Hong Kong
Environmental Protection
Department

Agreement No. CE57/2006 (EP) Review of Air Objectives and Development of a Long Term Air Quality Strategy for Hong Kong - Feasibility Study

Appendix G

Projected Emission and Emission Reduction

ARUP

G1 Projected Emission and Emission Reduction

G1.1 Emission Inventory

G1.1.1 Emission Inventories in Mid Term Review Study

Environmental Protection Bureau of Guangdong (GDEPB) and Hong Kong EPD released the report on the Mid-term Review of the Pearl River Delta Regional Air Quality Management Plan (hereunder refers to as "Mid-term Review") in November 2006 2007?. The study updated the regional pollutant emission of Yr 2003, recommended the strengthened control strategies and projected the emission for Control Scenario of Yr 2010 upon implementation of these measures for both governments.

Tables G1.1 and **G1.2** present the projected control emission for Yr 2010 for PRDEZ and HKSAR in the Mid-term Review Report. These two of sets of data serve as the basis for the emission projection in this study.

Table G1.1: PRDEZ emission inventory (in tonnes) in Yr 2010 under strengthened control strategies scenario

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	85,800	167,200	9,800	1,600
Industrial				
Agriculture	0.0	0.0	0.0	0.0
Alcoholic Beverage	3,600	1,100	700	1,600
Chemicals / Rubber/ Plastic	20,100	5,600	4,100	3,700
Pulp and Paper Industry	46,600	10,200	9,100	300
Petroleum Refinery	8,800	2,900	1,900	4,400
Petrol Distribution and Handling	0.0	0.0	0.0	3,000
Printing	100	0.0	0.0	6,900
Construction	3,900	500	1,300	0.0
Electronic Manufacture	3,500	700	300	0.0
Food and Beverage	15,500	5,400	3,800	200
Water, Gas and Waste Recycling	900	300	200	0.0
Light Industry	59,400	15,700	9,300	3,000
Heavy Industry	400	100	100	1,400
Mining / Mineral Extraction	20,100	8,800	6,200	3,600
Non-Metallic Mineral Products	86,600	38,200	117,900	4,900
Transportation				
Motor Vehicles (Tailpipes)	22,400	187,700	25,500	88,900
Petrol evaporation	-	-	-	10,300
Tire Wire	-	-	2,600	-
Marine Activities	13,500	33,700	1,300	600
Aviation	300	4,400	-	700
Railway	100	400	0.0	0.0
VOC Product				
Domestic Consumption	-	-	-	17,000

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Paint	-	-	-	18,100
Others				
Domestic and Commercial Fuel Consumption	37,100	14,000	11,900	2,400
Waste Burning	2,500	6,800	1,500	2,200
Pesticide Application	-	-	-	3,200
Total (in tonnes)	431,300	503,600	207,500	178,200

Table G1.2: HKSAR emission inventory (in tonnes) in Yr 2010 under strengthened control strategies

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	25,120	42,600	1,260	420
Industrial				
IDO combustion in Furnace	7	238	24	2
Towngas combustion	0	56	1	1
Chemicals / Rubber/ Plastic	0	0	0	24
Petrol Distribution and Handling (Fuel Terminal)	0	0	0	106
Petrol Distribution and Handling (Petrol Filling station)	0	0	0	77
Printing	0	0	0	4,236
Construction	4	2,374	251	344
Food and Beverage	0	0	0	73
Light Industry (Textile)	0	0	0	1
Light Industry (Others non-burning activities)	0	0	0	82
Mining / Mineral Extraction	0	0	207	0
Non-Metallic Mineral Products	0	0	0	0
Transportation				
Motor Vehicles (Tailpipes)	291	17,200	1,315	4,400
Petrol evaporation	0	0	0	1,600
Tire Wire	0	0	645	0
Marine Activities	4,438	18,957	568	345
Aviation	387	6,655	28	342
Off road mobile sources and machinery	4	2,852	298	410
VOC Product				
Domestic Consumption	0	0	0	9,526
Paint	0	0	0	8,614
Others				
Domestic Fuel Consumption	6	1,069	81	40

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Commercial Fuel Consumption	0	821	27	44
Waste Burning	0	8	23	10
Pesticide Application	0	0	0	320
Crematorium	0	17	9	0
Total (in tonnes)	30,237	92,847	4,737	31,017

G1.1.2 Emission Projection for Future Year

G1.1.2.1 General Approach

Two methods have been adopted to derive the future year emissions. For an emission source where future activity data is available, the future year emission has been directly computed based on the future activity data and relevant emission factors.

Emission = future activity data x emission factor

In case the activity data are not applicable or available, future year emissions have been estimated with projection surrogates such as GDP for each sectors and population growths etc which could suitably represent the trade, service or industry.

Emission = base year 2010 emission from Mid Term Review x growth factor of relevant projection surrogate; where

Growth factor of a projection surrogate = future year activity level / base year activity level

These methods are consistent and widely accepted in other inventory development projects worldwide.

The major uncertainty comes from the growth factors of relevant projection surrogate, which is determined from the trend of the activities.

G1.1.2.2 Methodology for Future Emission Inventory

The approach and methodology of emission projection for PRDEZ are summarised in **Table G1.3.**

Table G1.3: Summary of projection approach for future PRDEZ emission

Sector grouping	Sources	Approach to emission projection
Power Generation	Power plants	The future demand on electricity generation and its emission are estimated based on Mid Term Review.
Industry	Alcoholic beverage production Chemical / rubber / plastics Pulp and paper Petroleum Refinery Printing Electronic manufacture Food and beverage Gas, water & sanitary works Manufacture light industry Manufacture heavy industry Mining / mineral extraction	The emission is projected from Year 2010 Control Scenario of the Mid Term Review using industrial growth rate as projection surrogate. Historical development trend on the number of establishments for respective industry from Guangdong Statistical Yearbooks has been analysed to project the growth on the number of establishments for future year. For food and beverage, mining / mineral extraction and alcoholic beverage, the emissions are assumed to be the same as that of Year 2010 Control Scenario on the basis of no growth trend in their historical development trends according to the Guangdong Statistical Yearbooks.

<table>
<tr><th>Sector grouping</th><th>Sources</th><th>Approach to emission projection</th></tr>
<tr><td></td><td>Non-metallic mineral product</td><td></td></tr>
<tr><td></td><td>Petrol distribution and handling</td><td>Emissions are estimated in proportion according to changes in the projected number of motor vehicles using the emission of Year 2010 Control Scenario of the Mid Term Review as the basis.</td></tr>
<tr><td></td><td>Construction Industry</td><td>Emission is projected from Year 2010 Control Scenario of the Mid Term Review with respect to the forecast growth of construction gross domestic product (GDP). Regression analysis of the historical trend on construction GDP has been carried out to estimate the future growth up to Year 2047.</td></tr>
<tr><td>Transportation</td><td>Motor vehicles
Petrol evaporation
Tire Wear</td><td>Emission from motor vehicles, petrol evaporation and tire wear are expected to increase more or less in proportion with the growth in number of vehicles.
The emission from motor vehicles have taken into account the aging effect and the implementation schedules of different national standards:
<table>
<tr><th></th><th>Date (Light Goods vehicle)</th><th>Date (Heavy Goods vehicle)</th></tr>
<tr><td>Nation 1 (Euro 1)</td><td>2000.07</td><td>2000</td></tr>
<tr><td>Nation 2 (Euro 2)</td><td>Petrol: 2005.07
Diesel: 2003.09</td><td>2002</td></tr>
<tr><td>Nation 3 (Euro 3)</td><td>2007.07</td><td>2007</td></tr>
<tr><td>Nation 4 (Euro 4)</td><td>2010.07</td><td>2010</td></tr>
</table>
Regression analysis has been carried out on the historical population of vehicles to estimate the future growth up to Year 2030 and emission is then projected from Year 2010 Control Scenario of the Mid Term Review with respect to the forecast growth.</td></tr>
<tr><td></td><td>Marine</td><td>Emission is projected from Year 2010 Control Scenario with respect to the forecast growth of marine vessel. Historical data are available from the Guangdong Statistical Yearbooks. Regression analysis of the trend has been carried out to estimate the future growth and demand up to Year 2030.</td></tr>
<tr><td></td><td>Airport</td><td>Emission is projected from Year 2010 Control Scenario according to their growth rates, planning data and ultimate capacity. The growth rates for Guangzhou, Zhuhai and Shenzhen airports are determined according to its respective planned information and ultimate design capacity where information is available, otherwise on the basis of the previous flight records.</td></tr>
<tr><td></td><td>Railway</td><td>Emission is projected from Year 2010 Control Scenario with respect to the forecast growth of freight traffic volume by railways.</td></tr>
<tr><td>VOC</td><td>Domestic & commercial</td><td>Emission is projected from Year 2010 Control</td></tr>
</table>

Sector grouping	Sources	Approach to emission projection
containing product	aerosols Paint application	Scenario with respect to the forecast population growth in PRDEZ. Historical population data are available from the Guangdong Statistical Yearbooks. Regression analysis has been carried out to estimate the future growth up to Year 2030.
Miscellaneous	Commercial and domestic fuel consumption Waste incineration Pesticide application	Emission is projected with respect to population growth as VOC containing product.

