For Information

Legislative Council
Panel on Environmental Affairs

Improving Air Quality in Pearl River Delta Region

Introduction

In September 1999, the Hong Kong Special Administrative Region (HKSAR) Government and the Guangdong Provincial Government jointly commissioned a study on Pearl River Delta Regional Air Quality to identify the major sources of air pollution in the Pearl River Delta (PRD) Region, to make trend forecasts and to recommend long-term measures to improve regional air quality. The study has been completed.

2. At a meeting held on 29 April 2002, the Hong Kong/Guangdong Joint Working Group on Sustainable Development and Environmental Protection considered the study report. The two Governments reached a consensus to implement long-term measures to improve air quality in the Region.

3. This paper sets out the findings of and measures recommended in the study, and the consensus that the two Governments have reached.

Findings of the Study

4. The Executive Summary of the study report is at the Annex. A full set of the report has been deposited with the Secretariat of the Legislative Council and may be viewed or downloaded from the website of the Environmental Protection Department at http://www.info.gov.hk/epd.

5. The study shows that air quality in the PRD Region has been deteriorating, as evidenced by a decline in visibility due to smog. The smog phenomenon is caused by very fine particles formed in the atmosphere by complex chemical reaction among ozone, nitrogen oxides (NOx), sulphur dioxide (SO_2) and volatile organic compounds (VOC). Ozone is not emitted directly from any source; it forms under sunlight when NOx react with VOC. Other than poor visibility, high concentrations of ozone may cause eye irritation and aggravate respiratory illnesses. Very fine respirable suspended particulates (RSP) weaken lung function, aggravate respiratory illness and increase lung cancer risk. Therefore, to reduce smog, improve visibility and protect public health, it is necessary to reduce emissions of SO_2, NOx, RSP and VOC.

6. Using 1997 as a base, the study anticipates that the regional economy, population, electricity consumption and traffic would grow by 150%, 20%, 130% and 190% respectively by 2010. Under these growth trends, air quality in the Region will deteriorate unless the two Governments implement improvement measures in addition to those that they have implemented or are committed to implementing. This is because existing and committed measures would only improve local air pollution problems. To tackle the regional air pollution problem, which is caused by both local and regional emission sources, the concerted effort of the two Governments in implementing additional improvement measures would be required.

7. If the two Governments do not jointly implement additional measures, the regional emission of SO_2, NOx, RSP and VOC would increase by 53%, 34%, 34% and 25% respectively (using 1997 as a base). Visibility would also become a more serious problem.

8. If the two Governments implement the measures recommended in the study, the regional emissions of SO_2, NOx, RSP and VOC would be reduced by 40%, 20% 55% and 55% respectively. If this overall emission reduction potential is realised, Hong Kong would meet its current air quality objectives. Cities in the PRD Economic Zone would also meet the relevant national air quality standards for SO_2, NOx and RSP. The problem of ozone will remain in the PRD Economic Zone but will become much less serious than at present. The study indicates that technically, the two Governments could achieve the emission reduction targets in 2010 at the earliest.

Measures Recommended in the Study

9. The study recognizes that motor vehicles and power plants are the major emission sources of RSP and NOx in Hong Kong and that the bulk of VOC emissions come from printing operations and consumer products containing VOC. It acknowledges the effectiveness of the measures already in place and to which we are already committed, and that we cannot do much more to reduce emissions from motor vehicles. To achieve the emission reduction targets, we will have to take the following actions –

(a) reduce VOC emissions from sources such as printing operations and consumer products including paints and aerosol sprays of various kinds; and

(b) use cleaner fuel for power generation in order to reduce SO_2, NOx, and RSP emissions in Hong Kong.

10. The study identifies major emission sources in PRDEZ to be power plants, motor vehicles and industrial operations. To achieve the emission reduction targets, it recommends that the Guangdong Provincial Government should take the following measures –

(a) reduce emissions from power plants through transmission of hydro-electricity from the west, using natural gas instead of coal as fuel and upgrading existing plants;

(b) reduce motor vehicle emissions through speeding up the tightening of motor fuel and vehicle emission standards; and

(c) reduce industrial emissions through targeting the most polluting industrial processes and requiring their upgrading or the installation of control equipment.

