TECHNICAL ANNEX 6

Selection of the Regional Air Quality Control Measures

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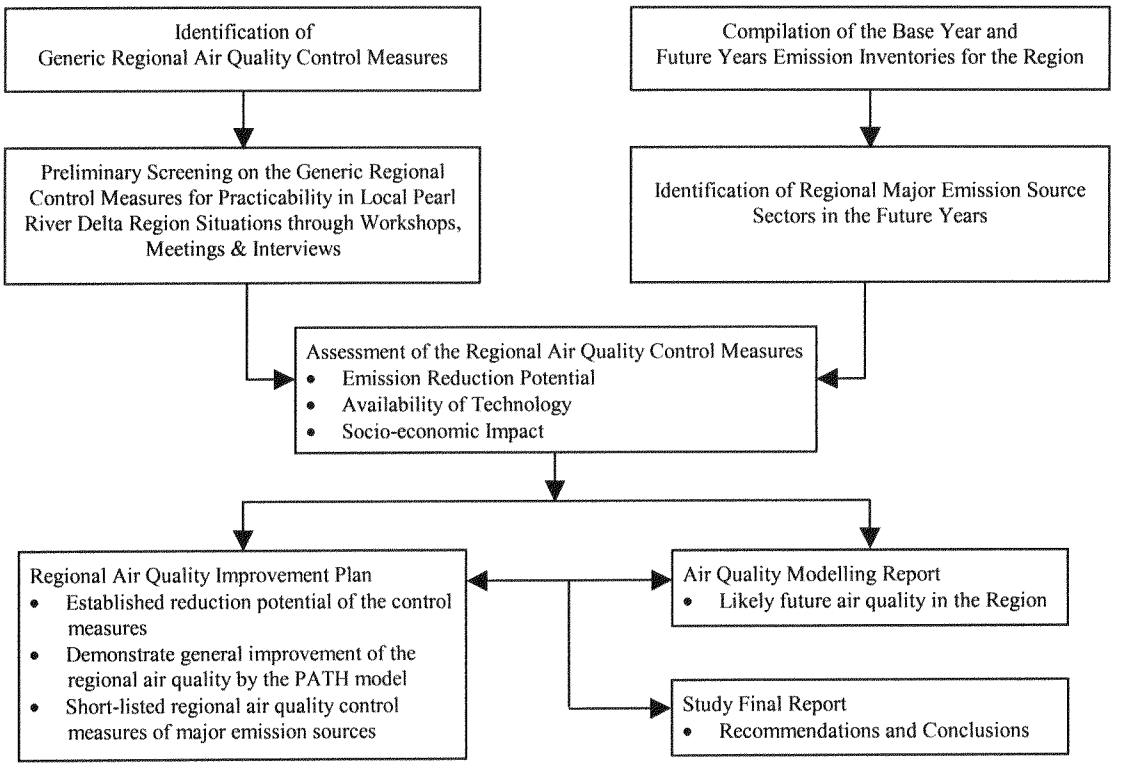
1. METHODOLOGY FOR THE SELECTION OF CONTROL MEASURES

1.1 Introduction

1.1.1 There are a series of screening procedures in the selection of the practicable and effective control measures for improving regional air quality. Figure 1-1 indicated the assessment sequence for short-listing the control measures for this study.

Figure 1-1 Assessment Sequence for the Selection of Regional Air Quality Control Measures



1.2 Identification of Generic Regional Air Quality Control Measures

1.2.1 There have been more control technologies and policy instruments developed in the western countries with respect to pollution control than in this Region. A list of worldwide control measures was compiled and extracted from references including air pollution control engineering handbooks, government environmental agencies web sites, official and governmental publications on air pollution controls, and conventional legally binding instruments. Nevertheless, successfully implemented control measures elsewhere may not be equally practicable for the Region due to local technical, policy and economic considerations.

1.2.2 A Technical Note "Proposed Regional Air Quality Control Measures" was prepared and submitted to the Steering Group members for information at early stage of the Study with an aim to summarise a generic set of regional air quality control measures based on reviewing of existing control measures implemented worldwide. This Technical Note provided a direction of the proposed regional air quality control measures for initialising discussions among relevant authorities and departments within the Region, which formed the bases for preliminary screening exercise to be carried out.

1.2.3 This preliminary screening exercise was performed through discussions with relevant government officials as well as stakeholders during the course of the Study. The screened set of control measures would then undergo further analysis based on a set of assessment criteria in this Technical Annex to form the short-listed control measures for which the PATH model would then be used to demonstrate their effects.

1.3 Selection Criteria for Evaluating the Short-listed Regional Air Quality Control Measures

1.3.1 An evaluation scheme based on 3 important considerations: emission reduction potential, availability of technology and socio-economic impact has been formulated for the selection of practicable control measures for the Region. By going through these 3 considerations, the short-listed control measures are not only technically feasible in emission reduction and implementation but also suitable for local situations in HKSAR and PRDEZ. However, the feasibility of implementing these measures may need more detailed assessment by the two Governments. The following are the selection criteria of the three considerations for the short-listed control measures.

1.3.2 Emission reduction potential: The total amount of pollutant that could possibly reduced by a control measure;

1.3.3 Availability of Technology: The likelihood of a control measure being available locally or worldwide to reduce the emission

1.3.4 Socio-Economic Considerations

- Output levels and value: Operation scale of the existing premises due to the implementation of the control measures;
- Prices of inputs and outputs: The cost on the operation of the premises;
- Cost-Effectiveness: The overall cost of a control measure in reducing one unit of emission. The cost shall include initial design, installation, commissioning, general maintenance and operation of the measures;
- Competitiveness: The fairness of a control measure (benefit or loss) being distributed among the relevant socio-economic groups;
- Cross boarder issues: The impact of the control measures among on the Governments on both side;
- Administrative and Implementation issues: The possibility of the control measure being enforced by the responsible government agency and adopted by the user;
- Employment: The changes in sectors likely to become more or less competitive, and employment creation potential in local environmental industries;
- Future operation: The impact on the future operation of the emission sector after the implementation of the control measures

1.3.5 The emission reduction potential and availability of technology of a control measure were referenced to publications and official reports. The consideration for the socio-economic impact was collected through a socio-economic impact assessment with details presented in Section 1.4.

1.4 Methodology for the Preliminary Socio-Economic Impact Review

1.4.1 A Technical Note "Methodology Report on Preliminary Socio-Economic Impact Review" setting out the proposed approach for the assessment had been prepared. Data for the assessment had been collected through literature review, direct interviews and a questionnaire survey carried out in Guangdong Province and HKSAR.

1.4.2 The direct interviews took place on 26 May 2000 in Hong Kong and on 29 May 2000 in Guangzhou. In Hong Kong, consultation meetings were arranged with CLP Power Limited and the Hongkong Electric Co Ltd. In Guangzhou, meetings were held with Guangdong Province Environmental Monitoring Centre (GPEMC) and representatives of large state-owned and joint-venture companies from the four most polluting industrial sectors: Cement production, Electricity generation, Printing and Surface Coating. The Guangzhou Research Institute of Environmental Protection Science (GRIEP) was also one of the interviewees.

1.4.3 Based on the results of the initial consultations, a questionnaire survey was designed and conducted, however, the response rate in Guangdong Province was disappointing. There were two main reasons for the poor response rate. The first was that there were several questions on the operation of businesses, which are generally considered confidential or proprietary information; companies were therefore unwilling to divulge this information to an outside party. Secondly, the Consultant team did not have the legal right to demand such confidential information in PRDEZ.

1.4.4 In HKSAR, questionnaires have been sent to about 35 transport operators/industry associations and direct interviews with a limited number of major transport operators/industry associations were set up during November and December 2000 to collect information on existing and planned air pollution control measures and their views on the air pollution control measures as presented in the control measures.

1.4.5 In view of the limitations in gathering original impact survey data, the assessment was largely qualitative and preliminary. In recognition of the lack of local information, international case studies had been reviewed to provide more comparative and indicative information for the Study. Detailed assessments were recommended in the future to review and verify the adequacy of local data when formulating the implementation schedule of the control measures.

1.5 Approach of the Short-listing of Control Measures

1.5.1 A scoring system based on the three considerations had been used for the selection of practical regional air quality control measures for this Study, which then a judgement on the overall benefits from the implementation of a measure could be derived. A control measure was recommended for implementation if its total score were the highly positive within the emission sector.

1.5.2 The emission reduction potential of a relevant pollutant in an emission sector was estimated by the Consultant with reference to information obtained from the official reports and technical journals. The score for emission reduction potential of a pollutant from a control measure under consideration is ranged from 'low (-2) (below 15%)', 'medium (0) (15% - 45%)', 'high (+1) (45% - 60%)' to very high (+2) (over 60%).

1.5.3 In addition to the reduction potential of the control measure, a scoring scheme was also applied to the availability of technology consideration ranging from 'not available for the Region (-1)', 'available but not well developed technology in the Region (0)' to 'mature local technology ready available in the Region (+1)'.

1.5.4 Moreover, the socio-economic analysis was also using a scale ranging from 'very negative (-2)', 'negative (-1)', 'no change (0) ' to a 'positive (+1)' and 'very positive (+2)', where, a 'positive' impact means a benefit and a 'negative' impact means a cost. It should be noted, however, that:

- the score was a collective mark for the 8 sub-criteria of the socio-economic impact;
- there were areas where impacts might be controversial, particularly where cross-boundary issues are involved;
- there were also areas where impacts change with time. In such a case, judgements had been made in relation to both short term and long term effects;
- as every measure might impose additional burdens on the administration system to ensure effective enforcement etc., all measures were expected to have a negative impact in relation to administration and implementation; and
- the quantification of the impacts of the measures generally required more detailed financial and technical performance data than those currently available for this Study. Therefore the socio-economic impact assessment of regional control measures had to rely on information obtained from the direct interviews, official statistics, together with regional and international comparative case studies.

2. ASSESSMENT OF CONTROL MEASURES FOR ENERGY SECTOR

2.1 Introduction and Assessment Criteria

2.1.1 The assessment for the energy sector is through a systematic system to identify the availability of control technology options and their potential effects on emission reduction in the Region. These control techniques are considered well established worldwide based on substantial practical experience for at least five years. The reduction potential review is based on information obtained from official documentation on the emission reduction technologies of sulphur dioxide, RSP and nitrogen dioxide and the cost associated with such control techniques.

2.1.2 There were limitations in selecting the control measures that best suit the Region including current regulation and legislation in HKSAR and PRDEZ, reduction potential requirement of the dominant sources, primary energy pattern, existing in-plant operational conditions of the sources, local economic circumstances and cost benefit of the control techniques.

2.1.3 In selecting the best available control techniques worldwide, the major emission sources from the energy sector had been sub-divided into different operational processes. The operation of these individual processes had been studied through site visits of typical premises accompanied by Guangdong Province EPB in PRDEZ during the preparation of the base and future years emission inventories. Table 2-1 listed the major emission sources in the energy sector including their classification, the process category and the application of such processes.

Table 2-1 Major Emission from the Energy Sector

Classification	Process Category	Purpose of Usage
Power Generation	Power Plants	Public power supply
Commercial Fuel Usage	Hotels, restaurant, institutional community facilities: Boiler and combustion engines	Power supply, heating, hot water
Domestic Fuel Usage	Household: domestic heaters, stoves	Cooking and heating

2.2 Categories of Control Measures for the Energy Sector

2.2.1 The approach for the control of emission from the energy sector could be broadly divided into two main streams: the technological option and management measures. Generic control measures being implemented worldwide for the control of emission from energy sector are listed in Table 2-2. This information was collected from worldwide environmental authorities, official reports published by Government departments and regulation and legislation of the countries.

Table 2-2 Regional Air Quality Control Measures Being Implemented World-wide for Energy Sector

Control Measures Concept	USA	UK	EU	Mainland	Australia
Energy policy and Management Options					
Tightening of emission standards	✓	✓	✓		✓
Emission charge				✓	
Implementation of Western provinces electricity					
Emission trading	✓				
Technological Control Options					
Fuel switching and alternative fuel mix	✓	✓	✓	✓	✓
Advanced combustion technologies	✓	✓	✓		✓
Processes and combustion modifications	✓	✓	✓		✓

✓ = *Control measure being implemented in the country/region*

2.2.2 Through preliminary screening of the generic control measures, the emission trading measure under the energy management control options would most unlikely to be feasible in the Region for the time being. Potential sources in HKSAR had either already fulfilled the regulatory requirements or had been discharging at an insignificant level when comparing with the regional level. On the assumption that the overall control level would not be significantly stricter than that of the current control level, a very limited level of quota trading activities would be expected in view of the current compliance situation and the limited number of emitters. Moreover, the current political and legislation structure in the Region is not mature enough to support such complicated mechanism. It is unlikely this measure would be feasible in the Region for implementation at the present stage. Nevertheless, the possibility of an incentive-based emission trading system in the Region is not ruled out as an innovative long-term measure.

2.2.3 Apart from emission trading as control measure, other generic control measures listed in Table 2-2 are very likely to be a feasible option for implementation in the Region. For the detailed assessment of the control measures, the approach of the control measures for energy sector were divided into the energy management, fuel mix and control technology options.

- Tightening of Emission Standards (E1)
- Pollution Emission Charges (E2)
- Import Western Provinces Electricity (E3)
- Alternative Fuel Mix for Energy Sources (E4)
- Advanced Combustion Technology and Operational Process Modifications (E5)

Tightening of Emission Standards (E1)

2.2.4 At present, there are Best Practicable Means (BPMs) issued by EPD to provide standards under the Air Pollution Control Ordinance to control emissions from fuel consumption in the energy sector. Currently, energy sector operations in HKSAR have either already fulfilled regulatory requirements or are discharging at an insignificant level. It is recommended that continuous review and tightening of relevant regulations be ensured to match the international trends.

2.2.5 In PRDEZ, there are national emission discharge standards (GB) for fuel consumption processes in thermal power plants (GB13223-1996). Nevertheless comparing the mainland emission standards with foreign emission standards regardless of the operating capacity, there is still allowance for further tightening of standards in PRDEZ. The potential effect on SO_2 emission is particularly significant, as shown in Table 2-3, when compared with the emission standard drafted by the United Nation for long-range transportation under the Convention on Long-range Transboundary Air Pollution (UNECE 1999). Through the tightening of the emission standards, the operator shall have the obligation to reduce emissions by modifying its operation pattern or installing effective control equipment, of which both actions would achieve emission reduction in this sector.

Table 2-3 Emission Standards for Fuel Combustion Processes in PRDEZ and European Countries

	Emission Standards (mg/m^3)	
Fuel Types	**PRDEZ (second level zone)**	**European Countries**
SO_2		
Solid fuels	900	200 – 850
Gaseous fuels	100	35
NO_2		
Liquid fuels	400	200 – 400
Gaseous fuels	400	100 – 200

Preliminary Socio-economic Impact Assessment

2.2.6 The Guangdong Provincial government will incur administrative cost in establishing the emission standards and providing enforcement action against any illegal discharge. Initial investments by local power companies may be needed for compliance with the tightened emission standards with the major cost on installation of environmental control equipment.

2.2.7 The strengthening of standards and their enforcement is an effective and immediate way in PRDEZ to control emissions from this sector. The reduction potential is "significant". In the initial PRDEZ consultation, representatives acknowledged that more stringent environmental controls were welcomed because major industrial operators face competition from small, inefficient and polluting producers. However, significant decrease in pollution standards would impact on the short-term competitiveness of enterprises, particularly on those who are mainly dependent on external markets. Social-economic impacts of this measure are expected to be notable in short term and ultimate produce a neutral effect.

2.2.8 As the enforcement system is quite adequate at the moment in HKSAR, strengthening of emission standard is not considered the first priority and the reduction potential of this control measure is expected to be "low".

Pollution Emission Charges (E2)

2.2.9 With the establishment of emission standards, any non-compliance of the emission discharges shall be subjected to charges in accordance to its exceedance. The primary control for emission charges is the operation standards for different processes, usually in terms of emission limits and specification of minimum stack heights. If emissions are found to exceed these limits, operators will have to pay an emission charge according to the discharges in excess of the limit. By implementing a stringent discharge limit, operators shall have a better incentive to reduce emission from their operations and resulted in emission reduction.

2.2.10 At present, there is no provision of pollution emission charge against the energy sector in HKSAR. The electricity companies presently comply with the emission standards stipulated under the Air Pollution Control Ordinance. In order to implement an effective pollution emission-charging scheme, a tightened emission standard for concerned pollutants would have to be introduced. Environmental and socio-economic effects from the tightening of emission standards for energy sector had been concluded in the previous section.

