination of the WHO AQGs and ITs?**

Question (5): **Do you agree that a mechanism should be put in place to regularly review the AQOs no less than every five years?**

6 PROPOSED EMISSION CONTROL MEASURES

6.1 To achieve the proposed new AQOs, the Review has identified a host of emission control measures targeting all major emission sources. Broadly speaking, the proposed measures can be grouped under the following main categories –

(a) emission capping and control;

(b) transport management;

(c) infrastructure development and planning; and

(d) energy efficiency measures.

6.2 The proposed emission control measures are further packed into three Phases according to their effectiveness in reducing emissions, practicability, maturity of the technologies and readiness of the affected sectors in accepting the proposed measures. The proposed Phase I measures are more ready for implementation over the short to medium term. For those proposed measures under Phases II and III, they could likely be implemented in a more distant future. It should be stressed that the proposed measures identified by the Review are by no means exhaustive. As new technologies continue to develop and mature, more practicable measures could be pursued in future to further improve air quality.

Cost-Benefit Analysis

6.3 Apart from assessing the emission reduction potential, the consultant has also conducted a cost-benefit analysis to provide an indication of the cost-effectiveness of the proposed emission control measures. In the analysis, the estimated principal costs include the administrative costs of the Government in pursuing the required policies and any other incidental capital and operational costs on the entire communi-

“ The sky I like is blue! ”

— Au Yat Tung
K3 Student

ty as a consequence of implementation. It should be stressed that **the analysis focuses mainly on the "social costs" to be borne by the entire community**. It makes no distinction as to whether the costs would at the end of the day be borne by the Government, power companies, transport operators or consumers. The benefits could be sub-divided into those of a direct nature (principally short and long-term health related cost savings, including the reduced costs of illness and reduced premature mortality, and savings in electricity costs) and indirect nature (principally impacts on the workforce and costs of maintenance and repair to buildings and structures and some lesser items). As the proposed measures are still at a conceptual stage, the estimates on costs and benefits are subject to a great deal of uncertainties and variations depending on the timing and details of implementation, market situations and community's responses, etc. Nonetheless, the cost-benefit analysis does provide a systematic framework for comparing the relative cost-effectiveness of different proposed measures. Details of the methodology and assumptions used for conducting the cost-benefit analysis can be found in the Final Report of the Review.

6.4 It should also be stressed that the findings of the cost-benefit analysis should not be considered as the only criterion for considering whether any of the proposed emission control measures should be implemented. Any decision on implementation of the proposed measures should be taken and balanced against different considerations, including emission reduction potential, costs and benefits, acceptance by the stakeholders, etc.

Proposed Phase I Emission Control Measures

6.5 The proposed Phase I emission control measures comprise a total of 19 initiatives. Assuming that the Guangdong side would continue to align itself with the best practices to curb emissions in tandem with its economic growth, the consultant's air quality modelling findings show that implementation of these proposed measures could help deliver the proposed new AQOs. Details of their emission reduction potential and cost-benefit estimates are presented at Annex E. They have been worked out by the consultant based on the best information available. As many of the proposed measures are still at the conceptual stage and the implementation details have yet to be mapped out, the findings of the emission reduction potential and cost-benefit analysis are subject to considerable uncertainties of the assumptions.

Emission Control Measures

(1) Increasing the Ratio of Natural Gas in Local Electricity Generation to 50% Together with Additional Emission Abatement Measures

6.6 The power sector is the largest source of emissions in Hong Kong. Compared with coal, natural gas is a much cleaner form of fuel for electricity generation. It virtually emits no SO_2 and RSP (or PM_{10}) and can reduce NOx by 85% or more. Raising the share of natural gas in the overall fuel mix for electricity generation is technically feasible, provided that a sufficient supply of natural gas is available and new gas-fired generation units are installed. In this connection, the Government has since 1997 banned the construction of new coal-fired electricity generating units. The signing of the Memorandum of Understanding on energy cooperation with the National Energy Administration and construction of the Second West-East Natural Gas Pipeline will facilitate further using more natural gas for power generation. In his 2008/09 Policy Address, the Chief Executive already indicated that the Government would study the feasibility of raising the share of natural gas from about 28% at present to 50% of the fuel mix for local electricity generation. **Together with other emission abatement measures[8], it is estimated that increasing the use of natural gas for electricity generation to 50% of the fuel mix would bring about huge reduction of 13,402, 25,225 and 523 tonnes of SO_2, NOx and RSP (or PM_{10}) emissions respectively**. Although local power plants are located away from population centres in Hong Kong and have tall stacks, which facilitate the dispersion of pollutants to farther areas, this proposed measure would have huge emission reduction potential and bring about positive impact on regional air quality[9].

6.7 Raising the share of natural gas from currently about 28% of our domestic electricity generation to 50% or even higher would have significant tariff implications due to the higher cost of natural gas and the need for additional gas-fired generators. **Our very preliminary assessment shows that the increase in electricity tariff by phases would be at least**

[8] *Possible additional emission abatement measures include enhancing the selective catalytic reduction (SCR) systems of the existing coal-fired units. However, the technical feasibility and financial viability of retrofitting the existing coal-fired units with enhanced SCR systems are not yet established and subject to more detailed examination with the concerned power company.*

[9] *Due to meteorological factors and the tall stacks of power plants, the potential improvement to air quality or health benefits brought about by burning more gas for power generation in Hong Kong would not be entirely reaped by Hong Kong residents. It is probable that the proposed measure could also produce considerable benefits to other cities in PRD. These "external" benefits are not captured in the current cost-benefit analysis which focuses entirely on the benefits of the individual measures on Hong Kong. Likewise, similar measures to curb emission from power plants in other PRD cities would benefit Hong Kong. This complexity in assessing the potential improvement to air quality and health benefits brought about by individual emission abatement measures to specific locality underlines the importance of taking a wider regional perspective in tackling the air pollution problem facing the PRD region.*

20% from the current level. The actual level of tariff increase would depend on a number of factors, such as the timing for the implementation of the proposal, the then prevailing fuel prices and the actual capital investments required by the power companies. Adopting energy efficiency measures such as mandating the implementation of the Building Energy Codes (BECs) and using more energy efficient electrical appliances (Measures 15 and 16 set out below) may help mitigate the impact on electricity tariff. How soon the share of natural gas for electricity generation could be substantially increased would hinge on the availability of gas supply and additional gas-fired power generation units. The power companies have advised that a lead time of at least four to five years would be required to secure the necessary gas supply and install the gas-fired generators.

(2) Early Retirement of Aged / Heavy Polluting Vehicles (Pre-Euro, Euro I and Euro II Commercial Diesel Vehicles and Franchised Buses)

6.8 Euro V vehicles emit only about 30% of NOx comparing to Euro II models. Early retirement of aged vehicles (including pre-Euro, Euro I and Euro II commercial diesel vehicles and franchised buses) and replace them with models meeting the latest Euro standards (i.e. Euro V standards which will be in force in the EU by phases starting this year) will help reduce significantly vehicular emissions. It is estimated that about 3,102, 300 and 184 tonnes of NOx, RSP (or PM_{10}) and VOC emissions could be reduced respectively following implementation of this initiative. **Due to the close proximity of vehicular emissions to receptors, the consultant's assessment shows that this initiative would generate significant health benefits**.

6.9 The Government has already put in place a one-off grant scheme to assist owners of pre-Euro and Euro I commercial diesel vehicles to replace their old vehicles with new ones meeting the latest emission standards. However, owing to the uncertain business outlook, many of the vehicle owners remain reluctant to replace their old vehicles with new ones despite the availability of Government subsidies. In addition, large scale replacement of franchised buses and other commercial vehicles cannot take place overnight because of the production capacity constraint of the vehicle manufacturers. For franchised buses, it is estimated

that replacing all Euro I and II franchised buses by, say, end 2014 could drive **the fare increase pressure to about 15% in a single year**, which would be on top of the fare increase due to factors such as higher operating cost. Commuters' willingness to accept the potential implications for bus fares and other transportation costs is crucial to taking forward this proposed measure.

(3) Earlier Replacement of Euro III Commercial Diesel Vehicles with Models Meeting Latest Euro Standards

6.10 Compared to Euro III models, Euro V vehicles emit only about 36% (for light duty diesel vehicles) to 40% (for heavy duty diesel vehicles) of NOx. Assuming that 50% of the Euro III commercial diesel vehicles are replaced with new models meeting Euro V standards, it would cut the emissions of NOx, RSP (or PM_{10}) and VOCs by about 743, 75 and 24 tonnes respectively. This proposed measure would generate major health benefits due to the close proximity of vehicular emissions to receptors. However, **the Euro III vehicles currently in use are relatively new (eight years old at most).** Depending on the types of vehicle, **their vehicle owners are likely to be more reluctant to replace them early with new ones**.

(4) Wider Use of Hybrid / Electric Vehicles or Other Environment-Friendly Vehicles with Similar Performance

6.11 Hybrid / electric vehicles produce about 80% less of both RSP and NOx emissions. It is expected that about 15, 216, 7 and 173 tonnes of SO_2, NOx, RSP (or PM_{10}) and VOC emissions respectively would be reduced if 20% of private cars and 10% of buses are replaced with hybrid / electric alternatives. While considerable health benefits could be generated by a wider use of hybrid / electric vehicles at the present stage, **the costs of hybrid / electric vehicles are much higher than conventional vehicles**. To promote their wider use, the Government has introduced first registration tax concession to hybrid / electric vehicles. At present, hybrid / electric vehicles are predominantly private cars. Some hybrid / electric buses and heavy duty vehicles are in operation in some countries but the numbers are small. Their ability to overcome the demanding local driving environment – hilly terrains and hot and humid summers – needs to be further ascertained.

(5) Ultra Low Sulphur Diesel for Local Vessels

6.12 Local vessels are currently fuelled by industrial diesel of not more than 0.5% sulphur content. Switching the fuel to ultra low sulphur diesel (ULSD) for local vessels with sulphur content of not more than 0.005% will reduce the SO_2 emission by 99%. About 675 and 18 tonnes of SO_2 and RSP (or PM_{10}) would be respectively reduced. While ULSD is slightly more costly, the consultant's assessment shows that the proposed measure is quite cost-effective in bringing about major health benefits. As a start, **we are now working together with the ferry operators to conduct a trial scheme to ascertain the technical feasibility of domestic ferries using ULSD**.

