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Clearing The Air – Still A Long Way To Go

A Comprehensive Review

Of Air Pollution Problems and Solutions

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Foreword

Hong Kong's air pollution has reached a point where immediate measures need to be taken to arrest the decline and protect public health. There is no shortage of measures that can be taken to address pollution from vehicles, the main source of roadside pollution, and the Government has proposed a number of initiatives. However, many of the measures appear ad-hoc and data is lacking on how the various initiatives will translate into actual air quality improvements. Air quality modelling is needed to evaluate whether the initiatives are sufficient to enable Air Quality Objectives to be met in future, and whether further measures are needed. Further, an overall air quality strategy should be devised which places the initiatives in context of overall efficacy and allows the public to see where the most cost-effective solutions lie. Since many solutions require significant lead-time, in terms of legal or infrastructure requirements, the earlier potential technologies can be identified and tested the better.

Many institutional problems need to be overcome if air pollution is to be effectively tackled. Many different departments and bureaux have a role to play in controlling air pollution but only EPD is responsible for air quality. The fact that Hong Kong's air quality objectives are not mandatory means that the EPD has no legal mandate to force change in areas over which they have no jurisdiction such as transport policy or power generation. A comprehensive legal framework is needed to drive continuous improvements in air quality, and overcome the conflict in priorities between different departments and bureaux.

The institutional problems within the Hong Kong Administration pale into insignificance compared to the uncharted territory of cross-border relations. Significant cultural differences between the two administrations, rivalry within the province, and a large imbalance in financial resources, compound the problems. This is not going to be solved by technical means alone, and significant political will is needed, as well as new kinds of communication tools.

Solving air pollution cannot be achieved by technical means alone. It is essentially a political problem involving many different players. The old ways of working simply do not work. The Government needs to become more open and invite experts both within and outside Hong Kong to assist. Many stakeholders are involved, including public transport providers, oil companies, vehicle manufacturers, business groups, academics, health experts and the public. These should be engaged to help formulate and review policies. The Government continues to insist that environmental protection is everyone's responsibility, yet fails to provide the public with means to register support for issues. Members of the public who have suffered from the impacts of air pollution for too long should be given full information on what solutions exist and their associated costs and benefits.

Report Summary

Basic Issues

Air pollution is a political problem which cannot be solved by technical means alone. A comprehensive legal framework is needed to drive continuous improvements in air quality and overcome institutional conflicts. A comprehensive Clean Air Ordinance is required to make Air Quality Objectives mandatory. The Government needs to involve all stakeholders, including the public, whose health is affected by polluted air, in developing successful reduction strategies.

While vehicles are the main source of street level pollution, power stations, marine vessels, fuel combustion, aircraft and even unpaved roads contribute to air pollution. Emissions from vehicles in non-urban areas exceeds that in urban areas.

Air pollution from the mainland could contribute up to 30% of ambient pollution although no accurate quantitative data is available. Certainly RSP concentrations rise when the winds have a northerly component. However, most of the RSP and NO2 pollution at roadside level is likely to be generated in Hong Kong.

Hong Kong's air quality has deteriorated in recent years in terms of emissions of NOx, RSP and ozone. Roadside concentrations of RSP and NO2 regularly exceed health standards with over 59 exceedances of short term AQOs in 1999 alone. Ambient levels of ozone, a regional problem, are also of concern, with levels increasing yearly. Levels of other pollutants, such as carcinogenic PAHs are high compared to other parts of the world. The health impacts associated with RSP include increased mortality and morbidity effects. Diesel exhaust has been shown to be a cancer risk. While there has been much focus on RSP, NOx, ozone, sulphur dioxide also impact health. Local medical experts have urged the Government to reduce all pollutant levels by 10% per year.

Situation in Hong Kong and Suggested Initiatives

Government has proposed a number of initiatives in recent months. While the Government expects Hong Kong should be able to meet its current AQOs by 2005, this claim is suspect when this assumes levels of cross-border pollution will remain constant and does not take into account future traffic growth. Air quality will fail health standards in 2016 for all projected traffic growth scenarios. Air quality in the North-West New Territories will deteriorate significantly due to growth in cross-border traffic and new highway infrastructure. Significant changes in air quality management are needed including 1) computer modelling to determine the effectiveness of emission control measures, 2) legal changes to ensure that Hong Kong complies with AQOs, 3) controlling and planning for future traffic growth and 4) controlling cross border pollution.

Ineffectiveness of Government Measures

Responsibility for smoky vehicles is fragmented and there are institutional problems between departments. Transport Department's plans to test for emissions as part of an annual road-worthiness test are inadequate, with insufficient equipment to test smoke emissions properly, and failure to address RSP and NOx.

A switch from diesel to LPG is proposed for taxis, and possibly for minibuses, requiring purchase of a new fleet of dedicated vehicles. Converting vehicles from diesel or petrol to LPG is not permitted even though it is a mature technology and could reduce costs. Low sulphur diesel will

be introduced but the preferential duty will increase the incentive to use illegal diesel which is readily available throughout Hong Kong. Trials of other cleaner fuels, such as natural gas, are being considered, but are not comprehensive and there is no timetable for adoption. The large number of technologies on the market which can help reduce emissions are not being evaluated systematically for performance.

There is a large problem with older vehicles which emit a disproportionate amount of the pollution. Over 70% of goods vehicles and buses were manufactured before the introduction of emission standards. These emit 10 times the RSP and 1.6 times the NOx of vehicles complying with current standards. There is currently no mechanism to encourage or require the early retirement of such vehicles.

High sulphur and illegal diesel is widely available, as 'marked oil' (meant only for industrial use), 'de-treated oil' (marked oil with the colour removed); or diesel illegally imported into Hong Kong. Due to significant financial incentives the practice is widespread and illegal filling stations have been found operating routinely in government carparks. Public transport vehicles have also been found using illegal fuel. Amendments to the law currently passing through LegCo will still leave some loopholes open. In addition, the Government estimates nearly half of the diesel consumed by vehicles in Hong Kong is high sulphur fuel from the mainland brought in legally by cross border vehicles. There is no limit on the amount of fuel which can be carried in.

Transport Policy and Air Pollution

There is a large disconnect between the stated policy, to provide transport services and infrastructure in an environmentally friendly manner and the actual practice. By 2016 RSP levels will be 200% of present levels even with LPG taxis, simply due to the increased traffic. Despite a stated policy of giving priority to rail, the budget allocated for highway construction is 5 times higher.

Fiscal measures to reduce traffic growth or integrate environmental and transport policy have not been properly explored. In congested urban areas such as Causeway Bay and MongKok where air circulation is poor, air pollution is particularly severe. The Government resists adopting vehicle restraint measures such as road pricing.

Non-Vehicular Pollution Sources

Coal-fired power stations are the single largest source of pollution in Hong Kong. Our regulatory structure is outdated and rewards utilities for producing more power rather than saving it. Hong Kong has barely begun to reap the economic and environmental benefits of increased energy efficiency. Hong Kong also lacks a dedicated, expert energy authority to properly regulate the energy market and promote energy efficiency and conservation.

Marine vessels are the third major contributor to air pollution after power stations and vehicles. Marine Department's regulation of smoke from marine vessels is perfunctory, and relies on public complaints rather than proactive measures. Emissions from aircraft could also be a growing source of air pollution in future due to the projected growth in passenger air travel

Summary of Recommendations

Main Recommendations

Mandatory Air Quality Standards
Enact a comprehensive Clean Air Ordinance which provides for mandatory ambient air quality standards for Hong Kong. Such standards could assist the Government in combating political resistance to its policies and emission control measures in Hong Kong.

Air Quality Modelling
The Government should undertake scenario modelling of the current air pollution reduction initiatives to gauge efficacy and impacts on future air quality.

Controls on older vehicles
- Ban pre-Euro vehicles from entering urban areas at all times.
- Phase out all pre-Euro and Euro I vehicles within 3 years unless they can meet Euro II standards through retrofitting.

Emission Testing
- Make annual emission control inspections at government approved centres a prerequisite to vehicle licensing for all vehicles (including petrol and LPG).
- Transport Department to install sufficient dynamometers for all commercial diesel vehicles.
- Emission tests for all vehicles should include tests for NOx and RSP.

Illegal Diesel
- Enact legislation to limit the amount of fuel carried by cross-border vehicles
- Tax cross-border crossings
- Amend the law to enable forfeiture of licences of public transport vehicles caught twice using illicit fuels
- Step-up investigation, including getting co-operation of the oil companies
- Ban the use of high sulphur diesel for industrial purposes.

Transport Policy
The Government needs to properly integrate environmental concerns into transport policy and seriously address the growth in traffic by a combination of measures including vehicle restraint, improving the efficiency and convenience of public transport (not taxis), shifting passengers to mass transit modes such as rail, and land use planning that reduces the need to take vehicular journeys.

Energy Policy
Establish an Energy Authority with responsibility for overseeing utilities and energy policy.

Other Recommendations

Cross-border pollution
- Hong Kong needs to keep up with legislative and other developments on the Mainland to identify areas of cooperation that are forward looking, such as emissions trading.
- Hong Kong should limit cross-border crossings by road and promote rail links instead.

- Establish a joint Hong Kong-Guangdong authority to develop sustainable cross-border transport plans.

Smoky Vehicles
The Police should set targets for issuing FPTs for smoke emissions.

LPG
- Permit conversions for taxis from diesel to LPG on condition that all safety and emission measures can be met.
- The subsidy for LPG taxis should be offered for a limited period of two years only and progressively reduced in the 2nd year to encourage early uptake.

Low Sulphur Diesel
Increase the duty on standard diesel to encourage the uptake of ULSD. Better still, ban the use of high sulphur diesel in Hong Kong.

Other Cleaner Fuels
Government should study various cleaner fuel options and financial incentives to facilitate their widespread adoption and use.

Particulate Traps
The criteria for product approval for the subsidy scheme should be based on overall environmental costs and benefits. It should not restrict itself to any one type of product. It should include any technology capable of achieving a certain reduction in emissions and should be low maintenance.

Road-pricing
Adopt ERP in congested urban areas and consider using the money collected to create a Transport Fund to offset the costs of Intelligent Transport Systems, Park & Ride Schemes and cleaner transport initiatives.