2.2.11 The existing pollution emission charges control in PRDEZ is governed by several mechanism and policy directions. Of the fees collected, 80% were used for grants and low-interest loans to pollution control projects and 20% were retained by local environmental protection bureau to support administrative and monitoring activities. The limitation of the system is that the emission charge is by far too low to simulate any possible control abatement. Currently, the emission charges announced by the Guangdong Province Government on 3rd September 1990 are NO_x and SO_2 RMB 400/tonnes, dust RMB 20-100/tonees and soot RMB 3-6 per tonnes of fuel. In addition to the low tariff, the emission charge in Guangdong Province has several design deficiencies:

- Emission charge established by State Environmental Protection Administration (SEPA), are often lower than the marginal cost of abatement required to meet the emission standard. As a result many industrial enterprises choose to remain non-compliance and pay the levy.
- Provincial Government do not have any power to amend the pollution fee level;
- Charges are based only on the pollutant that exceeds its standard by the greatest amount, rather than on all the pollutants that exceeded their standards;
- Charges are assessed only on above-standard emissions, so they provided no incentive for firm to abate emissions below the standard; and
- Charges are based on pollutant concentrations rather than on cumulative of pollutants emission to the environment

2.2.12 Despite these problems, emission charge, combined with subsidised loans from the emission fund and other subsidy programs, have created incentives to control pollution. It can be effectively applied to targeted pollutants and to heavy polluters because the expected gain in pollution reduction could justify the cost of monitoring and collection. To have a better achievement by this control measure, further institutional review of the existing emission charge scheme is therefore necessary.

Preliminary Socio-economic Impact Review

2.2.13 Pollution is the adverse external effect of energy consuming activities. It can result in economic costs to other production units or consumers. Socio-economic issues for this control measure can be categorised into two types:

- Economic measures: such as tradable quotas and pollution taxes or charges; and
- Administrative measures: such as detailed regulatory controls on permissible emissions

2.2.14 Since the current operations of the utility companies in HKSAR generally comply with the environmental regulations and standards, no emission charges would be resulted. Unless there is a provision to tighten the emission standards, the introduction of emission charges shall have no impact on Hong Kong. Given there was incompliance, the charges would not be very high as the exceedance level would be limited with the effect of state-of-art air quality control equipment. Significant increases in pollution charges would impact on the short-term competitiveness of enterprises, particularly on those that are mainly dependent on external markets. In the event with the implementation of the control measure in HKSAR, increases in operation costs incurred by emission charge on stricter environmental standards would result in a higher level of tariff, sooner or later. However, international experiences show this would not be significant.

2.2.15 Although the proposed charging system in PRDEZ might result in economic impact, as the current pollution charges have been set at very low levels compared with operation and control equipment costs, the impact of this control measure on operation cost is not expected to be the main area of direct influence.

2.2.16 An increase in charge levels would result in higher prices of outputs. The future impacts of the new system as a whole on prices of final outputs have been estimated and are shown in Table 2-4 (Yang, J.T. et al, 1998). Generally, the impacts on price are expected to be low. The average price increase is estimated to be 2.1%. The most sensitive industry is electricity (4.4%), followed by papermaking (4.3%).

Table 2-4 Estimated Impact on Prices by Industry in PRDEZ

Industry	Price Increase (%)
Coal mining and dressing	1.52%
Petroleum and natural gas extraction	0.95%
Minerals mining and dressing	1.93%
Non-metal minerals mining and dressing	1.59%
Food manufacturing	2.49%
Textile industry	1.82%
Garments and leather products	1.56%
Timber processing and furniture manufacturing	1.90%
Papermaking and cultural goods	4.32%
Electricity	4.43%
Petroleum and coking	1.41%
Chemicals	2.97%
Construction materials and non-metal minerals products	1.57%
Smelting and pressing of metals	2.36%
Metal products	1.76%
Machinery manufacturing	0.90%
Foods and beverages	1.86%
Others	2.35%

Source: Yang, J. T. *et al*, 1998, p.333.

2.2.17 If radical increases in the pollution tariffs were introduced (and collected) without a phase-in period to allow for adjustment, there might be impacts on employment in financially marginal enterprises in PRDEZ. It might be anticipated that any such negative impacts would, at least in part, be offset by the stimulus to spending on abatement equipment and cleaner production technologies. This spending would be expected to support increased employment in the Region's emerging environmental technology industry.

2.2.18 Setting emission charge shall create additional administrative cost on regular review of the existing tariffs scheme for the section. In addition, resistance to the more stringent charges can be expected from polluters in the Region. This might impact on their willingness to comply with the new scheme thus increasing the administrative burden in relation to enforcement.

2.2.19 Similar to E1, this control measure is one of the most direct and widely accepted approaches to pollution control. Its reduction potential is 'high'. Although the socio-economic impacts of the measure are largely negative, the positive environmental benefits incorporated the polluter pay principle with the cost-effectiveness of this market-based measure may justify its existence.

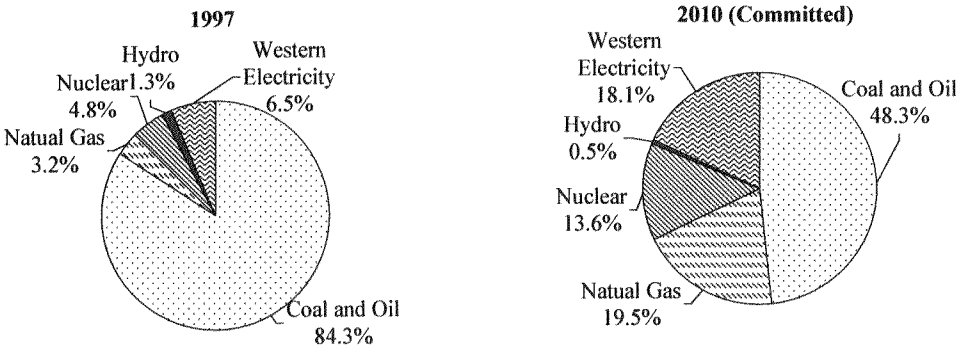
2.2.20 The reduction potential in HKSAR from this control measure is expected to be 'medium' to 'low' with the socio-economic impacts being neutral. The environmental benefits and the cost-effectiveness of this measure may not justify its potential implementation.

Import Western Provinces Electricity (E3)

2.2.21 The fuel mix under the current plan for electricity generation in PRDEZ is presented in Figure 2-1. Guangdong Provincial Government has already issued policy direction under the "Blue Sky" engineering programme that there will be no new coal-fired power plant of any size and power plant of less than 12.5MW to be built within the PRDEZ. Any future electricity demand due to economic growth shall be accommodated by one of the following measures:

- Improvement on the efficiency of the existing power plants in the Region;
- Commissioning new power plants with clean fuel, i.e. gas fired, hydro, or nuclear; and
- Increase the utilisation the electricity transmission from the Western Provinces.

Figure 2-1 Sources of Fuel Mix for Electricity Generation in the PRDEZ



2.2.22 Electricity generated from the Western Provinces is being utilised in PRDEZ through an existing power grid. Such that the basic infrastructure for transmission of electricity have already been provided. Further utilisation of electricity conveyed from Western Provinces in PRDEZ is possible as both the region and western provinces are being increasingly interconnected.

2.2.23 By utilising these "western electricity", the demand for the construction of new coal fired power plant within PRDEZ to support future economic growth could be much reduced, and consequently reducing the emission of air pollutants in the Region significantly.

2.2.24 This proposed measure provides for extensive utilisation of electricity from the western provinces, which is believed to have its practical value as it would help relieving Guangdong's acute and deteriorating environmental problems and sustaining the province's pace of economic development. Drawing on the electricity production base in the western provinces would also benefit these provinces economically for the time being, which is line with the current national economic development policy that encourages the development of the western (inner) part of the country.

2.2.25 The electricity generation industry in Hong Kong is operated under the Scheme of Agreement and an open market as well further improvement on the power grid infrastructure is necessary before such control measure could be benefit to HKSAR.

Preliminary Socio-economic Impact Review

2.2.26 According to a recent study on the interconnection in HKSAR electricity supply sector commissioned by the Hong Kong SAR Government (Government of HKSAR, 1999), the three Western Provinces (Guangxi, Yunnan and Guizhou) will continue to have large seasonal capacity surplus during 2000 to 2005. Prices for wholesale purchase of these surpluses are also expected to be very low at RMB 0.22 (i.e. about HK$ 0.21) per kilowatt-hour in daytime and RMB 0.10 (about HK$ 0.09) per kilowatt-hour in the evening. On the other hand, surpluses in hydropower will enable more cost-effective provision of power from these provinces to the Region in the future. As a result, other conventional fuel consumption operations in HKSAR and PRDEZ would be expected to enjoy lower operation overheads.

2.2.27 The availability of cheaper power in the PRDEZ and HKSAR would have positive implications for the Region's future competitiveness. Co-ordination between Hong Kong, Guangdong Province, and the western provinces would be needed to establish mutual trust and ensure the level of provision at a reasonable price. In PRDEZ, local thermal power plants which survive, would face competition from these Western Provinces and at the same time be subject to stricter environmental regulations, subsequently achieving an emission reduction locally.

2.2.28 Purchasing electricity from these Western Provinces to HKSAR through Guangdong Province would most probably be a utility company's commercial decision and this is unlikely to change in the medium term with the existing Scheme of Control Agreement. In any case, the wider inter-regional/trans-boundary transmission system needs to be upgraded for HKSAR.

2.2.29 To the targeted pollution sources, coal and oil fired power plants for instance in PRDEZ, this measure would be very effective to achieve a 100% reduction potential on emission with the replacement of the power generating capacity locally. There are some negative socio-economic impacts, particularly in relation to administrative and implementation issues. However, in anticipation of the potential to boost the use of clean energy technologies, the adverse socio-economic impacts might be partially offset through this switch. Therefore, the overall effect of the measure produced a net benefit.

2.2.30 This measure would not be very effective in Hong Kong for reducing pollution from the same sources in short term. There are some negative socio-economic impacts, particularly in relation to plants output levels and value, availability of transmission grid, administrative and implementation issues and employment.

Alternative Fuel Mix for Energy Sources (E4)

2.2.31 Coal and oil are the major fuels for the energy sector in the Region. By reducing the reliance on polluting fuel mix and increasing the use of cleaner fuels, the regional air quality could be much improved. The technical and socio-economic impact for fuel switch on power plants and other commercial sectors are totally different.

2.2.32 Clean fuel is defined as blends or substitutes with relatively low sulphur content fuel including compressed natural gas, methanol, ethanol, and liquefied petroleum gas. Cleaner energy sources could be provided for all new and planned industrial areas to avoid any unnecessary consumption of polluting fuels. Where electricity grid and surplus supply is available from the Western Provinces, installation of individual electricity generator set within the premises for normal operation should be prohibited. Incentive in the form of tax rebate could be initiated by the Government to promote the utilisation of these cleaner fuels in existing large industrial estates at which connection is engineering feasible.

2.2.33 After the commissioning of the LNG plant at Shenzhen, the rate of penetration of the clean fuel in the inner coastal areas of the Region shall be increased. In Guangzhou, piped gas shall have a penetration rate of 98% household after the commissioning of two 1-million m^3 gas depots in 2010.

Power Plants

2.2.34 In HKSAR, the power plants of the energy sector are the major coal burners and sources of RSP, NO_x, SO_2 and CO_2. The following features regarding the sector were noted in the course of consultation with the local power utilities.

- Fuel costs including low sulphur coal represents a predominant part of the overall operation costs. To CLP, for example, the share amounts to 80 – 90%, compared with 3% on payroll costs (CLP 2000).
- Among the fuels being consumed, coal represents a major part. There are economic as well as historical rationales behind the high level of coal consumption, such as:
  - Coal firing is the traditional way to power generation. A large part of the existing plants currently in service are of the type. For instance, there is a number of power generating units in HKSAR uses coal as the primary fuel. The total capacity of individual power generating units and their commissioned year is presented in Table 2-5.

- Maintaining coal-fired operation before the end of the economic life of the existing facilities is more cost-efficient, compared with retrofitting them for other means of operation, e.g. gas or oil. If coal-fired plants were retrofitted to consume gas, fuel costs would be 3 to 4 times higher.
- Due to high opportunity costs borne by these other means, particularly the remaining value of the existing coal-based facilities, the two utilities are more willing to maintain the traditional way of operation whilst taking mitigation measures in order to comply to the environmental standards.
- Although there has been a trend towards gas, oil and nuclear power applications, the coal-fired plants are expected to remain as major facilities until the end of their economic life span which can operate for at least over 10 years.

2.2.35 Although coal remains the major fuel source, emissions from the two utilities have largely been controlled against the current regulations. Newly established operations of the existing power companies are largely under the Best Practical Means of emission standards under the Air Pollution Control Ordinance, which imposes stringent requirements particularly on the use of fuel. It is the Hong Kong Government's aim to encourage the use of clean fuels for new power generation to reduce the emission of pollutants but not to restrict the fuel mix that may compromise the security of supply and thereby the reliability of power supply. The traditional coal-fired mode of operation in HKSAR is gradually be replaced by more environmentally friendly gas operations as presented in Table 2-5.

Table 2-5 Capacity and commissioned year of the power generating units in HKSAR

Power Plant	Generating Unit	Fuel Usage	Total Capacity	Commissioned Year
China Light & Power Limited Black Point Power Station	1	Gas	312.5 MW	1996
	2	Gas	312.5 MW	1996
	3	Gas	312.5 MW	1996
	4	Gas	312.5 MW	1996
	5	Gas	312.5 MW	1997
	6	Gas	312.5 MW	1998
	7	Gas	312.5 MW	2005
	8	Gas	312.5 MW	2006
China Light & Power Limited Castle Peak Power Station	A	Coal/Oil	1400 MW	1982
	B	Coal/Oil	2710 MW	1985
Hong Kong Electric Limited Lamma Power Station	L1-L3	Coal/oil	750 MW	1984
	L4-L6	Coal/Oil	1050 MW	1991
	GT1	Gas	55 MW	1991
	GT2-GT7	Gas	750 MW	1991
	L7-L8	Gas	700 MW	1997
	L9 New Extension	Gas	300MW 1800 MW	2004 for first 300MW

2.2.36 Apart from changing to cleaner fuel, there are currently energy saving programme being carried under the administration of Electrical and Mechanical Services Department. Demand Side Management (DSM) is a measure employed in HKSAR to influence the level or timing of electricity demand from customers in order to optimise the use of power generation facilities. Of the various types of DSM programs, Energy Efficiency Programs, Peak Clipping Programs and Load Shifting Programmed had been identified for implementation in the HKSAR as the first phase of DSM activities.

2.2.37 With the application of more energy efficient appliances and installations, the demand for expanding electricity generation will come down and ultimately reduce the demand for any new power plants in the Region in the long term. By managing to reduce electricity consumption, the consumers are able to benefit from a lower electricity bill, such that helping the environment by burning less fuel for electricity generation. Efficient use of energy as a result of using new innovative equipment and energy conservation management as identified by energy audit from end users with incentive provided by the HKSAR Government and power companies should be promoted and extended to the Region. There should be detailed study to investigate the possibility for implementation of demand side management programme in conjunction with the power plants for major industry in the Region.

2.2.38 Energy shortage is serious in Guangdong Province and it is much more serious than other parts of the Mainland due to its rapid economic growth. It was estimated that total coal consumption by the Guangdong Province is 76.82Mtons of which 70.00Mtons are imported or transferred from other provinces. In 2010, annual coal consumption of Guangdong Province is estimated to be 124.10Mtons, of which 118.10Mtons are imported or transferred from other provinces (SBG 2000).

2.2.39 As coal is currently still the major energy sources in Guangdong Province, it is necessary to have a tighter control of sulphur content for improvement the air emissions in PRDEZ. State Environmental Protection Administration has the following control strategies for reducing air emission by achieving the respective sulphur content in fuel.

- Existing sulphur content in fuel max 1% in coal, 1.5% in fuel oil;
- 2000 Acid Rain Control Zone, sulphur content coal 0.9%, fuel oil below 1%;
- 2005 Acid Rain Control Zone, sulphur content coal and fuel oil below 0.8%; and
- 2010 Acid Rain Control Zone, sulphur content coal below 0.7%, fuel oil below 0.8%

2.2.40 By restricting the import of high sulphur content solid and aqueous fuel into the PRDEZ shall enhance the penetration rate of other cleaner fuel in the Region. The consumption of low-grade fuels within the acid rain control zone of the Guangdong Province should be monitored through the implementation of a compulsory reporting system. Bulk storage, handling and distribution of fuel in the PRDEZ shall be licensed by the Provincial government for standardising the fuel quality. All operators shall require under their licensing conditions to submit regular fuel quality analytical results based on pre-approved testing method and the sale records. The information collected through this licensing system shall be inputted into an energy end-user database to form part of the regional emission inventory data for pollution control and management.

