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# *Living Under Blue Skies*

A Review of Air Pollution in Hong Kong  
and the Pearl River Delta

Business Environment Council  
(April 2005)



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## Executive Summary

This report has been prepared by the Business Environment Council (BEC) as a primer for discussion on the issue of air pollution in the Pearl River Delta (PRD)<sup>1</sup>. The BEC is a non-profit organisation comprising member companies which provides a platform for its members to engage and discuss key topics where business can take a leading role in tackling environmental problems.

### Background

Hong Kong is very much a victim of its own success. The migration of its industries in the 1980s to the PRD has helped to shape the latter's development into an industrial powerhouse that services the rest of China and, arguably, the rest of the world. However, the economic growth of the PRD - currently estimated by some to be at 8-9% per annum - means that environmental damage, such as air pollution, will result due to the resources and energy consumed to fuel this growth, together with the expected rise in consumer behaviour throughout the region. Hence, whilst managing to contain many of its own environmental excesses, Hong Kong suffers from downstream air pollution effects arising from sources in the PRD.

The majority of the main air pollutants, namely sulphur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), respirable suspended particulates (RSP) and volatile organic compounds (VOCs), come from the combustion of fossil fuels to produce energy and to meet transport needs; these sources of air emissions are stationary sources (like power plants) and mobile sources (such as vehicles, shipping and aircraft) respectively. In addition, we must consider the demand side, i.e. the high level of energy consumed in Hong Kong. Buildings and infrastructure are largely responsible for this demand, much of which could be avoided through better energy efficiency and conservation practices. Hong Kong also relies heavily on chemicals found in household and industrial products. Such products, particularly solvent-based ones, are responsible for the emission of VOCs. Other activities such as construction and restaurants are further responsible for the release of particulates to the atmosphere, although legislation has limited the scale of these sources.

Smog is a particularly pertinent air pollutant in Hong Kong's case due to its visibility and pervasiveness. Smog is formed when air pollutants generated by vehicular emissions (as well as industrial and commercial operations) react photochemically in the presence of sunlight. The declining visibility (taken as below 8 kilometres) is reflected in the percentage of such days taking place per year, which reached a high of 16% in 2004, and has a marked effect on the aesthetic value of many of the city's landmarks.

From a regional perspective, energy, industry, motor vehicles and VOC-containing products, make up more or less 90% of the total air pollution load in the PRD region. Each business, industrial or community sector contributes differently in separate air pollutant areas: vehicles and industry make up the majority of VOCs and RSPs respectively, whilst the bulk of NO<sub>x</sub> and SO<sub>2</sub> come from power plants. The problem is compounded by the long-term growth of factors like economy, population, electricity

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<sup>1</sup> The focus of this paper is on ambient air pollution, although it is recognised that indoor air quality is also an important issue in Hong Kong. This matter is dealt with separately in another BEC programme.

demand and vehicle mileage in the PRD region. Based on these projections, it is likely that air pollution in the region will increase rather than decrease even as the Hong Kong and Guangdong Governments continue to implement their existing improvement measures.

Geographically, the PRD is sheltered from the rest of the Mainland by hilly and mountainous ranges and hence the pollution in the region is localised. Because of this factor, Hong Kong's air quality problems do not dissipate easily. The problem is exacerbated by the phenomenon of "urban land-sea breeze circulation". During the day, as warm air over the urban areas rises, it leaves an area of low pressure that sucks in air from surrounding areas into urban areas. The air typically will rise to a height of about 1-2 kilometres, and then spread out horizontally before falling as it drifts out to the cooler ocean area. This effect leads to the formation of closed vertical circulations around the city centres. The air rising over urban centres carries away air pollutants emitted in the city, but these pollutants are re-circulated as they get sucked back in through the circulation cycle. The trapped pollutants can only be cleared when background winds are stronger than the land-sea breeze circulation to blow pollutants beyond its radius.

Quantifying the impacts of air pollution is difficult in most cases. What is universally recognised, though, is that cities experiencing poor air quality (measurable or not) tend to be regarded less favourably in terms of health, quality of life and overall prosperity. The impact of air pollution in Hong Kong has been quantified to some degree using healthcare costs, estimated to be about \$1.3 billion based on 2000 data. Other economic impacts arising from, say, smog in terms of losses in tourism, property and foreign investment are less easy to quantify due to the lack of in-depth research in this area.

In summary, the long-term prognosis for addressing air pollution in the PRD would appear to be gloomy due a number of factors but mainly as a result of the expected economic growth in industry. However, it is clear that for Hong Kong to maintain investor confidence and regional competitiveness air pollution must be one of the key issues to be addressed.

### **Measures undertaken**

The Hong Kong Government has made a number of resolutions in air emission reduction through tightening of motor petrol standards, applying Euro IV emission standards to new vehicles and negotiating with the power companies to further reduce air emissions and encourage the use of cleaner fuels, like natural gas, in electricity generation.

In Guangdong, the provincial government has focused on power plants, vehicles and the most polluting industrial processes by restricting the use of high-sulphur fuels, closing down small power generation units, retrofitting flue gas desulphurisation (FGD) systems to reduce emissions from power generation, and phasing out coal-fired boilers, industrial boilers and industrial technologies and equipment with inefficient energy consumption characteristics. However, one of the major challenges facing the Guangdong Government lies in the gathering and reporting of air monitoring data. Current initiatives are underway, such as the setting up of monitoring stations and the compilation of emissions inventories, but difficulties in obtaining accurate air monitoring data prevail due to the lack of resources in the province.

The most significant cross-boundary initiative on improving regional air quality was the agreement in 2002 between the governments of Hong Kong and Guangdong Province on

reducing smog-related air pollution. Taking 1997 as the base year, RSPs and VOCs are each to be cut by 55%, SO<sub>2</sub> by 40% and NO<sub>x</sub> by 20% by 2010. The two governments are also exploring ways to set up an emissions trading pilot scheme covering power plants in Hong Kong and Guangdong. The scheme has already obtained the endorsement of the Central People's Government and the State Environmental Protection Administration.

But, clearly, for air quality to improve, it is not just the two governments that are responsible. Other stakeholder parties like the power companies, transport companies, industrialists and communities will have to co-operate closely to share knowledge and resources and work towards common goals.

### **What can business do?**

From a business perspective, many Hong Kong companies are aligned in their interests to reduce air pollution.

- **Power companies** – China Light & Power issued its “Manifesto on Air Quality and Climate Change” in December 2004 committing the company to specific actions to improve air emissions generated by its activities, through bringing liquefied natural gas (LNG) to Hong Kong, reducing emissions from coal-fired generation by installing FGD systems and developing renewable energy. Hong Kong Electric has similar initiatives in hand, and will shortly publish its own environmental report outlining the company’s goals for reducing air pollution.