Vehicle Tax
- Waive or reduce First Registration Tax (FRT) depending on how 'clean' the vehicle is.
- Create a scale of Annual Licence Fees (ALFs) from the most expensive for the most polluting vehicle to none at all for environmentally sound vehicles.

Company Car Deductions
- Remove the tax exemption for company cars or link it to the fuel-efficiency and emissions from the vehicle.
- To encourage public transport use, consider tax deductions for public transport expenses.

Bus congestion
- Require private and public bus companies to monitor ridership on all routes to prevent oversupply.
- Encourage ITS development and implementation.
- Dedicate bus corridors in congested areas during peak traffic times.
- Use a variety of financial incentives to encourage use of mass transit over taxis and private vehicles.

Pedestrianisation

- Implement city-wide pedestrian schemes.
- Use planning regulations to create breezeways in existing and new development areas and impose building height restrictions in areas of poor air circulation.

Trolley buses and trams

- The Government should commence trials on limited routes in parallel with the current study.
- Upgrade the current tram system when the franchise expires.

Energy Policy

Set much higher rates for energy consumption beyond base levels in both domestic and commercial sectors to encourage conservation and reduce demand for new capacity

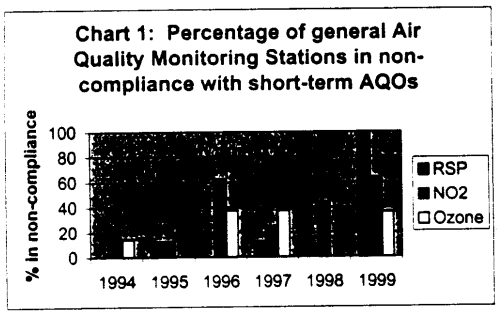
Marine Vessels

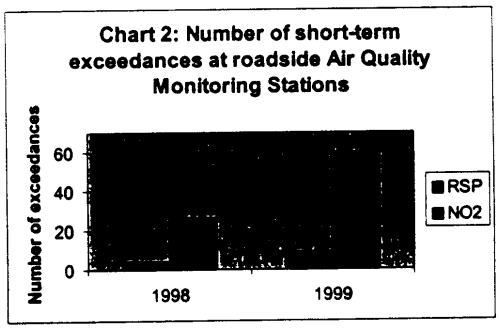
- Marine Department should step up enforcement action again smoky vessels.
- All Marine Department craft and public ferry areas should advertise a complaint telephone hotline for the public to encourage more reporting of smoky vessels.
- The Marine Department should conduct a comprehensive review of technical, financial and legislative means to reduce emissions from vessels.
- Monitoring of air pollution in ferry terminals, at container terminals and anchorages should be conducted by Marine Department to establish impacts of marine emissions.

PART I: INTRODUCTION – BASIC ISSUES

1. Deteriorating Air Quality

Air pollution in Hong Kong has reached crisis proportions. There was a substantial drop in air pollution compliance in 1999. Only 14% of the monitoring stations complied with the short-term Air Quality Objectives (AQO) and 50% complied with the long-term AQO.[1] While the levels of sulphur dioxide have seen dramatic improvements in recent years, the levels of respirable suspended particulates (RSP) have been bad for many years.[2] In 1996, the daily average AQO for RSP was breached 38 times over one month at 10 monitoring stations.[3] The Government has acknowledged that the trend is worrying.[4] In particular, ozone levels and visibility have deteriorated significantly in the last few years. Ozone levels have risen by almost 50% since 1990.[5]





[1] The Air Quality Objectives (AQO) set maximum limits for exposure to seven pollutants (sulphur dioxide, total suspended particulates, respirable suspended particulates, nitrogen dioxide, carbon monoxide, ozone and lead) at both short term and long term time periods beyond which negative health impacts can occur. Compliance with the AQO is not mandatory in Hong Kong.

[2] Annual levels of RSP were exceeded at 5 out of 8 monitoring stations in 1994.

[3] Wilbur Smith Associates Ltd. *Third Comprehensive Transport Study.* Strategic Environmental Assessment Technical Report, Report for the Government of the HKSAR Transport Dept, 10/99.

[4] Director of EPD, response to Legco question, 16/3/00, EFB45 Question No. 1003.

[5] EPD Annual Report, 1999.

Charts 1 and 2 show trends in short-term AQO exceedances at both general and roadside Air Quality Monitoring Stations (AQMS).[6]

Roadside concentrations of pollutants show even greater exceedances for nitrogen dioxide (NO2) and RSP. Ozone is more a problem for ambient air quality.[7] Yet even remote stations can experience isolated incidences of high air pollution. For example, Tung Chung and Tap Mun Air Quality Monitoring Stations, showed a number of short-term exceedances in 1999 for ozone and other pollutants, though they generally comply with long-term objectives.

2. Sources of Air Pollution

Diesel vehicles are the primary cause of territory wide street level pollution and acute pollution in Hong Kong's built-up area. The city has over 500,000 vehicles with about 150,000 vehicles powered by diesel accounting for approximately 70% of the total distance travelled.[8] Diesel emissions account for nearly 98% of RSP and 80% of nitrogen dioxide emitted by all vehicles, and are the dominant source of air pollution in urban areas.

Vehicle emissions are obviously a major source of pollution, but vehicle travel itself is a serious source of particulates created from the friction of tyres against paved roads.[9] Unfortunately, there are many other sources of ambient pollution including: power stations, marine vessels, fuel combustion, and aircraft.

Table 1: Quantities of NOx and RSP emitted by all sources in 1998 [10]

Source	Quantity of NOx emitted (figure in tonnes, % in parentheses)	Quantity of RSP emitted (figure in tonnes, % in parentheses)	Quantity of non-methane VOCs emitted (figure in tonnes, % in parentheses)
Vehicles	37370(32) (Urban areas 28%) (Non urban areas 71%)	5867(47) (Urban areas 30%) (Non-urban areas 69%)	14820(87)
Power station	55141(48)	4755(38)	294(2)
Marine vessel	9920(8)	788(6)	979(6)
Fuel combustion	9089(7)	784(6)	233(1)
Aircraft	4218(3)	39(<1)	690(4)
Total	114 738(100)	12234(100)	17016(100)

[6] There are currently 11 general AQMS. Yuen Long was introduced in 1995, Central/Western and Tap Mun were introduced in 1998 and Tung Chung and Eastern in 1999. Note that there are only 3 roadside monitoring stations. The new stations at Central and Causeway Bay were only introduced in 1998, which account for most of the exceedances in those two years.

[7] Ozone is not monitored at the roadside stations because the high levels of nitric oxide (NO) effectively suppress its formation. Engines emit both NO and NO2, which are collectively known as NOx. NO2 is responsible for the health impacts.

[8] Transport Department.

[9] Unpaved roads also contribute to air pollution. Wilbur Smith Associates Ltd. *Third Comprehensive Transport Study.* Strategic Environmental Assessment Technical Report, Report for the Government of the HKSAR Transport Dept, 10/99.

[10] http://www.info.gov.hk/epd/air/emission/hkape_4.htm

3. Cross-boundary Air Pollution

Monitoring and observation indicate that air pollutants originating from cross-boundary sources are substantially higher in winter. For example, the daily average RSP concentrations are two to three times greater when the prevailing winds have a northerly component.[11] Some academics estimated that roughly 30% of the ambient concentrations could be from the Mainland but beyond that there are no accurate quantitative data available.[12] The EPD and its Guangdong counterpart are conducting a joint 18-month study to identify the extent and nature of air pollution in the entire Pearl River Delta Region with a view to developing suitable strategies to tackle air pollution in the region. The study will be completed in early 2001 and both sides have pledged to devise control strategies to improve air quality in the region as soon as possible. However, given the difficulties of cross-border negotiations, this is likely to take many years.

3.1 Emissions from Vehicles

Some of the causes for Guangdong's air pollution are already known. In Guangzhou, weekly monitoring indicated that NOx is the major pollutant 94% of the time, mostly from motor vehicles.[13] This is significant because NOx is a major component in the formation of ground level ozone. Air monitoring in other Chinese cities shows that vehicular emissions are the predominant source of China's urban air pollution. In the last decade, the number of vehicles operating in China has tripled.[14] In the same decade the rate of oil consumption grew 70%, which was clearly related to transportation.

China faces the same problems in curbing its reliance on vehicles as Hong Kong. The World Bank predicts that unconstrained growth of vehicles with no enforcement of emissions would result in an approximately 25-fold increase in the amount of emissions released in 2020 compared to 1993. Even if China enforces tougher emission standards, improves traffic management and bus-based public transit, levels in 2020 will still be five times greater than in 1993.[15]

3.2 Industrial Emissions

The other major component of air pollution from Guangdong is sulphur dioxide. Sulphur emissions are high in southern China, due to the production and consumption of high sulphur coal for power generation to industrial usage to household stoves.[16] By contrast, particulate emissions from coal have remained flat since 1980, due to China's imposition of effective controls.[17]

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[11] See footnote 26.

[12] William Barron & Nils Steinbrecher, *Heading Towards Sustainability? Practical Indicators of Environmental Sustainability for Hong Kong,* The Centre of Urban Planning & Environmental Management, The University of Hong Kong, 1999.

[13] US Department of State, China Embassy. *China's Development of Alternative Fuel Vehicles,* 8/12/98.

[14] Weisbrod R E, *Solving China's Urban Crisis: China's Transportation Energy Future,* Journal of Urban Technology, Vol 6, No. 1 pp.89-100, 1999.

[15] Ibid.

[16] See footnote 33.

[17] Ibid.