Commercial Fuel Usage

2.2.41 There was existing policy for restaurants with a seating capacity over 200 converted to piped LNG starting from 1999 in Guangzhou. In 2001, it was reported that over half of the required restaurants had undergone such conversion in Guangzhou City (Guangzhou Daily 2000). Up to 90% of the commercial users will be connected to piped LNG in PRDEZ once the network of the LNG pipeline is developed in 2010.

Preliminary Socio-economic Impact Review

2.2.42 Power generation in HKSAR today is managed by two utility companies. In the power companies' agreements with the Government, meeting local demand is of higher priority. Due to continual expansions in the past, HKSAR has already attained a slight surplus in power generation capacity and is expected to maintain this demand-and-supply relationship in the future. Assuming HKSAR's power export would be unchanged in the near future, HKSAR's overall power production would remain steady. In case of higher environmental inputs, the value of unit output would be higher.

2.2.43 Expenditure on fuel varies according to the nature of operation. For power plants this can be as high as 60% (Source: consultation with Guangdong operators). The impact would be significant (~5% increase in operation costs) for future thermal power production. However, given the dominant nature of the power industry and the electricity demand and supply pattern, production levels would not be significantly affected due to fuel switch. There would however be an upward pressure on the unit price of electricity.

2.2.44 In the short term for HKSAR situation, capital costs incurred would mainly be on purchasing low pollutant content fuels and retrofitting existing production facilities. In the long term, 'greener' operation will come into play due to higher environmental accountabilities and Government encouragement, which has been reflected in the recently commissioned generation facilities.

2.2.45 The financial costs for switching bituminous coal with sulphur content from 0.75% to 0.5% is estimated at RMB 25 per tonne with a pollution reduction efficiency of RMB 5,000 per tonne of SO_2 in PRDEZ. The higher fuel prices would result in fluctuation in prices for final products or services in PRDEZ. Impacts on prices would vary from sector to sector. The estimated increase in prices in the machinery and electricity industries are the highest at 3.39% and 1.8% respectively, whilst those in other industries are estimated at below 1.2% as shown in Table 2-6.

2.2.46 The major industries affected by these proposed measures in PRDEZ are electricity. However, as electricity is primarily local-based, considering the current and future regulations of the market and the demand and supply pattern in the PRDEZ, the implementation of the measure is not expected to be the direct cause of major problems to the thermal power industry providing that the costs are recoverable through tariff adjustments. The major socio-economic impact of this measure would be on the financial costs of users, such that prices of outputs would become higher.

Table 2-6 Estimated Impact on Prices by Industry in PRDEZ

Industry	Price Increase (%)[1]
Coal mining and dressing	0.97%
Petroleum and natural gas extraction	0.00%
Minerals mining and dressing	0.00%
Non-metal minerals mining and dressing	0.74%
Food manufacturing	0.01%
Textile industry	0.12%
Garments and leather products	0.07%
Timber processing and furniture manufacturing	0.07%
Papermaking and cultural goods	0.09%
Electricity	1.79%
Petroleum and coking	0.49%
Chemicals	0.82%
Construction materials and non-metal minerals products	1.00%
Smelting and pressing of metals	1.13%
Metal products	0.67%
Machinery manufacturing	3.39%
Foods and beverages	0.00%
Others	0.64%

2.2.47 No significant additional administrative and implementation burdens are anticipated given the existing administrative provisions in HKSAR and PRDEZ. Long-term monitoring and auditing would be required together with a licensing system for handling and distribution of fuel oil in Guangdong. Moreover, in the short term, financial incentives to encourage fuel upgrade should also be considered. In the longer term, more resources would be needed for the promotion of clean fuel applications.

2.2.48 There is no direct impact on the local electricity-related labour market since fuels, environmental technologies and equipment are likely to be imported in the medium term. With the promotion of alternative clean fuels, more employment opportunities would emerge from related industries, such as natural gas and petroleum refinement. The traditional coal-fired mode of operation will gradually be replaced by more environmentally friendly operations. There is no substantial direct co-relationship between utilisation of lower sulphur content fuel and job losses in PRDEZ.

2.2.49 In PRDEZ, it is a very effective measure from an environmental point of view with a 'very high' reduction potential. However, the socio-economic impacts are slightly negative, particularly in relation to output levels and value. Given the highly positive environmental benefits, the overall impact of the measure is considered a net benefit.

2.2.50 The measure is also very effective from an environmental point in HKSAR and achieving 'very high' reduction potential and slightly 'negative' socio-economic impacts particularly in relation to operation costs. Nevertheless, the highly positive environmental benefits justify the overall impact of the measure.

[1] Based on the Consultants' estimate for 1995 national averages of *complete I/O consumption coefficient* for various industries against coal industry from the direct I/O consumption coefficient listed in Tang et al (1998, P332).

Advanced Combustion Technology and Operation Process Modifications (E5)

2.2.51 Apart from energy management measures, technological control options for flue gas treatment were also well established and available for consideration in the Region. There are existing engineering technologies for Flue Gas Desulphurization (FGD) available in the Mainland commercial market. Over 10 demonstration projects on large-scale power plant throughout the Mainland had been completed by the State Electricity Bureau (SEB 1999) with a reported control efficiency as high as 85%. Commercial FGD products with 35T/hr to 1000T/hr treatment capacity and a removal efficiency of 95% is commonly available in the market.

2.2.52 Energy generating facilities in HKSAR had already been installed with some forms of end-of-pipe control measures (FGD, low-NO_x burner, electrostatistic precipitator, etc) and similar emission reduction potential as those PRDEZ demonstration projects was recorded in HKSAR.

2.2.53 It is a common practice to have Low- NO_x burner installed for fuel consuming facilities for the reducing NO_x emission. Low NO_x Burner (LNB) is commercially available on the local market. Preliminary small scale pilot tests on the efficiency of these control equipment had been carried out, however, engineering feasibility for applying to small industries is still not certain until full scale testing being implemented. To retrofit LNB on an old coal fire boilers, the NO_x emissions may be 30-40% lower than for conventional burners (SEB 1999).

2.2.54 LNB may be applied as LNB only or in combination with Over Fire Air (OFA). Principle of OFA is simply forcing air into the top of a boiler to fan the flames. The combined LNB and OFA option may reduce emissions of NO_x by 30-60%. CLP Power Hong Kong Limited recorded an overall NO_x reduction potential of about 40% by the application of the low NO_x burner techniques in the processes (CLP 1997).

2.2.55 Capital cost for equipping new boilers with LNB is approximately RMB 10-15 per kW, which is about 30% higher than conventional boilers. The capital costs for retrofitting LNB in existing boilers are RMB 80-320 per kW for plants smaller than 300 MW. The lower end of this range (RMB 80) represents large plants and the higher end (RMB 320) represent smaller plants due to economy of scale (Air Quality Management and Planning System for Guangzhou 1999). Operating costs for these LNB retrofitted boilers are the same as conventional boilers.

2.2.56 For the control of RSP generated from the fuel combustion process, there are well-established technologies worldwide to achieve a high reduction efficiency of the emission. Table 2-7 summarised the available RSP control technologies.

Table 2-7 Summary of Available RSP Control Technologies, Their Efficiencies and Cost World-wide

Techniques	Efficiency	Total Cost (~HK$/m^3/yr)	Space Requirement	Application
Electrostatic precipitator	Excellent	1000	Large	Gas cleaning and recovery of process materials
Fabric filters	Fair - Good	200 – 350	Large	Dry operation and process environment
Cyclones	Fair	150 – 250	Moderate	Medium and coarse particles, for pre-cleaning upstream purpose
Scrubbers	Good	350 - 900	Moderate	Sticky emission to control RSP and acidic gas together

Source: Fundamentals of Air Pollution, 3rd Edition, Academic Press, 1994

2.2.57 Centralised system for power generation facilities could also be an alternative for these small but large number of operations. Such system aimed to reduce the pollution control cost for small and medium enterprise by setting up centralised unit which delivers e.g. electricity, process heat or steam and in which the waste gas can be treated at a much lower total cost if each of small units were to undertake this individually.

Socio-economic Impact Assessment

2.2.58 No significant technical impacts are envisaged in the Region. Given that international environmental technologies are readily available and comparatively mature, lower prices are expected to be the major area of advantage that the new local environmental technology industry could enjoy. This would benefit local industries.

2.2.59 Although local technologies are not necessarily cheaper at the outset, developing localised technologies means providing competition between them and therefore more market choice, which would lead to cheaper applications.

2.2.60 The most technical disability faced by the village and township enterprises in PRDEZ is the huge initial capital cost for the control equipment. Advanced foreign engineering design combined with local craftsmanship and financial support from the emission charge fund could make the control equipment more affordable and result in compliance with the emission conditions issued by the city Environmental Protection Bureau. To explore the national potential in developing locally produced equipment would basically have two benefits:

- It should help make environmental protection equipment more affordable, hence making it easier to control emissions.
- It would help produce new employment opportunities.

2.2.61 Guangdong Provincial Government could provide incentive to develop local environmental technologies, introducing foreign advanced technologies, attracting foreign investment in the industry and, if possible, providing eligible operators with incentives comparable to those given to other high-tech industries.

2.2.62 Environmental technology industry as a new industry would provide employment opportunities. Moreover, successfully developed localised technologies may also be marketed internationally, bringing in more jobs.

2.2.63 Reduction potentials would be very significant in PRDEZ. Taking socio-economic costs as most of which are positive into consideration, this measure is expected to be a very positive measure.

2.2.64 This measure in HKSAR should be viewed as a supporting measure to other more direct pollution reduction measures as lot of the control measure already implemented. Reduction potential is 'medium' to 'low' in HKSAR. The socio-economic impacts are likely to be neutral. This measure produces a net benefit.

2.3 Summary of the Short-listed Control Measures for Energy Sector

2.3.1 Table 2-8 below presented a summary of the preliminary analysis for the selection of control measures for the energy sector and the emission reduction potential associated with each measures for individual pollutants where quantifiable. The recommended control measures for the energy sector is presented in Table 2-9.

Table 2-8 Score of the Assessment Criteria for the Energy Sector

Assessment Criteria	Control Measures									
	PRDEZ					HKSAR				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
Assessment Summary										
Emission Reduction Potential	High	High	V. High (SO_2: -94536; NO_x: -59708; RSP: -7285; VOC: -479) tonnes	V. High (SO_2: -29045; NO_x: -21537; RSP: -10497; VOC: -5941) tonnes	V. High (SO_2: -204970; NO_x: -90654; RSP: -10799) tonnes	Low	Medium	Medium	V. High (SO_2: -54447; NO_x: -43096; RSP: -3340; VOC: -381) tones	Medium
Availability of Technology	Ava	Ava	M. Ava	Ava	Not. Ava	Ava	Not Ava	Not Ava	M. Ava	Ava
Socio-economic Impact	-	-	-	-	+	-	-	-	-	0
Assessment Score										
Reduction Potential	+1	+1	+2	+2	+2	-2	0	0	+2	0
Availability of Technology	0	0	+1	0	-1	0	-1	-1	+1	0
Socio-economic Impact	-1	-1	-1	-1	+1	0	-1	-1	-1	0
Total Score	0	0	+2	+1	+2	-2	-2	-2	+2	0

Not Ava = Not available in the Region; Ava = Technology available; M Ava = mature local technology available in the Region

Table 2-9 Summary of the Proposed Control Measures for Energy Sector

Control Measure	PRDEZ	HKSAR
E1. Tightening of Emission Standards	Neutral benefit	Under regular review
E2. Pollution Emission Charges	Neutral benefit Not Recommended	Net lost Not Recommended
E3. Import of Western Provinces Electricity	Net benefit Recommended	Net lost Recommended for long term only
E4. Alternative Fuel Mix for Energy Sources	Net benefit Recommended	Net benefit Recommended
E5. Advanced Combustion Technology and Operational Process Modifications	Net benefit Recommended	Neutral benefit

3. ASSESSMENT OF CONTROL MEASURES FOR INDUSTRY SECTOR

3.1 Introduction and Assessment Criteria

3.1.1 The base and future years emission inventories had helped to identify the industry sector as one of the major sources of pollutants. Site visits had been arranged with various industrial facilities to evaluate the existing operation conditions and the pollution control techniques being applied.

3.1.2 It was observed that industrial emissions are generally attributable to the fuel consumption and operation processes involved. It was understood that fuel consumption mostly emitted SO_2, NO_x and RSP, while operation processes mostly emitted RSP and VOC.

3.1.3 The investigation of control measures for industry sector focused on the major contributors as identified in Table 3-1.

Table 3-1 Major Emission Sources of the Industrial Sector

Emission Source	Process Description	Pollutant Involved
Fuel Consumption	Boiler, combustion engine, turbine and process heater	SO_2, NO_x, RSP
Operation Process – Non-metallic mineral products	Manufacture of cement, bricks, glassware and plaster products	RSP
Operation Process – Organic chemical operation	Oil depots and terminal fuel storage, handing, distribution and re-fuelling of vehicles	VOC
Operation Process – Printing and graphic art	Application of ink, thinner, coating or adhesive material for impressing or transferring an image onto a substrate	VOC
Operation Process – Process evaporative loss	Dry cleaning, organic solvent cleaning and surface coating	VOC

3.1.4 Considerations had been made in the following aspects:

- elimination of the operation entirely or partly
- relocation and modification of operations
- application of cost-effective engineering control techniques

3.1.5 Table 3-2 listed the generic control measures that are inline with the said considerations. These control measures are being widely adopted in other countries/regions in 2 levels, namely technological control and policy and management control.

Table 3-2 Control Measures Being Implemented World-Wide for Industrial Processes Operation

Control Measures Concept	USA	UK	EC	Mainland	Australia
Technological Control Options:					
Advanced reduction technologies	✓	✓	✓	✓	✓
Operational processes modifications	✓	✓	✓	✓	✓
Policy and Management Control Options:					
Force closure small operations				✓	
Promote product green labelling	✓	✓	✓		✓
Environmental management system	✓	✓	✓	✓	✓
Setting new/more stringent emission standards	✓	✓	✓		
Regular monitoring and audit	✓	✓	✓		✓

✓ = Control measure being implemented in the country/region

3.1.6 The line of control measures are likely feasible to this Region and had been preliminarily discussed with Guangdong Province environmental officials and HKEPD as part of the pre-screening process.

3.1.7 It is a well-established practice to reduce emissions through source elimination or closure of small and inefficient industrial facilities. Other option is to control emissions at source by modifying the operation procedures and production techniques to achieve cleaner production. Otherwise the application of engineering control equipment should be considered as end of pipe control measures.

3.1.8 To investigate the most suitable control measures for this Region, emphasis should not only be placed on their reduction potential, but also on the enforceability of the control measures under local conditions and specific industries.

3.1.9 Selected control measures to be discussed and further evaluated for this Region are as follow.

- Strengthening the pollution control system
- Technological control
- Environmental management system and green production
- Force closure of heavy polluting factories

3.2 Feasibility of the Control Measures in the Region

Strengthening the Pollution Control System (I1)

3.2.1 To effectively control industrial emissions, three major components of the pollution control system have to be regularly reviewed and strengthened. The major components of the system include the following and are to be discussed separately:

- Emission standard
- Pollution control regulations
- Environmental impact assessment and audit system

Tightening the Emission Standard

3.2.2 In PRDEZ, there are existing national emission discharge standards (GB) established for major fuel combustion processes for coal/oil/gas industrial boilers (GWPB3-1999), cement works (GB4915-1996), and industrial kiln and furnace (GB 9078-1996). Nevertheless comparing these emission standards with those in other countries, further tightening of the emission level is possible as shown in Table 3-3. Through tightening of emission standards, the application of Best Practical Means (BPM) and statutory regular environmental monitoring, pollution from the combustion processes could be closely monitored by the Authority and subsequently reduced.

Table 3-3 Emission Standards for Fuel Combustion Processes in PRDEZ and European Countries

	Emission Standards (mg/m^3)	
Fuel Types	**PRDEZ (second level zone)**	**European Countries**
SO_2		
Solid fuels	900	200 – 850
Gaseous fuels	100	35
NO_2		
Liquid fuels	400	200 – 400
Gaseous fuels	400	100 – 200

3.2.3 HKSAR has undergone a substantial economic restructuring over the past two decades, leading to an expansion of the tertiary sector and declining of the others, particularly the manufacturing sector. To date, all the industries remained in the Territory share the characteristics of being less labour- and land-dependent and some of them are high value-added and high-tech. These companies tend to be either environmentally friendly or capable of being environmentally accountable. In view of the situation in HKSAR, immediate tightening of the emission standards for industries in HKSAR is not considered a priority.