(6) Selective Catalytic Reduction for Local Vessels

6.13 Selective catalytic reduction (SCR) for local vessels has been used in some countries (e.g. the US) to cut NOx emission from vessels. Applying this technology to local vessels could result in a reduction of about 304 tonnes of NOx emissions. This proposed measure is expected to generate some health benefits. **The relatively high cost of retrofitting SCR devices and lack of adequate space of some of the existing vessels to accommodate the SCR devices are some of the constraints that need to be addressed in pursuing this proposed measure.**

(7) Electrification of Aviation Ground Support Equipment

6.14 Ground support equipment (GSE) in airport includes heavy diesel-fuelled compression ignition equipment to service and support aircraft operations. Overseas experience shows that GSE emissions would amount to about 10% to 15% of total airport NOx emissions. Experience of US airports, e.g. the Los Angeles International Airport, shows that it would be practicable to reduce emissions through electrification of GSE. Reduction of about 85, 759, 21 and 67 tonnes of SO_2, NOx, RSP (or PM_{10}) and VOCs respectively is expected upon implementation of this proposed measure. Owing to the location of the airport, which is far away from population centres, and **relatively high cost of electric GSE**, the consultant estimates that this proposed measure could generate relatively modest health benefits.

(8) Emission Control for Off-Road Vehicles / Equipment

6.15 Off-road vehicles / equipment are being widely used in construction sites, ports and airport. Use of ULSD and emission control devices, such as exhaust gas recirculation, emulsified technology and diesel particulate filter would help reduce emissions from off-road vehicles / equipment. It is estimated that the emission of some 4, 950, 239 and 326 tonnes of SO_2, NOx, RSP (or PM_{10}) and VOCs respectively would be avoided. The consultant's assessment shows that this proposed measure could **bring about considerable health benefits at relatively low cost to the society**.

(9) Strengthening Volatile Organic Compounds Control

6.16 Through chemical reaction of sunlight, VOCs are one of the key categories of air pollutant which play an important role in the formation of photochemical smog in Hong Kong and the PRD region. In 2007, we introduced legislative control over the contents of VOCs in a number of products such as hair spray, printing inks and architectural paints. Extending the control of VOCs to non-architectural paints, solvents, sealants and adhesives could lead to a further reduction of about 700 tonnes of VOC emissions. The proposed measure should be quite cost-effective in generating health benefits to the society. As a matter of fact, the Government has already initiated the necessary legislative amendments to extend the control of VOCs to vehicle refinishing paints, vessel paints, pleasure craft paints, adhesives and sealants. Subject to approval of the Legislative Council, the proposed control would take effect starting from 2010.

Transport Management

(10) Low Emission Zones

6.17 This proposed measure seeks to ban commercial vehicles of Euro III or below standards from entering busy areas such as Central, Mong Kok and Causeway Bay. It could help reduce the exposure of air pollutants at street levels within the low emission zones (LEZs), although net emission reduction in the whole territory is not expected as traffic might be diverted to other areas. The assessment conducted by the consultant shows that LEZs could bring about considerable health benefits to the population within the zones. The cost-effectiveness of the scheme would be highly dependent upon how the proposed LEZs are to be designed and implemented, and **whether the affected vehicle own-**

ers would agree to upgrade or replace their vehicles to meet the emission standards required for entering the LEZs, including those who operate businesses or live within the zones. The potential diversion of the more polluting vehicles to other areas will need to be considered carefully in designing LEZs.

(11) Car-Free Zones / Pedestrianisation Scheme

6.18 This proposed measure aims to extend the current time restrictions of pedestrianised streets in busy areas, such as Central, Mong Kok and Causeway Bay, to cover the whole day. The segregation of traffic from nearby residents and **passers-by could help further reduce their exposure to roadside air pollution**. A whole-day ban might not be welcomed by the businesses, particularly shop operators, inside the zones because of the inconvenience in refilling their stocks of merchandise. Similar to LEZs, net emission reduction in the whole territory is not expected. However, this proposed measure could generate considerable health benefits to local residents and commuters at relatively low costs.

(12) Bus Route Rationalization

6.19 Rationalization of bus routes has been an ongoing process. Between 1999 and 2007, some 5,700 bus trips per day and 4,800 bus stoppings per peak hour at busy corridors were reduced. Compared with the peak in 2002 when the franchised bus fleet reached 6,378 buses, the number of franchised buses in service was reduced by 489 to 5,889 in 2007. It is estimated that reducing bus trips by about 10%, which would mainly come from non-peak services where excess capacity in the system exists, could help further cut the roadside emissions of about 4, 156, 7 and 9 tonnes of SO_2, NOx, RSP (or PM_{10}) and VOCs respectively. **Considerable health benefits could be generated from this proposed measure, which would also help cut the operational costs of the franchised bus companies**. However, reducing the frequency or coverage of bus services will cause inconvenience to commuters. Support from the community and District Councils is essential for this proposed measure.

Infrastructure Development and Planning

(13) Expand Rail Network

6.20 Railway-based transportation generates substantially less air pollution than vehicles, even after taking into account emissions from power plants which produce the necessary electricity to power the trains. Following development of the committed rail projects including the Express Rail Line, the Sha Tin to Central Link (the Tai Wai to Hung Hom section), the West Island Line, the South Island Line (East), the Kowloon Southern Link and the Kwun Tong Line Extension, it is estimated that the transport sector's emissions of SO_2, NOx, RSP (or PM_{10}) and VOCs could be reduced by about 17, 501, 46 and 207 tonnes respectively, bringing about considerable health benefits to the community. Whilst the costs for developing the rail network are principally incurred and justified on transport grounds, the health benefits so generated would lend additional support to the case for expanding the rail network.

(14) Cycling Network Connecting to Major Public Transport Hubs

6.21 This proposed measure is intended for new development areas. Cycling does not produce emissions. Apart from serving recreational purpose, a well-planned cycling track connecting to public traffic hubs could help replace short vehicle trips, though the estimated emission reduction potential would be nominal, amounting to about 0.1, 2.3, 0.1 and 0.1 tonnes of SO_2, NOx, RSP (or PM_{10}) and VOCs respectively.

Energy Efficiency Measures

(15) Mandatory Implementation of Building Energy Codes

6.22 Buildings take up approximately 90% of the electricity consumed in Hong Kong. Promoting energy efficiency in buildings is therefore an area where significant energy savings and hence reduction in emissions from the power sector could be achieved. Making compliance with the Building Energy Codes (BECs)[10] compulsory would go a long way in enhancing the energy performance of our buildings and driving down electricity consumption. It is estimated that the emissions of SO_2, NOx, RSP (or PM_{10}) and VOCs so reduced would be in the order of about 151, 256, 8 and

[10] *The Electrical and Mechanical Services Department has issued four sets of BECs setting out the minimum design requirements on energy efficiency of four key types of building installation, including lighting, air conditioning, electrical installation, lift and escalator. It has also developed a set of performance-based BECs to address energy efficiency requirements of buildings in a systematic and holistic way.*

3 tonnes respectively. Given the **relatively low cost** of implementation, pursuing this proposed measure could generate substantial benefits to the society in terms of **major savings in electricity costs**.

(16) Energy Efficiency Standards for Domestic Electrical Appliances

6.23 To facilitate the public in choosing energy efficient appliances and raise public awareness on energy saving, the Government has introduced a mandatory Energy Efficiency Labelling Scheme covering room air conditioners, refrigerating appliances and compact fluorescent lamps. All prescribed products are required to be supplied with energy labels to help consumers choose energy efficient products and in turn reduce electricity consumption and emissions from the power sector. Actions are also in hand to extend the scheme to cover other types of electrical appliances. It is estimated that this proposed measure, which is already underway, would cut electricity consumption by 150 GWh per year, resulting in a reduction of about 84, 142, 4 and 1 tonnes of SO_2, NOx, RSP (or PM_{10}) and VOCs emissions respectively. **This proposed measure could bring about huge savings in electricity costs alongside health benefits**.

(17) Light-emitting Diode or Equivalent Alternatives for Traffic Signal / Street Lighting

6.24 Light-emitting diode (LED) is **more energy efficient and has longer service life than traditional light sources. It is, however, relatively more expensive**. Subject to further evaluation of the technical feasibility and acceptance by the public, using LED for traffic signal / street lighting could help reduce electricity consumption and avoid the emissions of about 3, 5 and 0.1 tonnes of SO_2, NOx and RSP (or PM_{10}) respectively from power plants.

(18) Tree Planting / Rooftop Greening

6.25 While tree planting / rooftop greening would not lead to any significant emission reduction, **it helps reduce urban heat island effect** which would accelerate the chemical reactions for air pollutant formation and re-circulation.

(19) District Water Cooling System for Kai Tak Development

6.26 Compared to individual cooling tower, district cooling system is more energy efficient. The Government has already put in place a plan to develop a district cooling system at the Kai Tak Development. The estimated emission reduction potential is in the region of 6, 16, 0.5 and 0.2 tonnes of SO_2, NOx, RSP (or PM_{10}) and VOCs respectively. **Reducing energy consumption for air cooling could bring down electricity costs**.

Health Benefits

6.27 **Implementation of the proposed Phase I emission control measures would bring about an anticipated benefits of about $1,228 million per year mainly due to improvement of public health and savings in energy costs, which are significantly higher than the estimated annualized cost of about $596 million to be incurred by the society. The consultant also estimates that some 4,200 hospital admissions would be avoided. The average life expectancy of the population would be increased by about one month or around 7,400 life years saved per year**.

Proposed Phases II and III Emission Control Measures

6.28 It is possible to further improve our air quality by embracing other more drastic measures that are less ready for implementation or involve the adoption of technologies which are still not yet fully developed. These possible Phases II and III emission control measures include, for instances, raising further the share of natural gas to 75% or even 100% of the overall fuel mix for electricity generation, increasing the import of nuclear energy, use of hydrogen fuel cell vehicles (a technology which has yet to be commercially available), electronic road pricing, further tightening emission control on local and ocean-going vessels, etc. Further details of the emission reduction potential and the cost and benefit estimates of these proposed measures are presented at Annex F.