The approach and methodology of emission projection for HKSAR are summarised in **Table G1.4.**

Table G1.4: Summary of projection approach for future HKSAR emission

Sector grouping	Sources	Approach to emission projection
Power Generation	Power plants	Emission projection is based on the emission caps stipulated under the Technical Memorandum of APCO and the projected emissions under the proposed emission reduction measures.
Industry	IDO combustion in Furnace	Emission is projected from Year 2010 Control Scenario of the Mid Term Review using manufacturing enterprises growth rate as projection surrogate.
	Towngas combustion	Emission is projected from Year 2010 Control Scenario of the Mid Term Review using growth of manufacturing enterprises as projection surrogate.
	Chemical / rubber / plastics Printing Manufacture light industry Food and beverage Mining / mineral extraction Non-metallic mineral product Light industry	Emission is projected from Year 2010 Control Scenario of the Mid Term Review using industrial growth rate as projection surrogate. Historical development trend on the number of establishments for the respective industries from Census has been analysed to project the growth with the positive regression trends for future year. For food and beverage, mining / mineral extraction and non-metalic mineral product, the emissions are assumed to be the same as that of Year 2010 strengthened control scenario on the basis of no growth trend in their historical development trends according to the Guangdong Statistical Yearbooks.
	Petrol distribution and handling	Chemical Storage: Emission due to chemical storage is assumed to be capped at 2010 control scenario Petrol filling: Emissions from petrol service station are estimated in proportion according to the change in VKTs using the emission of Year 2010 Control Scenario as the basis.

Sector grouping	Sources	Approach to emission projection
	Construction Industry	Emission is assumed to be the same as Year 2010 Control Scenario since significant growth in number/area of construction sites is not expected.
Transportation	Motor vehicles Petrol evaporation	Emissions from motor vehicles and petrol evaporation with HKSAR are predicted using EPD's Emfac-HK model. The VKTs for future years are forecasted using Arup's in-house Territory Transport Model. The road network assumptions adopted is based on committed government highway development plan, recommendations from various planning studies and advices from Transport Department, which were collected from various related parties in July 2007.
	Tire Wear	Emissions from tire wear with HKSAR are projected based on VKT, which are forecasted using Arup's in-house Territory Transport Model.
	Marine vessel	Emission is projected from Year 2010 Control Scenario of the Mid Term Review using marine growth rate as projection surrogate. The growth trend on marine vessels in term of Net Register Tonnage (NRT) from Census has been analysed to project the growth for future year.
	Airport	Emission from Year 2010 Control Scenario of the Mid Term Review study has been adopted as the basis. Year 2020 is assumed the practicable maximum and the emission inventories for years beyond 2020 are capped.
	Off road mobile sources and machinery	For off road mobile sources and machinery, the emission is assumed to be the same as Year 2010 Control Scenario since there is only limited number of off road mobile sources and machinery (diesel locomotives) operated in HKSAR.
VOC containing product	Domestic & commercial aerosols Paint application	Emission is projected from Year 2010 Control Scenario with respect to the forecast population growth in Hong Kong. The population forecast data are available from Hong Kong Population Projections 2007-2036, Census and Statistics Department. For years beyond 2036, the population is estimated by applying a growth factor of 0.7% which is the average annual rate from Yr 2006 to Yr 2036 according to the forecast data.
Miscellaneous	Commercial and domestic fuel consumption Waste incineration Pesticide application	Same as methodology of VOC containing product.

G1.1.2.3 Spatial Distribution of Emission Sources

In the PATH model, the emissions from PRDEZ power plants are modelled as point source while others including industrial emission, transportation emission, and VOC products etc

are regarded as area source. The spatial distribution developed for the 2010 control scenario under PRD-2002 study has been followed in this study.

For HKSAR, the emissions from power plants, major industrial plants (including furnaces and town gas combustion, textile, hospitals, hotels, restaurants), crematoria, fuel terminals, garages, airport, petrol handling stations have been modelled as point sources while others including printing, chemical / rubber / plastics, transportation emission, and VOC products etc are regarded as area sources. The emission apportionment method developed for the 2010 control scenario under PRD-2002 study for the PATH model has been followed in this study.

Point sources

The point source emission inventory previously developed in 2010 Control Scenario of PATH has been adopted as the basis for the PRDEZ spatial distribution. For future year scenarios, the emissions have been apportioned to the point sources in proportion according to the emission distribution previously established for 2010 Control Scenario of PATH.

The spatial distributions of power plant, crematorium, petrol filling station, VOC emission from garages for HKSAR were based on information available to the EPD. For other point sources, the defaulted spatial distribution of the PATH model is adopted.

Area sources

Same spatial allocation of the PRD-2002 has been used for area sources. The projected state-wide emission has been allocated to the respective counties in PRDEZ and HKSAR and apportioned to the model grid in PATH. In general, the emission has been allocated to the counties with respect to projection surrogates such as GDP for each sectors and population growths etc which could suitably represent the trade, service or industry. An example of spatial allocation for an area emission source is given below:

Emission from commercial & domestic fuel consumption in Guangzhou = Total emission from commercial & domestic fuel consumption in PRDEZ x Population in Guangzhou / Total population in PRDEZ

The spatial surrogates established in PATH model have then been used to allocate the county-wide emissions to the model grid cells. For example, a spatial surrogate based on a GIS coverage depicting major rail lines, has been used to apportion the county-wide emissions from locomotives to grid cells through which the locomotives travel.

The respective activity data used for spatial allocation for each pollutant source in PRDEZ is listed in **Table G1.5a**.

Table G1.5a: Summary of spatial allocation for area sources for future PRDEZ emission

Sector Grouping	Sources	Activity for Spatial Allocation
Industry	Alcoholic beverage production Chemical / rubber / plastics Pulp and paper Crude Oil Production Printing Electronic manufacture Food and beverage Gas, water & sanitary works Manufacture light industry Manufacture heavy industry Mining / mineral extraction	Apportion into counties with respect to their number of establishments for respective industries according to the Guangdong Statistical Yearbooks (Yr 2005), except for non-metallic mineral product. Non-metallic mineral product is apportioned according to EPD information. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.

Sector Grouping	Sources	Activity for Spatial Allocation
	Non-metallic mineral product	
	Petrol distribution and handling	Apportion into counties with respect to their number of motor vehicles according to the Guangdong Statistical Yearbooks (Yr 2005). Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
	Construction Industry	Apportion into counties with respect to their construction GDP according to the Guangdong Statistical Yearbooks (Yr 2005). Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
Transportation	Motor vehicles Petrol evaporation Tire Wear	Apportion into counties with respect to their number of motor vehicles according to the Guangdong Statistical Yearbooks (latest recent year). Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
	Marine vessel	Emission distribution established in PATH has been adopted. Major ports in PRD estuary (e.g Guangzhou, Shekou, Yantian, etc) have been updated.
	Airport	Emission distribution established in PATH has been adopted. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
	Railway	As there is no railway information available for each county, the emission is apportioned into grid cells according to the GIS coverage of the counties in the latest PATH model.
VOC containing product	Domestic & commercial aerosols Paint application	Apportion into counties with respect to the city population according to the Guangdong Statistical Yearbooks (Yr 2005). Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
Miscellaneous	Commercial and domestic fuel consumption Waste incineration Pesticide application	Apportion into counties with respect to the city population according to the Guangdong Statistical Yearbooks (Yr 2005). Apportion into grid cells according to the GIS coverage of the counties in the latest PATH

Sector Grouping	Sources	Activity for Spatial Allocation
		model.

The respective activity data used for spatial allocation for each pollutant source in HKSAR is listed in **Table G1.5b**.

Table G1.5b: Summary of spatial allocation for area sources for future HKSAR emission

Sector Grouping	Sources	Activity for Spatial Allocation
Industry	Printing	Apportion into counties with respect to built-in distribution in PATH model. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
	Mining / mineral extraction	Apportion into Anderson Road Quarry, Shek O Quarry and Lam Tei Quarry according to their areas. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
	Construction Industry	Apportion evenly into different districts. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
Transportation	Motor vehicles Petrol evaporation Tire Wear	Apportion into counties with respect to VKT. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
	Marine	Emission are apportioned according to anchorage locations; container terminal activities; marine activities (routings according to ocean going vessel, river trade, international ferry (PRD), international ferry (Macao), support ships and others) Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
	Off Road mobile sources and machinery	Apportion into counties evenly. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.
VOC containing product	Domestic & commercial aerosols Paint application	Emissions are apportioned according to projected population in Yr 2010. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.

Sector Grouping	Sources	Activity for Spatial Allocation
Miscellaneous	Commercial and domestic fuel consumption Waste incineration Pesticide application	Apportion into counties with respect to projected population in Yr 2006. Apportion into grid cells according to the GIS coverage of the counties in the latest PATH model.

G1.1.3 Emission Inventory For Yr 2015 – Yr 2030 for PRDEZ

G1.1.3.1 No further control scenario

Table G1.6 to **G1.8** present the emission inventory prediction from Yr 2015 to Yr 2030 for PRDEZ without further mitigation measures. The emission inventories are estimated based on "No further control" growth rate.