Mandatory Pollution Control Regulation

3.2.4 Mandatory control regulations aim to protect the environment through intervening in an operator's behaviours, for instance, a licensing system will normalise the practices of an operator to a standard which has been proved to be effective in minimising pollution or leading to compliance. It is applicable to old as well as new operators. As a result, operators need to achieve an emission target set by the Authority by altering its own operation pattern, installing best practicable pollution control equipment and preparing monitoring reports regularly. The control mechanism by the Authority to achieve the necessary air quality control in the Region was through the implementation of the statutory emission standard and in conjunction with the installation of the best practicable control measures, any non-compliance from the industrial process shall be penalised in accordance to the level of illegal discharge to ambient air.

3.2.5 Apart from statutory submission under the Environmental Protection Law for the new and large scale operations, an individual emission discharge permit system with clear guidelines on the application procedures through the issue of Code of Practice (CoP) or Technical Memorandum (TM) similar to the practice in HKSAR and other regions could be established in PRDEZ for various pollution emitting industrial processes to control discharge. The permit also specifies the maximum allowable emission from each individual premise and the control measures that associated with each emission point/source. Through this CoP or TM mechanism, the best practicable means of control measures on operation processes emission with cost indication on successful applications could be made available to the industry for information on the world wide web. Previous experience is found in US California, the South Coast Air Quality Management District maintained a web site (www.aqmd.gov/bact/) informing the potential permit applicants the best available control technology available for reducing emissions from over 27 industrial processes with due consideration on their financial implication for reducing the pollution down to the statutory compliance level.

3.2.6 The provision of pollution control regulation in HKSAR is quite mature. At present, HKSAR has provided guidance to industries through Code of Practise (CoP) and Technical Memorandum (TM). The relevant control regulation in HKSAR is Air Pollution Control (Specified Processes) Regulation and Air Pollution Control (Furnace, Ovens and Chimneys) (Installation and Alteration) Regulation. Amendment and tightening of the regulations has been made regularly in past years and the need for further revision is minimal at the moment.

Environmental Impact Assessment (EIA) and audit system

3.2.7 A statutory monitoring and audit report could be established after the completion of the EIA processes in PRDEZ and formed part of the discharge permit system as a control strategy to regulate the emission from major industrial process plants. These monitoring and audit programme shall provide the operator an early warning for any potential non-compliance emissions from the premises, which leads to prosecution by the Authority. In addition, these audits provide useful plant operation information, which could form part of the regional emission inventory database.

3.2.8 There is already a "3 synchronisation" mechanism in PRDEZ for the installation of pollution control equipment aiming to have the design, installation and commissioning processes to be carried in parallel with the construction of the project. Such mechanism should be extended after the commissioning of the plant with regular environmental monitoring and audit (EM&A) programme carried out by the plant operator. The EM&A programme aimed to oversee the emission compliance of the plant under the close supervision of the city Environmental Protection Bureau, the statutory EIA and auditing system could then be established, characterised by the following:

- whilst existing enterprises can choose either to control their emissions or to pay emission levies, the new enterprises would have to operate to the standard;
- environmental studies would have to be carried out before a development is undertaken or an enterprise starts operation; and
- only new enterprises or development projects would be affected.

3.2.9 With regular environmental report submitted to municipal Environmental Protection Bureau and real-time online monitoring system installed for significant sources, any non-compliance to the issued environmental permit could be rectified immediately. All technical information collected through this permit and reporting system shall form part of the regional emission inventory database for future pollution control management as Continuous Environmental Monitoring (CEM).

3.2.10 With the CEM programme to be implemented for the industry sectors, strengthening of the EPB officers' knowledge on environmental monitoring and industry operation processes in major cities would be necessary. Without such strengthening programme, the CEM programme shall not be successfully enforced in city level.

3.2.11 Under this policy, more knowledge-based, high-tech and high-value-added activities would be proactively introduced to PRDEZ. These activities are either relatively environmentally friendly or can afford to be more environmentally accountable. With the local economy being increasingly dependent on such kind of activities, it would be less vulnerable (in financial terms) to stringent environmental controls.

3.2.12 HKSAR already has provisions in similar areas, e.g. the recent government initiative in attracting more high-tech industries and instituting the Environmental Impact Assessment Ordinance, Air Pollution Control Ordinance, etc. Moreover, most of the major potential sources have established their own in-house environmental pollution control and auditing systems. These measures would therefore not have a significant additional impact on HKSAR.

Preliminary Socio-economic Impact Review

3.2.13 Experience elsewhere has shown that economic upgrading enables more resources to be put into environmental protection since such costs represent a smaller part of operation costs. Although various extra financial costs would be required, impacts on output levels and value are expected to be minimal. Environmental protection would therefore not have a significant adverse impact on new enterprises' output levels and value.

3.2.14 Considering the introduction of EIA in PRDEZ, the major costs anticipated would be for installation of environmental equipment and this may significantly affect the price of outputs. Costs on preparation of EIA and other documents and environmental auditing would be incurred and generally appear as a lump sum lower than 0.5-2% of total investment (LUC 1996). Auditing however brings about regular costs but these costs are usually insignificant compared with operation costs. Mitigation measures for air pollution usually involve purchasing and installing cleaning equipment, which are currently more expensive than the other options, e.g. pollution levy. This explains why many enterprises pay discharge fines and fees rather than invest in pollution control measures. For example, whilst one of the companies with whom we consulted has invested RMB 4 million for environmental protection, it nevertheless paid pollution fees of RMB 180,000 in 1999. The following costs would be incurred:

- Cost for mitigation, i.e. purchasing and installing cleaning equipment and using low sulphur content fuels. As mentioned above, these costs may be as high as 15% of total operation costs (e.g. for cement industry).
- Monitoring costs which are generally not comparable to mitigation costs.

3.2.15 Where heavy investments are made without government subsidy in environmental equipment, the competitiveness of the operator would weaken because these costs would be translated into higher prices of outputs.

3.2.16 Cross-boundary co-ordination would be needed to ensure that variations in enforcement stringency, if any, should not be used by any party as a means of increasing local 'competitiveness'. Attracting inward investment has long been the target of the Guangdong government at various levels. In this respect, HKSAR is a competitor for, as well as a provider of, inward investments. Under the circumstances, where pursuing local economic growth is the first policy priority, environmental protection targets can be frequently compromised, especially when facing development opportunities. Therefore, there would be a possibility for environmental costs that should be imposed under the statutory system to be exempted in an area to produce a comparative 'advantage' for attracting inward investments.

3.2.17 Establishment of the legal EIA and auditing system in PRDEZ may face challenges. Resistance may arise from lower tiers of government - local governments - fearful of thwarting inward investments. Education in, and promotion of, the system would therefore be necessary.

3.2.18 Co-ordination between governments at different levels and in different places would be needed to ensure consistency of stringency throughout the PRDEZ. The development of a comprehensive pollution control system requires time, capital, and efforts.

3.2.19 As future investments are expected to be concentrated in the sectors which are more environmentally friendly and potential to be more environmentally responsible, this measure would not have a significant adverse impact on attracting investment and hence on employment levels in PRDEZ. The development of a pollution control system would produce a demand for the divergence of local environmental technologies which would provide jobs locally. Another area of beneficiaries would be the environmental profession made up by environmental scientists, engineers, economists and managers.

3.2.20 With the rising awareness that it is enterprises' own social responsibility to control pollution, environmental investment would become a conventional part of industrial operation costs. Production activities would therefore be carried out to a higher environmental standard. In conclusion, the measure of developing a pollution control system ranks 'high' in terms of pollution reduction potential. It should be viewed as a complementary measure to other more direct pollution reduction measures for PRDEZ. The socio-economic impacts are largely negative, although the employment impacts are positive. Overall, the measure produces a net cost. However, it has a value as a complementary policy measure.

3.2.21 In HKSAR, there has already been a working environmental control system. Nevertheless, continuous effort should be applied to oversee the effectiveness and adequacy of the existing legislation and regulation for the ever-changing industrial structure in HKSAR. This measure ranks "low" in terms of pollution reduction potential for the future. It should be viewed as a complementary measure to other recommended measures. The socio-economic impacts are largely neutral. Overall, the measure produces a net benefit.

Technological Control (I2)

3.2.22 As mentioned in Section 3.1, industrial emissions are generally sourced from fuel consumtion and operation processes within the facilities. Therefore the discussion on technological control are presented for the two different streams. Based on the site visits to the identified major emission sources accompanied by the Guangdong Province Environmental Protection Bureau, the application of control measures to the industry sector had been evaluated. It is concluded from the site visits that the existing control measures being applied in PRDEZ were fairly premature and minimal.

Fuel consumption (combustion) control

3.2.23 The major uses of fuel in industries are to provide electricity and heat to the facilities. The general approach for controlling such emissions has been mentioned in the previous sections on the energy sector. Potential ways of control are:

- expanding electricity/heating network
- installing end of pipe control equipment

3.2.24 Technological control options for end of pipe flue gas treatments were well established locally and worldwide and readily available in the Region. There were existing engineering solutions for post combustion flue gas desulphurization (FGD) technology including additive injection, wet scrubbing and spray dry absorption available with a practical SO_2 removal efficiency of from 60 to 95% (UNECE 1994). The economic component of this equipment is presented in Table 3-4 as indication. Over 10 demonstration projects, which formed part of a UNDP funded study, on large scale power plants (>200MW) throughout mainland China have been completed by the State Electricity Bureau in 1999 with a practical control efficiency reported as high as 85% (SEB 1999).

3.2.25 Emission from new boilers with LNB may be less than half (45%) the emissions from a new boiler with a conventional burner. To retrofit LNB on an old coal fire boilers, the NO_x emissions may be 30-40% lower than for conventional burners. The cost of applying LNB is estimated at 3000-5000 RMB/ton of NO_x reduced.

Table 3-4 Economic Indication of Desulphurisation Technologies

Desulphurisation method	Approximate Cost (RMB) per tonne of SO_2 removed
Sorbent Injection in boilers	2250
Wet Flue Gas desulphurisation	4500
Screen Tower	700-1200
Water Tower	1200-1700
Film Tower	1900
Sulphur Fixation	1100
Wet Method	400
Calcium Injection	400
Recirculation	700

3.2.26 The basic types of control equipment for reducing industrial emissions are mechanical collectors, wet scrubbers, bag house, electrostatics precipitators, combustion system, condensers, absorbers and adsorbers. All of these have been used extensively worldwide to control emissions from a variety of industrial process operations. The final choice in an equipment selection is usually dependent heavily on its capability to achieve the required statutory compliance level of a particular pollutant at the lowest possible capital and operational cost.

3.2.27 RSP and VOC are the major pollutants identified from the base and future years emission inventories of the study. Table 3-5 and Table 3-6 listed the existing RSP and VOC control techniques with its control efficiency commonly available in the market respectively.

Table 3-5 A Summary of Available RSP Control Techniques, Their Efficiencies and Cost

Techniques	Efficiency	Total Cost (~HK$/$m^3$/yr)	Space Requirement	Industrial Application
Electrostatic precipitator	Excellent	1000	Large	Gas cleaning and recovery of process materials
Fabric filters	Fair - Good	200 – 350	Large	Dry operation and process environment
Cyclones	Fair	150 – 250	Moderate	Medium and coarse particles, for pre-cleaning upstream purpose
Scrubbers	Good	350 - 900	Moderate	Sticky emission to control RSP and acid gas together

Source: Fundamentals of Air Pollution, 3rd Edition, Academic Press, 1994

Operation Process – Non-metallic Mineral Products

3.2.28 Most of these premises in PRDEZ were operated without any kind of emission control equipment being installed thus generated an elevated RSP during the data collection period of this Study. However, it is observed that these premises have gradually been installed with dust collector recently. Non-metallic mineral products industrial processes in HKSAR are controlled under the Air Pollution Control (Specified Processes) Regulations. Under the Best Practicable Means of control measures issued by the HKSAR EPD, at least a fabric filtering system shall need to be installed for the non-combustion exhausts of the plant for the control of dust emission. Similar control techniques of a dust control system could be applied to the non-metallic mineral products operations in PRDEZ with an achievable reduction potential for RSP of 90%.

Operation Process – Organic Chemical Operation

3.2.29 VOC emission from the storage of petroleum products is a function of the size and type of the tanks, the vapour pressure of the liquid inside the tank and the atmospheric conditions of the tank. Three types of tank design are commonly used to store petroleum products in HKSAR and PRDEZ, fixed roof, external floating roof and internal floating roof. The rate of VOC emission from these design are different and floating roof technology with effective sealing and fitting system is the most economic control measures. Vapour control systems such as incinerator or refrigerated condensers are usually employed as an add-on control technique to reduce the emission. Moreover, sensors for internal pressure are installed to monitor any potential leakage of the tank to provide any early warning system of leakage although the capture rate is a challenge for such measure in some cases.

Table 3-6 A Summary of Available VOC Control Techniques, Their Efficiencies and Cost

Techniques	Lower Concentration in Air Flow		Higher Concentration in Air Flow		Application
	Efficiency	Cost	Efficiency	Cost	
Thermal incineration	H	H	H	M	Wide for high concentration flows
Catalytic incineration	H	H	H	M	More specialised for lower concentration flows
Adsorption (activated carbon filters)	H	M	M	M	Wide for low concentration flows
Adsorption (waste gas washing)	-	-	H	M	Wide for high concentration flows
Condensation	-	-	M	L	Special cases of high concentration flow only
Biofiltration	M to L	L	L	L	Mainly in low concentration flows
Concentration	Lower (L)	<3g/m^3			
	Higher (H)	>5g/m^3			
Efficiency	High (H)	>95%			
	Medium (M)	80 – 95%			
	Low (L)	<80%			
Total Cost	High	>500 ECU/t VOC abated			
	Medium	150 - 500 ECU/t VOC abated			
	Low	<500 ECU/t VOC abated			

Source : Convention on long-range Transboundary Air Pollution Concerning the Control of Emissions of Volatile Organic Compounds or Their Transboundary Fluxes

3.2.30 VOC vapour displaces the vapour space of it container and emits during its transfer from the bulk storage terminals to the consumers, through the pipelines, road tankers, filling station dispensers and the motor vehicle refuelling process. In late 1970s, USEPA tested at 30% of the petroleum products leaked through the fuel tanker and the storage tank. In 1983, the USEPA enacted a regulation *"Code of Federal Regulations, Protection of Environment, Title 40, Part 60, Subpart XX – Standards of Performance for Bulk Gasoline Terminals"* to limit the outlet emission of no more than 35mg/l or a recovery rate of about 95% for fuel terminal and fuel tankers. Then, close-circuit vapour recovery/balancing system is commonly used system to control the emission of VOC from the handling of petroleum products in the North America and Western European Countries for over 10 years.

3.2.31 In HKSAR, the petrol filling station and organic chemical works for bulk storage of organic liquid are required to equip with the Stage I vapour recovering system since April 2000, which involved a recovery system for the control of displaced vapour during refilling of the underground storage tank from the fuel tanker. The USEPA in 1975 had already issued technical document illustrated stage I design could achieve a reduction of 90% during underground tank loading losses *"Design Criteria for Stage I Vapour Control Systems Gasoline Service Stations"*.

3.2.32 In HKSAR, the Government is studying various options for further control on vapour emissions arising from refuelling motor vehicles. These options include a vapour recovery nozzle and hose that could effectively collect the displaced vapour or an onboard carbon absorber installed on the motor vehicle itself. Stage II design had been tested by California Air Resources Board in the California and found to achieve a reduction of displaced vapour by at least 95% when compared with uncontrolled scenarios and the cost to implement such control measures is as low as USD1.6 per driver per year. (SCAQMD 2000)

3.2.33 It is noted that vapour recovery systems have not yet been implemented in PRDEZ at the present stage. Therefore both Stage I & II vapour recovery systems are recommended to PRDEZ base on the experience in HKSAR and other cities.

Operation Process – Printing and Graphic Arts

3.2.34 Printing inks, coating materials, fountain solution additives, platemaking and press cleaning solvents are the main sources of VOC emission from the printing and graphic art process. The type and level of VOC emitted from each individual process depends on the operation scale of the business and job specific requirements. The most common processes of the printing and graphic art included:

- Non-heat and heat web printing
- Flexography
- Sheetfed offset printing

- Gravure printing
- Screen print

3.2.35 Solvent recovery using engineering control techniques as presented in Table 3-6 as well as low-solvent inks, pigments, fountain solutions are commonly employed to reduce emission for compliance with the stringent VOC emission in the United States, for instance, the VOC content of the graphic arts materials and fountain solution are limited to 300g/L and 80g/L respectively. Under the Rule 1130 implemented in January 2000 by the South Coast Air Quality Management District (SCAQMD) of California, US, all operations related to graphic arts shall have an emission control system to be used in conjunction with low-VOC emitting materials. Therefore, the series of control recommended for the Region are:

- Product reformulation
- vapour (solvent) recovery
- VOC destruction and removal system, e.g. incineration

3.2.36 In accordance to the existing operation processes of the graphic arts establishments in PRDEZ, no control measures of any form had been installed, an emission reduction potential of 90% is suggested for this industrial operation, as the effect would be the most if no control had been previously conducted.