Pace of Implementation and Price to be Paid

6.29 There is a community consensus that strong actions should be taken to improve air quality. **The sooner the emission control measures identified in the Review are implemented, the earlier we would be moving closer to the proposed new AQOs and deliver cleaner air**.

6.30 Whilst the proposed Phase I emission control measures are in general technically feasible, the pace for taking forward these measures and hence achieving the proposed new AQOs would be dependent upon the complexity of the individual measures and readiness of the stakeholders to accept the consequential impacts, including those on electricity tariff, transport fares and operational costs of the transport trades. As noted in the analysis in this Chapter, the nature and degree of complexity of individual proposed measures vary. Some of the proposed measures require huge capital investment and long planning lead time (such as increasing the share of natural gas for electricity generation). Some merely call for raising public awareness and behavioural changes (such as car-free zones, bus route rationalization and making smarter choices in using more energy efficient appliances). Some of the proposed measures envisage a new approach to infrastructure development (such as district cooling system) whereas others may require new legislations (such as mandatory implementation of BECs). Some of the measures identified by the consultant are already being pursued by the Government, but many of them are still on the drawing board. Obviously there will be debate over the pace for implementing the proposed emission control measures, and this is an important area on which the views of the community are being sought through this consultation.

6.31 The Review clearly shows that large reductions in air pollution are achievable through strong emission control measures. While every measure identified in the Review would be important in bringing us closer towards achieving the proposed new AQOs and improving our air quality, none would be easy. Nor would it be free. Implementation of these proposed measures would entail not only changes in lifestyle or the way businesses is conducted, but also potential increases in expenses for individuals or businesses in terms of electricity tariff, transportation costs, etc. The willingness of the society and the relevant stakeholders to contribute to improving air quality and bear the costs is critical to the decision on whether and, if so, the pace at which the proposed emission control measures are to be taken forward.

Question (6): **To what extent do you agree that the proposed emission control measures set out in this Chapter should be implemented for achieving the new AQOs and improving local air quality in general? What other measures do you think the Government should consider?**

Question (7): **How soon do you think these proposed emission control measures should be implemented?**

Question (8): **Are you willing to bear the costs arising from the implementation of the proposed emission control measures, such as higher electricity tariff and bus fares, as well as adjustments in your way of living?**

Question (9): **Do you have any other views on the Review?**

7 RESPOND TO THIS CONSULTATION

7.1 To help us to decide on how best the AQOs are to be updated and set an agenda for actions to improve our air quality, we would like to invite your views and comments on any part of this consultation paper. For ease of reference, a list of the key consultation points is set out at Annex G. Please send your comments to us before 30 November 2009 by mail, e-mail or facsimile to the following –

Address: Air Policy Group
Environmental Protection Department
33/F., Revenue Tower
5 Gloucester Road
Wan Chai, Hong Kong

E-mail: aqo_review@epd.gov.hk

Facsimile: 2838 2155

Website address: http://www.epd.gov.hk/epd/english/environmentinhk/air/air_quality_objectives/air_quality_objectives.html

7.2 When returning by mail, you can make use of the postage paid questionnaire at the centre pages of this consultation document. If you have any enquiries, please contact us on 2594 6218.

7.3 Please note that the Government would wish, either during private or public discussion with others or in any subsequent report, to be able to refer to and attribute views submitted in response to this consultation paper. Any request to treat all or part of a response in confidence will be respected, but if no such request is made, it will be assumed that the response is not intended to be confidential.

7.4 The new AQOs will have profound impact on the direction for managing our air quality in the future. We earnestly request you to let us have your views on our proposals set out in this paper before the close of the consultation.

Annex A
Key Emission Sources and Health Effects of Air Pollutants

(a) Sulphur dioxide

Sulphur dioxide (SO_2) is formed primarily from combustion of sulphur-containing fossil fuels. In Hong Kong, power stations are the predominant emission sources of SO_2, followed by marine vessels, fuel combustion and motor vehicles.

Exposure to high levels of SO_2 may cause a wide variety of health impacts, including –

- impairment of respiratory function;
- aggravation of existing respiratory and heart illnesses; and
- increasing the risk of developing chronic respiratory diseases.

Particularly sensitive groups include people with asthma, lung or heart disease, children and the elderly.

(b) Nitrogen dioxide

Nitrogen dioxide (NO_2) is mainly formed from oxidation of nitrogen oxides (NOx) emitted from fuel combustion. Emissions from power stations and motor vehicles are the two major sources of NOx in Hong Kong. The latter has greater impact on roadside air quality.

Exposure to NO_2 can give rise to adverse health effects including –

- lowering a person's resistance to respiratory infections;
- aggravation of existing respiratory diseases; and
- damaging lung tissue and reduction in lung function.

People with asthma or lung disease and children are more susceptible to the adverse effects of NO_2 exposure.

(c) Ozone

Ozone (O_3), a major constituent of photochemical smog, is formed by a series of complicated photochemical reactions of oxygen, NOx and volatile organic compounds in the presence of sunlight and warm temperature.

Being a strong oxidant, O_3 can cause a variety of adverse health problems, including –

- irritation to the eye, nose and throat even at low concentrations;
- airway irritation, coughing, wheezing and breathing difficulties;
- increase of lung inflammation; and
- aggravation of asthma and increased susceptibility to respiratory illnesses like pneumonia and bronchitis.

People with lung disease, children and the elderly will be more seriously affected by elevated O_3 exposure.

(d) Respirable and Fine Suspended Particulates

In Hong Kong, the ambient particulate matters (PM) are contributed mainly by the regional sources. Combustion sources, in particular diesel vehicle exhaust and emissions from power plants, are the major local sources of PM. Besides, fine particulates can be formed by atmospheric oxidation of SO_2 and NOx. Although to a lesser extent, crustal dust and marine aerosols are also sources of PM.

PM with particle sizes less than 10 microns, which are known as respirable suspended particulates or PM_{10}, can get deep into the lungs and cause a broad range of health effects, in particular, respiratory and cardiovascular illnesses, including –

- increasing respiratory symptoms, such as irritation of the airways, coughing, or difficulty in breathing;
- decreasing lung function;
- aggravation of asthma;
- development of chronic bronchitis;
- adverse effects on the cardiovascular system; and
- premature death in people with heart or lung disease.

People with heart or lung disease, children and the elderly are most likely to be affected by particulate pollution.

Recent medical researches show that the risk for various health impacts increases with exposure and there is little evidence to suggest a threshold below which no adverse health effects would be anticipated. It has also been shown that the health risks would be higher for those particles with particle sizes of 2.5 microns or less, which are commonly referred to as fine suspended particulates or $PM_{2.5}$.

(e) Carbon Monoxide

Carbon monoxide (CO) comes mainly from vehicular emissions, although a small amount of which may also come from incomplete combustion of fuels from factories and power stations.

CO can cause harmful health effects by reducing oxygen delivery to the body's organs, e.g. heart, brain and tissues. Symptoms due to CO exposures include –

- chest pain, headache, shortness of breath and loss of co-ordination;
- reduction of ability to exercise and contributing to other cardiovascular effects; and
- vision problems, reduced ability to work or learn, reduced manual dexterity and difficulty in performing complex tasks.

These health threats are more severe for those who suffer from heart disease. Also, at extremely high levels, CO is poisonous and can cause death.

(f) Lead

The use of leaded petrol was the most important source of lead (Pb). Since April 1999, the sale and supply of leaded petrol have been banned in Hong Kong. As a result, our ambient concentration level of Pb has been maintaining at low levels.

Pb, once taken into the body, may distribute throughout the body in the blood and accumulate in the bones. Depending on the level of exposure, Pb can cause the following adverse health effects –

- adversely affecting the nervous system, kidney function, immune system, reproductive and developmental systems and cardiovascular system;
- affecting the oxygen carrying capacity of the blood;
- neurological effects in children which may contribute to behavioral problems and learning deficits; and
- cardiovascular effects such as high blood pressure and heart diseases.

Annex B
Actions to Improve Regional Air Quality

Actions being Taken by Hong Kong

Controlling Emissions from Power Generation

- Banned all new coal-fired power plants since 1997.
- Imposed emission caps on all power plants since 2005 and stipulated emission caps for power plants for 2010 and beyond in the law.
- Linked the two power companies' permitted rate of return to their environmental performance.
- Signed a Memorandum of Understanding with the National Energy Administration of the Central People's Government to secure a stable and long-term supply of natural gas and nuclear power to Hong Kong.

Controlling Emissions from Road Transport

- Introduced the most stringent vehicle emission standards in tandem with the European Union (EU).
- Retrofitted pre-Euro diesel vehicles with particulate traps or catalytic converters.
- Replaced diesel taxis and light buses with liquefied petroleum gas (LPG) models.
- Deploying chassis dynamometers to test diesel vehicle smoke emissions and stepping up enforcement actions against smoky vehicles.
- Implementing a grant scheme for replacing older diesel vehicles.
- Providing tax incentives to promote the use of environment-friendly vehicles.
- Making preparation to promote the use of electric vehicles.
- Making preparation to ban idling vehicles with running engines.
- Mandated ultra low sulphur diesel (ULSD) for vehicle use five years ahead of EU.
- Introduced tax incentive to bring about early supply of Euro V diesel to the local market.

Controlling Emissions from Other Sources

- Controlling petrol vapour emissions from petrol filling stations.
- Making preparation to regulate the content of volatile organic compounds (VOCs) in a wider range of selected products.
- Mandated all industrial and commercial processes to use ULSD.
- Exploring the feasibility of using ULSD by local ferries.

Promoting Energy Conservation and Energy Efficiency

- Taking forward the legislation for mandatory implementation of the Building Energy Codes to enhance building energy efficiency.
- Reserved $450 million under the Environment and Conservation Fund to subsidize building owners to conduct energy-cum-carbon audits and energy efficiency improvement projects at buildings, and opened the schemes for application since April 2009.
- Planning to develop a district cooling system in the Kai Tak Development, which is 35% and 20% more energy-efficient than air-cooled and water-cooled air-conditioning systems respectively, to provide more energy-efficient air-conditioning services for the public.
- Implementing both voluntary and mandatory Energy Efficiency Labelling Schemes for electrical appliances.