The power industry faces several issues: the future composition of fuel mixes to include a higher proportion of cleaner fuels, incentives for further demand-side management, and the means by which the commitment of both power companies can be obtained to adopt renewable energy options and to support the cross-boundary emissions trading programmes with Mainland power stations.

- **Transport** – Currently, almost of all the taxis in Hong Kong run on LPG, which is a cleaner alternative fuel to diesel. A similar scheme for public light buses is under implementation. The introduction of Euro IV diesel and a requirement for all newly registered vehicles to comply with Euro III emission standards in 2003, combined with increased penalties for smoky vehicles, has led to a marked improvement in roadside air quality, particularly in SO<sub>2</sub> and RSP.

However, future issues to be addressed include extending the use of cleaner fuels (e.g. LPG or biodiesel) into private vehicles, introducing hybrid vehicles, more vehicle-related environmental initiatives (such as turning off idling engines and encouraging walking), how to prevent Hong Kong drivers “tankering” and bringing in lower-grade fuel from the PRD, and stop the use of low-grade bunker fuel in shipping and port activities. The growth of cross-boundary traffic, as new infrastructure such as the Shenzhen Western Corridor and the proposed HK-Macau-Zhuhai bridge are developed, will create further air pollution issues for Hong Kong as less tightly regulated vehicles from the Mainland are expected to use Hong Kong roads.

- **Industry** - The various Chambers of Commerce have come up with position statements representing their members’ concerns on the need to tackle air pollution and the translation of these statements into action. The Business Coalition for the Environment has proposed a charter for companies to sign to declare their intent to reduce air pollution within their respective industries. Taking into account that there

are about 70,000 factories in the PRD owned by Hong Kong companies, the Hong Kong Federation of Industries has come up with the “1-1-1” programme to encourage factories to individually come up with one environmental initiative (including curbing air emissions), every year, i.e. “one factory, one initiative, one year”. Another campaign led by Civic Exchange, a Hong Kong NGO, is promoting a fuel-switching campaign targeted at industrial on-site generation units used by factories in the PRD.

Issues for industry’s future consideration include how to further reduce the use of VOC-containing chemicals, promoting more energy efficiency and conservation initiatives and encouraging better practices throughout factories and offices in the PRD.

- **General** – There is a wide need to educate more companies, especially SMEs, on the relationship between wasteful energy habits and the unnecessary generation of air emissions from fossil fuel combustion. Some Hong Kong companies have also identified possible commercial opportunities from energy efficiency projects, notably those with property portfolios, and are looking at the wider issue of carbon emissions, climate change and trading in carbon emission and pollution credits.

### Next Steps

The next steps will be to harness business interests in identifying and taking possible actions to address this problem in a way that will complement the measures being carried out by the Hong Kong and Guangdong governments. The BEC, in its role as a platform for discussion, will continue to gather and disseminate published information on Hong Kong’s air pollution issues as well as any ongoing and planned initiatives in order to raise awareness amongst its members. In addition, the BEC will provide support to members and other groups wishing to or that are already involved in programmes to reduce air pollution levels. The BEC will also be launching key topic programmes to engage business, government and NGOs in order to form appropriate and effective partnerships that will address current and future issues in tackling air pollution.

The following key topics have been selected for their relevance to BEC members as well as to the wider community:

- **Sharing best practices for air pollution abatement** – case studies on energy efficiency, demand-side management, transport practices (including better motorist habits and encouraging pedestrianisation), energy conservation and clean processes (like alternative solvents and vapour-treatment technologies)
- **Use of clean energy** – clean fuels for transport (e.g. biodiesel, hybrid vehicles, LPG) and power generation (LNG and renewable energy) as well as how to stop the use of polluting fuels (e.g. bunker fuel and low-grade diesel)
- **Application of financial instruments** – using pollution-emissions trading and greenhouse gas projects as market instruments to tackle pollution.

## 1. Introduction

This paper has been prepared by the Business Environment Council (BEC) as a primer for business-led discussions on Hong Kong's air pollution. BEC is a non-profit organization comprising member companies, which provides a platform for its members to engage and discuss key topics where business can take a leading role in tackling environmental problems. The purpose of this paper is to review the current situation with regard to air pollution<sup>2</sup> in Hong Kong and the Pearl River Delta (PRD).

## 2. Background

### ***Hong Kong is a Victim of its Own Success***

Hong Kong is a victim of its own success. The migration of its industries in the 1980s to the PRD has helped to shape the latter's development into an industrial powerhouse that services the rest of China and, arguably, the rest of the world. However, the economic growth of the PRD - currently estimated by some to be at 8-9% per annum - means that environmental damage, particularly air pollution, will result due to the resources and energy consumed to fuel this growth, together with the expected rise in consumer behaviour throughout the region.

Hence, whilst managing to contain many of its own environmental excesses, Hong Kong suffers from downstream air pollution effects arising from sources in the PRD.

### ***Air Quality Affects All of Us***

The quality of the air we breathe is important if we are to maintain healthy and productive communities. In general, the advancement of economies worldwide has placed severe demands on energy and resource consumption, which in turn has led to the burning of fossil fuels with the resulting air emissions being the prime culprits of air pollution. Other causes are anthropogenic (man-made) activities which release chemicals like volatile organic compounds<sup>3</sup> (VOCs) to the atmosphere.

Cities, like Hong Kong, are struggling to keep a fine balance between modern progress and incurring the penalties of environmental degradation. However, over the past 5-10 years, it has become apparent that Hong Kong's air quality has been declining. As mentioned earlier, the shift of many of Hong Kong manufacturing industries to the PRD means that industrial sources of air pollution are fewer in Hong Kong; however air emissions from vehicles, power plants and chemicals still prevail as Hong Kong's economic growth continues.

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<sup>2</sup> The focus of this paper is on ambient air pollution although it is recognized that indoor air quality is also an important issue in Hong Kong. This matter is dealt with separately in another BEC programme.

<sup>3</sup> VOCs are a family of solvent-based chemicals associated with transportation, industry, applications of paints and other surface coatings and general solvent use



Hong Kong's air pollution problems have not escaped the world press. In December 2004, Time magazine<sup>4</sup> featured a picture of Hong Kong's air visibility problem on its cover highlighting, "Rapid economic development has led to filthy air". But whilst singling out Hong Kong for its air pollution problems, the article was quick to point out that "as much as 80% of the city's air pollution comes from across the border, where the factories and power plants operate with far fewer environmental restraints" confirming that Hong Kong's air problems are much more complex than first supposed.