Table G1.6: PRDEZ emission inventory (in tones) in Yr 2015 without further mitigation measures

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	103,892	202,456	11,867	1,938
Industrial				
Alcoholic Beverage	3,600	1,100	700	1,600
Chemicals / Rubber/ Plastic	25,749	7,174	5,252	4,740
Pulp and Paper Industry	59,696	13,067	11,658	385
Petroleum Refinery	12,230	4,030	2,641	6,115
Petrol Distribution and Handling	0	0	0	3,785
Printing	132	0	0	9,103
Construction	4,802	616	1,601	0
Electronic Manufacture	4,562	913	391	0
Food and Beverage	15,500	5,400	3,800	200
Water, Gas and Waste Recycling	1,133	378	252	0
Light Industry	73,895	19,531	11,570	3,732
Heavy Industry	521	130	130	1,822
Mining / Mineral Extraction	20,100	8,800	6,200	3,600
Non-Metallic Mineral Products	100,790	44,460	137,219	5,703
Transportation				
Motor Vehicles (Tailpipes)	28,258	236,788	32,169	112,150
Petrol evaporation	0	0	0	12,994
Tire Wire	0	0	3,280	0
Marine Activities	18,440	46,030	1,776	820
Aviation	442	6,477	0	1,031
Railway	126	505	0	0
VOC Product				
Domestic Consumption	0	0	0	17,887
Paint	0	0	0	19,044

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Others				
Domestic and Commercial Fuel Consumption	39,036	14,731	12,521	2,525
Waste Burning	2,631	7,155	1,579	2,315
Pesticide Application	0	0	0	3,367
Total (in tonnes)	515,530	619,736	244,602	214,852

Table G1.7: PRDEZ emission inventory in Yr 2020 (in tonnes) without further mitigation measures

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	121,983	237,711	13,933	2,275
Industrial				
Alcoholic Beverage	3,600	1,100	700	1,600
Chemicals / Rubber/ Plastic	31,397	8,748	6,404	5,780
Pulp and Paper Industry	72,792	15,933	14,215	469
Petroleum Refinery	15,659	5,160	3,381	7,829
Petrol Distribution and Handling	0	0	0	4,569
Printing	164	0	0	11,306
Construction	5,703	731	1,901	0
Electronic Manufacture	5,624	1,125	482	0
Food and Beverage	15,500	5,400	3,800	200
Water, Gas and Waste Recycling	1,365	455	303	0
Light Industry	88,389	23,362	13,839	4,464
Heavy Industry	641	160	160	2,244
Mining / Mineral Extraction	20,100	8,800	6,200	3,600
Non-Metallic Mineral Products	114,980	50,719	156,537	6,506
Transportation				
Motor Vehicles (Tailpipes)	34,116	285,875	38,838	135,399
Petrol evaporation	0	0	0	15,687
Tire Wire	0	0	3960	0
Marine Activities	23,379	58,360	2,251	1,039
Aviation	583	8,554	0	1,361
Railway	152	609	0	0
VOC Product				
Domestic Consumption	0	0	0	18,774
Paint	0	0	0	19,988
Others				
Domestic and Commercial Fuel Consumption	40,971	15,461	13,142	2,650
Waste Burning	2,761	7,509	1,657	2,430
Pesticide Application	0	0	0	3,534

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC
Total (in tonnes)	599,859	735,772	281,703	251,704

Table G1.8 : PRDEZ emission inventory (in tonnes) in Yr 2030 without further mitigation measures

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	173,426	337,958	19,809	3,234
Industrial				
Alcoholic Beverage	3,600	1,100	700	1,600
Chemicals / Rubber/ Plastic	42,695	11,895	8,709	7,859
Pulp and Paper Industry	98,984	21,666	19,329	637
Petroleum Refinery	22,517	7,420	4,862	11,259
Petrol Distribution and Handling	0	0	0	6,138
Printing	228	0	0	15712
Construction	7,505	962	2,502	0
Electronic Manufacture	7,747	1,549	664	0
Food and Beverage	15,500	5,400	3,800	200
Water, Gas and Waste Recycling	1829	610	407	0
Light Industry	117,378	31,024	18,377	5,928
Heavy Industry	882	221	221	3088
Mining / Mineral Extraction	20,100	8,800	6,200	3,600
Non-Metallic Mineral Products	143,360	63,237	195,174	8,112
Transportation				
Motor Vehicles (Tailpipes)	45,832	384,050	52,175	181,897
Petrol evaporation	0	0	0	21,075
Tire Wire	0	0	5,320	0
Marine Activities	33,258	83,021	3,203	1,478
Aviation	800	11,738	0	1,867
Railway	204	817	0	0
VOC Product				
Domestic Consumption	0	0	0	20,547
Paint	0	0	0	21,877
Others				
Domestic and Commercial Fuel Consumption	44,842	16,921	14,383	2,901
Waste Burning	3,022	8,219	1,813	2,659
Pesticide Application	0	0	0	3,868
Total (in tonnes)	783,709	996,608	357,648	325,398

G1.1.3.2 Further control scenario

The control strategies stated in the Pearl River Delta Environmental Planning (2020) and PRC national plans have been reviewed. **Table G1.9** summarizes the measures that will be implemented before Yr 2020 and the associated emission reduction estimates.

Table G1.9: Emission reduction in Yr 2020 based on control strategies in power plant / energy, petroleum industries and traffic

Control Strategies	Efficiency	Emission Reduction (T)				Remark
		SO_2	NO_X	PM_{10}	VOC	
Power Plant						
Renewable Energy	15%	18297	35657	2090	341	"The white paper on PRC energy status and policy" , PRC state council (2007) "Medium and Long Term development of Renewable Energy" , PRC state council (2007)
Western Electricity	41%	44,461	28,088	3,435	235	"Pan PRD Energy Co-operation-11th 5 year plan" Energy research Institute ational Development and Reform Commission (2006)
Promotion of natural gas	19.5%	15,980	31,140	1,825	298	Study of Air Quality in the PRD region, HKEPD (2002)
Nuclear Energy	13.6%	16,590	32,329	1,895	309	Study of Air Quality in the PRD region, HKEPD (2002) "Medium and Long Term development of nuclear Energy 2003 - 2020" , PRC state council (2007)
De-NO_X technology	70 – 80%	--	77,348	--	--	PRD Environmental Planning outline (2004-2020) , Guangdong Government(2006)
Industrial						
Hydrogenation and Dry distillation	100%	15,695	5,160	3,381	7,829	PRD Environmental Planning outline (2004-2020) , Guangdong Government (2006) World Energy Assessment Overview 2004 Update (2004)
1/3 furnaces switch to natural gas		74,125	25,465	46,265	1,682	"PRD environmental protection planning", PRD environmental protection planning committee, China Environmental Science Press (2006)

Control Strategies	Efficiency	Emission Reduction (T)				Remark
		SO_2	NO_X	PM_{10}	VOC	
Transportation						
Adopt Euro IV standard	Petrol Car ：60% Passenger vehicles：90% Goods vehicles：50%	4903	95352	5109	48314	Mid Term Review Report (2007) Guangdong Statistical Yearbook China Statistics Press (2006)
Develop green public transport (e.g electric and LNG vehicles)	Reduction 50% emission from public vehicles	2551	10245	1271	5180	PRD Environmental Planning outline (2004-2020)，Guangdong Government (2006)
Transportation dust control	90%	0	0	3564	0	"PRD environmental protection planning", PRD environmental protection planning committee, China Environmental Science Press (2006)
Domestic /Commercial						
All domestic natural gas	100%	40,623	14,454	9,311	1,251	"PRD environmental protection planning", PRD environmental protection planning committee, China Environmental Science Press (2006)

Table G1.10 and **G1.11** summarize the emission inventory in Yr 2015 and Yr 2020 under the above planned control measures. The emission inventory in Yr 2015 is based on the interpolation of the emission inventories between Yr 2010 and Yr 2020.

Table G1.10: PRDEZ emission inventory in Yr 2015 (in tonnes) with planned mitigation Measures

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	56,228	100,175	7,244	1,346
Industrial				
Alcoholic Beverage	3,600	1,100	700	1,600
Chemicals / Rubber/ Plastic	25749	7174	5,252	4,740
Pulp and Paper Industry	47653	10563	9840	354
Petroleum Refinery	4,400	1,450	950	2,200
Petrol Distribution and Handling	0	0	0	3,785
Printing	132	0	0	9103
Construction	4,802	616	1,601	0

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC
Electronic Manufacture	4,562	913	391	0
Food and Beverage	12,936	4,552	3,314	187
Water, Gas and Waste Recycling	1,133	378	252	0
Light Industry	73,895	19,531	11,570	3,732
Heavy Industry	415	105	110	1,677
Mining / Mineral Extraction	16,775	7,417	5,407	3,368
Non-Metallic Mineral Products	81,767	36,488	117,203	5,283
Transportation				
Motor Vehicles (Tailpipes)	27033	194233	30251	90583
Petrol evaporation	0	0	0	12994
Tire Wire	0	0	1498	0
Marine Activities	18,440	46,030	1,776	820
Aviation	442	6477	0	1031
Railway	126	505	0	0
VOC Product				
Domestic Consumption	0	0	0	17,887
Paint	0	0	0	19044
Others				
Domestic and Commercial Fuel Consumption	18,724	7,504	7,866	1,900
Waste Burning	2,631	7,155	1,579	2,315
Pesticide Application	0	0	0	3,367
Total (in tonnes)	**401487**	**452312**	**206800**	**187,412**

Table G1.11: PRDEZ Emission Inventory in Yr 2020 (in tonnes) with Planned Mitigation Measures

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	26,655	33,149	4,688	1,091
Industrial				
Alcoholic Beverage	3,600	1,100	700	1,600
Chemicals / Rubber/ Plastic	31,397	8,748	6,404	5,780
Pulp and Paper Industry	48,705	10,925	10,580	408
Petroleum Refinery	0	0	0	0
Petrol Distribution and Handling	0	0	0	4,569
Printing	164	0	0	11306
Construction	5,703	731	1,901	0
Electronic Manufacture	5,624	1,125	482	0
Food and Beverage	10,371	3,703	2,828	174
Water, Gas and Waste Recycling	1,365	455	303	0
Light Industry	88,389	23,362	13,839	4,464
Heavy Industry	429	110	119	1,954

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC
Mining / Mineral Extraction	13,449	6,034	4,614	3,135
Non-Metallic Mineral Products	76,934	34,776	116,505	5,665
Transportation				
Motor Vehicles (Tailpipes)	31,665	200,767	35,001	92,266
Petrol evaporation	0	0	0	15,687
Tire Wire	0	0	396	0
Marine Activities	23,379	58,360	2,251	1,039
Aviation	583	8,554	0	1,361
Railway	152	609	0	0
VOC Product				
Domestic Consumption	0	0	0	18,774
Paint	0	0	0	19,988
Others				
Domestic and Commercial Fuel Consumption	348	1,007	3,831	1,399
Waste Burning	2,761	7,509	1,657	2,430
Pesticide Application	0	0	0	3,534
Total (in tonnes)	**371,673**	**401,024**	**206,099**	**196,624**

According to the PRD Environmental Planning Outline (2004-2020), the planning data are up to Yr 2020. There is no public available environmental planning data after Yr 2020. Hence, the emission inventory with mitigation measures after Yr 2020 cannot be estimated. As a conservative assumption, the emission inventory after Yr 2020 is assumed as the same as Yr 2020.