4. Negative Health Impacts

Air pollution in Hong Kong is undoubtedly deadly. It is estimated that some 2,000 people a year die prematurely due to air pollution.[18] The number of hospitalisation days for respiratory cases has also increased by 23% since 1996, a portion of which are almost certainly attributable to air pollution.[19] Daily hospital admissions and daily mortality are adversely influenced by increases in NO2, SO2, RSP and ozone.[20] Government estimates show that the annual cost in medical costs and loss of productivity resulting from air pollution is $3.8 billion.[21]

Hospital admissions are only the tip of the iceberg. Exposure to pollutants, at levels commonly experienced in Hong Kong, have measurable short-term effects ranging from illness, doctor consultations and absenteeism from school for children, to serious acute, chronic and life-threatening hospital episodes for adults. More susceptible individuals include those with asthma, chronic obstructive pulmonary disease and cardiovascular disease. Even otherwise healthy adults and children are potentially threatened. The economic toll of the increased disease and mortality resulting from air pollution is vastly greater than doctor consultations and absenteeism from school and work.[22] Local medical experts want the government to reduce all pollutant levels by 10% per annum. That would reduce Hong Kong's exposure to the hazards by 50% in five years.[23]

Vehicle exhaust emitted in Hong Kong and in Guangdong is the source of many pollutants with serious health impacts. RSP, especially from diesel exhaust, has been the focus of great concern here in Hong Kong.[24] In 1997, the average level of RSP was 58μg/m3. However, as discussed in detail further in this section, NOx, ozone and volatile organic compounds also pose very serious health hazards (see Appendix 1).

Why is RSP of such great concern? Size is the simple answer. Unlike large particles that settle, smaller particles (less than 10 microns) remain suspended in the air for weeks. Not only are they more easily inhaled, but also they penetrate deep into the lungs and lymphatic system and remain

[18] Friends of the Earth, *What Price Clean Air? Position paper on the economic costs of air pollution.* July 1997.

[19] The total number of hospitalization days of patients of respiratory system diseases was 802, 385 in 1996, 822, 382 in 1997, 930, 784 in 1998 and 994, 612 in 1999 - Secretary for Health & Welfare response to a question in Legco, 1/3/00.

[20] But the real impact may be even greater as scientists have not comprehensively tracked the long-term effect of exposure to ambient air pollution. One sixteen-year study in the United States tracked the impact of air pollution on 8,000 individuals in sixteen different cities with different pollution levels. After accounting for age and smoking, researchers found that residents of the most polluted city had a 26% higher mortality rate than residents of the least polluted city. Another study correlated cancer statistics for 1.2 million residents of cites with different air pollution levels and concluded that residents of the most polluted cities had a 17% higher mortality.

[21] LegCo Paper CB(2)2073/99-00(01) 23/5/2000.

[22] See Barron W F, Liu J, Lam T H, Wong C M, Peters J and Hedley A. *Costs and Benefits of Air Quality Improvement in Hong Kong.* Contemporary Economic Policy. 8: 105-16. 1995.

[23] EPD's Sub-Working Group on the Review of Hong Kong's Air Quality Objectives: *Health Effects of Air Pollution,* Final Report. July 1999.

[24] In addition to being a directly emitted pollutant, RSP is also formed in the atmosphere due to the chemical transformation of emissions of NOx and SO2. United States Environmental Protection Agency, *National Air Quality and Emissions Trends Report.* 1977, EPA 454/r-98-016, December, 1998.

there.[25] Larger particles do not get past the body's defences. It is estimated that more than 98% of the particles in diesel exhaust are smaller than one micron, and diesel engines produce many more small particles than gas engines, making the prevalence of diesel vehicles of all types in Hong Kong is especially damaging to human health.[26] The Environmental Protection Department (EPD) have recently started monitoring PM2.5, a sub-fraction of RSP. A new AQO for this pollutant is recommended in view of its importance in terms of health effects.[27]

Particulates aggravate respiratory conditions like asthma, both in the frequency and the severity of attacks.[28] They also decrease lung function, increased respiratory stress and the likelihood of hospitalisation and cause premature death in sensitive people. Sensitive groups, at greatest risk from RSP pollution, include the elderly, children[29] and people with cardiopulmonary conditions.[30]

NOx, which refers to both NO and NO2, is also emitted from vehicles, as well as power plants and factories. Short-term exposure to NO2 pollution aggravates respiratory illnesses, while long-term exposures increases susceptibility to respiratory illnesses and may alter lung function.31 In Hong Kong, respiratory illnesses linked to NO2 exposure results in increased hospital admissions and increased premature death.[32]

Ground level ozone is the prime ingredient of smog. It is formed by photochemical reactions between volatile organic compounds and NOx in the atmosphere. The health effects of ozone include increased susceptibility to respiratory diseases, such as asthma, deceased lung function, premature ageing of the lungs and chronic obstructive lung diseases.33 Hong Kong experiences smog due to vehicular pollution created here and smog from Guangdong.

Air pollutants not addressed by Hong Kong's AQOs, but which demand stringent control are volatile organic compounds (VOCs) and heavy metals. They cause respiratory illnesses and are known and suspected carcinogens and mutagens.34 VOCs from diesel exhaust include benzene and Polycyclic Aromatic Hydrocarbons (PAHs), the largest single class of known chemical carcinogens. Levels of PAHs measured in Hong Kong are high compared to other urban areas of

[25] 96% of the particles found in the lung parenchyma at autopsy of adults who never smoked are no greater than 2.5 microns. J. Respri. Crit. Care Med; 155(6): 2109-2111(1997) cited in *Exhausted by Diesel,* Natural Resources Defense Council.

[26] A study published by the Health Effects Institute calculates that more than 98% of the total number of particles in diesel exhaust are smaller than one micron. See Bagley Susan I *et al* 1996, *Characterization of Fuel and After Treatment Device Effects of Diesel Emissions.* Research Report Number 76. Health Effects Institute, Topsfield, Massachusetts.

[27] PM2.5 refers to particles smaller than 2.5μm in diameter. The smaller particles are thought to do most of the health damage. See footnote 11.

[28] National Resources Defence Council, *Exhausted by Diesel: How America's Dependence on Diesel Engines Threatens Our Health.* http://www.nrdc.org/air/transportation/ebd/chap2.asp.

[29] Children below the age of six are especially harmed by RSP pollution because their respiratory systems are disproportionately large compared to adult systems. Hence, the impact of respiratory diseases in young children is comparatively greater.

[30] See footnote 12.

[31] See footnote 14.

[32] Department of Community Medicine and Unit for Behavioral Sciences, University of Hong Kong Medical Centre, Professor Anthony J. Hedley, personal communication.

[33] See footnote 12.

[34] See footnote 14.

the world.[35] Total concentrations of PAHs at Mongkok were found to be higher than published data for Beijing, Guiyang and Guangzhou.

These high levels in Hong Kong could have serious health consequences. Occupational studies of workers exposed to diesel exhaust over a ten-year period significantly increase the incidence of lung cancers, and possible bladder cancers. Another recent study shows that a 30% increase in lung cancers in diesel-exposed workers was due to that exposure, rather than chance or smoking.[36]

[35] Zheng M, Wan T S M, Fang M and Wang F. *Characterization of the non-volatile organic compounds in the aerosols of Hong Kong - identification, abundance and origin.* Atmospheric Environment, 3:2, 227-237, 1997.

[36] Bhatia R., Lopipero P., Smith AH, *Diesel Exhaust Exposure and Lung Cancer.* Epidemiology, 9:8, 4-91, 1998.

PART II: SITUATION IN HONG KONG & SUGGESTED INITIATIVES

While Hong Kong must work with Guangdong to reduce cross-border pollution, much of the pollution harming Hong Kong is generated here. In particular, *"in the case of RSP and NO2, little of these pollutants measured at roadside level are likely to originate outside Hong Kong."37*

5. Government Improvement Measures

In October 1999 and during the first half of 2000, the Government proposed various initiatives to reduce air pollution, such as technical measures to reduce tailpipe emissions, import of cleaner fuels, stronger actions against smoky vehicles, planning for pedestrian precincts and encouraging less polluting modes of transport. The initiatives also included a $1.4 billion subsidy to help taxi owners convert to LPG-powered taxis, and owners of taxis, light buses and other pre-Euro standard diesel vehicles install particulate traps and catalytic converters.38 Moreover, $213.3 million was allocated in 2000/2001 for the government air programme, an increase from $211.9 million over the previous year.

Table 2: Government initiatives to reduce NOx and RSP from vehicular sources and estimated reduction in urban areas due to these initiatives.39

Initiative	Contribution of vehicle type to urban NOX emissions (tonnes) (% vehicle contribution)	Reduction in urban NOX emissions due to initiative (tonnes) (% vehicle contribution)	Contribution of vehicle type to urban RSP emissions (tonnes) (% vehicle contribution)	Reduction in urban RSP emissions due to initiative (tonnes) (% vehicle contribution)
Replace all diesel taxis with LPG	1286(12%)	643(6%)	537(26%)	516(25%)
Replace all diesel light buses with LPG or other	331(3%)	221(2%)	105(5%)	84(4%)
Retrofit pre-Euro light buses with cats or traps	1411(13)	-	518(25)	83(4)
Retrofit pre-Euro buses with cats	1998(18)	-	247(12)	62(3)
Retrofit pre-Euro medium & heavy diesel with cats	3379(30)	-	622(30)	228(11)
All new vehicles to meet Euro III standards by 2001, fuel standards upgraded		2117(19)		751(36)
Total	8405(76)	2981(27)	2029(98)	1724(83)

[37] Response to Legco question 10/2/99.
[38] 1999 Policy Address, 6/10/99.
[39] Legco Question 19/1/00. Note this does not include estimated reductions from more recently announced initiatives such as adoption of low sulphur diesel.

With the implementation of the above initiatives and ***assuming no major change in the background levels of air pollution in the region,*** the Government expects the ambient levels of RSP and NOx to improve by about 35% and 20% respectively within 5 years. That is equivalent to a reduction in particulate and NOx emissions from all motor vehicles of 80% and 30% respectively by 2005. Assuming no change in the regional air quality, the Government estimates that Hong Kong should be able to meet its current AQOs by 2005.40

6. Air Quality Management Framework

Even with those measures, how healthy will Hong Kong's air be in 2005? How the estimated pollutant reductions translate into real air quality improvement will depend on factors such as changes in regional air quality, growth in traffic, as well as the height and location of emissions.

Reducing vehicular emission most likely will not be enough to improve air quality over the long term. For example, even if we reduce NOx emissions from vehicles, improving roadside NOx levels, overall, ambient levels will not change as dramatically since power stations are responsible for 45% of total NOx.[41]

Further, air pollution concentrations are also influenced by chemical interactions between the pollutants, long-range transport of ollution from elsewhere in the region and contributions from natural sources. For some compounds, such as carbon monoxide, which is relatively inert in the atmosphere, there is a correlation between transport emissions and pollution levels. However, compounds such as RSP and NO2 have more complex behaviour. For example, it is estimated that reducing the level of NOx by 50% will only provide a 15% reduction in NO2.[42]

Addressing the complexity of air pollution requires more than just short term technical fixes. Hong Kong must improve its air quality management framework and this will require the following significant changes: 1) assessment modelling to determine the effectiveness of its emission control measures, 2) legal changes to ensure that Hong Kong complies with the AQOs.