Figure 1. Time Magazine

Different countries have tried varying ways of tackling air pollution. Some have adopted air quality standards and objectives, each as an attempt to best suit specific economic situations and development needs. The Air Quality Objectives<sup>5</sup> (AQOs) adopted by Hong Kong, for example, have been developed with strong reference to the research carried out in the US and takes into account the statement by the World Health Organisation that "prevailing exposure levels, technical feasibility, source controls measures and social, economic and cultural conditions" must be considered.

### ***What are Hong Kong's Air Quality Problems?***

But what exactly make up Hong Kong's air pollution problems? Situated at the mouth of the Pearl River, Hong Kong experiences the downstream effects of many of the industrial activities in the PRD, and at the same time faces environment-related problems of its own in pursuing economic development. Many in Hong Kong regard this as a resigned fate pointing out that controlling sources of air pollution outside of Hong Kong in the PRD is too difficult to attempt.

It should further be recognised that Hong Kong itself is responsible internally for some of its own problems. Roughly, the total emission of regional pollutants is 40 kg per capita for Hong Kong, compared to 50 kg per capita throughout the whole of the PRD<sup>6</sup>.

In identifying the sources of air pollution in Hong Kong, it has been shown that the majority of pollutants come from the combustion of fossil fuels to produce energy and to meet transport needs i.e. stationary sources (like power plants) and mobile sources (like vehicles, shipping and aircraft) respectively. In addition, we must consider the demand side, i.e., the high level of energy consumed in Hong Kong. Our buildings and infrastructure are largely responsible for this demand, much of which could be avoided through better energy efficiency and conservation practices.

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<sup>4</sup> Time Magazine, "Bad Air Days", 13 December 2004

<sup>5</sup> Under the Air Pollution Control Ordinance (sections 7 and 8), a set of Air Quality Objectives (AQOs) has been established for 7 air pollutants, i.e. sulphur dioxide, nitrogen dioxide, carbon monoxide, photochemical oxidants, lead, total suspended particulates and respirable suspended particulates. The Environmental Protection Department (EPD) is tasked to achieve these objectives and to maintain the quality so achieved. As well as establishing the Air Quality Objectives, the Ordinance also stipulates the anti-pollution requirements for air pollution sources. It further empowers the EPD to impose a licensing control on major stationary emission sources, namely the Specified Processes, and issue legal notices to air pollution sources to demand remedial actions.

<sup>6</sup> Based on 1997 emission data (NO<sub>x</sub>, SO<sub>2</sub>, VOCs and RSP) from the EPD report, "Study of Air Quality in the PRD" (2002)

Lastly, in this modern environment, we rely heavily on chemicals in household and industrial products. Such products, particularly solvent-based ones, are responsible for the emission of VOCs. Other activities such as construction and restaurants are also responsible for the release of particulates in the air, although the scale of these sources is much less now due to legislation being introduced.

Hong Kong's air pollution levels are given below (see Table 1 below).

Air Pollutant	HK Emission Levels (tonnes)	
	1997	2003
NO <sub>x</sub>	110,000	96,600
RSP	11,200	7,380
VOCs	58,800	41,800
SO <sub>2</sub>	64,500	90,900

**Table 1. Hong Kong's Air Emission Levels (Source: Environmental Protection Department)**

### **Types of Air Pollutants**

Ambient air pollution comes in different forms. A list of common air pollutants is provided below:

Pollutant	Caused by:	Major Source in HK (2002)
Sulphur Dioxide (SO <sub>2</sub> )	Combustion of sulphur containing fossil fuels.	Power generation (89%); marine vessels (5%); fuel combustion (industrial/commercial/domestic) (5%);
Total Suspended Particulates (TSP)	Power stations, construction activities and vehicle exhausts	TSP comes from similar sources to RSP (defined below) – no separate breakdowns are available
Respirable Suspended Particulates (RSP or PM10)	Combustion sources, in particular diesel vehicle exhaust and emissions from power plants. RSP can also be formed by atmospheric oxidation of SO <sub>2</sub> and NO. Dust and marine aerosols are also significant sources.	Vehicles (38%); power generation (37%); non-combustion (dust, construction etc.) (15%); marine vessels (6%)
Nitrogen Oxides (NO <sub>x</sub> )	Fuel combustion.	Power generation (45%); vehicles (including diesel, petrol and LPG <sup>7</sup> ) (31%); marine vessels (16%); aircraft (4%); fuel combustion (industrial/commercial/ domestic) (3%)
Carbon Monoxide (CO)	Largely through vehicular emissions although a small amount may also come from incomplete combustion of fuels from factories and power stations	Vehicles (90%)

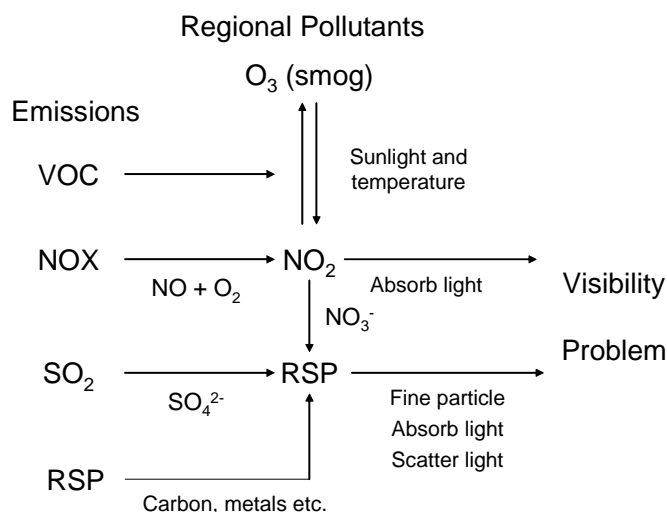
<sup>7</sup> Compared with diesel, vehicles running on LPG emit 1/20, 1/120 and 1/50 the amount of NO<sub>x</sub>, particulates and CO<sub>2</sub> respectively

Pollutant	Caused by:	Major Source in HK (2002)
Photochemical Oxidants (Ozone) (O <sub>3</sub> )	Ozone is not directly emitted from pollution sources. It is formed by chemical reactions of nitrogen oxides (NO <sub>x</sub> ) and volatile organic compounds (VOCS) in the presence of sunlight and warm temperature (see Figure 2 below).	See breakdowns of sources of the two ozone precursors; NO <sub>x</sub> and VOCs
Lead	Leaded petrol (banned in HK since Apr-1999)	Vehicles (100%)
Volatile Organic Compounds (VOCs)	Anthropogenic sources of VOC's include combustion and evaporation processes associated with transportation, industry, applications of paints and other surface coatings and general solvent use.	Non-combustion (consumer products, paints, printing etc.) (80%); vehicles (18%)
Carbon Dioxide (CO <sub>2</sub> )	Predominant contributor to greenhouse gases. Produced through combustion of fossil fuels (wood, natural gas, coal & oil)	Power generation (62%); vehicles (18%); waste (12%)

**Table 2. Common Air Pollutants in HK and their Characteristics**  
(Source: Environmental Protection Department )

### The Problem of Smog

Much has been reported recently on the visible impacts of Hong Kong's air pollution<sup>8</sup>. The occurrence of smog tends to overshadow many of the issues related to other aspects of air pollution due to its visibility and pervasiveness. Smog is formed when air pollutants generated by vehicular emissions (as well as industrial and commercial operations) react photochemically in the presence of sunlight and is at its worse when there are weak northerly winds in the PRD area or when the region is under the influence of subsiding air at the periphery of a typhoon.