G1.1.3.3 Post-2020 Emissions

No public available environmental planning information available is available beyond 2020. As such, two scenarios have been constructed as follows:

(a) High emission scenario:

To be conservative, the emissions after Year 2020 are assumed to be same as Yr 2020.

(b) Low emission scenario:

According to the experiences of other countries, a community would become more concern on their air quality as their GDP grows. In addition, it is reasonable to expect continual advancement in technology, change in economic structure and migration of industries. As such, it is expected that the emission inventory of PRD after Yr 2020 would be further reduced. The assumptions taken and the predicted emission inventory are shown respectively in **Tables G1.12 and G1.13**.

Table G1.12: Emission reduction potential under low emission scenario

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC	Remark
Power Plant	172,767	302,479	18,639	2,472	Renewable energy:15% Western Electricity: 32% Nuclear Energy: 15%

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC	Remark
					Remaining: 100% NG
Alcoholic Beverage	3564	796	591	608	100% NG and Clean Production
Chemicals / Rubber/ Plastic	42,268	8,609	7355	2,986	100% NG and Clean Production
Pulp and Paper Industry	97,994	15,680	16,324	242	100% NG and Clean Production
Petroleum Refinery	22,517	7,420	4,862	11,259	Hydrogenation and Dry distillation
Petrol Distribution and Handling	0	0	0	4,800	80% reduction (Petrol Recovery)
Printing	0	0	0	4,714	30% reduction (Tightening of VOC)
Construction	7,430	696	2,113	0	100% NG and Clean Production
Electronic Manufacture	7,670	1,121	561	0	100% NG and Clean Production
Food and Beverage	15,345	3,908	,3209	76	100% NG and Clean Production
Water, Gas and Waste Recycling	1,811	441	344	0	100% NG and Clean Production
Light Industry	116,204	22,453	15,520	2,253	100% NG and Clean Production
Heavy Industry	873	160	187	1,173	100% NG and Clean Production
Mining / Mineral Extraction	19,899	6,369	5,236	1,368	100% NG and Clean Production
Non-Metallic Mineral Products	141,926	45,767	164,827	3,083	100% NG and Clean Production
Motor Vehicles (Tailpipes)	40,120	333,716	36,125	150,830	40% hydrogen car + 15% electric vehicle + remaining 50% hybrid vehicle
Petrol evaporation	0	0	0	16,333	-
Tire Wire	0	0	4,788	0	90% reduction Road dust reduction
Marine Activities	32,925	66,417	320	0	All vessels install SCR and use of ULSD
Domestic Consumption	0	0	0	12,328	60% reduction (Tightening of VOC on consumer product)
Paint	0	0	0	8,750.8	40% reduction (Tightening of VOC on sealant, adhesives, etc)
Domestic and Commercial Fuel Consumption	44,394	12,246	12147	1,102	100% NG
Waste Burning	0	6,575	0	0	Flue Gas - DeNOx
Pesticide Application	0	0	0	0	-

Table G1.13: PRDEZ emission inventory under low emission scenario

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC

Pollution Sources (in tones)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	659	7096	1170	762
Industrial				
Alcoholic Beverage	36	304	109	992
Chemicals / Rubber/ Plastic	427	3,286	1,354	4,873
Pulp and Paper Industry	990	5,986	3,005	395
Petroleum Refinery	0	0	0	0
Petrol Distribution and Handling	0	0	0	1,200
Printing	228	0	0	10,998
Construction	75	266	389	0
Electronic Manufacture	77	428	103	0
Food and Beverage	155	1492	591	124
Water, Gas and Waste Recycling	18	169	63	0
Light Industry	1,174	8571	2,857	3,675
Heavy Industry	9	61	34	1,915
Mining / Mineral Extraction	201	2,431	964	2,232
Non-Metallic Mineral Products	1,434	17,470	30,347	5,029
Transportation				
Motor Vehicles (Tailpipes)	5,712	50,334	16,050	31,067
Petrol evaporation	0	0	0	4,742
Tire Wire	0	0	532	0
Marine Activities	333	16,604	2,883	1,478
Aviation	800	11,738	0	1,867
Railway	204	817	0	0
VOC Product				
Domestic Consumption	0	0	0	8,219
Paint	0	0	0	13,126
Others				
Domestic and Commercial Fuel Consumption	448	4,675	2,236	1,799
Waste Burning	3,022	1,644	1813	2,659
Pesticide Application	0	0	0	3,868
Total (in tonnes)	**16,002**	**133,370**	**64,502**	**101,020**

G1.1.4 Emission Inventory for Phase I near term, Phase II medium term and Phase III long term for HKSAR

G1.1.4.1 No further control scenario

Tables G1.14 to **G1.16** present the emission inventory prediction from Phase I to Phase III for HKSAR without further mitigation measures.

Table G1.14: HKSAR emission inventory in Phase I (in tonnes) without further mitigation measures

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	25,120	42,600	1,260	420
Industrial				
IDO combustion in Furnace	6	190	19	2
Towngas combustion	0	45	1	1
Chemicals / Rubber/ Plastic	0	0	0	17
Petrol Distribution and Handling (Fuel Terminal)	0	0	0	106
Petrol Distribution and Handling (Petrol Filling Station)	0	0	0	86
Printing	0	0	0.0	4,065
Construction	4	2,374	251	344
Food and Beverage	0	0	0	73
Light Industry (Textile)	0	0	0	0.9
Light Industry (Others)	0	0	0	66
Mining / Mineral Extraction	0	0	207	0
Non-Metallic Mineral Products	0	0	0	0
Transportation				
Motor Vehicles (Tailpipes)	295	11,223	680	3,682
Petrol evaporation	0	0	0	1,762
Tire Wire	0	0	719	0
Marine Activities	4,938	21,684	676	436
Aviation	469	8,073	34	415
Off road mobile sources and machinery	4	2,852	298	410
VOC Product				
Domestic Consumption	0	0	0	9,945
Paint	0	0	0	8,993
Others				
Domestic Fuel Consumption	6	1,116	85	42
Commercial Fuel Consumption	0	857	28	46
Waste Burning	0	8	24.	10
Pesticide Application	0	0	0	334
Crematorium	0	17	9	0
Total (in tonnes)	**30,842**	**91,040**	**4,291**	**31,255**

Table G1.15: HKSAR emission inventory (in tones) in Phase II without further mitigation measures

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	25,120	42,600	1,260	420
Industrial				

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
IDO combustion in Furnace	4	143	14	1
Towngas combustion	0	34	1	1
Chemicals / Rubber/ Plastic	0	0	0	10
Petrol Distribution and Handling (Fuel Terminal)	0	0	0	106
Petrol Distribution and Handling (Petrol Filling Station)	0	0	0	95
Printing	0	0	0	3,894
Construction	4	2,374	251	344
Food and Beverage	0	0	0	73
Light Industry (Textile)	0	0	0	1
Light Industry (Others)	0	0	0	49
Mining / Mineral Extraction	0	0	207	0
Non-Metallic Mineral Products	0	0	0	0
Transportation				
Motor Vehicles (Tailpipes)	327	8,379	326	3,466
Petrol evaporation	0	0	0	1,414
Tire Wire	0	0	793	0
Marine Activities	5569	24412	788	526
Aviation	552	9,490	40	488
Off road mobile sources and machinery	4	2,852	298	410
VOC Product				
Domestic Consumption	0	0	0	10365
Paint	0	0	0	9372
Others				
Domestic Fuel Consumption	7	1,163	88	44
Commercial Fuel Consumption	0	893	29	48
Waste Burning	0	9	25	11
Pesticide Application	0	0	0	348
Crematorium	0	17	9	0
Total (in tonnes)	**31,586**	**92,365**	**4,129**	**31,485**

Table G1.16: HKSAR emission inventory (in tones) in phase III long term without further mitigation measures

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	25,120	42,600	1,260	420
Industrial				
IDO combustion in Furnace	3	85	9	1
Towngas combustion	0	20	0	0
Chemicals / Rubber/ Plastic	0	0	0	4.

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Petrol Distribution and Handling (Fuel Terminal)	0	0	0	106
Petrol Distribution and Handling (Petrol Filling Station)	0	0	0	102
Printing	0	0	0	3,580
Construction	4	2,374	251	344
Food and Beverage	0	0	0	73
Light Industry (Textile)	0	0	0	1
Light Industry (Others)	0	0	0	29
Mining / Mineral Extraction	0	0	207	0
Non-Metallic Mineral Products	0	0	0	0
Transportation				
Motor Vehicles (Tailpipes)	349	6,945	235	3,633
Petrol evaporation	0	0	0	1,263
Tire Wire	0	0	854	0
Marine Activities	6,829	29,866	1,010	707
Aviation	552	9,490	40	488
Off road mobile sources and machinery	4	2,852	298	410
VOC Product				
Domestic Consumption	0	0	0	11,161
Paint	0	0	0	10,093
Others				
Domestic Fuel Consumption	7	1,252	95	47
Commercial Fuel Consumption	0	962	32	52
Waste Burning	0	9	27	12
Pesticide Application	0	0	0	375
Crematorium	0	17	9	0
Total (in tonnes)	**32,868**	**96,474**	**4,327**	**32,900**

G1.1.4.2 Further control scenario

The reduction potential for the Phase I, Phase II and Phase III control measures proposed in Section 3 are summarized in **Tables G1.17** to **G1.19**. The derivation of the emission potentials are summarized in Section F1.3. The corresponding emission inventories are also listed.