6.1. Air Quality and Emission Reduction Modelling

To translate emission reductions into projected air quality requires sophisticated computer modelling tools. No modelling has been done to assess quantitatively how the Government's air improvement initiatives would affect future air quality. Another problem is that the Government's improvement targets assumed that there would be no major change in regional air quality between now and 2005. Yet, all the trends indicate deterioration. Modelling various scenarios could provide the kind of information for Hong Kong to assess effectiveness of the solutions. An air quality management system comprises air quality standards, emission inventories, air quality modelling, control scenarios and measures, monitoring and corrective action. While Hong Kong

[40] In addition, vehicles are responsible for 81% of NOx measured at roadside monitoring stations, Legco Question 19/1/00.

[41] Legco Question 19/1/00.

[42] UK Department of Trade & Industry: *Technical solutions for reducing emissions from in-use vehicles,* Technology and Testing Working Group Report, 2/2000. The majority of NOx is emitted as nitric oxide (NO), which is oxidized in the atmosphere to NO2, mainly by its reaction with ozone (O3). As there is an excess of NO near to roads, the amount of NO2 is controlled by the amount of ozone for the reaction. Reductions in ozone concentrations would provide the most effective control mechanism for NO2.

has many of the components of an overall air quality management framework, it has yet to evaluate the air quality effectiveness of policies and measures.

Within this framework the Government should develop a short-term Air Pollution Episode Alert System to deal with short-term, unpredictable air pollution episodes and protection of public health.

Recommendation: The Government should undertake scenario modelling of the current initiatives to gauge efficacy and impacts on future air quality.

6.2. Mandatory Air Quality Standards.

During the winter, Hong Kong daily average air quality objectives (AQOs) are exceeded at an alarming rate. Repeated violations of the AQOs can occur because there is no penalty for such violations. The AQOs, although critical to the health and welfare of Hong Kong, are merely advisory. Hong Kong needs to make these objectives mandatory so that they will be taken seriously.

Mandatory air quality standards for the same criteria pollutants as Hong Kong's AQOs are the lynchpin of the Clean Air Act in the United States. Where a city like Los Angeles fails to comply with the standard for a given pollutant, for example ozone or particulates, the city must devise a plan for eventual compliance. The compliance plan must contain a timetable for each phase of the compliance efforts that is legally enforceable. Because cleaning up the air requires long-term effort, the plans hinge on pollution sources, from cars to power plants, adopting all reasonable, and available, pollution control measures and technologies.[43] Because of that mandate, California leads the world in innovative technologies to reduce pollution, especially from cars. California pioneered catalytic converters, anti-pollution pumps at petrol stations and regular pollution testing 999for vehicles as a precondition to licensing and license renewal. If Hong Kong made the air quality standards mandatory, Hong Kong would experience similar innovations all geared to cleaning our air.

A comprehensive Clean Air Ordinance is required that will provide for mandatory air quality standards, as well as providing the legal framework for businesses to develop and trade pollution credits. A pollution credit system would mean that where air quality standards are not met, new pollution sources are not permitted unless overall pollution levels do not increase. Any new polluting enterprise would therefore be obliged to work with existing polluters to reduce their emissions so that overall air pollution would not increase, and only when successful, could the new enterprise begin operation. The banking and trading of pollution credits is a burgeoning secondary market in the United States while overall air pollution levels steadily improve.

Recommendation: Enact a comprehensive Clean Air Ordinance which provides for mandatory ambient air quality standards for Hong Kong. Such standards could assist the Government in combating political resistance to its policies and emission control measures in Hong Kong.

6.3 Integrating Air Quality Issues Within the Government

Many Government departments and bureaux have responsibilities for different aspects of air quality control yet cooperation has been lacking over the years, most notably in the conflict

[43] See 42 USC Sections 7409(a), 7502(b) and 7503(1).

between transport, planning and the environment.[44] While the Secretary for Environment & Food, now heads up an inter-departmental task force to iron out some of the conflicts, she lacks authority over other policy chiefs, whose strategies are still at odds with the achievement of air quality objectives. Without an over-arching policy that places public health as the driving force behind all objectives, EPD will continue to fight a rear-guard action on air pollution.

The Legislative Council has also been another roadblock to improving air quality, although the worsening problem has forced many politicians to pay more attention to the issue. The political structure of Legco does not help. The transport functional constituency has a direct voice in the legislature, while commercial vehicle owners and drivers are also represented indirectly through various business functional constituencies. The transport trade is large and well organised and the Administration is nervous of upsetting them. The public, on the other hand, is a disparate body with no central organ to channel their concerns about air pollution and health. This lack of a political voice for the public has undermined much of the Government's efforts to push through air pollution prevention measures.

The growing problem of cross-border pollution requires integration of policy between the Hong Kong and Guangdong authorities. The Government has set up a "Joint Working Group on Sustainable Development and Environmental Protection" under the Hong Kong Guangdong Co-operation Joint Conference. While it is stated that priority will be given to air quality in the PRD and harmonising motor diesel fuel specifications the institutional mechanisms for more long term joint planning seem to be lacking.[45]

The severity of the air pollution problem in Hong Kong demands that the Government bureaus plan and act together. Mandatory Air Quality Standards, as recommended in 6.3 above, will provide the driver for all departments to work towards a common objective of cleaner air.

6.4 Controlling and Planning for Future Traffic Growth

Even if all the Government's improvement initiatives cut pollution so that its targets for 2005 are met, it will just provide temporary relief. Thereafter, the projected growth in traffic could start a reverse trend. By 2016, the Government predicts that air quality will be much worse at all the monitoring stations.[46] This deterioration will be due to the ever-escalating number of vehicles on the road, which generate particulate emissions merely due to the friction of tyres against the road, as well as end-of-the tailpipe emissions even with cleaner fuels and engines. The most significant deterioration is predicted at Yuen Long, Shatin and Kwai Chung.

44 The Economic Services Bureau is responsible for energy and fuel policy but have no expertise in the energy generation business or international development in the power sector; Electrical & Mechanical Services Department deals with energy efficiency and gas safety, but are not power experts; the Planning & Lands Bureau deals with urban planning, but is often in conflict with Transport Bureau on road-building plans; the Transport Department is responsible for regulating vehicles but have singularly failed to regulate emissions properly; the Transport Bureau is in charge of transport policy but despite stated policy to give priority to rail over roads, the reverse is true; the Customs & Excise Department is in charge of policing illegal fuel import and usage; the Police can issue Fixed Penalty Tickets for smoky vehicles but consider this a low priority.

[45] Response to question on draft Estimates of Expenditure, 2000, Question 0820.

[46] Wilbur Smith Associates Ltd, *Third Comprehensive Transport Study*. Strategic Environmental Assessment Technical Report [for the Transport Department]. 10/99.

Table 3: Projected growth in vehicle numbers by 2011 47

	1997	2011		
Scenario		Low growth	Medium growth	High growth
Private vehicles	327,000	417,000	560,000	746,000
Goods vehicles	117,000	134,000	167,000	212,000

A government-sponsored report also indicates that:

- Air quality will fail the AQO by 2016 for all traffic growth scenarios.
- RSP levels could increase by 89% and 69% respectively relative to 1997 for high and medium traffic growth scenarios.
- Air quality in the North West New Territories could deteriorate significantly due to growth in cross boundary traffic and local traffic, as well as the associated provision of new highway infrastructure.
- In Tai Po, Shamshuipo, Tsuen Wan, Shatin and Kwun Tong, air quality is predicted to deteriorate under most scenarios offsetting benefits of improved emission control technologies.
- RSP level is expected to increase in Mongkok, Kwun Tong, Tai Po, Tsuen Wan and Yuen Long.
- Cross-boundary traffic could **increase by 400%** by 2016, from nearly 30,000 vehicles a day in 1997 to 120,000 by 2016.
- When cross-boundary traffic is high, pollutant emissions showed an increase in all districts and most evident in districts with high cross boundary traffic.
- Strategies that favour moving goods by road result in significant increases in emissions in some districts, such as Yuen Long and North New Territories.
- The most significant growth (>200%) in emissions of all pollutants is predicted in Yuen Long, Sai Kung and Islands Districts by 2016.

Recommendation: The Government needs to properly integrate environmental concerns into transport policy and seriously address the growth in traffic by a combination of measures including vehicle restraint, improving the efficiency and convenience of public transport (not taxis), shifting passengers to mass transit modes such as rail, and land use planning that reduces the need to take vehicular journeys.

6.5 Controlling and Planning for Cross-border Pollution

Since Hong Kong companies are responsible for 70.7% of foreign direct investment in Guangdong, the potential for collaborative clean-up efforts is high, especially in industry.48 Suggestions made by business groups in Hong Kong to address cross-border pollution from industry include tradable emissions credits, direct regulation of Hong Kong companies operating in Guangdong and establishment of an Environmental Retrofit Fund (ERF) which would provide low-interest loans to companies wishing to purchase environmental technology.

Hong Kong needs to focus more on cross-border pollution and possible solutions. Legislation and technologies are developing quickly on the Mainland and Hong Kong needs to keep abreast

[47] Legco question 20/10/99.

[48] American Chamber of Commerce, Hong Kong, *Regional Pollution Abatement Initiatives*http://www.amcham.org.hk/Archives/index.html.

of developments there. Options for financing of solutions needs to be evaluated. Hong Kong and Guangdong should start working together immediately to proposals to attract the investment community. The sooner funding mechanisms are created, the sooner the Pearl Delta Region can fund the necessary infrastructure improvements and programmes that will be proposed as solutions when the Guangdong-EPD study is completed next year.