**Figure 2. Formation of Smog** (Source: Environmental Protection Department)

<sup>8</sup> South China Morning Post, "Fog has city in a funk" (29 March 2005)

Hong Kong's smog problem has raised concern in many circles, including the political arena<sup>9</sup>.

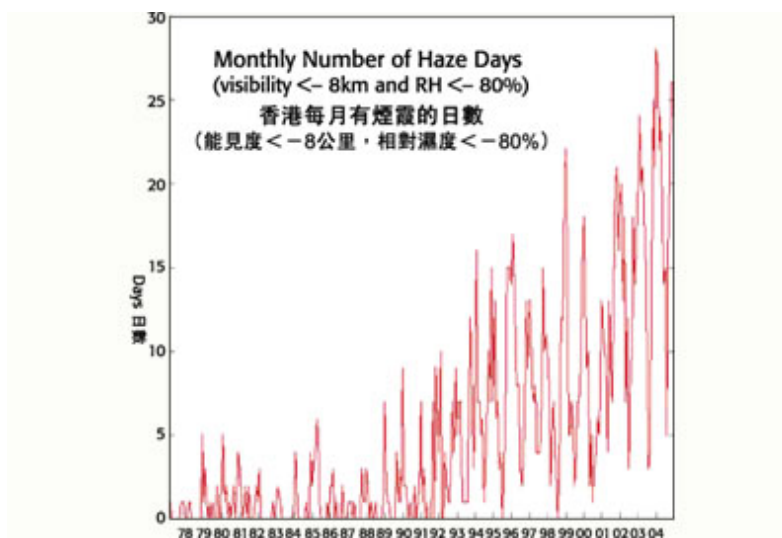


Figure 3. Number of Hazy Days  
(Source: Centre for Coastal and Atmospheric Research, HKUST)

As reported recently<sup>10</sup>, the declining visibility (below 8 kilometres) is reflected in the percentage days per year and this has reached a high of 16% in 2004 (see Figure 3), i.e. almost 60 days last year saw Hong Kong shrouded in fog affecting the aesthetic value of many of city's landmarks with possible economic impact.

## Sources

### Power plants

Air emissions from stationary sources<sup>11</sup> in Hong Kong come principally from the power plants owned by the two power companies, China Light and Power (CLP) and Hong Kong Electric Company (HEC)<sup>12</sup>. In 2003, these power plants contribute over 90% of the local levels of SO<sub>2</sub>, 60% of the local levels of NO<sub>x</sub> and 45% of local RSP emissions. VOCs are also produced by power plants in Hong Kong although emission levels are less than 1%.

### Vehicles

Hong Kong has 530,000 licensed vehicles on its roads making the road traffic density one of the highest in the world, i.e. roughly 275 vehicles per kilometre of road. About one-fourth of these vehicles use diesel fuel which is responsible for 98% and 75% of the RSP and NO<sub>x</sub> emissions respectively from vehicular sources. Owing to the high density of buildings, air pollutants cannot be dispersed effectively on the streets leading to an accumulation of RSP and NO<sub>x</sub> pollution at the roadside.

<sup>9</sup> LegCo Motion Debate on "Vigorously Reducing Air Pollution" held on 15<sup>th</sup> December 2004

<sup>10</sup> SCMP, "Seeking a solution through the haze" (26 October 2004)

<sup>11</sup> The Chemical Waste Incinerator and the landfill gas flares are not included in this report

<sup>12</sup> CLP operates Black Point Power Station (1,875MW), Castle Peak Power Station (4,108MW) and Penny's Bay Power Station (300MW); HEC operates Lamma Power Station (3,420 MW).

## Chemicals

Chemicals like VOCs are a major precursor to the formation of photochemical smog. Whilst Hong Kong is the recipient of upstream generation of VOC pollutants from activities in the PRD, it still has its own sources of VOCs namely vehicles, paint, printing inks and consumer products. Many of these sources are imported directly from overseas in the form of products and goods, hence Hong Kong faces trade implications as well in controlling the VOC component of air pollution<sup>13</sup>.

### *The Situation in the PRD*

Recognising that Hong Kong's air pollution problems are not in isolation from the rest of the PRD, the Hong Kong Government conducted a Joint Study<sup>14</sup> with its Guangdong counterparts to identify the relative significance of different industrial and commercial sources of pollution and their direct and indirect impacts on regional air quality so that pollution control measures could be prioritised accordingly. This was done by compiling an emission inventory on polluting activities in PRD, collecting representative air samples and evaluating the regional distribution of air pollutants through computer simulation, and taking meteorological conditions and topography into consideration.

According to the Joint Study, contributions to the regional base year (1997) air pollutants comprised the following:

<b>Emission</b>	<b>VOCs</b>	<b>RSP</b>	<b>NO<sub>x</sub></b>	<b>SO<sub>2</sub></b>
Approximate tonnes (1997)	470,000	270,000	560,000	570,000
<b>Breakdown:</b>				
Energy	1%	15%	42%	54%
Industry	11%	60%	13%	39%
Motor vehicles	55%	14%	31%	4%
VOC containing products	23%	0%	0%	0%
<b>Total</b>	<b>90%</b>	<b>89%</b>	<b>86%</b>	<b>97%</b>

**Table 3. Contributions of the Major Sectors to Regional Air Pollution  
(Source: Environmental Protection Department)**

As can be seen in Table 3, the four identified industry or business sectors - classed under energy, industry, motor vehicles and VOC containing products - make up more or less 90% of the total air pollution load in the region. Each sector contributes differently in separate air pollutant areas: vehicles and industry make up the majority of VOCs and RSPs respectively, whilst the bulk of NO<sub>x</sub> and SO<sub>2</sub> come from power plants.

To give an idea of the order of scale, there are currently about 45 power plants in Guangdong Province, with a total rated capacity of 11,290 MW. The largest of these is the Shajiao Power Plant in Dongguan of 4,000 MW capacity, which is reported to have emitted 90,000 tonnes of SO<sub>2</sub> in 2003.