Measures being Taken by Guangdong

Controlling Emissions from Power Generation

- Establishing a diversified clean energy production and supply system, including banning the development of new coal-fired or oil-fired power plants in the Pearl River Delta (PRD) region, development of gas-fired power plants and transmission of electricity from the western provinces.
- Requiring all thermal power plants that are under construction, alteration or expansion to carry out flue gas denitrification.
- Promoting adoption of desulphurization, dust removal, denitrification or low nitrogen oxides (NOx) combustion technologies at coal-fired or oil-fired power plants.
- Requiring all large-scale thermal power plants to carry out flue gas desulphurization.

- Requiring thermal power plants to install continuous emission monitoring systems with instant on-line access by local authorities.

- Offering better sales terms (e.g. higher rates and grid connection priority) to power plants that are equipped with flue-gas desulphurization and denitrification systems.

- Closing down small thermal power plants.

Controlling Emissions from Road Transport

- Requiring newly registered motor vehicles in Guangdong to comply with the National III standards (which are on a par with the Euro III standards).

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

- Restricting the growth of motorcycles at key cities and banning them in the Guangzhou and Dongguan city areas.

- Implementing an environment labeling pilot system for vehicles at key cities to restrict specified vehicles from using the roads when the ambient air quality is bad.

- Supplying National III standard motor fuels to all cities in the PRD region by the end of 2009 (in addition to Shenzhen, Guangzhou, Dongguan, Zhuhai and Zhongshan).

- Constructing metro expressway systems and developing green transportation.

Controlling Emissions from Industrial Sector

- Closing down serious polluting industries (including cement plants and iron and steel plants with low production capacity).

- Designating fuel use restriction areas as required, and banning installation of new coal-fired and oil-fired boilers within the restricted areas.

- Encouraging the use of clean energy at industrial boilers and kilns.

- Promoting adoption of desulphurization, dust removal, denitrification or low NOx combustion technologies at industrial boilers and kilns.

- Enhancing technological improvement at enterprises and promoting cleaner production.

Controlling Emissions from Other Sources

- Implementing comprehensive vapour recovery system at petrol filling stations, oil depots and tanker trucks at major PRD cities.

- Phasing out paint and coating products with high VOC content, and encouraging the production and sale of low VOC content products, including pesticide sprayers, cleansers, adhesives, hair styling gels, etc.

- Requiring industries (including vehicle manufacturing and repairs, petrochemical processing, furniture production, shoe production, printing, electronic product manufacturing and garment dry cleaning) to control fugitive VOC emissions in accordance with relevant technical standards and specifications.

- Prohibiting the use of waste asphalt, felt, rubber, plastics, leather and other materials as fuel to avoid emission of toxic smoke or fetor during combustion, and prohibiting open burning practice for recovery of metal.

- Requiring implementation of dust control measures when storing and stockpiling industrial and construction materials.

- Requiring implementation of dust control measures at construction sites.

- Requiring catering establishments to use clean energy such as electricity, natural gas and LPG.

- Prescribing the discharge limits and methods in respect of oily fume, smoke and particulate emissions from catering operators in urban areas.

Further Collaboration

- Both Hong Kong and Guangdong are striving to meet the 2010 emission reduction targets. Meanwhile, we are discussing with the Guangdong Provincial Government to map out a strategy to transform the Greater PRD Region into a green and quality living area. Improving regional air quality, including drawing up the post-2010 emission reduction arrangement, will be a major area of cooperation.

Annex C

Comparison of Hong Kong's Existing Air Quality Objectives with those Adopted by Other Countries / Economies and World Health Organisation Air Quality Guidelines / Interim Targets

Pollutant	Averaging Time	WHO AQGs / ITs µg/m³	Existing Hong Kong AQOs		United States[7,8]		European Union[9]		United Kingdom[9]		Australia[10]		Japan		Singapore[6]	
			µg/m³	No of Ex.	µg/m³	No of Ex.	µg/m³	No of Ex.	µg/m³	No of Ex.	µg/m³	No of Ex.	µg/m³	No of Ex.	µg/m³	No of Ex.
Sulphur Dioxide (SO_2)	10-minute	500	-	-	-	-	-	-	266 [1]	35	-	-	-	-	-	-
	1-hour	-	800	3	-	-	350	24	350	24	524	1	262	Note[11]	-	-
	24-hour	20 (IT-1: 125, IT-2: 50)[2]	350	1	365	1	125	3	125	3	210	1	105	Note[11]	-	-
	Annual	-	80	N/A	80	N/A	-	-	-	-	52	N/A	-	-	-	-
Respirable Suspended Particulates (RSP / PM_{10})	24-hour	50 (IT-1: 150, IT-2: 100, IT-3: 75)	180	1	150	3 times in 3 years	50	35	50	35	50	5	100	Note[11]	-	-
	Annual	20 (IT-1: 70, IT-2: 50, IT-3: 30)	55	N/A	-	-	40	N/A	40	N/A	-	-	-	-	-	-
Fine Suspended Particulates (FSP / $PM_{2.5}$)	24-hour	25 (IT-1: 75, IT-2: 50, IT-3: 37.5)	-	-	35	3-year avg. of 98th percentile	-	-	-	-	25 [3]	N/A	-	-	-	-
	Annual	10 (IT-1: 35, IT-2: 25, IT-3: 15)	-	-	15 [4]	N/A	25	N/A	25	N/A	8 [3]	N/A	-	-	-	-
Nitrogen Dioxide (NO_2)	1-hour	200	300	3	-	-	200	18	200	18	226	1	-	-	-	-
	24-hour	-	150	1	-	-	-	-	-	-	-	-	75 – 113	Note[11]	-	-
	Annual	40	80	N/A	100	N/A	40	N/A	40	N/A	57	N/A	-	-	-	-
Ozone (O_3)	1-hour	-	240	3	-	-	-	-	-	-	200	1	120	Note[11]	-	-
	4-hour	-	-	-	-	-	-	-	-	-	160	1	-	-	-	-
	8-hour	100 (High levels: 240, IT-1: 160)	-	-	147	3-year of 4th highest values	120	25	100	10	-	-	-	-	-	-
Carbon Monoxide (CO)	15-minute	100,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-minute	60,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1-hour	30,000	30,000	3	40,000	1	-	-	-	-	-	-	23,000	Note[11]	-	-
	8-hour	10,000	10,000	1	10,000	1	10,000	0	10,000	0	10,000	1	-	-	-	-
Lead (Pb)	3-month	-	1.5	N/A	1.5	N/A	-	-	-	-	-	-	-	-	-	-
	Annual	0.5	-	-	0.15 [5]	N/A	0.5	N/A	0.25	N/A	0.5	N/A	-	-	-	-

Notes:

[1] 15-minute average.

[2] "IT" stands for Interim Target.

[3] Advisory reporting standard only, not air quality standard.

[4] 3-year average of the weighted annual mean.

[5] Rolling 3-month average.

[6] Singapore does not have its own air quality standard. The National Environment Agency uses the United Stats National Ambient Air Quality Standards to assess the ambient air quality in Singapore.

[7] Measured at 298K(25°C) and 101.325 kPa (one atmosphere).

[8] $PM_{2.5}$ measured at ambient conditions.

[9] Measured at 293K(20°C) and 101.325 kPa (one atmosphere).

[10] Measured at 273K (0°C) and 101.325 kPa (one atmosphere).

[11] SO_2, CO, PM: Of the mean daily values obtained over one year, those within the top 2% (equivalent to the values of seven days, if daily measurements are taken for 365 days) are excluded (2% exclusion value) and the highest remaining values are compared with the environmental standard. If the measurement values exceed the environmental standard on more than two consecutive days, they are judged as nonattainment.

NO_2: For the mean daily values obtained over one year, those within the lower 98% are selected and compared with the environmental standard.

O_3: If the 1-hour mean value exceeds 0.06ppm, it is judged not to have attained the standard.

Annex D
Rationale behind Setting of Proposed New Air Quality Objectives

Sulphur Dioxide

1. Table D.1 below gives the concentration levels of sulphur dioxide (SO_2) and the number of exceedences against the World Health Organisation Air Quality Guidelines (WHO AQGs) and various Interim Targets (ITs) recorded in the general monitoring stations in 2008. The data collected from the Tap Mun air quality monitoring station, which does not have any local emission sources and should be representative of the extent of regional influence on Hong Kong's air pollution levels, are also presented in the table.

Table D.1 : Comparison of 2008 Monitoring Data on SO_2 with WHO AQGs / ITs

Averaging Time	WHO AQGs / ITs ($\mu g/m^3$)	Highest Concentration in 2008 (Ambient)	Highest Concentration in 2008 (Tap Mun)	No. of Exceedences in 2008 (Ambient)	No. of Exceedences in 2008 (Tap Mun))
10-min	AQG: 500	1,173	409	20	0
24-hour	IT-1:125	149	71	2	0
	IT-2: 50			86	1
	AQG: 20			284	63

Average annual ambient concentration: 20 $\mu g/m^3$.

2. The monitoring data show that the highest concentration levels and the number of exceedences recorded in Tap Mun are much lower than other ambient stations, suggesting that SO_2 concentration in urban areas is mainly contributed by local sources. Hong Kong has been taking strong actions to reduce SO_2 emissions. Since December 2007, diesel vehicles have been using Euro V diesel, which has virtually no sulphur and is the cleanest form of diesel. Hong Kong is amongst the very few places in the world which require the use of ultra low sulphur diesel across all industrial and commercial processes. Moreover, power plants are being retrofitted with flue gas de-sulphurisation devices as part of the efforts to achieve the regional 2010 emission reduction targets. The scope of further reducing drastically the local emissions as well as concentration of SO_2 over the short to medium term is thus rather limited.

3. Taking into account the local circumstances and making reference to the European Union (EU) air quality standards (i.e. 125 $\mu g/m^3$ with three exceedences), the Review proposes that the 24-hour SO_2 objective be tightened from the current 350 $\mu g/m^3$ to the WHO IT-1 of 125 $\mu g/m^3$ with three exceedences allowed.