Phase I Measures

Table G1.17: Emission reduction upon implementation of Phase I control measures

Phase I Measures					
		Emission Reduction Potential (Tonnes)			
		SO_2	NO_X	PM_{10}	VOC
Emission Capping and Control					
1.	Increasing the ratio of natural gas in local	13402	25225	523	0

Phase I Measures					
		Emission Reduction Potential (Tonnes)			
		SO_2	**NO_X**	**PM_{10}**	**VOC**
	electricity generation to 50% together with additional emission abatement measures [1]				
2.	Early retirement of aged / heavily polluting vehicles (pre-Euro, Euro I and Euro II commercial diesel vehicles and franchised buses)	0	3102	300	184
3.	Earlier replacement of Euro III commercial diesel vehicles with models meeting latest Euro standards	0	743	75	24
4.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance (20% private cars and 10% franchised buses)	15	216	7	173
5.	Ultra low sulphur diesel (ULSD) for local vessels	675	0	18	0
6.	Selective catalytic reduction (SCR) for local vessels	0	304	0	0
7.	Electrification of aviation ground support equipment	85	759	21	67
8.	Emission control for off-road vehicles / equipment	4	950	239	326
9.	Strengthening volatile organic compounds control	0	0	0	700
Transport Management					
10.	Low emission zones	Note [5]	Note [5]	Note [5]	Note [5]
11.	Car-free zone / pedestrianisation scheme	Note [5]	Note [5]	Note [5]	Note [5]
12.	Bus route rationalization	4	156	7	9
Infrastructure Development and Planning					
13.	Expand rail network[4]	17	501	46	207
14.	Cycling network to major public transport hubs	0.1	2.3	0.1	0.1
Energy Efficiency Measures					
15.	Mandatory implementation of Building Energy Codes [2]	151	256	8	3
16.	Energy efficiency standards for domestic electrical appliances [2]	84	142	4	1
17.	Light-emitting diode or equivalent alternatives for traffic signal / street lighting	3	5	0.1	0
18.	Tree planting / roof-top greening [3]	---	---	---	---
19	District cooling system for Kai Tak Development	6	16	0.5	0.2

Note:
[1] Emission data provided by EPD

[2] Energy saving data provided by EPD

[3] No local emission and cost data. Estimates are based on overseas data. In this assessment, the area available for roof top greening is assumed to be 10% of the urban area.

[4] The railway strategy includes Express Rail Line, Sha Tin to Central Link (the Tai Wai to Hung Hom section), West Island Line, South Island Line (East), Kowloon Southern Link, and Kwun Tong Line Extension.

[5] The LEZ and Car free zones are the transport management strategies. They will divert traffic to other districts. Hence, the overall emission reduction is zero. The benefit shown in the table is the net benefit.

Phase II Measures

Table G1.18: Emission reduction upon implementation of Phase II control measures

Phase II Measures					
		Emission Reduction Potential (Tonnes)			
		SO_2	**NO_X**	**PM_{10}**	**VOC**
Emission Capping and Control					
20.	Increasing the ratio of natural gas in local electricity generation to 75% with additional abatement measures (Additional to Phase I measure) [1]	5,163	5,761	178	0
21.	Increasing the ratio of renewable energy (2% wind energy)	502	852	25	8
22.	Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance [30% private cars, 15% buses (including franchised buses), 15% light goods vehicles (LGVs) plus 15% heavy goods vehicles (HGVs)] (Additional to Phase I measure)	40	849	79	174
23.	Ultra low sulphur diesel for ocean-going vessels and local vessels (Additional to Phase I measure)	2,392	1,145	15	0
24.	Selective catalytic reduction for ocean-going vessels and local vessels (Additional to Phase I measure)	0	7,153	0	0
25.	Electrification of on-shore power supply	377	2,361	297	404
26.	Tightening aviation emission standards[2]	0	3,587	0	0
27.	Further strengthening volatile organic compounds control	0	0	0	4870
Transport Management					
28.	Electronic road pricing (ERP) / congestion charging scheme for Hong Kong Island North	Note [3]	Note [3]	Note [3]	Note [3]
29.	Reduce parking provision (25%) to restrain car usage for Central	Note [4]	Note [4]	Note [4]	Note [4]
Energy Efficiency					
30.	District cooling system (35% in existing areas and 90% in new development areas)	120	197	5.5	1.9

Note:

[1] Emission data provided by EPD

[2] Emission reduction is based on Statement from the ICAO to the 26 Session of the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA), 2007.

[3] The ERP will have air improvement benefit in pollution hot spot area. However, it will divert traffic to other districts. Hence, the overall emission reduction will be zero.

[4] The reduction of car park is a transport management strategy. It will divert traffic to other districts. Hence, the overall emission reduction will be zero.

[5] In this study, it is assumed that there is no switching in fuel for ocean going vessels outside the control zone. In practice, vessels are able to switch fuel types. Hence, the benefit cost ratio will be higher.

Phase III Measures

Table G1.19: Emission reduction upon implementation of Phase III control measures

Phase III Measures					
		Emission Reduction Potential (Tonnes)			
		SO_2	**NO_X**	**PM_{10}**	**VOC**
Emission Capping and Control					
31.	Increasing the ratio of natural gas in local electricity generation to 100% (Additional to Phase II measure) [1]	6,553	7,430	270	0
32	50% nuclear power and 50% natural gas (Alternative Case compared to Base Case of 75% natural gas) [1]	6,554	8,422	381	210
33.	Wider use of hybrid / electric vehicles or other environment- friendly vehicles with similar performance (50% private cars, 50% buses (including franchised buses), 50% HGVs plus 50% LGVs) (Additional to Phase II measure)	63	789	42	232
34.	Vehicle permit quota system (to reduce around 50% private cars and 50% motorcycles)	29	93	3	119
35.	Use of Hydrogen Fuel Cell vehicles or equivalent alternatives (40% penetration)	140	2,778	94	1,453
Infrastructural Development and Planning					
36.	Rail for transport of cross-boundary goods	1	11	1	9

Note:

[1] Emission data provided by EPD

Table G1.20 to **G1.22** summarize the emission inventory from phase I to phase III under the above planned control measures. The emission inventory in phase I is based on the interpolation of the emission inventories between Yr 2010 and phase II.

Table G1.20: HKSAR emission inventory in Phase I (in tonnes) with Phase I mitigation measures

Pollution Sources (in tonnes)	**SO_2**	**NO_X**	**PM_{10}**	**VOC**
Power Generation				
Power Plant	11718	17375	737	420
Industrial				
IDO combustion in Furnace	6	190	19	2
Towngas combustion	0	45	1	1

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Chemicals / Rubber/ Plastic	0	0	0	17
Petrol Distribution and Handling (Fuel Terminal)	0	0	0	106
Petrol Distribution and Handling (Petrol Filling Station)	0	0	0	86
Printing	0	0	0	4,065
Construction	0	1,424	12	18
Food and Beverage	0	0	0	73
Light Industry (Textile)	0	0	0	1
Light Industry (Others)	0	0	0	66
Mining / Mineral Extraction	0	0	207	0
Non-Metallic Mineral Products	0	0	0	0
Transportation				
Motor Vehicles (Tailpipes)	259	6,502	245	3,085
Petrol evaporation	0	0	0	1,762
Tire Wire	0	0	719	0
Marine Activities	4,263	21,380	658	436
Aviation	384	7,314	13	348
Off road mobile sources and machinery	4	2,852	298	410
VOC Product				
Domestic Consumption	0	0	0	9,945
Paint	0	0	0	8,293
Others				
Domestic Fuel Consumption	6	1,116	85	42
Commercial Fuel Consumption	0	857	28	46
Waste Burning	0	8	24	10
Pesticide Application	0	0	0	334
Crematorium	0	17	9	0
Total (in tonnes)	**16,640**	**59,080**	**3055**	**29,564**

Table G1.21: HKSAR emission inventory in Phase II (in tonnes) with Phase II mitigation measures

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	6053	10762	534	412
Industrial				
IDO combustion in Furnace	4	143	14	1
Towngas combustion	0	34	1	1
Chemicals / Rubber/ Plastic	0	0	0	10
Petrol Distribution and Handling (Fuel Terminal)	0	0	0	106
Petrol Distribution and Handling (Petrol Filling Station)	0	0	0	95

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Printing	0	0	0	3,894
Construction	0	1,424	12	18
Food and Beverage	0	0	0	73
Light Industry (Textile)	0	0	0	1
Light Industry (Others)	0	0	0	49
Mining / Mineral Extraction	0	0	207	0
Non-Metallic Mineral Products	0	0	0	0
Transportation				
Motor Vehicles (Tailpipes)	266	6,870	193	3,075
Petrol evaporation	0	0	0	1,414
Tire Wire	0	0	793	0
Marine Activities	2,124	13,450	457	122
Aviation	466	5,145	19	421
Off road mobile sources and machinery	4	2,852	298	410
VOC Product				
Domestic Consumption	0	0	0	5,495
Paint	0	0	0	8,672
Others				
Domestic Fuel Consumption	7	1,163	88	44
Commercial Fuel Consumption	0	893	29	48
Waste Burning	0	9	25	11
Pesticide Application	0	0	0	348
Crematorium	0	17	9	0
Total (in tonnes)	**8,925**	**42,761**	**2,679**	**24,719**

Table G1.22: HKSAR emission inventory in Phase III (in tonnes) with Phase III mitigation measures