11. The study recommends that the two Governments should examine the implementation of the proposed measures in detail with regard to local circumstances.

Consensus Reached

12. Having considered the findings and proposed measures in the study report, the HKSAR Government and the Guangdong Provincial Government have agreed that –

(a) the two Governments would aim to reduce, on a best endeavour basis, the regional emissions of SO_2, NOx, RSP, and VOC by 40%, 20%, 55% and 55% respectively by 2010, using 1997 as the base year;

(b) to achieve the emission reduction targets set out in (a) above, the two Governments would, on a best endeavour basis, aim to strive to reduce by 2010 the emissions of the four air pollutants from their own sources by the same levels;

(c) the two Governments would jointly draw up a regional air quality management plan and assign the responsibility for coordinating and monitoring progress of the improvement measures to the departments concerned which will in turn report to the Hong Kong/Guangdong Cooperation Joint Conference; and

(d) the two Governments would set up an expert group comprising representatives of the Environmental Protection Department (EPD) of

the HKSAR and the Guangdong Environmental Protection Bureau to monitor jointly trends and changes in regional air quality and evaluate the effectiveness of the improvement measures. The expert group will also be responsible for training relevant personnel of the two Governments, exchanging technical know-how and keeping in view the feasibility of introducing new technologies and measures.

13. The Administration will arrange with the Clerk to the Panel to brief Members more fully on the study report on a later date.

Environment and Food Bureau
29 April 2002

1 INTRODUCTION

1.1 Background

The economic and population growth have been tremendous in the past decades, both within the Hong Kong Special Administrative Region (HKSAR) and in the Pearl River Delta Economic Zone (PRDEZ). This has resulted in deteriorating air quality within the entire Pearl River Delta Region (the Region).

The poor air quality at street level within the HKSAR is caused primarily by the high volume of traffic. The regional air quality problem, as evidenced by the poor visibility, high levels of respirable suspended particulates and ozone episodes becoming more frequent, is not only caused by emissions from motor vehicles, but also from power stations and industries both within the HKSAR and in the PRDEZ.

The control of street level pollution can be achieved by independent action within the HKSAR and the situation has improved significantly with recent efforts in the control of vehicular emissions. However, the control of regional air pollution requires a concerted effort by both the HKSAR and the Guangdong Governments since this pollution is caused by sources in the Region.

With this in mind, the Environmental Protection Department (EPD) of HKSAR Government and the Guangdong Province Environmental Protection Bureau (GDEPB) agreed to join forces to study the regional air pollution problem with a view to developing effective control strategies. The EPD commissioned CH2M HILL (China) Limited to undertake the Study of Air Quality in the Pearl River Delta Region (the Study) which started in October 1999.

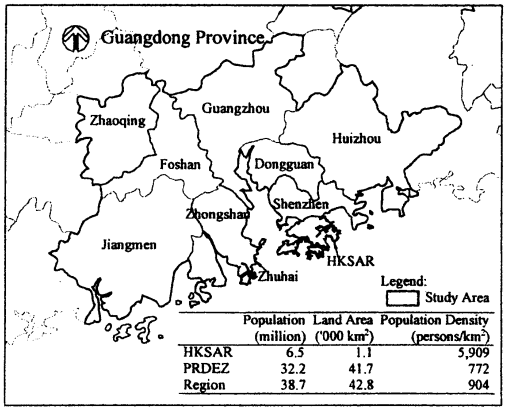
The objective of the Study is to investigate the air pollution problems in the Region with particular reference to ozone (O_3), respirable suspended particulates (RSP), and nitrogen dioxide (NO_2) which are the regional pollutants of concern. As a precursor of O_3 formation, volatile organic compounds (VOC) are also considered together with the regional pollutants in the investigation of possible measures to be carried out by the two Governments to improve regional air quality.

2 THE STUDY

2.1 The Study Area

The study area comprises the whole territory of the HKSAR and the PRDEZ including Guangzhou, Shenzhen, Zhuhai, Dongguan, Zhongshan, Foshan, Jiangmen, and part of Huizhou and Zhaoqing. Figure 2-1 illustrates the boundary of the Study area.