<sup>13</sup> The HK Government launched a consultation exercise in the last quarter of 2004 on a labelling scheme to control VOC emissions from paints, printing and selected consumer products.

<sup>14</sup> Environmental Protection Department, "Study of Air Quality in the PRD" (2002)

The problem is compounded by factors like economy, population, electricity demand and vehicle mileage in the PRD region which are predicted to grow by 150%, 20%, 130% and 180% respectively from 1997 levels to projected 2010 levels. Whilst these figures may be questioned as to the level of their accuracy, given the continuous economic growth of the PRD, it is likely that air pollution in the region will increase rather than decrease even as the Hong Kong and Guangdong governments continue to implement their existing improvement measures.

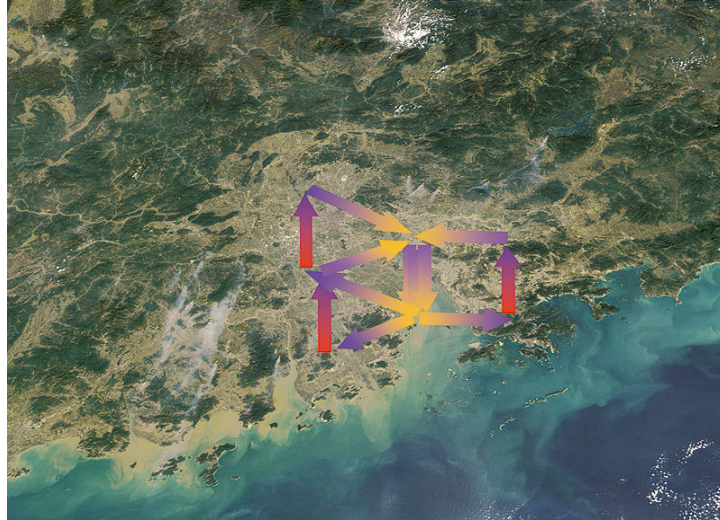
Equally, attention must be given to the need for power infrastructure in the PRD such as grid facilities and reliable power distribution. It is reported that industrial companies are forced to set up their own generation plants (e.g. diesel generators) to meet their immediate needs due to the unreliability of the existing electricity supply. The level of usage of these generators is hard to determine but discussions with many factory owners in the PRD (including those under Hong Kong ownership) indicate that use of these generators is common to avoid losses in productivity.

### ***Urban Land Sea Breeze Circulation***

Geographically, the PRD is sheltered from the rest of the Mainland by hilly and mountainous ranges and hence the pollution in the region is localised. Because of this factor, Hong Kong's air quality problems do not dissipate easily.

The phenomenon of "urban land-sea breeze circulation" also has a profound effect on the PRD, which in turn affects Hong Kong. Studies by the Centre for Coastal and Atmospheric Research at the HK University of Science and Technology have shown that the air pollution affecting Hong Kong remains confined to the region and is characterised by what is termed an "urban land-sea breeze circulation." In the afternoons, temperatures in urban areas tend to rise a few degrees higher than surrounding areas, due to energy use by various industrial and socio-economic activities in cities giving rise to an "urban heat island effect." As Hong Kong is mostly surrounded by water, the temperature of which only varies slightly, the temperature differences between urban areas and the surrounding water can be significant.

During the day, as warm air rises over the urban areas, it leaves an area of low pressure that sucks in air from the surrounding areas into urban areas during the day. The air typically will rise to a height of about 1-2 kilometres, and then spread out horizontally before falling as it drifts out to the cooler ocean area. This effect leads to the formation of closed vertical circulations around city centres, which is the so-called "urban land-sea breeze circulation".



**Figure 4. Urban Land-Sea Breeze Circulation**

Urban land-sea breeze circulation plays a significant role determining air quality. Air rising over urban centres can carry away air pollutants emitted in the city, but these pollutants are re-circulated as they get sucked back in through the circulation cycle. The trapped pollutants can only be cleared when background winds are stronger than the land-sea breeze circulation to blow pollutants beyond its radius.

In the PRD, the industrialisation of the region has led to the formation of widespread urbanised zones around the mouth of the Pearl River so instead of having just urban land-sea breeze circulations around the isolated urban centers like Hong Kong and Guangzhou, the circulations now are more widespread around the PRD.

With respect to air quality, this is bad news for the region as the complex urban land-sea breeze circulation can mix pollutants from different emission sources around the PRD (particularly over the cooler mouth of the Pearl River), and bring them into different city areas (like Hong Kong) in the afternoon through the return branch. More significantly, it implies that an air pollution trap is formed and stronger background winds will be required to disperse the pollutants. As wind currents do not change much from year to year, the level of air pollution is expected to increase as further urban and industrial development around the PRD continues.

### ***Impacts and Costs***

Quantifying the impacts of air pollution is difficult in most cases. What is universally recognised, though, is that cities experiencing poor air quality tend to be regarded less favourably in terms of health, quality of life and overall prosperity.

The health effects of air pollutants are well-reported:

<b>Pollutant</b>	<b>Health Effects</b>
SO <sub>2</sub>	Impairment of respiratory function and aggravation of existing respiratory disease causing sever respiratory distress and cardiac illnesses.
RSP	Chronic and acute effects on pulmonary function (deep penetration into the lungs) causing respiratory problems. Effects are enhanced if high RSPs are associated with higher levels of other pollutants such as SO <sub>2</sub> . Smaller particulates in RSP also impact visibility.
Fine Particulate Matter	In general, the smaller the particulate matter the deeper it can penetrate into the respiratory system and the more damage caused. Particulates smaller than 2.5 microns (also known as PM2.5) can damage lung tissue, aggravate existing respiratory and cardiovascular diseases and cause cancer.
NO <sub>x</sub>	Lowers a person's resistance to respiratory infections and aggravates existing chronic respiratory diseases.
VOCs	VOCs are precursor pollutants contributing to the formation of ground-level ozone (smog) and particulate matter.
Ozone	At low concentrations: causes irritation to the eye, nose and throat. At high concentrations: increases susceptibility to respiratory infections and aggravate pre-existing respiratory illnesses such as asthma.

**Table 4. Health Effects of Specific Air Pollutants (Source: EPD)**

Putting a cost to air pollution is more difficult. One common method is to calculate the cost of illness (direct cost of health service utilization and productivity losses) related to the effects of air pollution and thereby estimate the full economic value using 'willingness to pay' value estimates for the avoidance of mortality and morbidity. Health costs are therefore taken as the first component of air pollution impact. Lesser adopted methods include taking opportunity costs in the form of losses of income or asset value as a result of air pollution. Examples of such industry sectors affected would be tourism, foreign investment and property.