Pollution Sources (in tonnes)	SO_2	NO_X	PM_{10}	VOC
Power Generation				
Power Plant	0	2340	153	202
Industrial				
IDO combustion in Furnace	3	85	9	1
Towngas combustion	0	20	0	0
Chemicals / Rubber/ Plastic	0	0	0	4
Petrol Distribution and Handling (Fuel Terminal)	0	0	0	106
Petrol Distribution and Handling (Petrol Filling Station)	0	0	0	102
Printing	0	0	0	3580
Construction	0	1424	12	18
Food and Beverage	0	0	0	73

Pollution Sources (in tonnes)	**SO_2**	**NO_X**	**PM_{10}**	**VOC**
Light Industry (Textile)	0	0	0	1
Light Industry (Others)	0	0	0	29
Mining / Mineral Extraction	0	0	207	0
Non-Metallic Mineral Products	0	0	0	0
Transportation				
Motor Vehicles (Tailpipes)	97	2614	43	1603
Petrol evaporation	0	0	0	1263
Tire Wire	0	0	854	0
Marine Activities	3385	18904	680	303
Aviation	466	5145	19	421
Off road mobile sources and machinery	4	2852	298	410
VOC Product				
Domestic Consumption	0	0	0	6291
Paint	0	0	0	9393
Others				
Domestic Fuel Consumption	7	1252	95	47
Commercial Fuel Consumption	0	962	32	52
Waste Burning	0	9	27	12
Pesticide Application	0	0	0	375
Crematorium	0	17	9	0
Total (in tonnes)	**3,962**	**35,626**	**2,437**	**24,285**

G1.2 Assumptions for Estimating the Emission Reduction Potentials

(1) Increasing the ratio of natural gas in local electricity generation with additional emission abatement measures

Emission reduction potentials were determined by subtracting the respective emissions projected with the 2010 emission caps stipulated in the Technical Memorandum and the anticipated emission reduction with the measures committed by the power companied that are to be completed in 2009 to 2011.

The basis and assumptions taken are as follows:

(i) Additional gas-fired generation requirements
- For 50% NG electricity generation (compared to Business-As-Usual): 12% (increasing from 38% to 50% of total local electricity generation)
- For 75% NG electricity generation (compared to Business-As-Usual upon the completion of Phase I measure): 17% (increasing from 58% to 75% of total local electricity generation)
- For 100% NG electricity generation (compared to Business-As-Usual upon the completion of Phase II measure): 6% (increasing from 94% to 100% of total local electricity generation)

(ii) Breakdown of installed capacity by fuel at the end of 2008

Type of Fuel	Total Installed Capacity	% of the Total Installed Capacity
Coal	6,608 MW	62%
Natural Gas	3,200 MW	30%
Fuel Oil	855 MW	8%
Wind	0.8 MW	0.01%
Total	10,664 MW	

(iii) Local electricity demand for 2007

Total local sales (on sales basis)	40,900 GWh
Export sales	4,035 GWh

(iv) Anticipated average growth rate in local electricity generation: 2%

(v) Fuel mix for 2007 (on gross generation basis)

	Local generation (Not including import from nuclear plant at Daya Bay)	Including import from nuclear plant at Daya Bay
Coal-fired units	73%	57%
Gas-fired units	27%	21%
Nuclear	--	22%

(v) Number of gas-fired units required:

	50% NG [1]	75% NG [1]	100% NG [1]	50% LNG + 50% nuclear [2]
Existing number of gas-fired units	10	10	10	10
Estimated number of gas-fired units required for meeting the electricity demand growth	2	5	5	5
Additional number of gas-fired units required for achieving the respective % NG generation	2	4	17	9

[1] of local electricity generation
[2] of total electricity generation

(vi) Emission factors:
Compared with coal fired unit, natural gas fired unit emits virtually no SO2 and PM_{10} and will reduce NOx by 85% or above.

The following table summarizes the emission reductions due to 50% Natural gas generation.

Pollutant	Emission reduction (tonnes)
SO_2	13402
NO_x	25225
PM_{10}	523
VOC	0

(2) <u>Early Retirement of aged / heavily polluting vehicles (pre-Euro, Euro I and Euro II commercial diesel vehicles and franchised buses)</u>

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Projected vehicle profile for commercial vehicles (Phase I):

	LGV	HGV	Commercial (LGV + HGV)	Franchised Buses
Pre Euro	0	0	0	0
Euro 1	1,099	736	1,835	227
Euro 2	13,802	10,643	24,445	2,623
Euro 3	20,332	13,509	33,841	1,028
Euro 4	15,041	10,090	25,131	648
Euro 5	25,449	16,835	42,284	1,365

Note: LGV and HGV represent light goods vehicles and heavy goods vehicles, respectively.

- No of Pre Euro vehicles need to be replaced:
  LGV: 0
  HGV: 0
  Franchised bus: 0
- No. of Euro I vehicles need to be replaced:
  LGV: 1099

HGV: 736
Franchised bus: 227

- No. of Euro II vehicles need to be replaced:
  LGV: 13802
  HGV: 10643
  Franchised bus: 2623

(ii) Emission factors:

Petrol Passenger Cars

Pollutants	Limit values (g/km)					
	#pre-Euro	Euro I	Euro II	Euro III	Euro IV	Euro V
CO	15.11	2.72	2.2	2.3	1.0	1.000
HC + NO_x	4.85	0.97	0.5	*0.35*	*0.18*	*0.160*
HC	-	-	-	0.20	0.10	0.100
NO_x	-	-	-	0.15	0.08	0.060

Light Duty Diesel Vehicles (Design weight ≤ 3.5 tonne; RW > 1.7 tonne)

Pollutants	Limit values (g/km)					
	#pre-Euro	Euro I	Euro II	Euro III	Euro IV	Euro V
CO	-	6.9	1.5	0.95	0.74	0.740
HC + NO_x	2.24	1.7	1.2	0.86	0.46	0.350
NO_x	-	-	-	0.78	0.39	0.280
*HC	-	-	-	*0.08*	*0.07*	*0.070*
PM	0.6	0.25	0.17	0.10	0.06	0.005

Heavy Duty Diesel Vehicles (Design weight > 3.5 tonne, ESC and ELR tests)

Pollutants	Limit values (g/kWh)					
	#pre-Euro	Euro I	Euro II	Euro III	Euro IV	Euro V
CO	-	4.5	4.0	2.1	1.5	1.5
HC	2.34	1.1	1.1	0.66	0.46	0.46
NO_x	8.99	8.0	7.0	5.0	3.5	2.0
PM	0.68	0.36	0.15	0.10	0.02	0.02

Based on the above, the emission reduction percentages for different commercial diesel vehicles would be as follows:

Vehicle Types	SO_2	NO_x	PM	VOC
Private Light Bus	0%	47.6%	72.1%	20.7%
Public Light Bus	0%	31.23%	52.31%	11.37%
LDV	0%	26.9%	43.8%	10.6%
HDV	0%	29.51%	47.70%	23.82%
Non-Franchised Bus	0%	8.79%	14.86%	7.36%
Franchised Buses	0%	47.76%	67.64%	38.49%

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)[Note 1]
SO_2	0
NO_x	3102
PM_{10}	300

Pollutant	Emission reduction (tonnes)[Note 1]
VOC	184

Note [1]: With respect to short term no control scenario

(3) Earlier replacement of Euro III commercial diesel vehicles with models meeting latest Euro standards (Short Term)

Based on the assumptions presented in (2) above, the emission reduction percentages for different commercial diesel vehicles would be as follows:

Vehicle Types	SO_2	NO_x	PM	VOC
Private Light Bus	0%	6.6%	9.4%	1.0%
Public Light Bus	0%	16.2%	25.2%	2.3%
LDV	0%	22.90%	34.93%	3.38%
HDV	0%	16.94%	25.66%	7.22%
Non-Franchised Bus	0%	29.20%	50.62%	12.73%

The following table summarizes the emission reduction potential (Assuming that 50% vehicles will uptake latest Euro Standard earlier):

Pollutant	Emission reduction (tonnes)
SO_2	0
NO_x	743
PM_{10}	75
VOC	24

(4) Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance (20% private cars and 10% franchised buses)(Short Term)

(i) Projected population of private cars (Phase I)

- Vehicle growth rate: 2.5% (with the number of private cars in 2008 being 421,089)
- Vehicle population at the end of 2014: 444,076

(ii) Number of vehicles to be replaced (Phase I)

- Private cars: 88,815 (about 20%)
- Buses: 589 (Euro III, about 10% of total number of buses)

(iii) Emission factors:

The hybrid petrol vehicles emit about 80% less respirable suspended particulates and NO_x (Source: www.hybrid-car.org).

For the hybrid private car, buses, LGV and HGV, the emission reduction percentages are summarized as follows:

Types	SO_2	NO_x	PM	VOC[Note 2]
PC	80%	80%	80%	80%
Bus / LGV/ HGV[Note 1]	65%	40%	70%	65%

Note [1]: http://www.navc.org/HDemission1.html

[2]: VOC for Bus, LGV and HGV are estimated from fuel economy

The following table summarizes the emission reduction potential:

20%PC + 10% Bus

Pollutant	Emission reduction (tonnes)[Note 1]
SO_2	15
NO_x	216
PM_{10}	7
VOC	173

Note [1]: With respect to short term no control scenario

(5) Use ultra low sulphur diesel (ULSD) for local vessels (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Assuming no growth on vessels and emissions

(ii) Emission factors:

With the use of ULSD, emission reduction potential is 99% reduction in SO_2 and 10% reduction in PM.

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
SO_2	675
PM_{10}	18
VOC	0

(6) Selective catalytic reduction (SCR) for local vessels (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) The number of local vessels assumed to be fitted with SCR (Phase I):
146 vessels
(According to Port 2006, MD, there are 584 vessels in Hong Kong, it is assumed that 25% of local vessels would be capable to install SCR under this strategy)

(ii) Emission factors:

80% reduction in NO_x.