Operation Process – Process Evaporation

3.2.37 Process evaporative loss collectively referred to process emission from organic solvent cleaning and surface coating. Organic solvent cleaning referred to the process from which organic solvents are used to remove oils, grease, waxes from metals, plastic and printed circuit board. It is a pre-process prior to printing, coating and plating.

3.2.38 Enclosed design resulted a reduction of around 50% of the emission involving completely enclosure of the emission points, apart from a minimum sized single entrance and exit point for the enclosure. U bend designs could be utilised through the process to reduce the air diffusion throughout the process.

3.2.39 There is legislation in south coast of California, US limiting the VOC content of coating and emission from coating assembly lines, which aimed to reduce the VOC level discharged into the ambient air. These assembly lines including marine coating operations (Rule 1106), coating of metal parts and products (Rule 1107), motor vehicle and mobile equipment (Rule 1115 & 1151), metal container, closure and coil coating (Rule 1125), magnet wire coating (Rule 1126), paper, fabric and file coating (Rule 1128) and plastic, rubber and glass coating (Rule 1145).

3.2.40 The Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Gothenburg (Sweden) adopted on 30 November 1999 by various European countries and United States also presented a set of emission valves for the control of VOC process evaporative loss from industrial processes.

3.2.41 In complying the emission standards form the operational processes, the control measures recommended in the legislation for these coating operations generally fall into three areas: low-VOC coatings, higher transfer efficiency equipment and installation of air pollution control equipment. There are well established techniques and without losing good transfer efficiency by the application of powder, high-solid, and water based coatings for assembly line applications. By replacing the VOC content coatings with these low-VOC coatings, a reduction potential of 70 – 90% by volume or weight is achievable. Control equipment in the form of carbon adsorber, thermal incinerator and catalytic incinerator are commonly available in the commercial market. Testing was performed by USEPA in October 1999 (USEPA 1999) during full scale commercial operation of VOC control devices resulting average control device efficiencies of 91 to 96% based on the method used and the device tested.

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3.2.42 The socio-economic impact of these control measures on the control of emission for various industrial processes and operations shall be similar to those for the energy sector.

3.2.43 Reduction potentials would be very significant for this control measure. Taking the socio-economic costs with most of which are positive into consideration, this measure is expected to be a cost-effective one for PRDEZ.

3.2.44 Apart from print industry, most industrial sources are under some form of technological control and the emission level is 'medium' in HKSAR. The socio-economic impacts are mainly neutral positive. This measure produces a net benefit.

Environmental Management System and Green Management/Production (I3)

3.2.45 Promotion of green management and marketing for the manufacturing of consumer products could be encouraged in PRDEZ. This is the concept that embarked upon the road to sustainable development economies by making more effective use of local natural and human resources and enhancing their economy by manufacturing and marketing products and services in a more environmentally–being manner. Implementation of EMS that leads to ISO14001 certification or equivalent should also be widely promoted in PRDEZ

3.2.46 In recent years, there are a growing number of consumers eager for products of which the production does less harm to the environment. Green product marketing is the process by which businesses produce, label, distribute, and/or sell goods and services to consumers who prefer purchasing environmentally-responsible products. It is recommended the provincial government could set up a mechanism such that the green production could be distinguished. This not only allows firms to tap into and expand in the green market, but can also reduce the emission during operation processes from which finally benefit the environment.

3.2.47 Education should also be advanced in parallel for added effectiveness. Education can be considered in two tiers:

- Public education: to inform the consumers of the development of green production, the way to distinguish green products and the benefit of selecting such products.
- Corporate education: to promote to the industrialists the advantage of adopting cleaner production for long term benefits.

3.2.48 A vital step in green marketing is ensuring consumers that the product was produced in a manner that was environmentally sound. This can be simply done by "certifying" products through examining their compliance of green standards throughout their manufacturing processes. The product or raw materials in a product is then labelled by the provincial government so consumers are provided with the necessary information to make educated choices. Internationally, there are many successful programs for certifying and labelling timber and agricultural products and consumer goods which gives a new way to control emissions.

3.2.49 This measure requires a standard to be established to judge an operation environmental performance. Producers would then be educated as how to be environmentally more responsible and consumers as to how to avoid using products which have not obtained a 'green' mark. It should be noted that green markets require policing and/or endorsement of an independent body to retain their credibility. Also, proliferation of eco-labels leads to consumer confusion.

3.2.50 In HKSAR, green production includes two types of mechanisms: eco-labelling of products consumed in HKSAR and wide implementation of Environmental Management Systems (EMS) which may be certified to ISO14001. These mechanisms have the importance and potential to work in HKSAR because:

- HKSAR's role as a business management, financing, designing and marketing centre has been maintained during the industrial restructuring. It is evident that the practices of HKSAR companies have a notable influence on the industrial/business practices in the PRDEZ.
- HKSAR itself, as a major consumer market, also has power over the selections of product manufactured elsewhere. A wise exercise of this power might extend its influence to the production processes offshore.

3.2.51 Few companies in HKSAR are currently ISO14001 certified, or have an EMS in place. Recent studies suggest that supply chain pressure, applied to certain sectors such as the construction industry, and other support mechanisms, would have a positive effect on the number of companies prepared to clean up their production process. This may also have an influence on EMS taken up on the mainland by the manufacturing arm of HKSAR companies.

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3.2.52 In general, as the awareness of green management/production rises, a force for environmental development would result, which leads to increased investments in environmental industries.

3.2.53 In the medium term, to the extent that the 'green' mark provides increased market success, initial expenses in product research, development and production will be paid off due to increased market share.

3.2.54 To the extent that achieving the level of environmental good practice/excellence prescribed for the green mark involves changes to production methods and materials, there will be impacts on input and output prices. Such impacts will however be product-specific. Again, to the extent that products meeting green mark standards require different approaches to production, packaging, etc. there may be an impact on costs.

3.2.55 Differentiation of products on the basis of environmental criteria introduces diversity into consumer markets and allows new competitive dynamics to emerge. Should new and innovation products emerge, export opportunities may also present themselves (though compliance with often rigorous international evaluation procedures are likely to be required).

3.2.56 Providing common standards are adopted and verification systems are evenly applied, there is no reason why green mark schemes should not operate across several markets. Co-ordination between governments at different levels and in different areas would be needed to ensure a consistent standard for issuing 'green' marks throughout the PRDEZ, and in educating consumers.

3.2.57 It is evident that employment opportunities are not inversely related to the level of green productivity promotion. Rather, a company with a reputation for environmental responsibility tends to enjoy a higher level of acceptance worldwide.

3.2.58 Successful green mark schemes open new market opportunities for the participating firms. As some governments and large companies in the Region begin to look at 'green procurement strategies' in response to stakeholder pressure, green mark endorsement may provide a first-move advantage.

3.2.59 For PRDEZ, the pollution reduction potential of this measure is 'medium' and it should be viewed as a supporting measure to other more direct pollution reduction measures. The short-term socio-economic impact of this measure produces a neutral cost but the long-term impact is a net benefit. Overall, the measure will produce a neutral impact in the short term but it would become a net benefit in the long term for PRDEZ.

3.2.60 Local output levels and value would not be affected, however, external impacts would be incurred. The influence of the measure implemented in HKSAR would be the strengthening of the impacts of the corresponding policy in the PRDEZ.

3.2.61 In the HKSAR market, environmental costs expected to be supported by the higher level of willingness-to-pay for more environmentally accountable products on successful promotion of 'green' products. In the world marketplace, the responses would be twofold:

- Where environmental awareness is low, in expectation of green products to suffer from a declining demand (particularly due to the fact that most of these markets are relatively poor – where demand is more price-sensitive), old products are anticipated to continue to be sold there as, basically, getting certified and green-labelling is a voluntary commercial decision of companies.
- Where 'green' marks have already been successfully promoted, 'green' products from or via HKSAR would probably enjoy a market share growth, or even the removal of various trade restrictions.

3.2.62 However, from the long-term point of view, with growing global environmental awareness, green products will eventually gain in market value. Although there would be additional implementation burdens to be imposed on the current administrative system, these are expected to be minimal considering that the HKSAR Government has successfully implemented other similar programmes, e.g. EIA.

3.2.63 Higher demand for environmental technology from PRDEZ would also produce an opportunity for HKSAR to develop the relevant industry, hence providing more jobs locally.

3.2.64 The pollution reduction potential of this measure is 'low' for HKSAR. However, in addition to its nature as a supporting measure to other more direct pollution reduction measures, it helps further reduce pollution in the PRDEZ. The short-term socio-economic impact of this measure is neutral but the long-term impact is a net benefit. Overall, the measure produces a net benefit in the short term and an even higher benefit in the long term for HKSAR.

Force Closure of the Heavy Polluting Industrial Facilities (I4)

3.2.65 Under the existing regulation in HKSAR, abatement notice will be issued to an industrial facility if its emission exceeded the limit. The case will be brought to court unless the owner of the facility rectify the problem and pay for fine within a specified timeframe. The court may require the closure of the facility as the last resort. Therefore, this measure is not necessary in HKSAR and relevant regulation is already in place.

3.2.66 In addition, the manufacturing/production industries with extensive emissions are not common in HKSAR as this sector has been gradually diminishing for quite some years under the BPM.

3.2.67 In PRDEZ, an industrial facility will be forced to close under the 2 following conditions:

- if excessive pollution is found at the facility and not rectified within a specified period
- if the facility falls into an industry category that has been identified by the government as small and polluting operation.

3.2.68 In fact, industrial operation within the PRDEZ is changing from labour intensive manufacturing operations to knowledge base industries including electronic and information, biotechnology, petrochemical, precision instrument mechanic and automation. The operation scale of these plants is shifting from state owned enterprise or village and township enterprises to joint venture multi-national corporation with huge initial capital investment for advanced pollution control equipment.

3.2.69 In the initial consultations, representatives of major industrial polluters commented that enforcement stringency had been biased and leaned towards the benefit of small units. Experience suggests it is more difficult for the authorities to enforce environmental protection measures in small operators because of their 'amorphous' nature of operating - blossoming and withering (even disappearing) with the business cycle. This disadvantages those - usually large enterprises - which comply with environmental regulations in the sense that the small units are, *de facto*, often 'free' of environmental responsibilities. Therefore, closure of small polluting units is of potential both environmental and economic benefit.

3.2.70 The "15 Small Types Industry" which have been identified for closure by the government cover the following industries under the Blue Sky Engineering Program. The list should be reviewed regularly to provide a more effective control.

- coal mining;
- paper making;
- leather manufacturing;
- plate glass;
- cement;
- thermal power production and supply;
- non-ferrous metal;
- light industry;
- textile;
- petroleum processing;

- raw chemical materials and chemical product;
- timber processing, bamboo, cane, palm fibre and straw products;
- machinery manufacturing; and
- printing

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3.2.71 In some sectors, closure of small factories would result in a decrease in output levels in the short term. However, given that at present many large factories have spare capacity, the lost production has the potential to be gradually replaced by large more efficient enterprises and therefore output levels would not suffer from a reduction in the long run. Other factories that can comply with limit can secure their investment and slowly absorb employees from the closed industries,

3.2.72 In Guangdong, due to its institutional and regulatory characteristics, a part of the development of small establishments, e.g. power plants, has been a consequence of uncoordinated over investments. Although the capacity is expected to be replaced/partially replaced by the large units that will remain, the closure of the small operations before the end of their economic life would be associated with capital investments in new capacity which would be made earlier than otherwise would have been the case. These costs can be calculated from the remaining value of the small units to be shut down. The Guangzhou Government (Air Quality Management and Planning System for Guangzhou 1999) has estimated the costs at RMB 4,270 per tonne air pollutant (SO_2, NO_x or particles) reduction for the power generation sector. One other possible area of costs will be the costs of restructuring of the existing marketing/distribution network.

3.2.73 One less tangible benefit is that the closure of small units would help reduce the disincentives for large operators to clean-up, thereby bringing more large operators into line.

3.2.74 In the short term, Guangdong is expected to lose part of its market share since it takes time for market restructuring to be completed and for large operators to reclaim the lost share for Guangdong. However, it is anticipated that, in the long term, production would be more efficient and, with rising global environmental awareness and Guangdong's reputation as a more environmentally responsible production base, its products would become more competitive in the world market.

3.2.75 Given that air pollution has been the consequence of historical policies and practices, environmental protection should also be the responsibility of the community at large. An indiscriminate policy of closing firms because they are small rather than as a function of their actual environmental performance, or without providing a period for such firms to reach compliance with the given standards, clearly has serious implications for the investment climate of the Region affected.

3.2.76 The close relationship between the PRDEZ and the HKSAR, added to the preferential policies since the launching of the opening-up policy in China, has attracted enormous foreign investments to the PRDEZ, particularly from HKSAR, some of which might fall in the list identified for shutdown. To the extent that such plants are affected, and the policy will not discriminate on the basis of environmental performance, it is therefore the responsibility of the governments on both sides to co-operate and work out an acceptable implementation scheme.

3.2.77 Politically, closure of small plants would encounter resistance from the owners of these units. Some of these are actually owned by government, who might be still indebted or dependent on the cash flow of the operation of the unit. Various considerations, e.g. employment, local economic growth, interlaced with local protectionism, are therefore expected to come into play and make the problem more complicated in a short term.

3.2.78 However, large enterprises would probably welcome this policy. At present, large operators are very reluctant to invest in cleaning equipment given that small units enjoy the 'competitive edge' due to their low environmental accountabilities. Closure of these small units would certainly be beneficial to large enterprises because it would not only increase demand for their products/services but would also provide a fairer marketplace for environmentally accountable practices.

3.2.79 Although the closed capacity would be gradually replaced by large units, the labour force released would not be expected to be fully taken up by the expanded production activities in the large enterprises in short term. This is because:

- there may be a spatial mismatch in jobs demand and supply;
- there may be a mismatch in worker skills demand and supply (generally, larger operators tend not to employ lower-skilled workers from small plants); and
- as large units are more efficient than smaller ones, they are generally less labour-intensive per unit output.

3.2.80 After the closure of the targeted small units, there would be a need to restructure the market and, for electricity in particular, to upgrade the distribution network. Large units would gradually take up the market released and expand their production activities.

3.2.81 This measure in PRDEZ ranks 'very high' in terms of pollution reduction potential, however, the measure produced a negative socio-economic effect, particularly in the short term, and the lost employment opportunities, means that overall the measure produces a net cost in the short term. In the long term, however, the measure is more beneficial as the economy adjusts to more efficient production.

3.3 Summary of the Short-listed Control Measures for Industry Sector

3.3.1 Table 3-7 below presented a summary of the preliminary analysis for the selection of control measures for the industry sector and the emission reduction potential associated with each measures for individual pollutants where quantifiable. The recommended control measures for the industry are presented in Table 3-8.

Table 3-7 Score of the Assessment Criteria for the Industry Sector

	Control Measures							
	PRDEZ				HKSAR			
Assessment Criteria	**I1**	**I2**	**I3**	**I4**	**I1**	**I2**	**I3**	**I4**
Assessment Summary								
Emission Reduction Potential	High	V. High (SO_2: -154612; VOC: -91415; NO_x: -63428; RSP: -181453) tonnes	Medium	V. High	Low	Mediun	Low	NA
Availability of Technology	Ava.	Ava.	Ava.	M Ava.	M. Ava	Ava.	Ava.	NA
Socio-economic Impact	0	+	0	- -	0	0	0	NA
Assessment Score								
Reduction Potential	+1	+2	0	+2	-1	0	-1	NA
Availability of Technology	0	0	0	+1	+1	0	0	NA
Socio-economic Impact	-1	+1	0	-2	0	0	0	NA
Total Score	0	+3	0	+1	0	0	-1	NA

V. High = Very high; Not Ava = Not available in the Region; Ava = Technology available; M Ava = mature local technology available in the Region

Table 3-8 Summary of the Proposed Control Measures for Industrial Process Operation

Control Measures	**PRDEZ**	**HKSAR**
I1. Strengthening the Pollution Control System	Neutral benefit Recommended as policy measure	Neutral benefit Recommended as policy measure
I2. Technological Control	Net benefit Recommended	Net benefit Recommended with regular review
I3. EMS and Green management/production	Net cost in the short term, net benefit in the long term Recommended for long term measure	Negative benefit in the short term and even higher net benefit in the long term Recommended for long term measure
I4. Force Closure of heavy polluting industrial facilities	Net cost in the short term; becomes more beneficial in the long term Recommended for long term measure	Not applicable to HKSAR

4. ASSESSMENT OF CONTROL MEUASRES FOR MOTOR VEHICLES

4.1 Proposed Control Measures for the Region

4.1.1 With the rapid development and urbanisation in the Region, vehicular emission within the expanding city area is expected to increase rapidly and contribute to a significant portion of regional emissions. The air quality recorded in urban monitoring stations indicated the street level emission from motor vehicles has reached an alarming level with frequent exceedance of the air quality standards.