Recent studies<sup>15</sup> have shown that, for four criteria pollutants, NO<sub>x</sub>, SO<sub>2</sub>, RSP and ozone, an increase of 10 µg/m<sup>3</sup> concentration of pollutants is associated with a 0.2% to 3.9% increase across in respiratory, chronic pulmonary and cardiovascular heart diseases. Based on the results for respiratory and cardiovascular diseases in this analysis, the following cost estimates were obtained:

- Combining the results from an earlier study<sup>16</sup> on the effects of air pollution on general practitioner visits, the direct costs of illness in the year 2000 were estimated to be \$227.3 million for a 10 µg/m<sup>3</sup> change in pollutant concentration in total air pollution and \$289.7 million with productivity losses included.

<sup>15</sup> Environmental Protection Department, "Study of short term health impact and costs due to road traffic-related air pollution" (2004)

<sup>16</sup> Chinese University studies by Dr. Wong Tze-wai (date unknown)

- Using ‘willingness to pay’ estimates for the monetary value of morbidity and mortality and including the cost of public hospital care, direct costs in the year 2000 were estimated to be \$2.8 billion for a change of 10  $\mu\text{g}/\text{m}^3$  concentration in the total air pollution.
- Using mean concentrations in the year 2000, an overall estimate of the monetary value of the effects of air pollution on cardio-respiratory diseases in Hong Kong was \$11.1 billion for total air pollution and the direct cost of illness was \$1.3 billion.

Put in another way, there is a direct burden placed on society either through private resources or from the tax payers that appears to result from the effects of air pollution. Medical professionals in Hong Kong concur with this notion<sup>17</sup>, highlighting the further risks to asthma sufferers and people prone to heart and respiratory problems during periods of when high API values are recorded.



**Figure 5. Healthcare costs**

The Civic Exchange<sup>18</sup>, an NGO think tank, has extended the argument to cover other economic losses in the form of:

- Losses in tourist and associated revenue as a result of reduced or shortened trips and the diversion of tourists to destinations perceived to be cleaner;
- Reduced property values as demand for housing in more polluted areas slackens; and
- Knock-on effects from these that will affect the local economy.

Whilst these points are pertinent and research elsewhere (notably in the US) has linked the loss of economic value with declining air quality<sup>19</sup>, research in Hong Kong is lacking to show whether there is any direct correlation between air pollution and economic performance. Discussions that the author has conducted with InvestHK, the HK Tourism Board and property developers at this point in time have not disclosed any links, empirical or otherwise, between economic losses and air pollution although some past tourism surveys have provided interesting results<sup>20</sup>.

Recent incidences of marine collisions in Victoria Harbour<sup>21</sup> and the cancellation of flights due to fog in Shenzhen<sup>22</sup> may lend some economic weight to the negative impacts of smog but these are still conjectural.

<sup>17</sup> SCMP, “Shocked doctors warn of health risk” (15 September 2004)

<sup>18</sup> Civic Exchange “Air Quality Management in the HK and PRD Region” (November 2004), “Economic Impacts of Impaired Visibility” (November 2004)

<sup>19</sup>U.S. Environmental Protection Agency, “Regulatory Impact Analysis for the Final Clean Air Interstate Rule” (EPA-452/R-05-002 March 2005)

<sup>20</sup> Thomas Bauer and Andrew Chan, “Does the environment matter? Experiences, attitudes and revisit intentions of international visitors to Hong Kong”, *Pacific Tourism Review*, Vol. 5, pp. 75-82 (2001)

<sup>21</sup> SCMP, “Fog blamed for three collisions in HK waters”, (29 March 2005)

<sup>22</sup> SCMP, “Life in Shenzhen marred by food, smog and traffic” (7 April 2005)

### 3. Measures to Reduce Air Pollution

As stated in earlier sections of this paper, the long-term prognosis for addressing air pollution in the PRD would appear to be gloomy due to the growth in industry and its likely continuation, as well as taking the geographical conditions in the PRD into account. However, it is clear that for Hong Kong to maintain investor confidence and regional competitiveness, air pollution must be one of the key issues to be addressed.

#### *Hong Kong Government Focus*

The Hong Kong Government has made a number of resolutions in air emission reduction through:

- Tightening of motor petrol standards to Euro IV with effect from 1 January 2005;
- Mandatory installation of vapour recovery systems for vehicle refuelling at petrol filling stations from 31 March 2005;
- Applying Euro IV emission standards to newly registered vehicles by 2006;
- Negotiations with the power companies to further reduce emissions and increase the use of natural gas in electricity generation; and
- A proposed scheme to control VOC emissions from paints, printing and selected consumer products.



Figure 6. Measures in HK to Reduce Air Pollution - Transport, Power and VOCs

## Guangdong Government Focus

The Guangdong Environmental Protection Bureau in its 2002 report<sup>23</sup> stated that its implementation of the “Guangdong Blue Sky Project”, urban ambient air quality “has been maintain[ed] to national standard Grade II, dust pollution has been reduced and provincial acid rain frequency has been decreased slightly”.

Focusing on power plants, vehicles and the most polluting industrial processes, the objectives stated by the Guangdong provincial government include the following:

- To promote clean energy production and supply systems, construct gas-fired power plants and provide for the transmission of electricity from the western provinces;
- To restrict the use of high sulphur fuels, close down small power generation units and retrofit such units with flue gas desulphurisation (FGD) systems to reduce emissions from power generation;
- To phase out coal-fired boilers, industrial boilers and industrial technologies and equipment with inefficient energy consumption and causing serious pollution;
- To reduce VOC emissions from paints; and
- To build metro expressway systems, develop green transport and reduce vehicle emissions to control pollution caused by the exhaust of motor vehicles.

In addition, the Guangdong authorities have recently indicated their intention to reduce emission of SO<sub>2</sub> by 225,000 tonnes each year working with the power generation sector in the PRD by applying the following measures:

Initiative	By when
FGD systems:	2005
<ul style="list-style-type: none"> <li>• Shenzhen Xibu Power Plant (Units 5 and 6)</li> <li>• Dongguan Shajiao Power Plant A (Unit 5) Taishan Power Plant (Units 1 and 2)</li> </ul>	
FGD retrofitting:	2006
<ul style="list-style-type: none"> <li>• Shenzhen Mawan Power Plant</li> <li>• Three power plants in Shajiao , Dongguan</li> <li>• Guangzhou Huangpu Power Plant</li> <li>• Zhujiang Power Plant</li> <li>• Zhuhai Power Plant</li> </ul>	
FGD retrofitting all power generation units of a capacity above 125MW	2007
Construction of four Liquefied Natural Gas (LNG) power plants	2006

**Table 5. Guangdong Province Initiatives in Curbing Power Plant Emissions (Source: EPD)**

Further statements indicate that the Guangdong authorities have made headway in addressing vehicular emissions by introducing low sulphur containing diesel (0.05%) and setting tighter emission standards equivalent to Euro II for new vehicles with effect from July 2005. As part of Guangdong’s transport development plans, it is intended that the

<sup>23</sup> 2002 Report on the State of Guangdong Provincial Environment

construction of metropolitan and inter-city rail lines will further reduce the need for vehicles on the road.