Solving China's urban air pollution problems will also require vehicles that run on clean fuel. Hydrogen is the ultimate choice, with methane as interim fuel.[49] Hong Kong clearly has a role to play in promoting the use of cleaner fuels. Hong Kong must first act quickly to make all vehicles here clean burning. Hong Kong should consider grants and loans to Guangdong to ease the shift to cleaner burning vehicles. At the same time, Hong Kong should restrict the entry of dirty-fuel vehicles across the border (see Section 14)

Recommendation: Hong Kong needs to keep up with legislative and other developments on the Mainland to identify areas of cooperation that are forward looking, such as emissions trading.

[49] World Bank, *Clear Water Blue Skies: China's Environment in the New Century*. China 2020 Series. 1997.

PART III: INEFFECTIVENESS OF GOVERNMENT INITIATIVES

7. Control of smoky vehicles

The current, scattered emissions control scheme is ineffective. The responsibility for controlling smoky vehicles primarily rests with EPD but also the Police and Transport Department (TD). About 30,000 smoky vehicles are hauled in for testing in a year through the EPD's Smoky Vehicle Control Scheme where official "spotters" report offending vehicles. The vehicle owner has to take his vehicle to an EPD testing centre within two weeks for testing, and if it fails, the vehicle license is cancelled.[50]

But franchised buses are not subject to EPD's smoky vehicle spotting scheme. Instead Transport Department's bus engineering unit carries out spot checks on emissions. The vigilance of the bus engineering unit must be questioned. While they carried out a total of 3,374 spot checks on the 5 franchised bus companies in 1999, no buses were deemed to emit excessive smoke.[51] Nor were any in 1998.

However, only the Police can issue Fixed Penalty Tickets for smoky vehicles, for which the current fine is only $450 but will be increased on 1 December 2000 to $1,000.[52] Moreover, the Police do not aggressively issue smoky vehicle tickets, and only issued 13,051 in 1999, compared to one million parking tickets.[53] The problem appears to be institutional with the Police reluctant to do what they view as EPD's responsibility.

Recommendation: The Police should set targets for issuing FPTs for smoky vehicles.

8. Inspection and Maintenance

Hong Kong has yet to develop an adequate system of vehicle inspection to test pollutants. A thorough inspection system will make owners maintain their vehicles better since the penalty for failing the annual road-worthiness test is revocation of the road licence. The impact of inspection and maintenance on motor vehicle emissions could result in average reductions in RSP of 9%.[54]

The TD conducts annual road-worthiness tests on all commercial vehicles but emissions are not adequately tested at their centres. The current test is a simple free acceleration smoke test, not designed to check NOx and RSP. In order to check smoke and pollutant levels properly, a dynamometer is necessary. The EPD testing centres already have a number of dynamometers but the TD only has plans to install one for light diesel vehicles in October 2000. Dynamometer testing should be carried out on all commercial vehicles annually, as well as for petrol and LPG vehicles in line with international practice.[55] Indeed, private vehicles should also be tested for 50A chassis dynamometer test for light diesel vehicles was introduced in September 1999. About 17% of vehicles tested under the old system failed, but with the dynamometer, the failure rate doubled to 34% indicating a large number of drivers were tampering with their engines to pass the test. EPD intends to introduce chassis dynamometers for heavy diesel vehicles by the end of 2000.

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[51] Transport Department, personal communication.

[52] The Chief Executive pledged to introduce a resolution in October 1999, but it was only done in May 2000. See Legco rebate for the passage of the resolution on 21/5/2000.

[53] This is considerably higher than the previous decade where an average of 2,000 per year was issued.

[54] UK Department of Trade & Industry, *Technical Solutions for Reducing Emissions from In-use Vehicles*, Cleaner Vehicle Taskforce, Technology and Testing Working Group Report, Appendix G, 2/2000.

[55] *Introduction of Emission Tests for Petrol and LPG Vehicles*, LegCo Paper 8/5/00.

NOx since results in the United Kingdom indicate that they may be heavy emitters too. While the TD has the intention to do so, it will need to install many more dynamometers before they can serve Hong Kong's vehicular fleet.[56]

Improved maintenance can undoubtedly reduce RSP emissions. However, caution is needed because in some cases this can actually increase emissions of NOx.[57]

Recommendation: (a) Make annual emission control inspections at government approved centres a prerequisite to vehicle licensing for <u>all</u> vehicles (including petrol and LPG vehicles). (b) Transport Department to install sufficient dynamometers for all commercial diesel vehicles. (c) Emission tests for all vehicles should include tests for NOx and RSP.

9. Liquefied Petroleum Gas (LPG)

LPG is a mixture of propane and butane. The air quality benefits of LPG are significant, with most emissions better than diesel. LPG vehicles emit virtually no RSP although emissions of NOx are approximately the same as unleaded petrol.[58]

The technology for LPG-powered vehicles is mature, having been used in 40 countries for over 30 years. It can be used in both light and heavy-duty vehicles, but large fuel tanks are required for the latter. The Government plans to introduce a requirement that new taxis must be LPG-powered by early 2001. To encourage early switches, the Government will provide subsidies of $40,000 each to owners to buy a new LPG taxi, estimated to cost $210,000 to $230,000 per vehicle. The constraint in the early days will be the lack of LPG filling stations, but by mid-2001, many more should start coming on stream. The subsidy should stop by the end of 2002 to ensure as many taxis switch by 2003, and not by 2005 as originally planned by the Government.

A 6-month trial was launched in June 2000 to test LPG for use in light buses.[59] If the results are satisfactory, the Government intends to work out a programme to encourage light bus operators to switch to LPG too.[60]

There is a cheaper and quicker way to change the taxi fleet. Converted LPG vehicles are common in Australia, New Zealand, the United States, the Netherlands and Canada. The cost of conversion ranges from around $13,000 in Japan to $21,728 in the United States.[61] However, the Government is concerned about safety of converted vehicles compared to original equipment

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[56] UK Department of Trade & Industry, *Technical Solutions for Reducing Emissions from In-use Vehicles*, Cleaner Vehicle Taskforce, Technology and Testing Working Group Report, Appendix G, 2/2000.

[57] Ibid.

[58] A proposed scheme to switch diesel taxis and light buses to unleaded petrol was rejected by LegCo in 1995 ostensibly due to concerns about benzene emissions from unleaded petrol and maintenance costs of petrol vehicles. There was suspicion that the main reason for opposition from the trade was that this would have undercut the market in illegal diesel.

[59] The trial will include both LPG and electric light buses. A preparation committee has been set up comprising light bus operators, experts in transport and government departments.

[60] Use of LPG taxis alone would double the current consumption of LPG whilst use of LPG for all diesel vehicles would increase it 10-fold. DNV, *Quantitative Risk Assessment Study of Gas Vehicles and Associated Infrastructure in Hong Kong.* Summary Report for EMSD. August 1998.

[61] *A Study on LPG as a Fuel for Vehicles,* Research and Library Services Division, LegCo 3/97. The Japanese Government provides subsidy to owners of diesel-driven vehicles weighing 2.5 tonnes or less if they purchase LPG vehicles to replace their own vehicles. In case of conversion, subsidy is given for half of the modification expenses with a ceiling equivalent to HK$8,280 per vehicle.

manufactured (OEM) vehicles. However, this can be addressed by allowing properly certified engineering companies to convert existing vehicles, subject to proper safety checks and a maximum vehicle age.

There are several solutions. First, the Government should direct TD and EPD to work together to study conversions in other countries and adopt standards for conversions suitable to Hong Kong. Conversions of commercial vehicles should be subsidized by a one-off grant from TD.

Recommendation: (a) Permit conversions on condition that all safety and emission measures can be met. (b) The grant for LPG taxis should be offered for a limited period of two years only and progressively reduced in the 2nd year to encourage early uptake.

10. Low Sulphur Diesel

Ultra Low Sulphur Diesel (ULSD) has 0.005% sulphur and is in use in Europe. It can be used in all existing diesel vehicles.[62] Compared to standard diesel (0.05% sulphur) it can reduce most pollutants, particularly black smoke and RSP. Combined with a diesel catalyst or a particulate trap, emissions are comparable to natural gas or LPG.

ULSD is more expensive however.[63] The incremental cost for importing ULSD from Europe is estimated to be $0.88 per litre. If ULSD were to be supplied locally from Asian refineries the incremental cost would be $0.30 cents per litre. Hong Kong's diesel is currently imported from Singapore, whose refineries do not produce low sulphur diesel. However, with the right fiscal incentive, rapid adjustments are possible.[64] The Hong Kong Government has announced that there will be a duty preference for ULSD over standard diesel.

For maximum benefit, simultaneous adoption of enforcement measures to curb the use of illicit fuel is needed. One of the problems with increasing the price differential between ULSD and standard diesel is that this will increase the incentive to use illicit diesel (see Section 14). Rightly, the Government intends to harmonise the quality standard between marked oil (0.5% sulphur diesel for industrial use) and standard diesel for vehicular use to reduce temptation. However, it would be more effective to ban the use of high sulphur diesel altogether so as to remove a source of black market fuel in Hong Kong. This will have cost implications for industry and marine vessel owners, but could improve air quality significantly.

Of course, such a ban will only work if the Government concurrently moves to crack down on black market fuels.

Recommendation: Increase the duty on standard diesel to encourage the uptake of ULSD. Better still, ban the use of high sulphur diesel in Hong Kong.

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[62] The quantity of sulphur in diesel fuel directly affects quantity of RSP and other pollutants produced. Hong Kong's diesel contains 500ppm or 0.05% of sulphur, although the Government intends to reduce the sulphur content to not more than 0.035% in January 2001. ULSD contains 50ppm or 0.005%. In California diesel has a maximum content of 0.0015%.

[63] In February 2000, the average retail price of diesel in Hong Kong was $6.28 per litre ($1.48 import value, $2 duty).

[64] The UK Government has taken steps to encourage the manufacture and use of ULSD. A one pence per litre duty differential in favour of ULSD was introduced in 1997. This was increased to 2 pence per litre in 1998 and 3 pence per litre in 1999. The policy led to almost the entire diesel market converting to ULSD, way ahead of most other European countries, http://www.hm-treasury.gov.uk/budget2000.

11. Other Cleaner Fuels

The Government has announced it will support the trial of natural gas, fuel cell or hybrid vehicles, although no details are available. First, the Government should test all of these alternatives as soon as possible and simultaneously, to ensure that these new technologies could be adapted to Hong Kong as soon as possible. The Government should concurrently run or sponsor trials of other cleaner fuels such as biofuels. (See Appendix 2). Second, the Government should develop financial incentive programs to facilitate the quick adoption of whatever technologies prove most suited to Hong Kong, including waiving duties, one-time grants and subsidized fuel purchases.