4.1.2 The two principal power generators for motor vehicles, namely petrol and diesel fuelled internal combustion engines, are projected to remain in use for the future years. Therefore there is an increasing need to reducing the emission from motor vehicle by controlling its growth rate in parallel with the implementation of tighter exhaust emission standard.

4.1.3 There is a set of control strategy and their associated measures commonly applied in urbanised cities worldwide to reduce vehicular emission. These generic sets of control measures are listed in Table 4-1.

Table 4-1 Regional Air Quality Control Measures Being Implemented World-wide for Motor Vehicles

Control Measures Concept	USA	UK	EC	Mainland	Australia
Implement tighter vehicular emission standards	✓	✓	✓	✓	✓
Strengthen I/M Programme for existing vehicles	✓	✓	✓	✓	✓
Increase phase out rate for in-used vehicles	✓	✓	✓	✓	✓
Improve the fuel quality	✓	✓	✓	✓	✓
Develop alternative fuelled vehicles	✓	✓	✓	✓	✓
Traffic Management and planning	✓	✓	✓	✓	✓

✓ = Control measure being implemented in the country/region

4.1.4 Previous studies in HKSAR (CTS-3) and PRDEZ cities (UNDP studies for Guangzhou) for the control of vehicular emission presented similar ideas as the generic measures. As a result, the preliminary screening assessment concluded that all of these control measures should go through the second stage evaluation for the selection of the most practicable control measures for the Region.

4.1.5 Apart from tighter exhaust emission standards for motor vehicles, a multi-pronged approach shall be adopted to support the implementation of tighter emission standards. The vehicular emission control measures proposed for HKSAR SAR and PRDEZ will be examined and discussed in the following order:

- Advanced Implementation of Emission Standards for New Vehicles complemented by improved fuel quality; (M1)
- Inspection/Maintenance (I/M) Programme; (M2)
- Environmentally Friendly Transportation Plan
  - Traffic Management and Transport Planning (M3)
  - Alternative Fuelled Vehicles (M4)

4.2 Feasible of the Control Measures for the Region

Advanced Implementation of Emission Standards for New Vehicles (M1)

4.2.1 In HKSAR, the majority of vehicles are imported from Japan, the EU and the United States. These countries lead the world in setting the most stringent vehicle emissions standards and fuel specifications and are pursuing the best available technology for reducing emissions from new vehicles. The tightening of emission standards for new vehicles is therefore not an issue for HKSAR as it is anticipate that new vehicles to be imported will meet international emission standards. Euro IV will be applied to new vehicles starting in 2005 and it is planned that HKSAR will follow the European schedule for new emission standards thereafter. The current European implementation schedule is presented in Table 4-2 as reference.

Table 4-2 Mandatory Vehicle Emission EURO Standards for EU Countries

Standard	Directive	Type of Vehicle	Date of Introduction
EURO I	91/444/EEC	Passenger cars	31 December 1992
	93/59/EEC	Light commercial vehicles	1 October 1994
	91/542/EEC	Heavy diesels	1 October 1993
EURO II	94/12/EEC	Passenger cars	1 January 1997
	96/69/EEC	Light commercial vehicles	1 October 1997
	91/5442/EEC	Heavy diesels	1 October 1996
EURO III	98/69/EC	Passenger cars & light commercial vehicles	1 January 2001
	99/96/EC	Heavy diesels	1 October 2001
EURO IV	99/96/EC	Passenger cars & light commercial vehicles	1 January 2006
		Heavy diesels	1 October 2006

4.2.2 In HKSAR starting from 2001, all the EURO III emission standards was applied to newly registered vehicles of gross weight not exceeding 3.5 tonnes in parallel with the European Counties, as presented in Table 4-2. A vehicle meeting EURO III standard will emit about 30% less RSP and 40% and 30% less VOC and NO_x than its equivalent EURO II model, and 86% less RSP and 75% and 44% less VOC and NO_x than EURO I model. Figure 4-1 and 4-2 indicated the comparison of new vehicle exhaust standard for heavy diesel vehicle (less than 3.5tones) and petrol vehicle respectively (EFB 2001). The general trend in HKSAR for bus operators is to order new Euro III vehicles and in the future, to purchase Euro IV/V vehicles when available.

Figure 4-1 Comparison of New Vehicle Exhaust Standard for Heavy Diesel Vehicle (>3.5tones)

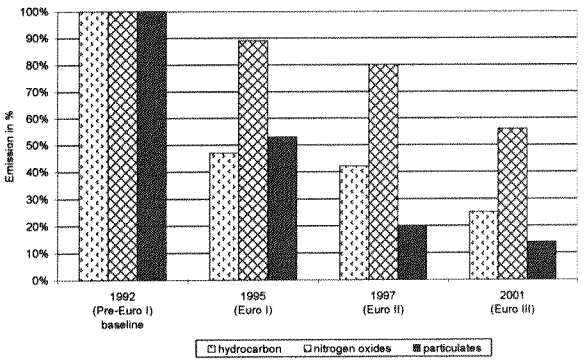
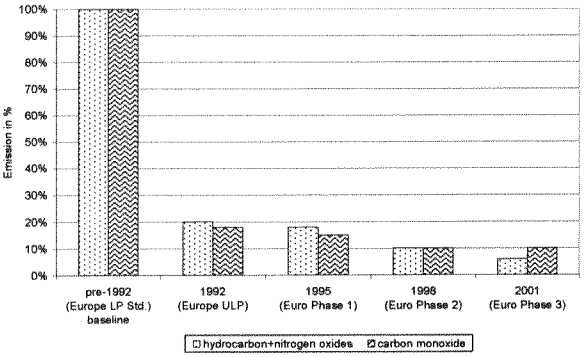


Figure 4-2 Comparison of New Vehicle Exhaust Standard for Petrol Vehicle



4.2.3 Existing motor vehicles in the PRDEZ are mostly pre-EURO standard and there is plan to upgrade the standards by the SEPA as presented in Table 4-3. Guangzhou Research Institute of Environmental Protection estimated that 70% of vehicles in Guangdong are locally made. Vehicle emissions standards of locally produced vehicles are generally lower compared with imported vehicles. Vehicle production technology particularly engine technology has to be advanced in accordance to the schedule shown in Table 4-4. If the proposed advance schedule is to be adopted, the motor vehicles would be upgraded to Euro IV by 2010, which is 5 years ahead of the original schedule.

Table 4-3 Existing SEPA Proposed Emission Standards for Motor Vehicles in PRDEZ

(Year of commencement)	1997	2000	2001	2004	2005	2010
Motorcycle	Pre-Euro		Euro 1		Euro 2	Euro 3
Small Petrol Vehicle	Pre-Euro	Euro 1		Euro 2		Euro 3
Large Petrol Vehicle	Pre-Euro		Euro 1		Euro 2	Euro 3
Diesel Goods Vehicle	Pre-Euro	Euro 1		Euro 2		Euro 3

Table 4-4 Proposed Emission Standards for Motor Vehicles in PRDEZ

(Year of commencement)	1997	2000	2001	2004	2005	2006	2010
Motorcycle	Pre-Euro		Euro 1		Euro 3		Euro 4
Small Petrol Vehicle	Pre-Euro	Euro 1		Euro 2		Euro 3	Euro 4
Large Petrol Vehicle	Pre-Euro		Euro 1		Euro 3		Euro 4
Diesel Goods Vehicle	Pre-Euro	Euro 1		Euro 2		Euro 3	Euro 4

4.2.4 It is important that the fuel quality necessary to be upgraded in the Region to meet future emissions standards. In HKSAR, the maximum allowable sulphur content in diesel and petrol following the European Countries standards since 1995 as indicated in the Table 4-5 under the Air Pollution Control (Motor Vehicle Fuel) Regulation. The quality of diesel in PRDEZ should follow the Euro standard as listed in Table 4-5 support the tightened vehicular emission standards. Further improvement on the quality of diesel equivalent to that of ultra low sulphur diesel (ULSD – 0.005%S) in HKSAR today should be encouraged.

Table 4-5 Maximum Allowable Sulphur Content in Motor Vehicle Fuels of different Euro Standards

Standards	Petrol	Diesel
Pre-EURO	0.1	0.5%
EURO I	0.1	0.2%
EURO II	0.05	0.05%
EURO III	0.015	0.035%
EURO IV	0.005%	0.005%

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4.2.5 The implementation of more stringent emission standard for new vehicles is a direct and very efficient measure in Hong Kong. It associates with insignificant socio-economic impact in Hong Kong and produces a high net benefit.

4.2.6 For the automobile industry in the PRDEZ, improvement in production technology is likely to increase the value of products and may help the industry enter into new markets where more stringent emissions standards are set for new vehicles. The overall output level is anticipated to increase. In 1999 the output of the transport equipment manufacturing sector in PRDEZ was as 36,000 million RMB. This is equivalent to over 90% of output of the sector in Guangdong Province.

4.2.7 Production costs of automobiles are likely to increase as better quality vehicles are to be produced. More expensive materials may be used; production process may also be more labour intensive and may involve more advanced technology. The cost to implement Euro 1 and Euro 2 standards for new vehicles would be 20800 RMB/tonne of NOx reduced in PRDEZ. To have Euro 3 substituted for Euro 2 new diesel and gasoline vehicles, the cost would be 32500 RMB/tonne. The installation of three-way catalytic converter in motor vehicles would cost about 150 RMB/tonne of RSP reduced. (UNDP 2001, GZG 1999)

4.2.8 The potential growth of automobile industry may create employment opportunities in the PRDEZ. Automobile manufacturers may not have the required production technology. Investments in research and technology may be required to design vehicles that could meet more stringent emissions standards. Costs for importing new technology from other countries may be incurred. There may be additional costs associated with higher skilled labour to be employed.

4.2.9 This measure will increase the competitiveness of the automobile industry in PRDEZ as better quality vehicles are produced. They may enter into new markets. Vehicles may be exported to other cities in mainland (such as Beijing) where emission standards for new vehicles are more stringent.

4.2.10 To implement this measure it is essential to maintain a reliable record of vehicle registration, to offer means of measuring emissions levels accurately and methods for enforcing the emission standards. Enforcement is often a key issue in many developing countries according to the World Bank Report (World Bank 2000). The report also noted that tightening emission standards for new vehicles may be less cost-effective than measures to reduce emissions from in-use vehicles since old and poorly maintained vehicles are generally responsible for the greatest part of vehicle emissions.

4.2.11 The proposed measure allows a reasonable period of time, 4 years, for the automobile industry to improve their production technology, which should be acceptable by the industry. In addition foreign investments may also be attracted.

4.2.12 Since the quality of fuel is to be standardised in the entire Guangdong Province, better quality fuels will be supplied in bulk. This may create an impact on the petrochemical industry in PRDEZ to adjust to the new regulation. Moreover, the demand for low quality fuels worldwide is likely to drop when more stringent emissions standards are set in the future. It is likely that the fuel prices could be kept at a reasonable level in the future.

4.2.13 The socio-economic impacts of improving fuel quality in PRDEZ are assessed with reference to bus operators' experience in HKSAR. At the end of 1999, there were some 12,120 buses licensed for operation in HKSAR. Over 50% of public buses are operated by the five franchised bus companies in HKSAR (C&SD 2000). All major bus operators in HKSAR have recently switched to using ULSD. Their bus fleets consumed regular diesel (0.05% sulphur) in the past. The suitability of ULSD (0.005% sulphur) for HKSAR and its effect on emissions were studied in a trial scheme in 2000. Test results revealed no noticeable difference in vehicle performance, fuel consumption and maintenance requirements for buses running on ULSD and regular diesel.

4.2.14 Consultations with the bus operators, carried out before the switch to ULSD, revealed that if they were required to use ULSD and the price of ULSD did not come down to a reasonable level, the bus operation profits would drop significantly. The operators indicated that they would likely apply to increase their tariffs given the potential surge in operation costs. They held discussions with one of the oil companies regarding the supply of ULSD, urging them to make ULSD available in bulk, at an assured delivery rate and at an affordable price.

4.2.15 In early 2001, however, major bus operators announced their switching to ULSD without increasing their tariffs. It is not certain whether tariffs will be raised at a later stage. For other diesel vehicles in HKSAR, the market price of ULSD is 8% less than regular diesel although no longer available in the market, attributed to the provision of preferential duty terms by the Government.

4.2.16 Based on HKSAR's experience, costs related to vehicle maintenance and training of technicians upon consumption of better quality fuel are likely to be insignificant. In addition, modification of engines is not necessary. No major competitiveness issues are envisaged as the price of fuels, and therefore operation costs of all businesses, will change across the entire Guangdong Province.

4.2.17 Similar to many developing countries, enforcement will be a key issue in the PRDEZ. Proper actions to control the use of illegally imported fuels will be the key to successful implementation. It should however be noted that the efficiency of fuel might vary in different locations, depending on local climate, urban setting and vehicle characteristics. The impact of switching to better quality fuels should therefore be studied prior to implementation.

4.2.18 No major employment issues are envisaged as training of technicians and modifications of vehicle engines are not necessary upon a switch to better quality fuels. The measure will be acceptable to the transport industry and private car owners if the price of better quality fuels is kept to a level similar to that of presently used lower-quality fuels.

4.2.19 Tightening of emission standard is a direct and very efficient measure from the environmental point of view. In PRDEZ, it is associated with some socio-economic benefits as well as costs, and the overall socio-economic impact is assessed to be neutral. It therefore produces a net benefit.

Inspection/Maintenance (I/M) Programme (M2)

4.2.20 At present all vehicles in Guangdong are required to participate in annual inspection and roadside inspection. Emissions levels of two pollutants, hydrocarbons (HC) and carbon monoxide (CO), are monitored. Technology for testing NO_x and CO_2 is not readily available in Guangdong Province.

4.2.21 Drivers are required to install catalytic converters for removing HC and CO if their vehicles fail the emissions tests. The cost of installing a catalytic converter is 8,000 to 12,000 RMB (AQMPSG 2000). The vehicles are to be re-tested upon installation of converters. Retro-fitting a catalytic converter on locally produced vehicles is sometimes a problem as the design may not be able to accommodate a catalytic converter. In Guangdong 70% of vehicles are Government owned. Public transport is largely operated by public agencies. Installation costs of catalytic converters are therefore mainly borne by the Government. (Source: Consultations in Guangdong)

4.2.22 The measure is to strengthen the existing I/M programme in the PRDEZ as presented in USEPA report that an effective I/M programme can yield a 28% reduction in emissions (USEPA 1996). The feasibility of providing centralised and decentralised emission testing centres should be considered. Emissions tests will be extended to include other pollutants such as NO_x and RSP. New technology including remote sensing techniques will be employed. The programme will also involve creation of a database system and education system for drivers, test operators and public. However, a challenge for I/M in PRDEZ is the control on vehicles across from areas outside the Region.

4.2.23 Starting from November 2000 in HKSAR, all petrol vehicles over 6 years of age will need to undergo the emission test during the annual examination. From October 2000 onward, all diesel vehicles will be tested under the enhanced test procedures in their annual inspection and roadworthiness examination. Major bus operators carry out emissions tests regularly (every 3 to 4 weeks) on their fleets. Owners and drivers of taxis, PLBs and goods vehicles in general value the importance of vehicle maintenance. Polluting vehicles are fined and the fines have been increased from HK$450 to HK$1,000 from 1 December 2000. Generally the maintenance technique should be simultaneously upgraded and introduced to the Region to result in effective emission reduction. The I/M system has to be regularly reviewed and tightened with a view in the transportation characteristics in different parts of the Region.

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4.2.24 In PRDEZ, public transport is largely operated by public agencies. Costs related to inspection and maintenance should be absorbed by the operators. The level of impact will depend on the size of increase in inspection fee and the emissions standards set for in-use vehicles.