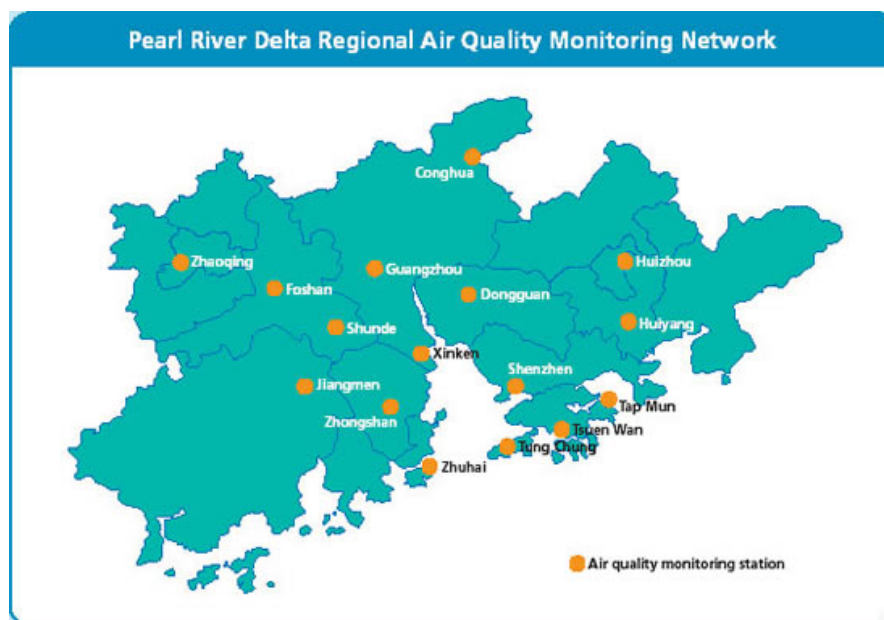
One of the major challenges for the Guangdong Government lies in the gathering and reporting of air monitoring data. Current initiatives are underway but obtaining accurate air monitoring data requires investment in equipment and resources, which the Guangdong Government must find.

### ***Cross-Boundary Initiatives***

The most significant cross-boundary initiative on improving regional air quality was the agreement in 2002 between the governments of Hong Kong and Guangdong Province on reductions in smog-related air pollution. Taking 1997 as the base year, RSPs and VOCs are each to be cut by 55%, SO<sub>2</sub> by 40% and NO<sub>x</sub> by 20% by 2010.

Under the Joint Working Group on Sustainable Development and Environmental Protection, which has representatives from both Governments, the following steps have been taken:

- An air quality management plan for the PRD region has been prepared and endorsed;
- A joint handbook is in the process of being drafted defining how air pollution is to be calculated to determine if improvements are being made;
- A draft joint inventory of emissions has been completed; and
- 16 air quality monitoring stations around the region have been set up (see Figure 7 below).



**Figure 7. Regional Air Monitoring Stations**

The two Governments are exploring ways to set up an emissions trading pilot scheme in 2006 covering power plants in Hong Kong and Guangdong. The scheme has already obtained the endorsement of the Central People's Government and the State Environmental Protection Administration.

In this scheme, it is proposed that the 45 or so power plants in the PRD together with the power plants owned by CLP and HEC can use the 2010 goals as the targets and any plants that achieve emission levels below the targets can register the saved pollutant loads as credits that can be sold to other power plants that have exceeded their target levels. A possible scenario would be for Hong Kong companies (not just the two power companies) to invest in projects to upgrade Guangdong power plants and in doing so accrue credits that can be traded on a national or international market. The mechanisms for this have yet to be worked out but there has been interest expressed by other companies, such as the financial institutions and law firms, in developing this concept.

Emissions trading has been tried elsewhere in the world (notably the US) and has had varying success as a market tool to involve the private sector in air pollution control. In the author's discussions with Government and power company representatives, it was made clear that the success of such a scheme would depend on:

- A transparent mechanism so that all can see what is being traded;
- Fair pricing of the credits; and
- Accurate measurement of the pollutant loads (some doubt was cast on how NO<sub>x</sub> and RSPs could be measured).

Clearly from the above, it is not just the two governments who need to be involved to achieve air quality improvement; other stakeholder parties like the power companies, transport companies, industrialists and communities must cooperate closely to share knowledge and resources and work towards common goals.

### ***What is Business Doing About This?***

From a business perspective, many Hong Kong companies are aligned in their interest to reduce air pollution as follows.

#### **Power Companies**

CLP issued its "Manifesto on Air Quality and Climate Change" in December 2004 committing the company to specific actions to improve air emissions generated by its activities through bringing liquefied natural gas (LNG) to Hong Kong, reducing emissions from coal-fired generation by installing FGD at the Castle Peak Power Station and developing renewable energy. HEC has similar initiatives in hand, and will shortly publish its own environmental report outlining the company's goals towards reducing air pollution.

Both power companies have acknowledged the possibility of running emissions trading programmes with Mainland power stations but both have equally expressed caution at this stage preferring to wait until the scheme is further developed before committing to participate. Both also have openly stated their support for renewable energy and demand side management, although recognizing the constraints of cost and space in Hong Kong.

The power industry therefore faces several issues: the future composition of fuel mixes to include a higher proportion of cleaner fuels, incentives for further demand-side management, and the means by which the commitment of both power companies can be obtained to adopt renewable energy options and to support the cross-boundary emissions trading programmes with Mainland power stations.

## Vehicles

The Liquefied Petroleum Gas (LPG) taxi incentive scheme was completed in late 2003 and, currently, almost all taxis in Hong Kong run on LPG. A similar scheme for public light buses is under implementation. The introduction of Euro IV diesel and the requirement for all newly registered vehicles to comply with Euro III emission standards in 2003, combined with increased penalties for smoky vehicles, has led to a marked improvement in roadside air quality with RSP and NO<sub>x</sub> roadside levels dropping by 9% and 24% respectively.

Future issues to be addressed include extending the use of cleaner fuels (e.g. LPG or biodiesel<sup>24</sup>) into private vehicles, introducing hybrid vehicles<sup>25</sup>, more vehicle-related environmental initiatives (such as turning off idling engines and encouraging walking), how to prevent Hong Kong drivers “tankering” and bringing in lower-grade fuel from the PRD, and stopping the use of low-grade bunker fuel in shipping and port activities.