Recommendation: The Government should concurrently study the various cleaner fuel options and financial incentives to facilitate their widespread adoption and use.

12. Particulate Traps, Diesel Catalysts & Other Emission Reduction Products

Particulate traps are devices for diesel vehicles that can be installed at the exhaust to trap particulates. They need to be removed from time to time for cleaning, as often as every few days for the model developed by Hong Kong Polytechnic University. Catalytic converters produce a similar result when installed in larger diesel vehicles. A Continuous Regenerating Trap (CRT) is a newer product along the same line.[65]

A one-year trial of particulate traps was launched in August 1999 on about 60 light duty diesel vehicles. The initial results show the trap has a potential to reduce the emissions of smoke and RSP from individual diesel vehicles by up to 50% and 20% respectively.[66] The Government committed $50.88 million for a one-off grant to assist owners of pre-Euro diesel light vehicles of up to 4 tonnes to retrofit their vehicles.[67] Eligible owners will be able to approach authorised contractors, who will be reimbursed for the installation of particulate traps. The installation will be a pre-requisite for licence renewal for these vehicles one year after the grants are made available.

Once ULSD is available, the Government plans to retrofit CRTs on Euro I government-owned vehicles to maximise benefits. They will also work with the franchised bus companies to retrofit CRTs on buses. The Government has started a trial to retrofit heavy diesel vehicles with catalytic converters, which will be completed by the end of 2000. This involves 20 government in-house vehicles and a similar number of private vehicles. Depending on the outcome of the trail, the Government plans to provide free installation of catalysts capable of reducing RSP by 50% for all pre-Euro standard medium and heavy diesel vehicles. Fitting these various devices to pre-Euro, Euro I and Euro II engines of heavy-duty vehicles is the most cost-effective option for reducing RSP.[68]

There are many other well-tested emission reduction devices on the market as well. The EPD intends to set up a committee to study these products in 2000-2001. Appendix 3 provides data on 65 A CRT is a particulate trap with an oxidation catalyst which continuously oxides the particulate matter. It requires practically sulphur-free fuel for proper operation.

[66] LegCo question 16/6/99.

[67] One-off grant to assist owners of pre-Euro diesel light vehicles to retrofit their vehicles with particulate traps, LegCo Finance Committee 12/5/00.

[68] *Technical Solutions from Reducing Emissions from In-use Vehicles.* Technology and Testing working-group report, UK Department of Trade and Industry, 2/2000.

some of the products currently being promoted in Hong Kong by various companies. Due to their relative low cost, ease of installation and ability to reduce emissions from all vehicles, EPD should review all potential technologies as a matter of priority.

Recommendation: The criteria for product approval for the subsidy scheme should be based on overall environmental costs and benefits. It should not restrict itself to any one type of product. It should include any technology capable of achieving a certain reduction in emissions and should be low maintenance.

13. Emission Standards/Controls on Older Vehicles

Hong Kong should consider a mandatory phase out of older vehicles, especially those that fail to meet even Euro-I standards, akin to that adopted in the United States, such as setting a legal limit to the useful life of light duty vehicles, motor vehicles and motorcycles based either on years on the road or vehicle miles travelled, whichever is less.[69]

The Government is progressively tightening standards for diesel vehicles. Currently, all new diesel vehicles imported need to meet Euro II standards, the most advanced European standard. The more advanced Euro III standards will be introduced in 2001. However, this does not address the problem that most of Hong Kong's commercial diesel fleet has pre-Euro and Euro I engines. A Euro I vehicle emits about 50% less RSP and about 10% less nitrogen oxides than a pre-Euro engine. A Euro II vehicle emits almost 90% less RSP and over 40% less nitrogen oxides than pre-Euro versions.[70]

Table 4: Numbers of franchised buses and goods vehicles complying with Euro standards.[71]

	Buses	Light goods	Medium goods	Heavy goods	Total
Pre-Euro	2 447(41%)	49 208(69%)	27 696(76%)	1 484(56%)	80 835(70%)
Euro I	1 334(22%)	15 658(22%)	4 791(13%)	594(22%)	22 377(19%)
Euro II	2 211(37%)	5 461(7%)	3930(10%)	566(21%)	12 168(11%)
Total	5 992(100%)	70 327(100%)	36 417(100%)	2 644(100%)	115 380(100%)

71% of light, medium and heavy goods vehicles and 41% of the franchised buses are pre-Euro. Those vehicles account for 75% of the diesel fleet and 34% of the vehicle km travelled in Hong Kong.

The TD requires all franchised bus companies to withdraw buses from service when they reach 18 years of age. Normally, buses are withdrawn from service between the age of 14 to 17 years.[72] While there is little financial incentive for bus companies to withdraw buses before this, the franchised bus companies have taken the initiative to introduce newer engines before legally required.[73]

The public interest would be served by accelerating this scrappage process by imposing a tax on

[69] See 42 USC Section 7521(a) and (d).
[70] See footnote 38.
[71] Legco questions 27/10/99 and 24/11/99.
[72] Legco question 24/11/99.
[73] First Bus announced on 27/4/99 it would be upgrading 177 pre-Euro II buses with engine conversion and catalytic converter installation, which could reduce RSP by 50%.

older polluting vehicles, and to provide incentives or grants for the purchase of new, environmentally friendly replacements.[74] The Government should also encourage scrappage indirectly by banning pre-Euro vehicle models from entering the main urban districts on high pollution days. Most of the affected vehicles would be goods vehicles. This could be enforced by electronic monitoring, as used in Singapore, or some type of signage or special license plate.

Recommendation: (a) Ban pre-Euro vehicles from entering urban areas. (b) Phase out all pre-Euro and Euro I vehicles within 3 years unless they can meet Euro II standards through retrofitting.

14. Controls on Illegal and High Sulphur Diesel

High sulphur diesel (sulphur content 0.1-0.4%) is legally purchased on the Mainland and stored in fuel tanks of cross-border vehicles coming back into Hong Kong. While the use of such fuel is not "illegal" as such, the sulphur content is 10 times higher than the standard grade sold in Hong Kong. While a duty is imposed on bringing over 300 litres of high sulphur diesel into Hong Kong, there is no mandatory limit on how much fuel can be carried in the fuel tank. With 30,000 vehicles crossing the border each day (15,000 returning), the amount of high sulphur diesel used on Hong Kong's roads is considerable. Fuel prices on the Mainland are considerably cheaper than in Hong Kong, hence drivers tend to load up before coming back, knowing that the Customs Department is not going to check at the border.

The Government does not know how much high sulphur diesel is consumed in Hong Kong, but estimates that some 613 million litres of high sulphur diesel, equivalent to 44% of all diesel oil consumed by vehicles, is consumed legally within Hong Kong borders. Stopping this use will be very difficult since the financial benefit of using high sulphur diesel, irrespective of source or type, is huge.[75]

To curb the legal transport of high sulphur fuel across the border, an ordinance allowing no more than half a tank of fuel should be passed. Then Customs would randomly check vehicles' fuel gauges as part of its normal cross border inspection. Approaching the problem from the opposite perspective, EPD suggests that new controls could require a vehicle leaving Hong Kong to have a fuel tank that is at least three quarters full.[76] Another solution is to provide duty free diesel filling stations on the Hong Kong side of the border.

Yet another suggestion is to tax drivers for the routes they use to cross to the Mainland. For all small vehicles, such as private cars, motorcycles and passenger vans, a lower tax can be imposed

[74] In New Delhi, a Supreme Court order banning commercial vehicles over 8 years old recently came into effect. It removed over 20,000 old vehicles from the roads, estimated to cause 70% of Delhi's air pollution. After the ban took effect, levels of CO fell by 55% within 3 days. A Supreme Court order of 28/7/98 directed the replacement of all pre-1990 autos and taxis with new vehicles on clean fuels by 31/3/00; all 8-year buses to use CNG or other clean fuels by 1/4/00 and the entire city bus fleet to be steadily converted to CNG. An earlier order dated 22/9/98 directed phasing out of all commercial/transport vehicles, which are more than 15 years old in a time-bound manner. With effect from 1/10/98 all commercial/transport vehicles more than 15 years old had been phased out, Consulate General of India, Personal Communication 3/5/00.

[75] Substantial savings can be made from using illicit fuels (Appendix VI). For example, based on prices in January 2000, a taxi driver can save nearly $3,000 a month through using illegal fuels. As for the illicit fuels trader, the Customs Department estimated that the monthly profit for selling 3,000 litres of illicit "marked oil" could be $135,000.

[76] *Hong Kong - The Environmental Challenge, EPD 1986-1996,* EPD 1996.

than for larger vehicles, such as buses and trucks since larger vehicles are more polluting. The tax collected could be used to clean up air pollution.[77]

Illegal diesel also has a high sulphur content and is obtained from different sources.[78] Much of this is so-called 'marked oil' which is high-sulphur diesel sold legally for industrial use. Hospitals, boats, construction sites, factories are all legitimate users of 'marked oil'. Duty-exempt, it is much cheaper than diesel sold at the pump, and is being diverted for illegal use in vehicles.

Table 5: Estimated quantities of duty-paid and duty-not-paid light diesel oil (DNP LDO) consumed in 1997 and 1998.[79]

Year	Quantity of duty-paid LDO (000L)	Estimated consumption of LDO (000L)	Estimated consumption of DNP LDO (000L)	Quantities of DNP LDO seized by C & ED (000L)	Estimated quantity of DNP LDO brought in by cross-border tanks (000L)
1997	697 422	1 583 000	885 578	2 204	Not estimated
1998	672 900	1 641 000	968 100	5 092	879 000
1998*	672 900 [80]	1 384 000	711,100	5 092	613 000 [81]

* Revised figures provided by EFB

Illegal trafficking in fuel has been on going for a long time. The fact that the places where illicit fuels can be bought are well known to the transport trade indicates that officials have turned a blind eye for an equally long time. While illegal filling sites are not always easy to locate, as some of them are in residential areas, many of them are operating in broad daylight in open-air car parks. In January, the Customs Department identified 55 sites harboring illegal filling activities, with 25 of them on government land leased out temporarily for car park use. Yet, very few of the tenancies were terminated ostensibly because transport officials were concerned that there would be inadequate parking facilities thereby causing traffic congestion.[82]

In 1996, the law was amended so that any non-public transport vehicle found using illicit fuel twice would have its license forfeited and the owner committing the offence fingerprinted. However, public transport vehicles are exempted, even though these comprised 43% of the cases of vehicles caught using illegal fuel in 1999.[83] Plainly, the effectiveness of the law was undermined before it even was enacted. Furthermore, amendments to the Dutiable Commodities Ordinance in 2000 presume that any dealings in diesel oil is dutiable, whereas before it can only be invoked if a person is actually transferring it to or from a vehicle's fuel tank.