4.2.25 Apart from the potentially higher maintenance costs involved when new emissions tests are introduced, there are costs associated with the time to be spent on inspection and maintenance of vehicles. Competitiveness will not be relevant as the measure will impact on all different sectors in the transport industry in PRDEZ.

4.2.26 As mentioned above costs related to inspection and maintenance of vehicles are likely to be borne by the Government since public transport is largely operated by public agencies. The measure will create jobs in PRDEZ when new inspection centres are developed. There will also be new higher skilled jobs associated with maintenance of vehicles. Vehicle maintenance will generally be better valued by transport operators in the future contributing to larger asset lifetimes for vehicles.

4.2.27 The reduction potential of this measure in PRDEZ is 'medium'. It is also associated with some socio-economic costs. However, with its value as a supporting measure being taken into account.

4.2.28 This is a supporting measure for tightening of emission standard in Hong Kong. Although the reduction potential of it is 'low', with its value as a supporting measure being taken into account, the measure produces a slightly negative benefit, particularly given the fact that it is not associated with any negative socio-economic impact.

Environmentally Friendly Transportation Plan and Traffic Management (M3)

4.2.29 The CTS3 Study had developed a few long term policy directions on transportation planning and management elements for HKSAR. The policy of these directions as listed below aimed to reduce the need for further infrastructure and the impact on the environment by utilising an approach in which land-use, transport and environment are considered in an integrated manner.

- Develop comprehensive transportation plan which largely encourage public transport
- Establish management plan to facilitate the transportation plan
  - Reduction of congestion and improvement in mobility
  - Better distribution of roads and network
  - Investment in transportation network for an improved efficiency

4.2.30 Although these policy directions were originally developed for HKSAR, the Guangdong Province government had proposed similar approaches for the control of localised vehicle emission in city areas. These approaches, for the time being, provided a directional framework for detailed studies in PRDEZ urbanised cities.

4.2.31 Electronic Road Pricing (ERP) is a system for traffic management being applied in Singapore. A feasibility study on ERP was commissioned by Transport Department in March 1997with the objective of examining the practicability of implementing ERP system in Hong Kong and assessing the need for such a system to meet transport objectives. The study was completed in 2001 and revealed that there were no transport grounds for applying drastic restraint measures like ERP in Hong Kong at this stage and that there were equally effective measures to discourage the use of private cars, increase the use of public transport services and reduce traffic congestion, if necessary.

4.2.32 The applicability of ERP to achieve environmental objectives has also been considered by the Government. It concluded that while ERP could be used as a tool to improve air quality, its impact would mainly be on roadside air quality. ERP will not provide the solution to the wider ambient air pollution. To improve the air quality of the Pearl River Delta Region requires the joint effort of SARG and the Guangdong Government. Nonetheless, the Government will continue to monitor the development of its technology as well as the traffic situation in Hong Kong so as to review the need for additional restraint measures in future.

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4.2.33 The economic benefits of implementing traffic management/traffic-demand management and better transport planning will be significant as it will reduce congestion and facilitate improved mobility. Many consultees felt that air pollution at street level is in fact caused by traffic congestion. A bus operator estimated that 43% of time of a bus running on a popular routes are idle (Consultation with relevant operators). Very often their vehicles are stuck in traffic jam. If congestion problems are to be alleviated by implementing traffic/traffic-demand management, public transport services will certainly be more reliable and better supported by the users. In addition fuel consumption will also be reduced, which may help reduce operation costs and tariffs.

4.2.34 There may be significant administrative costs associated with traffic/traffic-demand management. These costs are to be borne by the Government. Measures such as electronic road pricing schemes will involve significant initial investment costs. The World Bank paper (2000) also noted that many traffic management schemes become less effective over the time when drivers change their driving habits. The effectiveness of these measures should therefore be monitored from time to time.

4.2.35 The promotion of public transportation and priorities of public transport in the use of roads are certainly welcomed by public transport operators. Rationalisation of bus routes was considered by bus operators as a key to reducing traffic congestion and air pollution. They will continue to explore opportunities to rationalise other bus routes.

4.2.36 Impacts on employment are likely to be too diffused to be reliably estimated as a direct impact of these measures.

4.2.37 The reduction potential of the measure is 'high' in PRDEZ. Moreover, it imposes burdens on the current administration system and prices of inputs and outputs. The measure therefore is a less cost-effective one. However, with its value as a supporting measure being taken into account, the measure produces a net benefit, particularly given the fact that it has no other particular negative socio-economic impacts in addition to the administrative one.

4.2.38 The reduction potential of the measure is 'high' in HKSAR. Moreover, it imposes burdens on the current administration system and the prices and inputs and outputs. The measure therefore is a less cost-effective one. However, with its value as a supporting measure being taken into account, the measure produces a net benefit, particularly given the fact that it has no other particular negative socio-economic impacts.

Alternative Fuelled Vehicles (M4)

4.2.39 Alternative fuelled vehicles generally include vehicles that run on fuels other than diesel and gasoline. The use of alternative fuelled vehicles has been explored in many countries with a view to reducing vehicular emissions.

4.2.40 The Clean Fleet Project carried out by Battelle Memorial Institute (Battelle Memorial Institute, 1995) showed that alternative fuels had fewer emissions than regular gasoline. Compressed natural gas was shown to generate 68 to 77% less carbon monoxide and 90 to 95% less ozone precursors; liquefied petroleum gas, 48% carbon monoxide and 68 to 70% ozone precursors; and methanol, 50% and 59%, respectively. Electric vehicles, without a combustion engine, were shown to have the greatest emission reduction. However, they still contribute to regional air pollution through the use of electricity that has to be produced by power plants.

4.2.41 Gaseous fuels such as CNG (compressed natural gas) and LPG (liquefied petroleum gas) are the most popular alternative fuels at present. Emissions test resulting from CNG and LPG aftermarket conversions is generally not as promising as the original equipment manufacturer's models. Other options such as alcohol and biofuels are considered to be uneconomic under most circumstances. The use of electricity is limited by battery technology today.

4.2.42 In many countries the problems encountered in introducing LPG to the transport sector are related to the distribution system. Investments in LPG distribution and refuelling stations have been a constraint on widespread LPG use.

4.2.43 HKSAR is exploring the opportunity for using alternative fuelled vehicles. The LPG taxi scheme was launched in 1999 and a target set for the conversion of the 18,000 licensed diesel vehicles to LPG by 2005. A one-time subsidy of up to a maximum of $40,000 is available to each taxi owner who wishes to replace their vehicle with a new LPG vehicle before 2003. A budget of some $720 million is available for this purpose. The most popular LPG vehicle is priced at $205,000. The maximum level of subsidy is therefore equivalent to about 20% of the cost of the vehicle. As at the end of October 2000, the Government had subsidised the replacement of 2,586 vehicles.

4.2.44 The potential to introduce LPG powered Public Light Buses (PLBs) is currently being considered. The HKSAR Government has purchased 11 LPG PLBs to study the feasibility of running LPG vehicles on fixed and non-fixed routes. The trial scheme is to be completed in early 2001. The replacement of diesel PLBs by electrically powered PLBs is another measure currently under consideration in HKSAR. The Government has purchased 5 electric PLBs to study the feasibility of running these vehicles on fixed routes.

4.2.45 The HKSARG commissioned a feasibility study on introducing a trolleybus system in Hong Kong. The study revealed that trolleybus operation in urban areas would involve important technical and operational difficulties. It was concluded that there was not a strong case for introducing trolleybuses in existing built-up areas in Hong Kong. The Government would however further explore the merits of introducing trolleybuses vis-à-vis other environmentally friendly transport modes in new development areas.

4.2.46 A bus operator was also undertaking a trolley bus trial scheme and it is considered as an attractive option by this bus operator. They anticipate that the ridership level in HKSAR will better justify the investment compared with any other cities. Conversion of diesel buses to electric trolley buses is considered practical and viable.

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4.2.47 Taxi fares in HKSAR are charged according to the approved fare scales. The fare structure of PLBs used for scheduled services (green minibuses) is also controlled by the Government. Tariffs are therefore the same for diesel and LPG vehicles. For PLBs used for non-scheduled services (red minibuses), they are free to operate without control over routes or fares. Tariffs may therefore increase if operation costs increase upon a switch to LPG.

4.2.48 The dedicated LPG stations sited on land provided on favourable terms by the government currently sell LPG at $2.01 to $2.04 per litre. This price is fixed for one year (Oct 2000 to Oct 2001). The price is almost 50% lower than the market price, currently $3.88 per litre. The other seven LPG stations sell the fuel at the market price. The fuel cost of LPG vehicles is estimated to be 40% lower than diesel vehicles if they purchase LPG at dedicated refuelling stations.

4.2.49 There are additional costs associated with the switch to LPG. The energy content of LPG is significant lower than diesel, LPG vehicles therefore consume fuel significantly faster (70% faster for taxis) than diesel vehicles. In addition the fuel tank capacity in LPG vehicles is only slightly larger than diesel vehicles as vehicles with larger fuel tank are too heavy and bulky to run. LPG fuel tanks capacity may need to be filled two to three times a day compared with once a day for diesel PLB. However, we would suggest the additional time cost entailed is small and outweighed by lower fuel costs.

4.2.50 There are also additional costs associated with the use of electrically powered PLBs in previous trials. These vehicles need to be recharged for 15 minutes at least twice and possibly up to four times a day at the light bus stations. The industry associations are of the view that the proposed electric PLB scheme is impractical for this reason. There is also a concern that electric vehicles might lose power unexpectedly and have difficulty reaching a charging station thus imposing time and inconvenience costs on the operator and the passengers. There are also concerns that the life span of electric/LPG powered vehicles may be significantly shorter. International experience shows that the reliability of electric vehicles is generally good and acceptable by the operators. Battery technology today however is not entirely satisfactory. Very often batteries need replacement every 2 to 3 years, rendering operation uneconomic.

4.2.51 It is understood from the consultation with public transport operators in HKSAR that operators are likely to increase their tariffs if operation costs increase. The size of increase will largely depend on the future price of fuel which is undetermined at present. In addition the charges of freight transport services are likely to increase if the price of fuel goes up. This is likely to impact on businesses in particular trading industries.

4.2.52 With lack of local scientific data on the alternative fuel trial, the Study took reference to a recent report on alternative transportation fuel completed by the United Kingdom's Department of Environment. The study reports on a trial to provide and combine comprehensive data on the economics, exhaust emissions and energy consumption performance of alternative fuels on a comparative basis under UK operating conditions.

4.2.53 The trials found that the converted LPG and CNG vehicles tended to be somewhat unreliable. The poor level of reliability was attributed to the one-off nature of the conversions. If a more standardised conversion package was available, the situation would be expected to improve.

4.2.54 The fuel consumption of the gas vehicles was considerably greater than for the diesel equivalent. In energy terms, the gas vehicles used about 60% more fuel than the diesel vehicles. On a litre/km basis, the fuel use of the LPG vehicles more than doubled. The biodiesel vehicles gave a small decrease in fuel use in energy terms but an increase in volume terms. Electricity consumption at point of use in the electric vehicles was considerably lower than for the other fuels. However, this conceals the fact that there are considerably higher energy losses in the production of electricity as compared with the other fuels, and a fair comparison would need to be done on a life-cycle basis.

4.2.55 It is found that the costs for running on various fuels are in the ascending order of CNG, LPG, diesel, biodiesel, and electricity. The LPG and CNG fuels show a cost increase of between 20% and 30% as a consequence of their higher fuel consumption, despite the fuel prices being lower than diesel. The biodiesel shows an increase of around 80%. In terms of fuel costs, the electric buses operated at the same cost per kilometre as their diesel equivalent.

4.2.56 The cost of the vehicle conversions to CNG or LPG was between £8,000 and £14,000. Running on biodiesel required no conversion costs.

4.2.57 Putting the reliability problems of the converted vehicle aside, there is no substantial increase in the cost for regular maintenance.

4.2.58 The introduction of alternative-fuelled vehicles may also carry an important objective for reducing the reliance on the supply of oil of which the price is anticipated to increase continuously in the future. It is believed that reducing the reliance on the supply of petroleum products will ultimately benefit their economy as a whole.

4.2.59 The competitiveness of alternative fuelled vehicles vis other vehicles will depend on the relative tariffs of these vehicles in relation to other vehicles and passengers' perceptions and experiences with regard to the relative reliability of the different vehicles.

4.2.60 However, given that alternative fuelled vehicles will be licensed to operate locally, there should be no direct cross boundary issues between HKSAR and PRDEZ associated with the introduction of this measure.

4.2.61 Employment issues are not particularly relevant in this case. Similar number of staff will be required to operate and maintain different types of vehicles. Trolley bus scheme maybe an exception. Trolley buses could run 24 hours a day, as they are a lot quieter than diesel buses. Workers for trolley bus services at night may be required subject to the actual demand for overnight services.

4.2.62 In PRDEZ, the reduction potential of the measure is 'high'. Moreover, it imposes significant burdens on the current administration system. The measure therefore is a less cost-effective one. However, with its value as a supporting measure being taken into account, the measure produces a net benefit, particularly given the fact that it has no other particular negative socio-economic impacts in addition to the administrative one.

4.2.63 Similar to PRDEZ, the reduction potential of the measure is 'high' in Hong Kong and it also imposes significant burdens on the current administration system. The measure therefore is a less cost-effective one. With its value as a supporting measure being taken into account, the measure produces an overall net benefit for long term, particularly given the fact that it has no other particular negative socio-economic impacts.

4.3 Summary of the Short-listed Control Measures for Motor vehicles

4.3.1 Table 4-6 below presented a summary of the preliminary analysis for the selection of control measures for the motor vehicle and the emission reduction potential associated with each measures for individual pollutants where quantifiable. The recommended control measures for the motor vehicles are presented in Table 4-7

Table 4-6 Score of the Assessment Criteria for the Motor Vehicles

Assessment Criteria	Control Measures							
	PRDEZ				HKSAR			
	M1	M2	M3	M4	M1	M2	M3	M4
Assessment Summary								
Emission Reduction Potential	V. High (up to 36%) (SO_2: -9231; NO_x: -24891; RSP: -8205; VOC: -28094) tonnes	Medium	High	V. High	High	Low	High	High
Availability of Technology	Not Ava.	Not Ava	Not Ava	Not Ava.	Not Ava	Ava	Ava	Ava
Socio-economic Impact	0	-	0	-	0	0	-	-
Assessment Score								
Reduction Potential	+2	0	+1	+2	+1	-1	+1	+1
Availability of Technology	-1	-1	-1	-1	-1	0	0	0
Socio-economic Impact	0	-1	+1	-1	0	0	-1	-1
Total Score	+1	-2	+1	0	0	-1	0	0

Not Ava = Not available in the Region; Ava = Technology available; M Ava = mature local technology available in the Region

Table 4-7 Summary of the Proposed Control Measures for Mobile Vehicles

Control Measures	PRDEZ	HKSAR
M1.Emission Standards for New Vehicles	Net benefit Recommended	Under regular update
M2. Inspection/Maintenance (I/M) Programme	Net cost Recommended as supporting measure	Net cost Recommended as supporting measure
M3. Traffic Management and Transport Planning	Neutral benefit Recommended for long term	Net benefit Recommended for long term
M4. Alternative Fuelled Vehicles	Net benefit Recommended for long term	Net benefit Recommended for long term

5. ASSESSMENT OF CONTROL MEASURES FOR VOC CONTAINING PRODUCT

5.1 Introduction and Assessment Criteria

5.1.1 As presented in other technical annexes, the VOC containing product sector had been identified in the base year emission inventory as a heavy contributor of regional VOC. Although there were limited activity data available in the Region for accurate prediction of the future VOC emission, it is understood that there would be a rising trend in the emission level. Therefore effective control mechanism applicable to both HKSAR and PRDEZ would be in need. Worldwide-established control experience in this area had been researched. However, there were neither a complete list of control measures nor management system that could be directly adopted from overseas experience.

5.1.2 It is recommended that the control measure for VOC containing products be consisted of 3 components as listed in Table 5-1. The recommended components of the measure are similar to that for reducing greenhouse gas (GHG). In view of the successful implementation of GHG control in HKSAR and other western countries, the same approach would most likely be feasible for the control of the VOC in the Region. Since there is currently no local provision on VOC containing products, the combined effects of the control measure would be substantial as this measure is the first step taken for the Region. The three components should be implemented as a package.