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
NO_x	304

(7) Electrification of aviation ground support equipment (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Number of GSE:
- Being used in the airport to be electrified: 700

The major ground support handling agents in Hong Kong Airport will include the Hong Kong Airport Services Ltd. and Jardine Air Terminal Services Ltd. According to the Sustainable Development Report of Hong Kong Airport Services Ltd (HAS), the fleet size of GSE in Yr 2007 was around 2586. Amongst those GSE, non-electrical motorized GSE was around 422. For the Jadine Air Terminal, the number of GSE was around 1300

(http://www.jats.com.hk/scopeofservices.html). However, there was no breakdown in their information. Hence, the GSE profile from HAS was used to estimate the number of non-electrical motorized GSE, which was estimated to be around 212. The total number of non-electrical motorized GSE was estimated to be 634. On allowing 10% margin, it is estimated that the number of non-electrical motorized GSE was around 700.

(ii) Emission factors:

Electrified GSE emit zero emissions

The following table summarizes the emission reduction potential.

Pollutant	Emission reduction (tonnes)
SO_2	85
NO_x	759
PM_{10}	21
VOC	67

(8) Emission Control for off-road vehicles / equipment (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Number of construction equipment
- Number of construction sites in Hong Kong: 1,007
- Average number of construction equipment per site: 30
- Number of construction equipment to be subject to control: 30,210

(ii) Emission factors:

Emission reduction percentages with the use of ULSD and Exhaust Gas Recirculation / Diesel Particulates Filter (EGR/DPF):

	SO_2	NO_x	PM	VOC
ULSD + EGR /DPF	100%	40%	95%	95%

(Source: Genesis Engineering and Levelton Engineering Ltd (2003) Non Diesel Road Emission Study, Puget Sound Clean Air Agency Oregon Dept of Environmental Quality, USEPA.)

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
SO_2	4
NO_x	950
PM_{10}	239
VOC	326

(9) Strengthening Volatile Organic Compounds control (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Quantity of products consumed: 11,736 tonnes / year

(ii) The current VOC content of typical products and the proposed VOC content limits.

(iii) Extending the control of VOCs to non-architectural paints, solvents, sealants and adhesives

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
VOC	700

(10) Low Emission Zones (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Vehicles to be affected: All Euro III and pre-Euro III vehicles

(ii) Area to be designated as LEZ: Districts with heavy traffic - most areas of the Central, Mong Kok and Causeway Bay districts

(iii) Demarcation of the LEZ by streets are as follows-

Mong Kok:	Central:	Causeway Bay:
Boundary Street	Garden Road	Marsh Road
Yim Po Fong Street	Connaught Road Central	Victoria Park Road (in Western)
Soy Street	Lower Albert Road	Gloucester Road
Tong Mi Road	Hollywood Road	Leighton Road
Pitt Street	Queen's Road West	Morrison Hill Road
Ferry Street	Charter Road	
	Ko Shing Street	

(iv) Other assumptions-

- About 18% and 30% (Central and Mong Kok respectively) of the vehicle trips are assumed to be passing through, respectively, LEZs of Central and Mong Kok frequently.
- Of these vehicle trips, two thirds would be assumed to be upgraded by installing emission reducing equipment (as their vehicles are relatively new and it is cheaper to do so) and the remainder one third would replace by new vehicles (more expensive, but they have older vehicles that are closer to the age of replacement).

(11) Car-free zone / pedestrianisation scheme (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) The present time restrictions in pedestrian streets in Mongkok, Causeway Bay and Central are extended to all time

(ii) Assume vehicle restrictions for all vehicles in traffic calming streets in Mongkok, Causeway Bay and Central

(12) Bus route rationalization (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Bus trips would be reduced by 10%, mainly from the reduction of bus trips in non-peak times where excess capacity in the system exists.

(ii) Emission factors:

Emission reduction percentage: Take as same as the percent of bus trips reduced, i.e., 10%

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
SO_2	4
NO_x	156
PM_{10}	7
VOC	9

(13) Expand rail network (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Committed rail projects including Express Rail Line, Sha Tin to Central Link (the Tai Wai to Hung Hom section), West Island Line, South Island Line (East), Kowloon Southern Link, and Kwun Tong Line Extension will be commissioned and in operation

(ii) Emission factors:

Emission reduction was estimated by assuming a reduction in vehicle trips of about 248 millions annual VKT

(Reference: The Second Railway Development Study, HyD, 2000).

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
SO_2	17
NO_x	501
PM_{10}	46
VOC	208

(14) Cycling network to major public transport hubs (Short Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Five cycling networks, with each 10 km long and 4 m wide, are assumed. The location has not been specified

(ii) Emission factors:

Emission reduction was estimated by assuming a daily passenger trip decreased by 0.15% (territory wide). The figure was derived by referencing to the "Cycling Study (Contract No TD100/2002) - Final Report 2004" commissioned by TD in Yr 2001 which estimated that the existing cycling track of around 170km would contributing to daily passenger trips of about 2% (in new town) or 0.5% (territory wide). As a conservative assumption, the passenger trips are assumed to be bus trips.

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
SO_2	0.1
NO_x	2.3
PM_{10}	0.1
VOC	0.1

(15) Mandatory implementation of Building Energy Codes

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) 10-15% energy saving inside new commercial building (~ 2800 million kWh per decade), the annual energy consumption of electricity in Yr 2015 will be ~ 46,000,000 MWh (Based on ~2% growth rate and the energy consumption in Yr 2007 is 40,853,000MWh). Hence, the energy saving is around 0.6%.

(References:
1. Energy Efficient Management For Street Lightings, Lighting Division Highway Dept, May 2008
2. A Proposal on the Mandatory Implementation of the Building Energy codes, Environment Bureau, Electrical and Mechanical Service Dept, Hong Kong SAR. Noting: Pg 22 "*On average, the payback period for the additional capital investment is 6 years*")

(ii) Emission factors:

Emission reduction percentage of SO_2, NO_x, and PM_{10} from the energy sector will be the same as energy saving percentage, i.e., 0.6%.

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
SO_2	151
NO_x	256
PM_{10}	8
VOC	3

(16) <u>Energy efficient standards for domestic electrical appliances</u>

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) All domestic air conditioners and refrigerators are of grade 3 or above, and only compact fluorescent lamps are used. The development of energy efficiency standards for domestic electrical appliances will reduce the electricity consumption. This will lead to a reduction in emissions through savings in electricity used (~ 150 GWh).The annual energy consumption of electricity in Yr 2015 will thus be ~ 46,000,000 MWh (derived from ~2% growth rate with energy consumption in Yr 2007 of 40,853,000MWh). Hence, the energy saving is around 0.3%.

(ii) Emission factors:

Emission reduction percentage of SO_2, NO_x, and PM_{10} from the energy sector will be the same as energy saving percentage, 0.3%.

The following table summarizes the emission reduction potential.

Pollutant	Emission reduction (tonnes)
SO_2	84
NO_x	142
PM_{10}	4
VOC	1

(17) <u>Light-emitting diode or equivalent alternatives for traffic signal / street lighting (Short Term)</u>

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) The number of street lights/lanterns: 15,000 street lights and 6,000 lanterns (21,000 total).
The saving in energy due to this measure is around 5 GWh (3GWh saving for retrofitting with regulating electronic ballasts; 2GWh saving for 6000 replacement of less efficient lanterns) or 0.011% of the total energy consumption. The total energy consumption is ~ 46,000,000 MWh in Yr 2015.

(ii) Emission factors:

Emission reduction percentage of SO_2, NO_x, and PM_{10} from the energy sector will be the same as energy saving percentage, 0.011%.

The following table summarizes the emission reduction potential.

Pollutant	Emission reduction (tonnes)
SO_2	3
NO_x	5
PM_{10}	0.1
VOC	0

(18) Tree planting/ roof-top greening

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Assumed coverage area: 13.74 km^2 (i.e. 10% of our total urban area)
(ii) Emission factors:

No local data available.

(19) District cooling system for Kai Tak Development (Short term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) About 0.038% of total electricity consumption reduction for South East Kowloon after using the district cooling system

(Reference:

1. Territory-Wide Implement Study for Water-cooled air conditioning systems in Hong Kong, EMSD 2003
2. Implementation Study for a District Cooling Scheme at South East Kowloon Development, December 2003, Ove Arup and Partners Hong Kong

(ii) Emission factors:

Emission reduction percentage of SO_2, NO_x, and PM_{10} from the energy sector will be same as energy saving percentage, i.e., 0.038%.

The following table summarizes the emission reduction potential.

Pollutant	Emission reduction (tonnes)
SO_2	6
NO_x	16
PM_{10}	0.5
VOC	0.2

(20) Increasing the ratio of natural gas in local electricity generation to 75% with additional emission abatement measures (Medium Term)

Please refer to measure 1 for assumptions and emission factors.

The following table summarizes the emission reductions due to 75% Natural gas generation.

Pollutant	Emission reduction (tonnes)
SO_2	5163
NO_x	5761
PM_{10}	178
VOC	0

(21) Increasing the ratio of renewable energy (2% wind energy) (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) an additional 2% penetration of renewable energy in HK energy sector. The increase in renewable energy would replace the same amount of energy from coal-fired generation.

(ii) Emission factors:

Renewable Energy emits zero emissions

The following table summarizes the emission reductions.