4. The WHO also sets a 10-minute AQG of 500μg/m³ for SO_2. The Review proposes to adopt the WHO AQG of 500 μg/m³ and, similar to 24-hour AQO, allow three exceedences a year. The WHO has not proposed any 1-hour and annual concentration guidelines for SO_2 because achieving the 10-minute and 24-hour concentration guidelines can provide adequate health protection. The Review therefore proposes to do away with the current 1-hour and annual objectives for SO_2.

Nitrogen Dioxide

5. The WHO has not proposed any IT for the concentration levels of nitrogen dioxide (NO_2). Table D.2 below shows that the NO_2 concentration recorded in Hong Kong's general air quality monitoring stations (except the Tap Mun station) in 2008 exceeded the WHO AQGs' 1-hour guideline on a large number of occasions. No exceedence was recorded in Tap Mun, indicating that NO_2 concentration in urban areas is largely contributed by local sources. Further modelling results also show that implementation of suitable emission control measures, particularly those targeting at vehicular emissions, could help bring down the concentration levels of NO_2 in Hong Kong.

Table D.2 : Comparison of 2008 Monitoring Data on NO_2 with WHO AQGs

Averaging Time	WHO AQGs (μg/m³)	Highest Concentration in 2008 (Ambient)	Highest Concentration in 2008 (Tap Mun)	No. of Exceedences in 2008 (Ambient)	No. of Exceedences in 2008 (Tap Mun))
1-hour	AQG: 200	282	119	84	0
Annual	AQG: 40	69	14	Not Met	Met

Average annual ambient concentration: 53 μg/m³.

6. Having considered the standards being adopted by other advanced countries, particularly the EU, and our local circumstances, the Review recommends that the respective WHO AQGs of 40 μg/m³ and 200 μg/m³ for annual and 1-hour NO_2 be adopted, which represent a substantial tightening as compared with the existing AQOs of 80 μg/m³ and 300 μg/m³ respectively. On the number of exceedences allowed for 1-hour NO_2, the Review recommends that 18 exceedences per year be allowed taking account of the allowable exceedences being adopted by the EU and the consultant's modelling results.

Fine Suspended Particulates

7. There are currently only concentration targets for respirable suspended particulates (RSP or PM_{10}) but not fine suspended particulates (FSP or $PM_{2.5}$) under the existing AQOs. Evidence has accumulated in recent years to show that health risk attributable to exposure to particulate matters (PM) is better represented by $PM_{2.5}$. The Review therefore proposes to introduce a set of new AQOs for this air pollutant.

8. Despite major reduction in local PM emissions of 62% between the peak in the early 1990's and 2007, the data collected in our general air monitoring stations, as set out in Table D.3 below, show that widespread exceedences of the WHO AQGs and ITs for $PM_{2.5}$ were recorded in various parts of Hong Kong including Tap Mun. Based on these measurements and the fact that Hong Kong's PM emissions account for only about 1% to 2% of the entire emissions in the Pearl River Delta (PRD) region, it is apparent that $PM_{2.5}$ concentration in Hong Kong is subject to very strong regional influence. It would be difficult to significantly bring down the concentration level of $PM_{2.5}$ in Hong Kong solely through local efforts. Concerted actions on a regional scale would be required to bring about improvement.

Table D.3 : Comparison of 2008 Monitoring Data on FSP (or $PM_{2.5}$) with WHO AQGs / ITs

Averaging Time	WHO AQGs / ITs ($\mu g/m^3$)	Highest Concentration in 2008 (Ambient)	Highest Concentration in 2008 (Tap Mun)	No. of Exceedences in 2008 (Ambient)	No. of Exceedences in 2008 (Tap Mun))
24-hour	IT-1: 75	113	99	39	13
	IT-2: 50			128	87
	IT-3: 37.5			191	160
	AQG: 25			259	219
Annual	IT-1: 35	41	35	Not Met	Met
	IT-2: 25			Not Met	Not Met
	IT-3: 15			Not Met	Not Met
	AQG: 10			Not Met	Not Met

Average annual ambient concentration: 38 $\mu g/m^3$.

9. Taking into account the strong regional influence, the Review proposes that as a start the respective WHO IT-1 of 35 $\mu g/m^3$ and 75 $\mu g/m^3$ for annual and 24-hour $PM_{2.5}$ be adopted. The EU directive does not provide for any 24-hour $PM_{2.5}$ limit. Given that $PM_{2.5}$ concentration is contributed significantly by regional

sources, the Review proposes to allow nine exceedences in a year, which has been determined with reference to the results of the mathematical air quality modelling following implementation of the proposed Phase I emission control measures set out in Chapter 6.

Respirable Suspended Particulates

10. As with $PM_{2.5}$, widespread exceedences of the WHO AQGs and ITs were recorded for PM_{10} in 2008 (please refer to Table D.4 below). The predominant regional contribution to local background PM_{10} concentration underscores the importance of regional collaboration in reducing PM emissions.

Table D.4 : Comparison of 2008 Monitoring Data on RSP (or PM_{10}) with WHO AQGs / ITs

Averaging Time	WHO AQGs / ITs ($\mu g/m^3$)	Highest Concentration in 2008 (Ambient)	Highest Concentration in 2008 (Tap Mun)	No. of Exceedences in 2008 (Ambient)	No. of Exceedences in 2008 (Tap Mun))
24-hour	IT-1: 150	164	147	4	0
	IT-2: 100			51	19
	IT-3: 75			134	78
	AQG: 50			211	167
Annual	IT-1: 70	60	52	Met	Met
	IT-2: 50			Not Met	Not Met
	IT-3: 30			Not Met	Not Met
	AQG: 20			Not Met	Not Met

Average annual ambient concentration: 51 $\mu g/m^3$.

11. $PM_{2.5}$ accounts for about 70% of PM_{10} found in Hong Kong. Taking account of this $PM_{2.5}$ / PM_{10} ratio and the concentration objectives for $PM_{2.5}$ proposed above, the Review proposes to tighten the annual and 24-hour PM_{10} objectives from 55 $\mu g/m^3$ and 180 $\mu g/m^3$ to the WHO IT-2 of 50 $\mu g/m^3$ and 100 $\mu g/m^3$ respectively. In line with the number of exceedences for $PM_{2.5}$, nine exceedences per year are proposed for PM_{10}.

Total Suspended Particulates

12. The existing AQOs also set out the concentration targets for total suspended particulates (TSP), which are PM with larger particle sizes. TSP mainly cause nuisance rather than adverse health effects on the public. As the health effects of PM have been aptly represented by $PM_{2.5}$ and PM_{10}, the Review proposes to take away TSP from the AQOs. This proposal is in line with the international practices.

Ozone

13. Ozone (O_3) is not a pollutant directly emitted from man-made sources. It is formed by photochemical reactions between sunlight and other primary pollutants such as nitrogen oxides (NOx) and volatile organic compounds (VOCs). As it takes several hours for these photochemical reactions to take place, O_3 recorded in one place could be attributed to VOC and NOx emissions from places afar. Measurements from the general air monitoring stations set out in Table D.5 below indicate that the WHO AQG and IT were widely exceeded at both Tap Mun and other monitoring stations.

Table D.5 : Comparison of 2008 Monitoring Data on O_3 with WHO AQG / IT

Averaging Time	WHO AQGs / ITs ($\mu g/m^3$)	Highest Concentration in 2008 (Ambient)	Highest Concentration in 2008 (Tap Mun)	No. of Exceedences in 2008 (Ambient)	No. of Exceedences in 2008 (Tap Mun))
8-hour	IT-1: 160	320	320	29	19
	AQG: 100			185	184

Average annual ambient concentration: 39 $\mu g/m^3$.

14. Taking into account the local circumstances and the results of the mathematical air quality modelling following implementation of the proposed Phase I emission control measures, it is recommended that the existing 1-hour objective of 240 $\mu g/m^3$ for O_3 be replaced by the 8-hour objective of 160 $\mu g/m^3$ under the WHO IT-1 with allowance of nine exceedences per year. This proposed new AQO is statistically similar to the EU air quality standard of 120 $\mu g/m^3$ with allowance of 25 exceedences.

Carbon Monoxide

15. The monitoring data in Table D.6 below show that carbon monoxide (CO) concentration in Hong Kong was very low. The current 1-hour and 8-hour AQOs of 30,000 $\mu g/m^3$ and 10,000 $\mu g/m^3$ respectively for CO, which are the same as the WHO AQGs, have been met.

Table D.6 : Comparison of 2008 Monitoring Data on CO with WHO AQGs

Averaging Time	WHO AQGs ($\mu g/m^3$)	Highest Concentration in 2008 (Ambient)	Highest Concentration in 2008 (Tap Mun)	No. of Exceedences in 2008 (Ambient)	No. of Exceedences in 2008 (Tap Mun))
15-minute	AQG: 100,000	3,439	2,312	0	0
30-minute	AQG: 60,000	3,324	2,116	0	0
1-hour	AQG: 30,000	3,220	2,060	0	0
8-hour	AQG: 10,000	3,034	1,536	0	0

Average annual ambient concentration: 748 $\mu g/m^3$.

16. It is therefore proposed to retain the current AQOs for CO with no exceedence allowed.

Lead

17. The principal source of lead (Pb) emissions in Hong Kong used to be the Pb additives in petrol. Following the introduction of the unleaded petrol in April 1991 and the ban on leaded petrol in April 1999, the concentration levels of Pb in Hong Kong have been very low. The 2008 monitoring data set out in Table D.7 below show that the concentration of Pb in Hong Kong was much lower than the annual WHO AQG of 0.5 μg/m^3.

Table D.7 : Comparison of 2008 Monitoring Data on Pb with WHO AQG

Averaging Time	WHO AQG (μg/m^3)	Highest Concentration in 2008 (Ambient)	Highest Concentration in 2008 (Tap Mun)	No. of Exceedences in 2008 (Ambient)	No. of Exceedences in 2008 (Tap Mun))
Annual	AQG: 0.5	0.064	[1]	Met	[1]

[1] Lead is not measured at Tap Mun.
Average annual ambient concentration: 0.054 μg/m^3.

18. The current AQO provides for a 3-month concentration objective of 1.5 μg/m^3. In line with the WHO guidelines, it is proposed to update the current AQO for Pb by adopting the WHO AQG of 0.5 μg/m^3 averaged over one year.