Figure 2-1 Boundary of the Region for the Study



	Population (million)	Land Area ('000 km²)	Population Density (persons/km²)
HKSAR	6.5	1.1	5,909
PRDEZ	32.2	41.7	772
Region	38.7	42.8	904

2.2 Study Approach

To understand current air quality in the Region – analyze existing air quality data obtained from regular monitoring network in the Region and also from additional data collected in this study.

To understand the sources of air pollution – use 1997 as base year and compile an emission inventory using the best available information obtained from official sources with methodologies widely accepted by developed countries and international organisations, with adjustment for local peculiarities.

To predict future air quality – estimate future levels of emission by projecting the emissions in the Region according to economic growth trends and development figures. With a comprehensive air quality modeling system developed by EPD, the future air quality scenarios are predicted.

To determine the direction of further control – consider the current and committed air pollution control measures in the Region and the overseas experience in controlling regional air pollution and suggest possible measures for effective regional air quality improvement.

2.3 Regional Pollutants and Air Quality Standards

The regional air pollutants of concern in this Study include O_3, RSP and NO_2. Their ambient air quality standards in the Region are presented in Table 2-1.

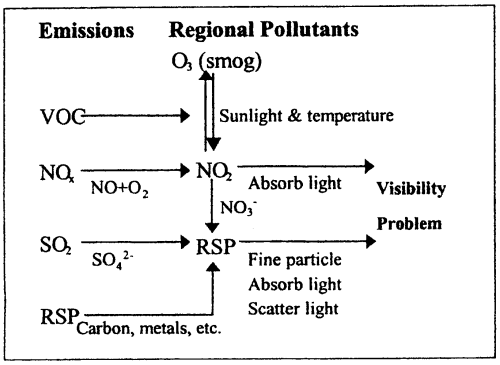
Table 2-1 Ambient Air Quality Standards in the Region

Region	Pollutant	Concentration limit for different Averaging Times (μg/m³)		
		1-hr	24-hr	1 yr
HKSAR Hong Kong Air Quality Objective (HKAQO)	O_3	240 (2)	-	-
	RSP	-	180 (3)	55
	NO_2	300 (2)	150 (3)	80
PRDEZ National Ambient Air Quality Standard (1) (NAAQS)	O_3	200	-	-
	RSP	-	150	100
	NO_2	240	120	80

(1) Class 2 NAAQS is applicable to residential, urban, commercial, industrial, and village areas in the Mainland
(2) 1-hr objectives are not to be exceeded more than 3 times/yr in HKSAR
(3) 24-hr objectives are not to be exceeded more than once/yr in HKSAR

There are no air quality objectives or standards for VOC. It is included in this study as reactive VOC plays an important role in photochemical reaction and ozone formation. Figure 2-2 is a simple schematic chart showing the relationships of anthropogenic emissions and regional pollutants.

Figure 2-2 Formation Processes of the Regional Air Pollution



Ozone is formed under a complex chain of chemical reactions in the presence of sunlight and warm temperatures involving a host of precursors, the key ones being oxygen, nitrogen oxides (NO_x), and reactive VOC. RSP comprises particles with a nominal aerodynamic diameter of 10 micrometers or less. Others, such as sulphates and nitrates, are formed from sulphur dioxide (SO_2) and NO_x, as they get involved in chemical reactions in the atmosphere. NO_2 is formed primarily from nitric oxide emitted from combustion sources. It is also a product of photochemical smog.

2.4 Air Quality in the Region

Compliance with objectives or standards

In HKSAR, non-compliance of the HKAQO in 2000 for hourly O_3 and annual RSP was observed at 1 air monitoring station. Non-compliance of the daily RSP objective occurred at 2 air monitoring stations in the same year.

In PRDEZ, there were individual monitoring stations exceeding the NAAQS in discrete periods in 2000. Exceedances of the hourly O_3 standard, hourly and daily NO_2 standards, and daily RSP standard were recorded. The highest hourly O_3 recorded was 2.3 times the Class 2 NAAQS, while the highest daily RSP recorded was 2.4 times the Class 2 NAAQS.