The growth of cross-boundary traffic, as new infrastructure such as the Shenzhen Western Corridor and the proposed HK-Macau-Zhuhai bridge are developed, will create further air pollution issues for Hong Kong as less tightly regulated vehicles from the Mainland are expected to use Hong Kong roads once these projects have been completed.

## Industry

There are a number of initiatives being undertaken. The various Chambers of Commerce have come up with position statements representing their members’ concerns on the need to tackle air pollution and the translation of these statements into action. The Business Coalition for the Environment has proposed a charter for companies to sign to declare their intent to reduce air pollution within their respective industries.

Taking into account that there are about 70,000 factories in the PRD owned by Hong Kong companies, the Hong Kong Federation of Industries has come up with the “1-1-1” programme to encourage factories to individually come up with one environmental initiative every year, i.e. “one factory, one initiative, one year”. Whilst the initiatives cover other areas (like noise, water and waste), air emissions and energy conservation figure prominently and will be most applicable in reducing air pollution levels that have an immediate impact on Hong Kong.

Civic Exchange, a Hong Kong NGO, has made air pollution a focal point and is looking at energy supply and demand side issues pertaining to manufacturers in the PRD to promote a fuel-switching campaign targeted at industrial on-site generation units, on the basis that there is much gain to be achieved through using higher quality fuel which may only cost marginally more.

## General

There is a wide need to educate more companies, especially small and medium enterprises (SMEs), on the relationship between wasteful energy habits and the

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<sup>24</sup> Biodiesel is a synthetic diesel fuel that is produced from fatty feedstocks such as soybean oil and recycled cooking oil. Although more expensive than conventional diesel, it has some important advantages. The most notable advantage is that because biodiesel is very similar to conventional diesel, the fuel can be used in existing diesel engines.

<sup>25</sup> Hybrid vehicles combine petrol driven engines with electric power. The latter is partly generated from harnessing torque forces during braking as well as conventional charging.

unnecessary generation of air emissions from fossil fuel combustion. Some Hong Kong companies have also identified possible commercial opportunities from energy efficiency projects, notably those with property portfolios, and are looking at the wider issue of carbon emissions, climate change and trading in carbon emission and pollution credits.

## **4. Conclusions**

This paper has been prepared by the BEC as a primer for business-led discussions on Hong Kong's air pollution. In conclusion, the following points are noted:

- Hong Kong is learning to deal with the problems of air pollution. Prevalent amongst the challenges faced is the smog issue. The overall impact of air pollution is difficult to quantify but healthcare costs (based on 2000 data) are estimated to be \$1.3 billion. The impacts arising from smog in terms of losses in tourism, property and foreign investment are less easy to quantify.
- The air pollution situation in Hong Kong has deteriorated over the last 5 years and will worsen as industrial activities in the PRD region continue to grow, together with greater ownership of vehicles.
- In recognition of this problem, governments from Hong Kong and the PRD have agreed to reductions in the main pollutants by 2010. Whilst Hong Kong has made significant progress in this area, precise data from the Guangdong Government has yet to be produced to see if the planned measures within the province have resulted in similar improvements.
- On an encouraging footing, the Hong Kong Government has introduced a series of measures designed to combat the rising levels of pollution from vehicles and power plants. Industry has also responded positively and measures to do more not just within Hong Kong but expanding the sphere of influence into PRD activities have been initiated

### ***Next Steps***

The next steps will be to harness business interests in identifying and taking possible actions to address this problem. BEC will continue to gather and disseminate published information on Hong Kong's air pollution issues as well as any ongoing and planned initiatives in order to raise awareness amongst its members. In addition, BEC will provide support to members and other groups wishing to or already involved in programmes to reduce current air pollution levels. BEC is also looking at launching key topic programmes to engage business, Government and NGOs in order to form appropriate and effective partnerships that will address current and future issues in this area.

### ***Key Topics***

The following key topics have been selected for their relevance to BEC members as well as to the wider community:

- Sharing best practices for air pollution abatement
- Use of clean energy
- Application of financial instruments

## **Best Practices**

The range of activities under this topic heading is vast, hence it is intended to only look at selected activities being carried out by specific industry groups in HK e.g. the power companies, oil and gas companies, transport companies, manufacturing companies and property companies. This topic will focus on case studies on energy efficiency, demand-side management, transport practices (including better motorist habits and promoting pedestrianisation), energy conservation and clean processes (like alternative solvents and vapour-treatment technologies)

## **Clean Energy**

This topic will look at the areas of cleaner fuels, renewable energy and environmental technologies. Key to this topic discussion will be the incentives in or about to be put in place in Hong Kong for businesses to consider switching to clean energy methods. It is worth noting that this topic was considered as part of the recent study carried out by the Council for Sustainable Development<sup>26</sup>. Areas that will be covered include clean fuels for transport (e.g. biodiesel, hybrid vehicles, LPG) and power generation (LNG and renewable energy) as well as how to stop the use of polluting fuels (e.g. bunker fuel and low-grade diesel)

## **Financial Instruments**

This topic will look at the current trends in the use of financial instruments through pollution-emissions trading and greenhouse gas projects as market instruments to tackle pollution and encouraging companies to minimise air pollution. As well covering PRD cross-boundary exchange schemes of pollutant loads (which the respective governments are discussing), the role of carbon trading will be considered, on the basis that a reduction in fossil fuel combustion will be a reduction in pollution load. The topic will also look at the greenhouse gas protocol<sup>27</sup> issued by the World Business Sustainable Development Council, as well as the use of Clean Development Mechanisms<sup>28</sup> to promote the concept of carbon emissions trading from a HK and regional perspective.

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<sup>26</sup> The Council for Sustainable Development engaged the community of Hong Kong in a discussion about Hong Kong's sustainability between July and December 2004. In order to move towards Sustainable Development, the Council sought the views of stakeholders about how best to advance Hong Kong's economic and social development while protecting the natural environment. Three pilot areas were chosen, one of which was renewable energy.

<sup>27</sup> The Greenhouse Gas Protocol Initiative is a multi-stakeholder partnership of businesses, non-governmental organizations (NGOs), governments, and others convened by the World Resources Institute (WRI), a U.S.-based environmental NGO, and the World Business Council for Sustainable Development (WBCSD), a Geneva-based coalition of 170 international companies.

<sup>28</sup> According to the UN Climate Change Convention, the Clean Development Mechanism works by "industrialized countries pay[ing] for projects that cut or avoid emissions in poorer nations -- and are awarded credits that can be applied to meeting their own emissions targets. The recipient countries benefit from free infusions of advanced technology that allow their factories or electrical generating plants to operate more efficiently -- and hence at lower costs and higher profits. And the atmosphere benefits because future emissions are lower than they would have been otherwise."

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