Despite these measures, the authorities are clearly not doing enough to investigate these various 77 Citizens Party's 2000 shadow budget, *New Fiscal Structure for a World Class City*, 22/2/2000, http://www.citizensparty.org.

[78] (a) "Marked oil" a red-coloured high-sulphur (0.5%) diesel meant only for industrial use but illegally used for transportation; (b) "de-treated oil", marked oil with the colour removed to disguise it; (c) diesel illegally imported or purported to be re-exported but diverted back into the SAR.
[79] Legco question 31/3/99.
[80] Environment & Food Bureau, personal communication, 27/4/00.
[81] It is assumed that of the 876 million litres brought into Hong Kong, 70% is consumed locally, i.e. 613 million litres. The remaining 263 million litres is assumed to be consumed on the Mainland when the vehicles return.
[82] LegCo Paper CB(1)360/99-00(3), 18/4/2000.
[83] Customs & Excise Department, personal communication, 13/5/00.

crimes. They need to get the cooperation of the oil companies to better understand purchase and usage patterns of illicit fuels. Resources for the Customs Department's Diesel Enforcement Division also need beefing up.[84] The widespread availability of high-sulphur 'marked oil' should be stemmed by banning high sulphur diesel for industrial purposes.

Recommendation: (a) Enact legislation to limit the amount of fuel carried by cross-border vehicles (b) Tax cross-border vehicle crossings (c) Amend the law to enable forfeiture of licences of public transport vehicles caught twice using illicit fuels (d) Step-up investigation, including getting co-operation of the oil. (e) Ban the use of high-sulphur diesel for industrial purposes.

[84] In the short-term, more police resources should be deployed to provide backup to the under-resourced Diesel Enforcement Division. In 1999 the Police passed 707 intelligence referrals to the Customs Department and carried out 11 joint operations resulting in 19 arrests for marked oil offences. However, with only 22 staff handling this work, they cannot follow-up all the leads.

PART IV: TRANSPORT POLICY IN HONG KONG

15. Transport Policy

"The most effective way to tackle roadside air quality is to eliminate or reduce the emission sources. This can be achieved by "zero emissions" vehicles e.g. electric vehicles, trolley buses or controlling the number of vehicles using the roads."[85]

One of the stated objectives of the Government's transport strategy is to provide transport infrastructure and services in an environmentally acceptable manner to ensure the sustainable development of Hong Kong. Yet, there is still a large disconnect between the stated policy and the actual practice.[86] Below are a number of specific measures the Government can and should adopt to address the unsustainable growth in traffic, which will in turn help improve air quality.

15.1 Electronic Road Pricing (ERP)

In 1996, the Government commissioned a $90 million study on Electronic Road Pricing (ERP), which was due to be completed in June 1999.[87] There has been no release of that study, nor any opportunity for public debate on this issue. The study considered two types of technologies, namely the use of satellites to charge vehicles according to the traffic zone they are in, and microwave technology, similar to auto-toll systems. The TD claimed that the study only considers the technologies to be used, and not the acceptability of ERP.

ERP is a fair and effective means to reduce unnecessary road trips. The monies collected could be used to create a transport fund to offset car licence fees and be ploughed back to improve public transport. This would benefit both the private car owners who would enjoy less congested driving conditions, and public transport users who would have better services and shorter travelling times.

Recommendation: Adopt ERP in congested urban areas. Consider using the money collected to create a Transport Fund to offset the costs of Intelligent Transport Systems, Park & Ride Schemes and cleaner transport initiatives.

15.2 Restricting Vehicle Access & Pedestrianisation Schemes

Hong Kong's skyscrapers trap vehicular pollution, especially at street level, where pedestrians breathe a concentrated, noxious cocktail of pollutants everyday. Consequently, in areas where air circulation is poor, such as Mongkok and Causeway Bay, air pollution becomes particularly severe. Vehicle access to such areas should be restricted, particularly on high pollution days. Closing roads at certain periods or designating delivery times, for example, prohibiting goods vehicles from the road during the morning and evening peak hours, should also be considered. The scope for implementing large-scale pedestrian schemes in both existing urban areas and new development areas is enormous. In certain areas, simply reducing the amount of vehicular pollutants may not be enough. Planning regulations should be used to create breezeways in existing and new areas of development, and impose building height restrictions in areas of

[85] See footnote 26.

[86] Despite a stated policy that accords priority to railways over roads, the Government continues to allocate more funding to roads and remains reluctant to take real measures to tackle traffic growth.

[87] http://www.legco.gov.hk/yr97-98/english/panels/tp/papers/tp13035a.htm.

restricted air circulation.

Recommendation: (a) In the short-term, on high pollution days, ban all vehicles from entering polluted urban areas, (b) Implement city wide pedestrian schemes.[88] (c) Use planning regulations to create breezeways in existing and new development areas and impose building height restrictions.

15.3 Fiscal Measures

The Government has not sufficiently explored using fiscal measures to drive fuel, vehicle and road usage that will have a lighter impact on the environment. A comprehensive review is urgently needed to achieve environmental objectives:

(a) *First Registration Tax (FRT) and Annual Licence Fees (ALF)*

Hong Kong uses FRT as a tool to reduce growth in private vehicles but it takes no account of the polluting nature of the vehicle.[89] It should do so. Medium and heavy goods vehicles, which emit much higher levels of noise and air pollution than private cars, are taxed at only 4%.[90]

But Hong Kong could use tax policy to encourage fuel efficiency. Germany, for example, imposes duties on six classes of passenger vehicles correlated to emissions and fuel efficiency standards. Diesel vehicles pay twice the taxes of petrol vehicles. Tax credits are granted to unusually efficient cars, such as, ones that meet Euro III emission standards. Japan also uses duties to discourage polluting vehicles.[91] On the other hand, the United Kingdom imposes an increasingly higher tax on vehicles according to the number of axles and weight of each vehicle. A tax deduction is given for low emission trucks.

Hong Kong could likewise use duties and tax credits to purge its roads of polluting, old vehicles. Polluting vehicles, especially diesel vehicles, should be stringently taxed. Those who buy new clean vehicles should receive a tax credit. Hong Kong could encourage purchase of electric vehicles, and other new technologies, by granting them an even larger tax credit. If Hong Kong adopted a comprehensive system of duties and credits concurrently with statutory limits on the age of older pre-Euro vehicles and trucks, the region would benefit from rapid turnover of its current polluting vehicle fleet.

To promote the uptake of cleaner vehicles on a more systematic basis, the Government could base the FRT and ALF on environmental standards (noise and emission standards, fuel efficiency) to create a financial incentive for cleaner, more efficient vehicles. Overall this will be revenue-neutral but more polluting vehicles will be taxed at a higher rate.[92]

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[88] Citizens Party: *A Walk on the Wild Side - Better Planning for Pedestrians.* http://www.citizensparty.org/pedduplicate.pdf. See also Hong Kong Institute of Planners proposals for a pedestrian precinct in Des Voeux Road Central http://www.hkip.org.hk.

[89] The rate of FRT is expressed as a percentage of the value of vehicles and varies according to the class of motor vehicle specified in a schedule. FRT for private cars range from 40-60%.

[90] While the Government has waived FRT for electric vehicles since 1996, due to the lack of supporting infrastructure, electric vehicles have not proved popular.

[91] Government of Japan, See Report on Auto-Related Environment Taxes, http://www.eic/eanet/en/org/aret/chl.html.

[92] A similar measure was introduced in the UK 1999 Budget. Vehicle Excise Duties for new cars will be based primarily on their carbon dioxide emission rates, with discounts for cars using cleaner fuels and

Recommendation: Waive or reduce FRTs depending on how "clean" the new vehicle is to create a financial incentive for cleaner vehicles. Create a scale of ALFs from the most expensive for the most-polluting cars to none at all for environmentally sound vehicles.

(b) ***Company car tax deductions***

Businesses can claim initial and annual depreciation allowances for company cars and deduct their running costs in computing their profits tax liabilities. These concessions provide a positive incentive for companies to purchase private cars, when our present pollution and congestion problems mandate that Hong Kong do the opposite.[93]

Recommendation: The Government should remove the tax exemption for company cars or link it to the fuel-efficiency and emissions from the vehicle.[94] To encourage public transport use the Government could also consider tax deductions for public transport expenses.[95]

16. More Environmentally-Friendly Modes of Transport

The Government estimates that by 2016, particulate levels will be 200% of present levels, even with LPG vehicles on our roads, simply due to increased vehicle traffic, Hong Kong must discourage the use of private vehicles and taxis by ensuring the attractiveness of public transport and adopt less-polluting modes of public at the same time.[96]

The Government should upgrade the tram system on Hong Kong Island when the franchise comes up for renewal in 2005. In addition, electric trolley buses offer a clean alternative to diesel buses.[97] They are flexible, energy efficient, silent in operation, and best suited to high intensity, urban bus operation. Most importantly, they emit no pollution from the tailpipe (though obviously some emissions will be transferred to power stations). These benefits have been confirmed by an

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technologies and a small supplement on diesel cars to reflect their higher emissions http://www.hm-treasury.gov.uk/budget/1999.

[93] For a car costing $200,000 to buy and with an annual operating cost of $50,000, a company can save $30,000 in tax in the first year after acquisition and about $10,000 each year subsequently during the first year of ownership.

[94] The UK has also initiated a fundamental reform of the company car tax regime, to be implemented on a revenue neutral basis in 2002. This will replace incentives to drive extra miles with an incentive to use more fuel efficient cars.