Air Quality Trends

The trends show that in HKSAR O_3 levels have increased by about 39% while NO_2 levels by 26% since 1991, whereas RSP concentrations have decreased over the same period by 8%. Moreover, due to the air quality problem, the percentage of time of having poor visibility in HKSAR has increased threefold approximately.

The long-term data to demonstrate pollution trends in the PRDEZ were not available. Instead, the visibility trends in some cities in the Region have been used as a surrogate for air pollution. In Shenzhen and Guangzhou, the percentage of time with poor visibility in the late 1990s was 9 times and 5 times of that in 1991 respectively.

Characteristics of Regional Air Pollution

The sources of RSP in the atmosphere can be primary, directly injected into the atmosphere, or secondary, formed in the atmosphere by gas-to-particle conversion processes. The secondary pollutants of RSP comprise mainly fine particles of sulphate, nitrate, and ammonium particles. Secondary pollutants of RSP, by nature of the atmospheric chemical formation processes, are regional in nature. About 26% to 33% of RSP observed at all monitoring sites is secondary in nature and is subject to long distance regional transport.

The annual regional background RSP and NO_2 concentrations are about 40μg/m^3 and 12μg/m^3 respectively. This regional background RSP concentration is significant. It is equivalent to about 70% of the 1-year HKAQO and about 40% of the 1-year Class 2 NAAQS.

The O_3 pollution in the region can exhibit a strong regional nature. Days with high O_3 concentrations in Hong Kong concurred with high O_3 concentrations in Foshan and Shenzhen, where data were available. This is caused by the fact that often the Region is subject to the same meteorological conditions responsible for the transport and mixing of O_3 and O_3 precursors throughout the Region.

Seasonal Variability and Weather

Air pollution episodes occur under special meteorological conditions. In the Region, O_3 values are generally high in late spring and early autumn while RSP and NO_2 concentrations tend to be high in winter. Elevated regional air pollution levels are associated with stagnating high-pressure systems. For O_3, however, there are two other ingredients, sunshine and warm temperatures. Lower levels of all three pollutants in the summer can be attributed to strong convective instability and the high rainfall associated with the summer monsoon.

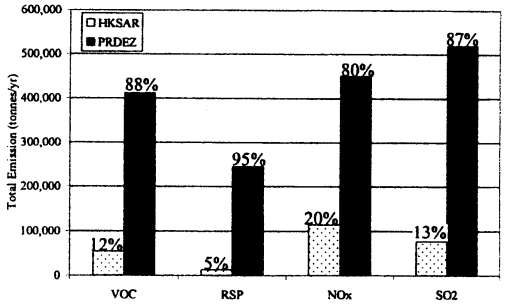
2.5 Emission Inventory of the Region

Base Year Emission Inventory

The key regional pollutants, namely RSP, NO_X, SO_2 and VOC, are inventoried in this Study. They are targets for emission reduction as part of the overall control strategy for regional air quality improvement. Ammonia (NH_3) contributes to secondary RSP formation and is also inventoried.

The year 1997 is used as the base year for the emission inventory as data on PRDEZ are more readily available. For HKSAR, the emission inventory is developed from EPD data while for PRDEZ, data have been provided primarily by the Guangdong Province Environmental Protection Monitoring Center (GPEMC) of the GDEPB and reviewed by Mainland experts. Figure 2-3 is a summary of the base year emission inventory for HKSAR and PRDEZ, excluding the biogenic VOC emissions in the Region.

Figure 2-3 Base Year Emission Summary



Emissions from PRDEZ contribute to 88%, 95%, 80% and 87% respectively of the regional emissions of VOC, RSP, NO_X and SO_2. This tallies with the industrial activities and population in PRDEZ which are about 5 times those of HKSAR. The total emission of regional pollutants is about 40 kg/capita in HKSAR and 50 kg/capita in PRDEZ.

Table 2-2 summarizes the contribution of major emission sources in the Region. Emissions from the four major sectors are about 90% of the regional emission.