Pollutant	Emission reduction (tonnes)[Note 1]
SO_2	502
NO_x	852
PM_{10}	25
VOC	8

Note [1]: With respect to medium term no control scenario

(22) Wider use of hybrid / electric vehicles or other environment-friendly vehicles with similar performance [30% private cars, 15% buses (including franchised buses), 15% light goods vehicles (LGVs) plus 15% heavy goods vehicles (HGVs)] (Medium Term)

(i) Projected population of private cars (Phase II)
- Vehicle growth rate: 2.5% (with the number of private cars in 2008 being 421,089)
- Vehicle population at the end of 2020: 502,432

(ii) Projected population of Light Goods Vehicles (LGV) (Phase II)
- Vehicle growth rate: -1.2% to 0.7% (with the number of LGV in 2008 being 72,382)
- Vehicle population at the end of 2020: 73,825

(iiI) Projected population of Heavy Goods Vehicles and non-Franchised bus (HGV) (Phase II)
- Vehicle growth rate: 0.5% (with the number of HGV in 2008 being 47,743)
- Vehicle population at the end of 2020: 53,120

(iv) Number of vehicles to be replaced (Phase II)
- Private cars: 150,729 (about 30%)
- LGV: 11074 (about 15%)
- HGV (incl non-franchised buses): 7968 (about 15%)
- Buses: 884 (Euro III, about 15% of total number of bus)

(v) Emission factors:

The hybrid petrol vehicles emit about 80% less respirable suspended particulates and NOx (Source: www.hybrid-car.org).

For the hybrid buses, LGV and HGV, the emission reduction percentages are summarized as follows:

Types	SO_2	NO_x	PM	VOC[Note 2]
PC	80%	80%	80%	80%
Bus / LGV/ HGV[Note 1]	65%	40%	70%	65%

Note [1]: http://www.navc.org/HDemission1.html
[2]: VOC for Bus, LGV and HGV are estimated from fuel economy

The following table summarizes the emission reduction potential:

30%PC + 15% LGV + 15%HGV (incl non Franchised Buses)+15%Franchised Buses

Pollutant	Emission reduction (tonnes)[Note 1]
SO_2	40
NO_x	849
PM_{10}	79
VOC	174

Note [1]: With respect to medium term no control scenario

(23) Ultra low sulphur diesel (ULSD) for ocean-going vessels and local vessels (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Emission projected based on historical trends of net register tonnage from 1996 to 2006.

(ii) Emission factors:

With the use of ULSD, emission reduction potential is 99% reduction in SO_2 , 64% reduction in NO_2 (AP42, Table 1.3, USEPA) and 10% reduction in PM.

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
SO_2	2392
NO_x	1145
PM_{10}	15
VOC	0

(24) Selective catalytic reduction for ocean going vessels and local vessels (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Emission projected based on historical trends of net register tonnage from 1996 to 2006.
(ii) The number of ocean going vessels assumed to be fitted with SCR (Phase II): 350 vessels registered in Hong Kong (derived from Port Statistics 2006, MD)
(iil) Emission factors:

80% reduction in NO_x.

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
NO_x	7153

(25) Electrification of on shore support power supply (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Emission from container terminal projected based on the fuel usage data

(ii) Emission factors:

80% reduction in pollutants

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)[Note 1]
SO_2	377
NO_x	2361
PM_{10}	297
VOC	404

Note [1]: With respect to medium term no control scenario (based on 80% reduction for all pollutants)

(26) Tightening aviation emission standards (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Emission from aviation projected based on Landing and Takeoff Cycle (LTO) and planning data of Airport Authority Hong Kong

(ii) Emission factors:

45% reduction in NO_2 from the current standard (Reference Twenty-Sixth Session of the UNFCCC Subsidiary Body for Scientific and Technological Advice, 2007)

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)[Note 1]
SO_2	0
NO_x	3587
PM_{10}	0
VOC	0

Note [1]: With respect to medium term no control scenario (based on 80% reduction for all pollutants)

(27) Further Strengthening Volatile Organic Compounds Control (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) The projected VOC emission due to consumer products is 9740 Tonnes Yr 2020.

(ii) Emission factors:

The emission reduction percentage for consumer products is estimated to be 50% reduction efficiency (Reference: California Air Resources Board (CARB) http://www.arb.ca.gov/consprod/geninfo/cpsmog.htm)

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
VOC	4870

(28) Electronic road pricing / congestion charging scheme (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Vehicles to be affected: All vehicles

(ii) Area to be designated as ERP: Districts with heavy traffic – Hong Kong North

(iii) Emission factors:

- 2% and 0.4% reduction in NOx and PM_{10} respectively (Clause 6.13 of Feasibility study on electronic road pricing, TD, 2001).

(29) Reduce parking provision (25%) to restrain car usage for Central (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Parking Space: Reduction of parking space by 25% in Central business district will result in 4% reduction in private cars

(iii) Emission factors:

Emission reduction percentage of SO_2, NO_x, and PM_{10} from the private car will be the same as reduction in private cars, 4%.

(30) District cooling system (35% in existing areas and 90% in other new development areas) (Medium Term)

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) About 0.5% of total electricity consumption reduction for South East Kowloon after using the district cooling system

(Reference:

1. Territory-Wide Implement Study for Water-cooled air conditioning systems in Hong Kong, EMSD 2003

2. Implementation Study for a District Cooling Scheme at South East Kowloon Development, December 2003, Ove Arup and Partners Hong Kong

(ii) Emission factors:

Emission reduction percentage of SO_2, NO_x, and PM_{10} from the energy sector will be the same as energy saving percentage, i.e., 0.5%.

The following table summarizes the emission reduction potential.

Pollutant	Emission reduction (tonnes)
SO_2	120
NO_x	197
PM_{10}	5.5
VOC	1.9

(31) Increasing the ratio of natural gas in local electricity generation to 100% (Long Term)

Please refer to measure 1 for assumptions and emission factors.

The following table summarizes the emission reductions due to 100% Natural gas generation.

Pollutant	Emission reduction (tonnes)
SO_2	6553
NO_x	7430
PM_{10}	270
VOC	0

(32) 50% nuclear power and 50% natural gas (Long Term)

(i) Please refer to measure 1 for assumptions.

(ii) Emission factors:

The following table summarizes the emission reductions due to increase nuclear power ratio to 50% energy generation.

Pollutant	Emission reduction (tonnes)
SO_2	6554
NO_x	8422
PM_{10}	381
VOC	210

(33) Wider use of hybrid vehicles / electric vehicles or other environment-friendly vehicles with similar performance (50% private cars, 50% buses (including franchised buses), 50% HGVs plus 50% LGVs) (Long Term)

(i) Projected population of private cars (Phase III)

- Vehicle growth rate: 2.5% (with the number of private cars in 2008 being 421,089)
- Vehicle population at the end of 2030: 643,155

(ii) Projected population of Light Goods Vehicles (LGV) (Phase III)

- Vehicle growth rate: -1.2% to 0.7% (with the number of LGV in 2008 being 72,382)
- Vehicle population at the end of 2030: 81,430

(iiI) Projected population of Heavy Goods Vehicles and non-Franchised bus (HGV) (Phase III)

- Vehicle growth rate: 0.5% (with the number of HGV in 2008 being 47,743)
- Vehicle population at the end of 2030: 55,837

(iv) Number of vehicles to be replaced (Phase III) (taken into account 50% penetration of Hydrogen fuel cell vehicles)

- Private cars: 160,789 (about 50%)
- LGV: 20,358 (about 50%)
- HGV (incl non-franchised buses): 13,959 (about 50%)
- Buses: 1,473 (about 50% of total number of bus)

(v) Emission factors:

The hybrid petrol vehicles emit about 80% less respirable suspended particulates and NO_x (Source: www.hybrid-car.org).

For the hybrid PC, buses, LGV and HGV, the emission reduction percentages are summarized as follows:

Types	SO_2	NO_x	PM	VOC[Note 2]
PC	80%	80%	80%	80%
Bus / LGV/ HGV[Note 1]	65%	40%	70%	65%

Note [1]: http://www.navc.org/HDemission1.html
[2]: VOC for Bus, LGV and HGV are estimated from fuel economy

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)[1]
SO_2	63
NO_x	789
PM_{10}	42
VOC	232

Note[1]: With respect to long term no control scenario (taken into account the hydrogen fuel cell)

(34) <u>Vehicle permit quota system (Long Term)</u>

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Private car would be reduced by 50%

(ii) Emission factors:

Emission reduction percentage: It is assumed as the same as the reduction percentage of private car, i.e., 50%

The following table summarizes the emission reduction potential

Pollutant	Emission reduction (tonnes)[Note 1]
SO_2	28
NO_x	93
PM_{10}	3
VOC	119

Note [1]: With hydrogen fuel cell and hybrid vehicles taken into account

(35) <u>Use of hydrogen fuel cell vehicles or equivalent alternatives (Long Term)</u>

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) The share of registration of hydrogen fuel cell is around 10 - 15% according to Figure 3-2 of "*TRENDS IN VEHICLE AND FUEL TECHNOLOGIES, ESTO, 2000".* It is predicted that the penetration rate of hydrogen fuel cell vehicles is around 40% in long term.

(ii) Emission factors:

No pollutant emission for Hydrogen fuel cell.

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)[Note 1]
SO_2	140
NO_x	2,778
PM_{10}	94
VOC	1453

(36) <u>Rail for transport of cross-boundary goods (Long Term)</u>

The basis and assumptions taken for estimating the emission reduction potential of this measure are as follows:

(i) Planned rail projects including Port Rail Line

(ii) Emission factors:

Emission reduction was estimated by assuming a reduction in vehicle trips of about 20,600 VKT (Average Scenario)

- Daily NOx reduction: 0.079 tonnes (Table 7.7, Second Railway Development Study, Final SEA study);
- Daily PM_{10} reduction: 0.011 tonnes (Table 7.7, Second Railway Development Study, Final SEA study);

(Reference: Second Railway Development Study – Final SEA report, 2000).

The following table summarizes the emission reduction potential:

Pollutant	Emission reduction (tonnes)
SO_2	1
NO_x	11
PM_{10}	1
VOC	9