Annex E

Proposed Phase I Emission Control Measures and Their Respective Emission Reduction Potential and Cost-Benefit Analysis

		Emission Reduction Potential (t)				Cost – Benefit Analysis[1]		
		SO_2	NOx	RSP / PM_{10}	VOCs	Cost ($M)	Benefit ($M)	B/C Ratio[2]
Emission Capping and Control								
1.	Increasing the ratio of natural gas in local electricity generation to 50% together with additional emission abatement measures[3]	13,402	25,225	523	0	2,032[4]	1,803	0.9[4]
2.	Early retirement of aged / heavily polluting vehicles (pre-Euro, Euro I and Euro II commercial diesel vehicles and franchised buses)	0	3,102	300	184	3,882[5]	24,344	6.3
3.	Earlier replacement of Euro III commercial diesel vehicles with models meeting latest Euro standards	0	743	75	24	2,668[5]	6,134	2.3
4.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance (20% private cars and 10% franchised buses)	15	216	7	173	4,326[5]	2,417	0.56
5.	Ultra low sulphur diesel (SCR) for local vessels	675	0	18	0	378	6,331	16.7
6.	Selective catalytic reduction for local vessels	0	304	0	0	249	74	0.30
7.	Electrification of aviation ground support equipment	85	759	21	67	1,449	3.8	0.003
8.	Emission control for off-road vehicles / equipment	4	950	239	326	845	2,123	2.5
9.	Strengthening volatile organic compounds control	0	0	0	700	18	124	6.9
Transport Management								
10.	Low emission zones	Note [6]	Note [6]	Note [6]	Note [6]	3,696	2,586	0.7
11.	Car-free zone / pedestrianisation scheme	Note [6]	Note [6]	Note [6]	Note [6]	42	400	10
12.	Bus route rationalization	4	156	7	9	14	548	39
Infrastructure Development and Planning								
13.	Expand rail network	17	501	46	207	Note [7]	3,850	Note [7]
14.	Cycling network to major public transport hubs	0.1	2.3	0.1	0.1	836	8	0.01
Energy Efficiency Measures [8]								
15.	Mandatory implementation of Building Energy Codes	151	256	8	3	95	2,634	28
16.	Energy efficiency standards for domestic electrical appliances	84	142	4	1	84	2,277	27
17.	Light-emitting diode or equivalent alternatives for traffic signal / street lighting	3	5	0.1	0	47	105	2.2
18.	Tree planting / roof-top greening [9]	Note [9]	Note [9]	Note [9]	Note [9]	6,357	1,603	0.3
19	District cooling system for Kai Tak Development	6	16	0.5	0.2	2,788[10]	4,047	1.5

Notes:

[1] In its simplest form, the costs and benefits of each policy are quantified and valued in monetary terms. The cost-benefit analysis is subject to a wide range of assumptions used by the consultant for compiling the assessment of different proposed emission control measures. As these assumptions are subject to change, the findings of the cost-benefit analysis should be read with caution. Nonetheless, it provides a systematic framework to compare the potential cost-effectiveness of different measures.

[2] A benefit-cost ratio above one indicates that the overall monetized benefits of the proposed measure are expected to be higher than the costs to be borne by the society. A ratio below one indicates the otherwise.

[3] Possible additional emission abatement measures include enhancing the SCR systems of the existing coal-fired units. However, the technical feasibility and financial viability of retrofitting the existing coal-fired units with enhanced SCR systems are not yet established and subject to more detailed examination with the concerned power company.

[4] The figure includes estimated costs due to increasing the ratio of natural gas in local electricity generation to 50%. It does not cover the costs of the additional emission abatement measures, such as enhancing the SCR systems of the existing coal-fired units, the technical feasibility and financial viability of which would be subject to further examination.

[5] The cost of early retirement of the concerned vehicles is calculated based on the residual value foregone of these vehicles over the remaining period of their normal serviceable life. The upfront capital costs required for procuring the replacement vehicles would be higher than the figures set out in the table.

[6] Emission reduction potential would not be substantial as it involves mainly transferring emission from one place to another.

[7] The railway strategy includes the Express Rail Line, the Sha Tin to Central Link (the Tai Wai to Hung Hom section), the West Island Line, the South Island Line (East), the Kowloon Southern Link and the Kwun Tong Line Extension. The railway strategy will have additional ride-on effect on improvement of air quality. Only benefits are presented.

[8] Benefits include material damage, energy saving as well as acute and chronic health benefits. For strategies 15, 16, 17 and 19, the majority of benefits are due to energy savings, not health benefits. Emission reduction of energy efficiency measures is generated from less electricity demand. To be conservative, they have not been included in the net total emission reduction.

[9] The proposed measures help reduce urban heat island effect and improve air pollution dispersion. No local emission and cost data are available. Estimates are based on overseas data for roof top greening of 10% of the urban area.

[10] The figure includes both the capital and operational costs of the plant for the coming 50 years.

Total Emissions (Tonnes) With and Without Proposed Phase I Emission Control Measures

	Without Proposed Measures				With Proposed Meaures			
Sector	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**
Power	25,120	42,600	1,260	420	11,718	17,375	737	420
Transport	5,706	43,832	2,407	6,705	4,910	38,048	1,933	6,040
Vehicles	*299*	*14,075*	*1,697*	*5,854*	*263*	*9,354*	*1,262*	*5,257*
Marine (Figure in brackets for local vessels)	*4,938 (682)*	*21,684 (3,994)*	*676 (179)*	*436 (91)*	*4,263 (7)*	*21,380 (3,690)*	*658 (161)*	*436 (0)*
Aviation	*469*	*8,073*	*34*	*415*	*384*	*7,314*	*13*	*348*
Industry and Others	16	4,608	624	24,131	12	3,658	385	23,104
Total	**30,842**	**91,040**	**4,291**	**31,255**	**16,640**	**59,080**	**3,055**	**29,564**

Annex F

Proposed Phases II and III Emission Control Measures and Their Respective Emission Reduction Potential and Cost-Benefit Analysis

Proposed Phases II Emission Control Measures and Their Respective Emission Reduction Potential and Cost-Benefit Analysis

		Emission Reduction Potential (t)				Cost – Benefit Analysis[1]		
		SO_2	NOx	RSP / PM_{10}	VOCs	Cost ($M)	Benefit ($M)	B/C Ratio[2]
Emission Capping and Control								
20.	Increasing the ratio of natural gas in local electricity generation to 75% with additional abatement measures (Additional to Phase I measure)	5,163	5,761	178	0	1,702	383	0.2
21.	Increasing the ratio of renewable energy (2% wind energy)	502	852	25	8	13,069	206	0.02
22.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance [30% private cars, 15% buses (including franchised buses), 15% light goods vehicles (LGVs) plus 15% heavy goods vehicles (HGVs)] (Additional to Phase I measure)	40	849	79	174	9,026	14,447	1.6
23.	Ultra low sulphur diesel for ocean-going vessels and local vessels (Additional to Phase I measure)	2,392	1,145	15	0	4,563	15,087	3.3
24.	Selective catalytic reduction for ocean-going vessels and local vessels (Additional to Phase I measure)	0	7,153	0	0	1,333	1,173	0.9
25.	Electrification of on-shore power supply	377	2,361	297	404	1,579	6,243	4.0
26.	Tightening aviation emission standards	0	3,587	0	0	Note [3]	12	Note [3]
27.	Further strengthening volatile organic compounds control	0	0	0	4,870	37	634	17.2
Transport Management								
28.	Electronic road pricing (ERP) / congestion charging scheme for Hong Kong Island North	Note [4]	Note [4]	Note [4]	Note [4]	Note [4]	577	Note [4]
29.	Reduce parking provision (25%) to restrain car usage for Central	Note [5]	Note [5]	Note [5]	Note [5]	757	18	0.02
Energy Efficiency Measures [8]								
30.	District cooling system (35% in existing areas and 90% in other new development areas)	120	197	5.5	1.9	19,347	11,578	0.6

Proposed Phases III Emission Control Measures and Their Respective Emission Reduction Potential and Cost-Benefit Analysis

Emission Capping and Control								
31.	Increasing the ratio of natural gas in local electricity generation to 100% (Additional to Phase II measure) [7]	6,553	7,430	270	0	348	255	0.7
32.	50% nuclear power and 50% natural gas (Alternative Case compared to Base Case of 75% natural gas) [7]	6,554	8,422	381	210	-2,894	91	–
33.	Wider use of hybrid / electric vehicles or other environment- friendly vehicles with similar performance (50% private cars, 50% buses (including franchised buses), 50% HGVs plus 50% LGVs) (Additional to Phase II measure)	63	789	42	232	8,530	7,751	0.91
34.	Vehicle permit quota system (to reduce around 50% private cars and 50% motorcycles)	28	93	3	119	691	251	0.4
35.	Use of hydrogen fuel cell vehicles or equivalent alternatives (40% penetration)	140	2,778	94	1,453	Note [8]	10,420	Note [8]
Infrastructural Development and Planning								
36.	Rail for transport of cross-boundary goods	1	11	1	9	Note [9]	115	Note [9]

Notes:

[1] In its simplest form, the costs and benefits of each policy are quantified and valued in monetary terms. The cost-benefit analysis is subject to a wide range of assumptions used by the consultant for compiling the assessment of different proposed emission control measures. As these assumptions are subject to change, the findings of the cost-benefit analysis should be read with caution. Nonetheless, it provides a systematic framework to compare the potential cost-effectiveness of different measures.

[2] A benefit-cost ratio above one indicates that the overall monetized benefits of the proposed measure are expected to be higher than the costs to be borne by the society. A ratio below one indicates the otherwise.

[3] Costs for this proposed measure will be borne by the aircraft industry (and hence consumers) worldwide and only air quality benefits to Hong Kong have been calculated.

[4] The ERP strategy will have additional ride-on effect on improvement of air quality. The overall emission reduction potential would not be substantial. The ERP measure will have incidental improvements to air quality. Only these benefits have been calculated here. The estimated cost for the proposed ERP scheme is about $1 billion (including the cost of in-vehicle units for existing vehicles) with an annual recurrent cost of about $200 million.

[5] Emission reduction potential would not be substantial as it involves mainly transferring emission from one place to another.