Table 2-2 Contributions of the Major Sectors to the Regional Base Year Emission Inventory

Emission	VOC	RSP	NO_x	SO_2
Energy	1%	15%	42%	54%
Industry	11%	60%	13%	39%
Motor Vehicle	55%	14%	31%	4%
VOC Containing Product	23%	0%	0%	0%
Total	90%	89%	86%	97%

Future Years Emission Inventory for the Region

The emission inventories for years 2000, 2005, 2010, and 2015 are projected from the emission inventory for the base year. These projections have taken into account predicted economic growth in the Region and the effects of control measures committed by the governments before June 2000.

The future economic growth has been estimated from different indicators obtained from official forecasts, and from historical trends including Gross Domestic Product (GDP), population, land-use patterns, infrastructure development, transportation statistics, and energy generation. The estimated growth in GDP and population is presented in Table 2-3.

Table 2-3 Estimated growth in GDP and Population

Indicator	Entity	Base Year	Projected Years			
		1997	2000	2005	2010	2015
GDP (HK$ billion)	HKSAR	1318	1440	1838	2291	2787
	PRDEZ	481	694	1223	2156	3632
Population (million people)	HKSAR	6.5	6.9	7.3	7.7	8.1
	PRDEZ	32.2	33.3	35.7	38.2	40.9

Without additional control measures, the estimated future emissions from different sectors are expected to increase significantly by 2015 (Figure 2-4). Emissions of the key pollutants are predicted to grow by 36% to 75% overall in the Region. In HKSAR depending on the pollutant, emissions would increase by 5% to 76%, while in PRDEZ, emissions would increase by 30% to 80%.

In general, emission loadings increase as the activity of the emitter (or its projection surrogate) increases. With motor vehicles, however, vehicular emissions are projected to decrease steadily from 2000, even though the vehicle kilometers traveled are projected to increase steadily and would increase by 107% and 291% in HKSAR and PRDEZ respectively from 1997 to 2015. This illustrates the effectiveness of vehicular emission control strategies committed by the two Governments.

Improvements in technology and the implementation of control measures already committed by the two Governments in the Region will slow down those emission growth rates of emissions from the other sectors. Yet this is not sufficient to prevent emissions from increasing from present levels. In other words, air quality is bound to deteriorate in the future if no additional efforts were made to further reduce emissions.

2.6 Possible Control Measures for Improving Air Quality in the Region

The identified sectors responsible for the majority of the VOC, RSP, NO_x, and SO_2 emissions in the Region are Energy, Industry, Motor Vehicle, and VOC Containing Product.

The additional measures suggested below are based primarily on direct effectiveness, followed by technological availability as evident from successful implementation in other parts of the world. These suggestions have gone through preliminary socio-economic analysis. Opinions from key trade sectors were sought and desktop estimates of cost were calculated. These possible measures are reasonable engineering methods to reduce pollution. The two Governments have to examine their implementation in detail with regard to local circumstances.

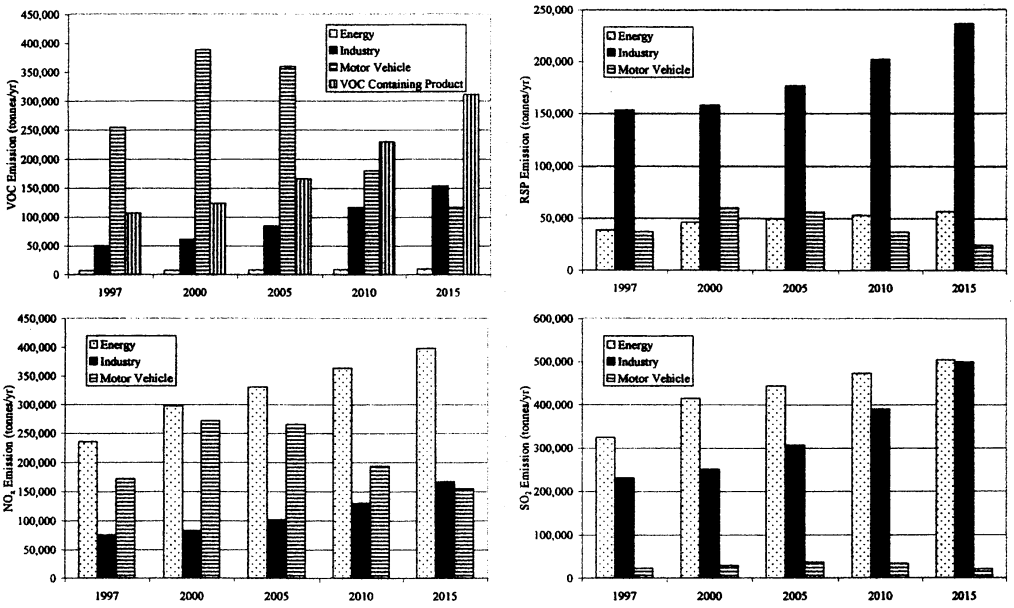
The following description covers the major sectors contributing to overall air pollution. Continual review of the control measures and the ever-changing technologies will be essential to ensuring significant air quality improvements at least costs, and with public acceptance.