Table 5-1 Air Quality Control Measure Being Implemented World-wide for VOC Containing Products

Control Measure – Major Components	USA	UK	EC	Mainland	Australia
VOC containing product survey	✓	✓	✓		
Labelling of VOC containing products	✓	✓	✓		✓
Establishment of emission limit for VOC containing products	✓	✓	✓		✓

✓ = Control measure being implemented in the country/region

5.1.3 The base year and future years emission inventories indicated that VOC containing products are originated from two sources:

- Paint application including architectural coating, paint, varnishes, thinner including (dissolvers, viscosity reducers), lacquer, latex, and cleaning agents
- Domestic products including as personal care aerosols products, household cleaning products, toiletries (products that expels pressurised materials by means of a propellant-induced force), office, adhesive, rubbing compounds

5.1.4 Since HKSAR and Guangdong have limited provisions for controlling VOC emission, little lesson can be drawn from past practices. The Study therefore referred to the western experiences for control options. It was understood that outside experiences might not be fully appropriate for local situation due to difference in product application, enforcement system and control penetration rate. Nevertheless, the existing worldwide experience provided an opportunity to understand the most up-to-date development in the field for improving regional air quality. Experience in other countries/regions showed that there existed engineering feasible control for VOC containing products, nevertheless, a detail local management plan would be necessary to utilise foreign technologies the Region. Furthermore, the actual schedule and timeline for implementing the suggested components would require more intensive investigations and have to be inline with future policy direction of the governments.

5.2 Components of Control Measure

5.2.1 As mentioned, the recommended control measure has 3 components. These 3 components shall form the package of the VOC control measures with the details for each component will be discussed individually. World-wide experiences adopted in the United States and European Union countries indicated that the implementation sequence of the three components could be carried out simultaneously or in sequence, subject to technical feasibility of the local situation and public acceptability.

VOC Containing Product Survey

5.2.2 The purpose of a product survey is to research on the types of VOC containing products in the market and to understand their emission characteristics so as to facilitate the smooth progress of implementing VOC control measure on VOC containing products. In other words, product survey is a tool to collect critical technical information for developing source specific classification of the VOC containing products in the commercial market. Technical information includes sales volume of individual products and classification, product applications and emissions, product ingredients and speciation profile.

5.2.3 The result of the survey would help to develop an overall management plan for VOC control. It would also provide enhanced activity data to fill in gaps in the compilation of emission inventory as most of these data were not readily available for the Region.

5.2.4 In California, product survey on VOC containing products had been carried out continuously since 1993 as part of the state government's VOC control strategy. The survey provides an understanding of VOC containing products in terms of content, applications, and consumption pattern. The completed survey in 1998 provided the California Government with useful database for the upcoming review of VOC control strategy to reduce the formation of smog. Final report of the survey could be referred to the California Air Resource Board's web site. (http://www.arb.ca.gov/coatings/arch/Survey/results/Final.htm). The most recent one that aimed to collect updated information was completed in 2001.

5.2.5 California had conducted product survey for architectural coatings in form of questionnaire survey (http://www.arb.ca.gov/coatings/arch/Survey/results/AppendA.pdf) which could serve as an example for the Region. Obviously direct adoption of the questionnaire to local application is not feasible, unless, the form had been reviewed for suitability.

5.2.6 The United States Army had also completed a VOC product survey specifically for paints. The results are published in the USEPA "Environmental Preferable Purchasing Program, Painting the Town Green: Aberdeen Proving Ground's Paint Pilot Project, USEPA, November 1999" on determination of the VOC emission level from commercially available paints. Based on the survey and test performed on 565 commercial available paints, classification had been established for low VOC content paints that accounted for at least 15% of the market share.

5.2.7 A report published in June 2000 presented the findings of a 'Study on the Potential for Reducing Emissions of Volatile Organic Compounds Due To The Use of Decorative Paints and Varnishes for Professional and Non-professional Use.' The contributors to the study report were University of Amsterdam, Chemiewinkel, Enterprise Ireland and Institute of Environmental Management.

5.2.8 The study reported that there were almost 1,300 significant paint manufacturers and over 3,200 small-localised family businesses existed in the EU and six major 'accession countries'. From the product survey of the study, the overall market share of water-based paints across the EU was about 70%. Water-based coatings had high penetrations (up to 100% in some countries) in wall paints, and considerably lower penetrations (5%-40%) in trim paints and varnishes. The contribution of the decorative paints sector to total man-made VOC emissions in the EU is about 4%-5%.

5.2.9 For this Region, product surveys for both architectural coatings and domestic products could be carried out in parallel. Key technical information and results could assist the governments in formulating future comprehensive package of VOC control measures.

VOC Containing Product Labelling

5.2.10 VOC product labelling refers to the displaying of a label on the package of the VOC containing product to show the product VOC content. The purpose is to provide the general pubic an understanding of VOC content in these products so that they have a freedom of choice to choose the products that they prefer, and promote public awareness on the impact of the VOC containing products.

5.2.11 Presenting the composition of household products on their packages is a common practice worldwide to inform consumers of the safety contents of products. Therefore a list of active ingredients (or the formula) in domestic products, VOC content for instance, is recommended to be included on the product package. Through such labelling system for VOC products, the consumer would have their own choice on the purchase of environmentally friendly products.

5.2.12 At present, in a number of European Union member states as well as accession countries, eco-labelling schemes, voluntary agreements and information campaigns had been implemented to encourage the use of low VOC containing products.

5.2.13 Under the administrative requirements of the Rule 1113 – Architectural Coating (http://www.aqmd.gov/rules/html/r1113.html) of the California Air Resources Board in the United States, containers for all coatings must display mandatory the date of manufacture of its contents, including the VOC content by a pre-determined formula. Manufacturers of the coatings then register this information with the authority.

5.2.14 Furthermore, labelling systems had been implemented locally for other consumer products. In particular, the HKSAR Environment and Food Bureau (EFB) had initiated a public consultation on the product labelling procedure for genetically modified (GM) food on 26th February 2001. The proposed labelling scheme aimed to provide more information for consumers on the selection of food products, although such labelling scheme is still being developed internationally. The proposed labelling system should eventually ensure that the supply and cost of our food would not be adversely affected; additional labelling requirement should not greatly increase costs for the food trade and information provided to consumers should be useful and easy to understand. Three options for a GM food labelling system were proposed by EFB in the recently completed consultation exercise.

- To encourage the food trade to label GM food voluntarily following a set of guidelines issued by the Government;
- To provide for mandatory labelling by introducing legislative amendments; and
- As a first step, to encourage the food trade to label GM food voluntarily following guidelines issued by the Government and to provide for mandatory labelling by legislation

5.2.15 Further studies would be required in later stage to study the feasibility of applying the experience from GM food labelling scheme and/or other world-wide experience to the VOC containing products in the Region.

5.2.16 The EMSD in Hong Kong is currently operating energy efficiency labelling for a few household appliances and photocopies since 1995. The label has provided the consumers with information on the energy consumption and efficiency rating of the appliances. Consumers are therefore given additional information in the selection of products.

5.2.17 The Region could refer to the above experiences in considering the labelling system for VOC containing products. Emission reduction potential for this control measure is hardly quantifiable; nevertheless, the labelling of VOC containing products is a critical component of the overall control package for VOC emitting sources for the Region. An education programme to arouse public awareness could further complement this measure.

Product Emission Limit

5.2.18 The establishment of permitting VOC content of VOC containing products is recommended as one of the component of the VOC control measures for the Region. The objective is to initiate emission reduction by controlling the VOC content in a product in a voluntary or mandatory manner and resulted the substitution of the VOC portion of a material with lower VOC emission level or re-formulate the product to emit minimal VOC.

5.2.19 The benefits of limiting the product VOC content to reduce emission include avoidance of a need for threshold solvent usage levels to minimise burdens on the small enterprises and to avoid the transfer of the compliance responsibility to a limited number of product manufacturers or suppliers.

5.2.20 Setting emission limit for VOC containing products is one of the most commonly employed and practicable control measures being used worldwide including the United States and the European countries to reduce the VOC emission. This control measure should be part of the VOC management plan for the Region.

5.2.21 By establishing a voluntary or mandatory emission limit for VOC containing products, manufacturers in California found different cost-effective approaches to reduce the emission as follows:

- Performance Standards set allowable VOC content for a product category, companies can choose how to modify their product formulas to reduce VOC content.
- Innovative Products Provision allows manufacturers to exceed performance standard VOC limits if they can demonstrate alternative ways of lowering emissions. For instance, increasing the amount of "active ingredients" and changing the dispenser can lower the amount of VOC emitted per application.
- Alternative Control Plan allows manufacturers to average or "bubble" their emissions from noncomplying products with those from products that have a margin below the standard. The resulting average emission must be less than or equal to the emission limit for individual products.

5.2.22 In addition to the consideration of the reduction potential, the California Government also considered the commercial and technological feasibility of the newly introduced products. The existing products would not be forced to eliminate given a more environmentally friendly product of similar (or same) uses is introduced. In any of the approaches mentioned above, the control measures aimed to reduce the VOC emissions by product reformulation, product substitution, and repackaging of the products.

(i) Paint Application

5.2.23 In South Coast of California US, there were VOC emission standards specific for architectural products under the Rule 1113: Architectural Coatings with an implementation programme up to 2008 aiming to reduce the emission from products progressively. The VOC control limits for various coatings in the South Coast of California are presented in Table 5-2.

Table 5-2 Selected VOC control limits under Rule 1113

Coating	Current limit (g/L)	Limit effective 2006 (g/L)
Essential public service coatings	420	100
Floor coatings	420	50
Industrial maintenance coatings	420	100
Quick dry enamals	400	50

5.2.24 In August 2000, there was an UK study reported on the investigation of potential product based approach to reducing VOC emissions from the European Union (EU) vehicle-refinishing sector. The title of the study is *'Reducing VOC emissions from the Vehicle Refinishing Sector'*. The study was undertaken by Entec UK Limited and The Paint Research Association in the UK.

5.2.25 The study investigated into low VOC coatings for vehicle refinishing (VR) applications by product surveys, the categorisation and VOC content of ready-for-use coating products. The coatings identified were commercially available and had high achievable levels of VOC reduction in comparison with typically used coatings. The VOC content specified for each coating category in Table 5-3 is the maximum permitted content of the coating, discounting the water content.

Table 5-3 Proposals for Reference Coatings for VR Applications

Category	Coatings	VOC g/l
Preparation and Cleaning	Category 1: Gun wash, Paint stripper, Degreaser (including anti-static types for plastic)	850
	Category 2: Body wipe, silicon removers, temporary coating removers - de- waxing fluids, flatting compounds / polishers	100
Bodyfillers / stoppers	All types	250
Primers / Sealers / Surfacers / Fillers	Category 1: General (Metal) primer, Adhesion promoter, Sealer	150
	Category 2: Primer - surfacers, Undercoats, Plastic primer, Wet on wet, Non- sand filler, Spray fillers	500
	Category 3: Wash / etch primer, Weldable primers, Mordant solution - galvanised and zinc	650
Topcoats / Finishes	Single layer - Solid colour	420
	Multiple layer base - Solid colour and metallic / pearl effect	150
	Clear Coat (inc. tinted)	420
Special Finishes	Single layer metallic / pearl effect, high performance solid colour and clear coats (e.g. anti-scratch and fluorinated clear coat), Reflective base coat, textured finishes (e.g. hammer), anti-slip, under-body sealers, anti-chip coatings, interior finishes etc.,	650

5.2.26 Representatives from industries and painting contractors had been consulted on the effectiveness of different types of measures. To level the playing field, legal limits to the VOC content of decorative coatings were generally preferred over financial measures, eco-labels or other labels, information campaigns or voluntary agreements. However, some of the non-legal measures could enhance the implementation of the legal measures.

(ii) Domestic Product

5.2.27 Deodorants, hair spray, cleaning products and insecticides are examples of common domestic products containing VOC. The California's clean air plan, the State Implementation Plan committed the State Government to reduce 85% of its VOC emissions from domestic products in 2010 with the assistance from advanced technological development and possibly market incentives (http://www.arb.ca.gov/html/brochure/consprod.htm). In order to achieve such reduction, near, mid and long term pollution reduction measures with targets dates of 2000 (-30%), 2005 (-55%) and 2010 (-85%) respectively had been established for 28 product categories. Apart from reducing the smog **forming** chemicals in domestic products, the California State Government had been working hand in hand with the industry to make sure that all the replacement products are economically and technologically feasible. Through the Consumer Products Programme Regulations, more product categories would be added. (http://www.arb.ca.gov/consprod/regs/regs.htm).

5.2.28 For the control of VOC emissions from domestic products, the products' reactivity potential to form ozone were being studied in the US. Through the study of reactivity, the California State Government aimed to identify the most ozone forming potential chemicals in these domestic products and formulate a more cost-effective control strategy that could reduce the impact on the consumers as well as the manufacturers.

Preliminary Socio-economic Impact Review

5.2.29 The European eco-label scheme has so far not resulted in any significant market shift, although product development towards lower VOC products may have been enhanced. In addition, public education and awareness programme would be required to promote the labelling system. The socio-economic impact due to labelling system is relatively low and mostly related to government administrative procedures.

5.2.30 The prime human health and environmental benefits would arise due to reductions in ground level concentrations of ozone, for which VOC is a key precursor. These include:

- reduction in human health impacts - acute mortality / morbidity and chronic mortality / morbidity;
- reduction in damage to crops;
- reduction in damage to materials (e.g. paint, rubber, textiles); and
- reduction in damage to forests and ecosystems.

5.2.31 In addition, there would be some benefits gained due to the reduction in direct health impacts from VOC emissions. The benefits include deaths not brought forward (acute effects only); respiratory hospital admissions avoided or not brought forward (acute effects only) and the reduction in damage to crops.

5.2.32 Switching to available low solvent or solvent-free alternatives could achieve significant. The reduction in VOC from paint would cost about 13317 USD/tonne (AQMD 1999). The average cost of reducing pollution from consumer products is comparable to other VOC regulations, about 25 to 85 cents for every pound of VOC emissions prevented as reported by the California Government (http://www.arb.ca.gov/html/brochure/consprod.htm).

5.2.33 In conclusion, the reduction potential of the components as a control measure is 'very significant' in PRDEZ and HKSAR. Even though the socio-economic costs is slightly negative, as most of which are low into consideration due to administrative procedures and educationwareness programme, this measure is necessary for controlling the regional air quality.

5.3 Summary of the Short-listed Control Measures for VOC Containing Product

5.3.1 Table 5-4 below presented a summary of the preliminary analysis for the control measures for VOC containing products and the emission reduction potential associated. The effectiveness of the recommended control measure for VOC containing products is presented in Table 5-5. VOC is the major pollutants in VOC containing products for which PRDEZ and HKSAR currently have no policy provisions for reducing their concentrations. Implementation of the measure for VOC containing products would therefore be inevitable although they might produce negative socio-economic impacts due to administrative procedures and education programme. The control measure could provide a positive effect on the emission reduction and therefore recommended for implementation, disregard there are some socio-economic disadvantage.

Table 5-4 Score of the Assessment Criteria for the VOC Containing Products

Assessment Criteria	Control Measures	
	PRDEZ	HKSAR
Assessment Summary		
Emission Reduction Potential	V. High (90%) (VOC: -161759 tonnes)	V. High (90%) (VOC: -44901 tonnes)
Availability of Technology	Not Available	Not Available
Socio-economic Impact	-	-
Assessment Score		
Reduction Potential	+2	+2
Availability of Technology	-1	-1
Socio-economic Impact	-1	-1
Total Score	0	0

Table 5-5 Summary of the Proposed Control Measures for the VOC Containing Products

Control Measures	PRDEZ	HKSAR
Control for VOC Containing Products	Neutral benefit Recommended	Neutral benefit Recommended

6. REFERENCES

- Air Quality Management and Planning System for Guangzhou 1999, Guangzhou Air Quality Action Plan 2001
- AQMD 1998, Clean Air Solvent (CAS) Certification Program, South Coast Air Quality Management Board
- CLP 1997, Reporting on EHS Progress, CLP Power Hong Kong Limited, 1997
- C&SD 2000, Hong Kong Annual Digest
- EFB 2001, Report on Progress with Protection against Environmental Pollution
- Government of HKSAR 1999, Interconnection and Competition in the Hong Kong
- Guangzhou Daily 2000
- SEB 1999, Technical Assessment for the Selection of SO2 Emission Control for Coal-fired Power Plant, State Electricity Board
- UNDP 2001, Capacity Development for NOx Pollution in Guangzhou, UNDP Project CPR/96/305
- USEPA 1996, Program Evaluations, Vehicle I/M Best Practices, Office of Transportation and Air Quality, U.S Environmental Protection Agency
- USEPA 1997, Development of a Proposed Procedure for Determining the Equivalency of Alternative Inspection and Maintenance Programs, Sierra Research, Inc, California, 1997.
- UNECE 1999, The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, United Nations Economic Commission for Europe
- World Bank 2000, China Air, Land, and Water, Environmental Priorities for a New Millennium, World Bank, Washington