[6] Emission reduction of energy efficiency measure is generated from less electricity demand. To be conservative, they have not been included in the net total emission reduction.

[7] The “increase ratio of natural gas in local electricity generation to 100%” scenario and “50% nuclear power and 50% natural gas” scenario are either-or case. Adoption of only one of these proposed measures would be expected.

[8] Fuel cell technology has not yet matured, and there are no local cost data. Hence only the likely air quality improvement benefits have been calculated.

[9] Only the air quality improvement benefits have been calculated. The capital cost of the freight rail would be about $5 billion to $9 billion.

Total Emissions (Tonnes) With and Without Proposed Phase I and II Emission Control Measures

	Without Proposed Measures				With Proposed Meaures			
Sector	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**
Power	25,120	42,600	1,260	420	6,053	10,762	534	412
Transport	6,451	45,133	2,244	6,304	2,861	28,317	1,760	5,442
Vehicles	*331*	*11,231*	*1,416*	*5,290*	*270*	*9,722*	*1,284*	*4,900*
Marine (Figure in brackets for local vessels)	*5,569 (682)*	*24,412 (3,994)*	*788 (179)*	*526 (91)*	*2,124 (7)*	*13,450 (3,690)*	*457 (161)*	*122 (0)*
Aviation	*552*	*9,490*	*40*	*488*	*466*	*5,145*	*19*	*421*
Industry and Others	15	4,632	625	24,761	11	3,682	386	18,865
Total	**31,586**	**92,365**	**4,129**	**31,485**	**8,925**	**42,761**	**2,679**	**24,719**

Total Emissions (Tonnes) With and Without Proposed Phase I, II and III Emission Control Measures

	Without Proposed Measures				With Proposed Meaures			
Sector	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOCs**
Power	25,120	42,600	1,260	420	0	2,340	153	202
Transport	7,734	49,154	2,438	6,501	3,952	29,515	1,894	4,000
Vehicles	*353*	*9,797*	*1,388*	*5,306*	*101*	*5,466*	*1,195*	*3,276*
Marine (Figure in brackets for local vessels)	*6,829 (682)*	*29,866 (3,994)*	*1,010 (179)*	*707 (91)*	*3,385 (7)*	*18,904 (3,690)*	*680 (161)*	*303 (0)*
Aviation	*552*	*9,490*	*40*	*488*	*466*	*5,145*	*19*	*421*
Industry and Others	14	4,720	629	25,980	10	3,770	391	20,083
Total	**32,868**	**96,474**	**4,327**	**32,900**	**3,962**	**35,626**	**2,437**	**24,285**

Annex G
Key Consultation Points

Question (1): Do you agree that the existing Air Quality Objectives (AQOs) need updating?

Question (2): Do you agree that protection of public health should be the key consideration in updating the AQOs?

Question (3): Do you agree that the AQOs should be set with reference to the guidelines and interim targets (ITs) published by the World Health Organisation (WHO) and that a staged approach be adopted to update the AQOs with a view to achieving the WHO Air Quality Guidelines (AQGs) as a long-term goal?

Question (4): Do you agree to the proposed new AQOs which have been set with reference to a combination of WHO AQGs and ITs?

Question (5): Do you agree that a mechanism should be put in place to regularly review the AQOs no less than every five years?

Question (6): To what extent do you agree that the proposed emission control measures set out in Chapter 6 should be implemented for achieving the new AQOs and improving local air quality in general? What other measures do you think the Government should consider?

Question (7): How soon do you think these proposed emission control measures should be implemented?

Question (8): Are you willing to bear the costs arising from the implementation of the proposed emission control measures, such as higher electricity tariff and bus fares, as well as adjustments in your way of living?

Question (9): Do you have any other views on the Review?

綠色香港 我鍾意
I Love Hong Kong
I Love GREEN

Environment Bureau
Hong Kong SAR Government

Annex B

A Comparison between Hong Kong's Existing AQOs, WHO and Overseas Standards / Guidelines

Pollutant	Avg Time	Hong Kong's Existing AQOs	WHO AQGs µg/m^3	USA		EU		UK		Australia		Japan		Singapore [7]	
				µg/m^3	No. of Exceed-ences Allowed	µg/m^3	No. of Exceed-ences Allowed	µg/m^3	No. of Exceed-ences Allowed	µg/m^3	No. of Exceed-ences Allowed	µg /m^3	No. of Exceed-ences Allowed	µg/m^3	No. of Exceed-ences Allowed
Sulphur Dioxide	10-min	-	500	-	-	-	-	266 [1]	35	-	-	-	-	-	-
	1-hour	800	-	-	-	350	24	350	24	524	1	262	-	-	-
	24-hour	350	20 (IT-1: 125, IT-2: 50)[2]	365	1	125	3	125	3	210	1	105	7 [6]	365	1
	Annual	80	-	80	NA	-	-	-	-	52	NA	-	-	80	NA
Respirable Suspended Particulate (PM10)	24-hour	180	50 (IT-1: 150, IT-2: 100, IT-3: 75)	150	3 times in 3 years	50	35	50	35	50	5	100	7 [6]	150	3 times in 3 years
	Annual	55	20 (IT-1: 70, IT-2: 50, IT-3: 30)	-	-	40	NA	40	NA	-	-	-	-	-	-
Fine Suspended Particulate (PM2.5)	24-hour	-	25 (IT-1: 75, IT-2: 50, IT-3: 37.5)	35	3-year avg of 98th percent-ile	-	-	-	-	25 [3]	NA	-	-	35	3-y avg of 98th percent-ile
	Annual	-	10 (IT-1: 35, IT-2: 25, IT-3: 15)	15 [4]	NA	25	NA	25	NA	8 [3]	NA	-	-	15 [4]	NA

Pollutant	Avg Time	Hong Kong's Existing AQOs	WHO AQGs $\mu g/m^3$	USA		EU		UK		Australia		Japan		Singapore [7]	
				$\mu g/m^3$	No. of Exceed-ences Allowed	$\mu g/m^3$	No. of Exceed-ences Allowed	$\mu g/m^3$	No. of Exceed-ences Allowed	$\mu g/m^3$	No. of Exceed-ences Allowed	$\mu g /m^3$	No. of Exceed-ences Allowed	$\mu g/m^3$	No. of Exceed-ences Allowed
Nitrogen Dioxide	1-hour	300	200	-	-	200	18	200	18	226	1	-	-	-	-
	24-hour	150	-	-	-	-	-	-	-	-	-	75-113	7	-	-
	Annual	80	40	100	NA	40	NA	40	NA	57	NA	-	-	100	N
Ozone	1-hour	240	-	-	-	-	-	-	-	200	1	120	-	-	-
	4-hour	-	-	-	-	-	-	-	-	160	1	-	-	-	-
	8-hour	-	100 (High levels: 240, IT-1: 160)	147	3-year of 4th highest values	120	25	100	10	-	-	-	-	147	3-year of 4th highest values
Carbon Monoxide	15-min	-	100,000	-	-	-	-	-	-	-	-	-	-	-	-
	30-min	-	60,000	-	-	-	-	-	-	-	-	-	-	-	-
	1-hour	30,000	30,000	40,000	1	-	-	-	-	-	-	23,000	7 [6]	40,000	1
	8-hour	10,000	10,000	10,000	1	10,000	0	10,000	0	10,000	1	-	-	10,000	1
Lead	3-month	1.5	-	1.5	NA	-	-	-	-	-	-	-	-	1.5	NA
	Annual	-	0.5	0.15 [5]	NA	0.5	NA	0.25	NA	0.5	NA	-	-	0.15 [5]	NA

Note:
[1] 15-minute average.
[2] IT stands for interim target.
[3] Advisory reporting standard only, not air quality standard.
[4] 3-year average of the weighted annual mean.
[5] Rolling 3-month average.
[6] Non-attainment only when exceeding the standard on more than two consecutive days.
[7] Singapore does not have own air quality standard. The National Environment Agency uses US NAAQS to assess the ambient air quality in Singapore.

Annex C

A Comparison between Hong Kong's Proposed New AQOs, WHO and Overseas Standards / Guidelines

Pollutant	Avg Time	Proposed New Hong Kong AQOs		WHO AQGs µg/m^3	USA		EU		UK		Australia		Japan		Singapore [7]	
		µg/m^3	No. of Exceed-ences Allowed		µg/m^3	No. of Exceed-ences Allowed	µg/m^3	No. of Exceed-ences Allowed	µg/m^3	No. of Exceed-ences Allowed	µg/m^3	No. of Exceed-ences Allowed	µg /m^3	No. of Exceed-ences Allowed	µg/m^3	No. of Exceed-ences Allowed
Sulphur Dioxide	10-min	500	3	500	-	-	-	-	266 [1]	35	-	-	-	-	-	-
	1-hour	-	-	-	-	-	350	24	350	24	524	1	262	-	-	-
	24-hour	125	3	20 (IT-1: 125, IT-2: 50)[2]	365	1	125	3	125	3	210	1	105	7 [6]	365	1
	Annual	-	-	-	80	NA	-	-	-	-	52	NA	-	-	80	NA
Respirable Suspended Particulate (PM10)	24-hour	100	9	50 (IT-1: 150, IT-2: 100, IT-3: 75)	150	3 times in 3 years	50	35	50	35	50	5	100	7 [6]	150	3 times in 3 years
	Annual	50	0	20 (IT-1: 70, IT-2: 50, IT-3: 30)	-	-	40	NA	40	NA	-	-	-	-	-	-
Fine Suspended Particulate (PM2.5)	24-hour	75	9	25 (IT-1: 75, IT-2: 50, IT-3: 37.5)	35	3-y avg of 98th percent-ile	-	-	-	-	25 [3]	NA	-	-	35	3-y avg of 98th percent-ile
	Annual	35	0	10 (IT-1: 35, IT-2: 25, IT-3: 15)	15 [4]	NA	25	NA	25	NA	8 [3]	NA	-	-	15 [4]	NA