Energy sector

For HKSAR, it is suggested that cleaner fuel be used for power generation to reduce the amount of pollutants generated.

For PRDEZ, the use of control equipment including flue gas desulphurisation, low NO_X burners and electrostatic precipitators for RSP is suggested. Changes of fuel mix to cleaner fuel for power generation purposes are also suggested. In addition, more electricity should be acquired from western provinces. The fuel quality for domestic and commercial uses should also be improved. These measures should be coupled with more stringent emission limits for enhanced effectiveness. Alternate energy such as hydroelectric power, wind energy, solar energy and geothermal energy should be explored.

Figure 2-4 Estimated VOC, RSP, NO_x and SO_2 Emission Trends in the Region without Additional Control Measures



Industry sector

HKSAR has already adopted stringent planning and industrial emission control measures. Continuous review and update of the control measures is required to cater for local changes and international practices. An area to be strengthened is the control on VOC emissions from printing and service station refuelling processes.

The emissions from the industry sector in PRDEZ are in two tiers, namely fuel combustion and production process. Both involve the promotion of use of cleaner production technology. The control measures suggested for the fuel combustion portion are similar to those for the energy sector. The use of control equipment including flue gas desulphurisation, low NO_X burners and electrostatic precipitators is suggested. For the process portion RSP and VOC need to be targeted and process control equipment installed. VOC control over chemical works, fuel handling, and printing are also essential since there are currently no control measures in place. Furthermore, the enforcement of emission regulations will be necessary.

Motor vehicle sector

HKSAR has already implemented a stringent vehicle emission control programme that will reduce 80% of the RSP and 30% of the NOx emissions from motor vehicles by 2005. HKSAR has also a plan to continue tightening the vehicle emission standards in accordance with international time tables. Notwithstanding these achievements, HKSAR should continue to expand environmentally friendly transportation in its strategic plan for the long-term benefit of HKSAR. The Government should continue to monitor closely the development of alternative fuel vehicles and other environmental friendly transportation modes and where practicable, consider their introduction to HKSAR. The provision of efficient and affordable public transportation such as railway is considered effective in reducing emissions.

For PRDEZ, the improvement in vehicle engine technology as well as fuel quality should be accelerated to comply with more advance emission standards – such as achieving Euro III by the 2005/6 prescribed schedule, and ultimately in line with the international emission standards. The introduction of

newer inspection and maintenance techniques would also be necessary to complement the advancement in emission standards. PRDEZ could consider limiting the increase in polluting vehicles. It is also suggested that PRDEZ explore the use of alternative fuel vehicles. The PRDEZ has the advantage of being at a relatively early stage of economic development to consider the adoption of an environmentally friendly transportation plan which could harness the lessons learnt from the developed economies of the world.

VOC containing consumer products sector

Common VOC sources include paints and VOC containing domestic products for household and cosmetic use. To reduce VOC emissions in the Region, it is necessary to have a product labelling system on VOC containing products and set VOC content limits for these products. At the same time the public should be made aware of the VOC emissions associated with using these products.

Potential Emission Reduction

With the above additional control measures adopted, it is estimated that the overall reduction of VOC by 54%, RSP by 55%, NO_X by 20%, and SO_2 by 39% from 1997 base year emissions could be achieved technically by 2010 the earliest.