Pollutant	Avg Time	Proposed New Hong Kong AQOs		WHO AQGs µg/m³	USA		EU		UK		Australia		Japan		Singapore [7]	
		µg/m³	No. of Exceed-ences Allowed		µg/m³	No. of Exceed-ences Allowed	µg/m³	No. of Exceed-ences Allowed	µg/m³	No. of Exceed-ences Allowed	µg/m³	No. of Exceed-ences Allowed	µg /m³	No. of Exceed-ences Allowed	µg/m³	No. of Exceed-ences Allowed
Nitrogen Dioxide	1-hour	200	18	200	-	-	200	18	200	18	226	1	-	-	-	-
	24-hour	-	-	-	-	-	-	-	-	-	-	-	75-113	7	-	-
	Annual	40	0	40	100	NA	40	NA	40	NA	57	NA	-	-	100	NA
Ozone	1-hour	-		-	-	-	-	-	-	-	200	1	120	-	-	-
	4-hour	-		-	-	-	-	-	-	-	160	1	-	-	-	-
	8-hour	160	9	100 (High levels: 240, IT-1: 160)	147	3-year of 4th highest values	120	25	100	10	-	-	-	-	147	3-year of 4th highest values
Carbon Monoxide	15-min	-	-	100,000	-	-	-	-	-	-	-	-	-	-	-	-
	30-min	-	-	60,000	-	-	-	-	-	-	-	-	-	-	-	-
	1-hour	30,000	-	30,000	40,000	1	-	-	-	-	-	-	23,000	7 [6]	40,000	1
	8-hour	10,000	-	10,000	10,000	1	10,000	0	10,000	0	10,000	1	-	-	10,000	1
Lead	3-month	-	-	-	1.5	NA	-	-	-	-	-	-	-	-	1.5	NA
	Annual	0.5	-	0.5	0.15 [5]	NA	0.5	NA	0.25	NA	0.5	NA	-	-	0.15 [5]	NA

Note:
[1] 15-minute average.
[2] IT stands for interim target.
[3] Advisory reporting standard only, not air quality standard.
[4] 3-year average of the weighted annual mean.
[5] Rolling 3-month average.
[6] Non-attainment only when exceeding the standard on more than two consecutive days.
[7] Singapore does not have own air quality standard. The National Environment Agency uses US NAAQS to assess the ambient air quality in Singapore.

Annex D

Proposed Emission Control Measures and Emission Reduction Potential

(i) Baseline Emissions (Tonnes) in 2006

Sector	**SO_2**	**NOx**	**RSP / PM_{10}**	**VOC**
Power	66,000	41,800	1,860	416
Transport	5,170	43,520	2,330	8,645
Vehicles	*956*	*21,800*	*1,810*	*8,080*
Marine (figure in brackets for local vessels)	*3,920 (682)*	*16,700 (3,994)*	*499 (179)*	*304 (91)*
Aviation	*294*	*5,020*	*21*	*261*
Industry and Others	2,660	9,530	1,675	32,198
Total	**73,830**	**94,850**	**5,865**	**41,259**

(ii) Proposed Phase I Emission Control Measures

		Emission Reduction Potential (Tonnes)			
		SO2	**NOx**	**RSP / PM_{10}**	**VOC**
Emission Capping and Control					
1.	Increase ratio of natural gas in local electricity generation to 50% together with additional emission abatement measures[1]	13,402	25,225	523	0
2.	Early retirement of aged / heavily polluting vehicles (pre-Euro, Euro I and Euro II commercial diesel vehicles and franchised buses)	0	3,102	300	184
3.	Earlier replacement of Euro III commercial diesel vehicles with models meeting latest Euro standards	0	743	75	24
4.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance (20% private cars and 10% franchised buses)	15	216	7	173
5.	Ultra low sulphur diesel for local vessels	675	0	18	0
6.	Selective catalytic reduction for local vessels	0	304	0	0
7.	Electrification of aviation ground support equipment	85	759	21	67
8.	Emission control for off-road vehicles / equipment	4	950	239	326
9.	Strengthening volatile organic compounds control	0	0	0	700
Transport Management					
10.	Low emission zones	Note [2]	Note [2]	Note [2]	Note [2]
11.	Car-free zone / pedestrianisation scheme	Note [2]	Note [2]	Note [2]	Note [2]
12.	Bus route rationalization	4	156	7	9
Infrastructure Development and Planning					
13.	Expand rail network	17	501	46	207
14.	Cycling network to major public transport hubs	0.1	2.3	0.1	0.1
Energy Efficiency Measures [3]					
15.	Mandatory implementation of Building Energy Codes	151	256	8	3
16.	Energy efficiency standards for domestic electrical appliances	84	142	4	1
17.	Light-emitting diode or equivalent alternatives for traffic signal / street lighting	3	5	0.1	0
18.	Tree planting / roof-top greening [4]	Note [4]	Note [4]	Note [4]	Note [4]
19.	District cooling system for Kai Tak Development	6	16	0.5	0.2

Baseline Emissions (Tonnes) Upon Completion of Phase I Measures

Sector	**SO2**	**NOx**	**RSP / PM_{10}**	**VOC**
Power	11,718	17,375	737	420
Transport	4,910	38,048	1,933	6,040
Vehicles	*263*	*9,354*	*1,262*	*5,257*
Marine	*4,263*	*21,380*	*658*	*436*
Aviation	*384*	*7,314*	*13*	*348*
Industry and Others	12	3,658	385	23,104
Total	**16,640**	**59,080**	**3,055**	**29,564**

(iii) Proposed Phase II Emission Control Measures

		Emission Reduction Potential (Tonnes)			
		SO2	**NOx**	**RSP / PM_{10}**	**VOCs**
Emission Capping and Control					
20.	Increase the ratio of natural gas in local electricity generation to 75% with additional abatement measures (Additional to Phase I measure)	5,163	5,761	178	0
21.	Increase ratio of renewable energy (2% wind energy)	502	852	25	8
22.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance [30% private cars, 15% buses (including franchised buses), 15% light goods vehicles (LGVs) plus 15% heavy goods vehicles (HGVs)] (Additional to Phase I measure)	40	849	79	174
23.	Ultra low sulphur diesel for ocean-going vessels and local vessels (Additional to Phase I measure)	2,392	1,145	15	0
24.	Selective catalytic reduction for ocean-going vessels and local vessels (Additional to Phase I measure)	0	7,153	0	0
25.	Electrification of on-shore power supply	377	2,361	297	404
26.	Tightening aviation emission standards	0	3,587	0	0
27.	Further strengthening volatile organic compounds control	0	0	0	4,870
Transport Management					
28.	Electronic road pricing (ERP) / congestion charging scheme for Hong Kong Island North	Note [5]	Note [5]	Note [5]	Note [5]
29.	Reduce parking provision (25%) to restrain car usage for Central	Note [6]	Note [6]	Note [6]	Note [6]
Energy Efficiency Measures [3]					
30.	District cooling system (35% in existing areas and 90% in other new development areas)	120	197	5.5	1.9

Baseline Emissions (Tonnes) Upon Completion of Phase II Measures

Sector	**SO2**	**NOx**	**RSP / PM_{10}**	**VOC**
Power	6,053	10,762	534	412
Transport	2,861	28,317	1,760	5,442
Vehicles	*270*	*9,722*	*1,284*	*4,900*
Marine	*2,124*	*13,450*	*457*	*122*
Aviation	*466*	*5,145*	*19*	*421*
Industry and Others	11	3,682	386	18,865
Total	**8,925**	**42,761**	**2,679**	**24,719**

(iv) Proposed Phase III Emission Control Measures

		Emission Reduction Potential (Tonnes)			
		SO2	**NOx**	**RSP / PM_{10}**	**VOC**
Emission Capping and Control					
31.	Increase ratio of natural gas in local electricity generation to 100% (Additional to Phase II measure) [7]	6,553	7,430	270	0
32.	50% nuclear power and 50% natural gas (Alternative Case compared to Base Case of 75% natural gas) [7]	6,554	8,422	381	210
33.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance (50% private cars, 50% buses (including franchised buses), 50% HGVs plus 50% LGVs) (Additional to Phase II measure)	63	789	42	232
34.	Vehicle permit quota system (to reduce around 50% private cars and 50% motorcycles)	28	93	3	119
35.	Use of hydrogen fuel eell vehicles or equivalent alternatives (not less than 40% penetration)	140	2,778	94	1,453
Infrastructural Development and Planning					
36.	Rail for transport of cross-boundary goods	1	11	1	9

Baseline Emissions (Tonnes) Upon Completion of Phase III Measures

Sector	**SO2**	**NOx**	**RSP / PM_{10}**	**VOC**
Power	0	2,340	153	202
Transport	3,952	29,515	1,894	4,000
Vehicles	*101*	*5,466*	*1,195*	*3,276*
Marine	*3,385*	*18,904*	*680*	*303*
Aviation	*466*	*5,145*	*19*	*421*
Industry and Others	10	3,770	391	20,083
Total	**3,962**	**35,626**	**2,437**	**24,285**

Notes:

[1] Possible additional emission abatement measures include enhancing the selective catalytic reduction (SCR) systems of the existing coal-fired units. However, the technical feasibility and financial viability of retrofitting the existing coal-fired units with enhanced SCR systems are not yet established and subject to more detailed examination with the concerned power company.

[2] Emission reduction potential would not be substantial as it involves mainly transferring emission from one place to another.

[3] Benefits include material damage, energy saving, acute and chronic health benefits. For strategies 15, 16, 17 and 19, the majority of benefits are due to energy savings, not health benefits. Emission reduction of energy efficiency measures is generated from less electricity demand. To be conservative, they have not been included in the net total emission reduction.

[4] The proposed measures help reduce urban heat island effect and improve the air pollution dispersion. No local emission and cost data are available. Estimates are based on overseas data for roof top greening of 10% of the urban area.

[5] The ERP strategy will have additional ride-on effect on improvement of air quality. The overall emission reduction potential would not be substantial. The ERP measure will have incidental improvements to air quality. Only these benefits have been calculated here. The estimated cost for the proposed ERP scheme is about HK$1 billion (including the cost of in-vehicle units for existing vehicles) with an annual recurrent cost of about HK$200 million.

[6] Emission reduction potential would not be substantial as it involves mainly transferring emission from one place to another.

[7] The "increase ratio of natural gas in local electricity generation to 100%" scenario and "50% nuclear & 50% natural gas" scenario are either-or case. Adoption of only one of these measures would be expected.