The ambient air quality in the Region following implementation of the additional control measures is predicted with air quality modeling. Modeling results show that other than a small number of local hot spots, all current objectives for O_3, RSP, and NO_2 would be met in HKSAR in the future and that all standards for RSP and NO_2 would be met in PRDEZ. The local hot spots are likely to be caused by motor vehicle emissions. The O_3 standard in PRDEZ would still not be achieved over a large area under special meteorological conditions for which the chances of occurrence would be reasonably low. All in all there would be a significant improvement in the Region.

3 CONCLUSION AND RECOMMENDATIONS

3.1 Study Conclusions

Key findings of the study are further summarized as follows:

In 2000, there were individual monitoring stations in HKSAR and PRDEZ that did not comply with respective HKAQO or Class 2 NAAQS in discrete period.

In HKSAR, O_3 and NO_2 levels have increased by about 39% and 26%, respectively, since 1991 while RSP levels have decreased by 8%. In HKSAR, Shenzhen and Guangzhou, the percentage of time with poor visibility in the late nineties was 3 times, 9 times and 5 times of those in 1991 respectively.

Regional emissions of VOC, RSP, NO_X, and SO_2 are estimated to increase from 1997 to 2015 by 36%, 45%, 40%, and 75%, respectively even with committed air pollution control measures by the two Governments.

While emissions are projected to increase for most sources, vehicular emissions are projected to decrease steadily from 2000 despite a steady increase in the number of vehicles and the vehicle kilometers traveled.

Additional control measures for four major source categories: energy, industry, motor vehicle and VOC containing product, are recommended in order to achieve improvement in regional air quality.

Technically speaking, these additional control measures can achieve by 2010 the earliest the reduction of the overall emissions of VOC by 54%, RSP by 55%, NO_x by 20%, and SO_2 by 39%. Modeling results have shown that other than a small number of local hot spots, HKSAR will meet all HKAQO. PRDEZ will also meet all Class 2 NAAQS for RSP and NO_2. There will still be exceedances of the O_3 standard over a large area under infrequent meteorological conditions but the chances of occurrence will be reasonably low.

3.2 The Way Forward

The conclusions drawn from this study clearly show that the efforts to improve air quality in the Region are a mammoth task. It will take the commitment, devotion and collaboration of the two Governments to make it work. The first criterion is to provide institutional set up for the two Governments to work together with a well defined mandate or terms of reference followed by an intense programme for capacity building, technology transfer and training.

This joint effort on air quality should be led by high level officials and its activities should have the full support of the two Governments.

Specifically, the co-operation among the two Governments should cover the following functions:

- ***Establishment of goals for the improvement of regional air quality.*** The establishment of goals specifying the desired level of improvement in air quality in terms of pollutant levels, visibility, etc, in a practicable timeframe.
- ***Design a Regional Air Quality Management Plan to achieve the goals.*** The Regional Air Quality Management Plan will lay down specific milestones to achieve various goals within a practicable time frame. The Plan should state the obstacles and major criteria for achieving the goal. Future evaluation of the proposed control measures based on economic viability, legislative requirement, public acceptability, implementation programme, and effectiveness will be required. An independent auditing mechanism could be considered to monitor the implementation status and effectiveness of the control measures. Public awareness programme will also give impetus to the achievement of goals.
- ***Establishment of a system to track new technology and options for controlling air pollution.*** As pointed out in this study, there are at present no practicable control measures that would permit attainment of the O_3 standard in PRDEZ. As control technology evolves, other control measures that might become feasible and practicable should be considered. Furthermore, the principles of emission offset or trading could be explored with collaboration between the two Governments as well as amongst the industrial entities.
- ***Establishment of a system to update the regional air quality emissions inventory.*** As air pollution control measures are implemented, the emission inventory developed under this study needs to be updated to reflect the effect of the control measures. This inventory will also serve as a guide for monitoring the effect of control measures and ensuring that they are adequate for achieving the goals set in the plan.
- ***Establishment of a regional air quality monitoring network.*** The air quality monitoring network will help to fill in the gaps that currently exist on our understanding of the spatial and temporal variability of regional air quality, its trend, as well as the meteorological conditions affecting regional air quality. This will also allow effectiveness of air pollution control measures to be quantified.