[95] Many major cities in the US including New York, Washington DC and San Francisco have implemented a transit voucher programme. Under a 1993 federal tax law employees can use up to US$65 a month of their pre-tax salary to purchase public transportation passes, enabling them to save more than US$300 per year in taxes. http://www.nytransit.com/NewSite/tcheckpages/wel_tck.html. Through the Metrocheck programme over 50,000 employees in Washington Dc receive transit subsidies of US$65 a month for public transportation. Qualifying companies deduct the benefit from their taxes. http://www.co.fairfax.va.us/comm/trans/chek/htm.

[96] Citizens Party's response to the Third Comprehensive Transport Study public consultation. http://www.citizensparty.org/environmentalpp8.html.

[97] An electric trolley bus is a bus powered by an electric motor rather than a conventional diesel engine and gearbox, and which draws its energy source from a pair of overhead wires. Unlike trams, trolley buses move on tyres and no road-embedded tracks are required.

initial TD study in 1999.[98]

The study concluded that trolleys would be well suited to include "*busy urban and suburban services including those in severely polluted corridors and hilly residential areas*."99 It was estimated that if trials proceeded smoothly and "*with due expedition*" the first trolley bus route could be operating in the spring of 2001. The study thought it was conceivable that well over 1,000 trolley buses could be running by the middle of the next decade "*given the will to do so*". The biggest drawback is the cost. Initial infrastructure costs can be high but maintenance costs are comparable to ordinary diesel buses. Trolley buses are in use in 26 cities in China and cities in Europe, North America and South America, totalling 342 systems worldwide.[100] Here in Hong Kong, the Government has allocated additional funds in the 2000-2001 Budget for a second, similar study. In the meantime, Citybus is embarking on a $5 million pilot test.

Recommendation: The Government should commence trials on trolley buses on limited routes at the same time that it conducts the second trolley study.

17. Traffic Control Measures

17.1 Intelligent Transport Systems

A number of technologies can be adopted to improve the overall operational efficiency of traffic management. Traffic congestion in general can be reduced by the deployment of intelligent transport systems (ITS).[101] New buses that feature location tracking using GPS are already being tried in Hong Kong.[102]

17.2 Bus Congestion

With more competition on bus routes, the number of bus routes and buses has increased correspondingly. In the last 3 years the number of buses has more than doubled from 5,310 in 1997 to 11,645 in 1999. Much of the increase is due to non-franchised single-decker buses. There are now many empty buses clogging the main business districts and adding to air pollution. The Government should require the private bus companies to monitor ridership to ensure that

[98] The report, untitled and unattributed, considered performance, power distribution, compatibility with other public transport systems, legislative requirements and comparative costs. It also evaluated the criteria for a trial scheme.

[99] The study recommended the first route to be tested should be Citybus's Route 98 (Lei Tung to Aberdeen) which could form the nucleus of a more extensive network in the Aberdeen area, such as Routes 48 and 95C, as well as New World's 78 and 95. Ibid

[100] Lyndon Rees, Citybus. Electric Trolley Buses for Hong Kong - It's Time. Presentation to CLEAR THE AIR Bus Forum, 13/3/99.

[101] In Southampton, UK, a number of parking signs have been installed providing advice to drivers on the location and availability of parking spaces within the city centre, controlled by a central processor which monitors the number of vehicles in each of the centre car parks. Results showed that average searching and queueing times were reduced by up to 50% with attendant reductions in emissions. Hampshire County Council, "Summary of Achievements of Thermie Project ENTRANCE", January 1998. www.hants.gov.uk/scrmxn/c23674.html.

[102] Stopwatch real time passenger information has improved the passenger bus service in Southampton, UK and increased patronage as a result of increased confidence in public transport.

routes are not oversupplied (indeed doing so is in the companies' financial interest).[103]

However, it is vital that Hong Kong people have access to regular, reliable and convenient bus or mass transit service so all monitoring must keep that goal paramount. Perhaps the better goal is to increase ridership. There are several options: 1) by making bus travel faster than taxi and car travel by dedicating street lanes in congested areas to mass transit, including buses; 2) by raising the price of all-day parking in business districts to encourage car drivers to choose mass transit instead; and 3) by requiring taxi passengers to pay a use surcharge for travelling in peak commuting areas and at peak times, again to make choosing mass transit more inviting.

Of course, buses must be compelled to use non-polluting fuels to achieve a key goal of mass transit: reducing air pollution.

Recommendation: Require private and public bus companies to monitor ridership on all routes to prevent oversupply. Encourage ITS development and implementation. Dedicate bus corridors in congested areas during peak traffic times. Use a variety of financial incentives to encourage use of mass transit over taxis and private vehicles.

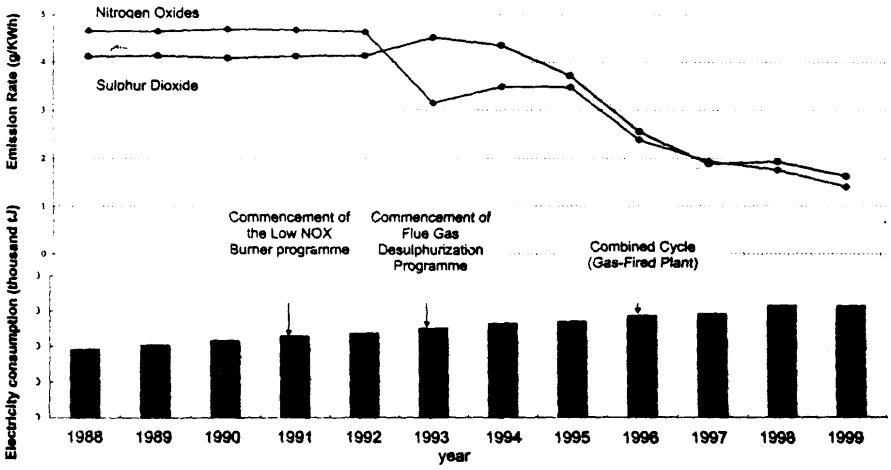
[103] They have cancelled 3 bus routes passing through Central and Admiralty, re-routed another 19 routes to avoid the congested roads, reduced the service frequencies on 6 routes and reorganised the bus stopping arrangements for more than 100 bus routes. Transport Bureau. Letter to Christine Loh, 18/1/00.

PART V: NON-VEHICULAR POLLUTION SOURCES

18. Power Station Emissions

Hong Kong has 4 power stations with an installed capacity of 12,070 MW. The main power stations at Castle Peak and Lamma Island are coal-fired while the new Black Point power station is gas-fired. Since 1991, power plants have been controlled as Specified Processes under the Air Pollution Control Ordinance. Their licences, issued by the EPD, require them to reduce emissions.[104] (see Appendix 4) Since then, NOx and SO_2 emissions per unit of electricity generated halved. The problem is that electricity consumption continues to increase so that the overall emissions from power stations have not been reduced.

Figure: NOx and SO_2 emissions related to electricity consumption[105]



Coal-fired Castle Peak and Lamma Island stations emit much higher levels of pollutants and these plants should be phased out. While Hong Kong explores how cleaner coal burning technologies can be applied in the short term, a great push is needed to adopt efficiency and conservation measures to reduce electricity demand, and in turn, emissions from power plants.

Hong Kong has barely begun to reap the economic and environmental benefits of increased

[104] EPD. *A Guidance Note on the Best Practicable Means for Electricity Works.* BPM 7/1. July 1992. The licence covers the design of chimneys, emission limits, fugitive emission controls, type of fuel, monitoring, commissioning and maintenance.
[105] Chart from EPD.

energy efficiency.[106] Its antiquated regulatory system make investment in efficiency less attractive than investment in generating capacity, which ultimately hampers competitiveness.[107] Utilities should be rewarded for the amount of energy savings they can make for consumers rather than how much capital they invest in, as is the case today. Lack of comprehensive energy efficiency legislation and standards also hinders adoption of the lowest cost energy options.

Considerable work has been done locally and internationally, identifying opportunities for energy savings. Hong Kong urgently needs an expert, dedicated Energy Authority to effectively regulate the power sector and create the financial incentives and regulations to facilitate the widespread adoption of efficiency/conservation measures. The creation of such an authority would allow for coordinated study and adoption of policies and technologies to maximise energy efficiency in all sectors of Hong Kong's economy.[108] The limited efficiency measures the Government has promoted to date have focussed primarily on the domestic sector, when it the commercial sector where energy conservation measures would have the greatest impact in reducing peak demand, thus, delaying the need for new generating capacity.

Fundamental changes are required in Hong Kong.[109] Laws and policies must be changed to allow small, clean power producers to feed into the power grid. Also while Hong Kong steps up energy rates to discourage consumption beyond a base amount, the difference in the price of "extra" energy is too small to be an incentive to conserve. Plainly, the rates for "extra" energy use must be raised substantially to encourage conservation, even simple conservation measures like retail establishments closing their doors to retain air conditioning inside.

Recommendation: Establish an Energy Authority with responsibility for overseeing utilities and energy policy. Set much higher rates for energy consumption beyond base levels in both domestic and commercial sectors to encourage conservation and reduce demand for new capacity.

19. Marine Vessels

Recent studies indicate that ships' exhaust emission may be responsible for up to 14% of the

[106] The Government spent HK$1 billion on electricity in 1997-98. The potential savings in electricity expenditure of police buildings alone amounts to $30 million a year. Director of Audit "*Management of electricity consumption by the Government*", report No. 31, October 1998.

[107] The Scheme of Control Agreement is the contract between the two power companies and the Government. It links the permitted returns (profits) to investment in fixed capital assets. The contract duration is 15 years and the current contract is due to expire in 2008.

[108] For example, one technology that has never been utilised in Hong Kong is District Heating and Cooling, in which waste heat is used for heating water and to produce chilled water for air conditioning. Compared to the overall efficiency of air conditioning powered by electricity that is 13%, DHC has an efficiency of 70%. This system is ideal for hospitals, hotels and large institutions which generate a lot of waste heat. The redevelopment of South East Kowloon also offers an opportunity to use DHC. Unfortunately the 'District Cooling' system planned for South East Kowloon uses conventional chiller units running on electricity with low efficiency. The Scheme of Control limits the potential for independent power producers, since the existing utilities are unwilling to accept power feeding into the grid. Hong Kong needs an Energy Authority to drive the legal and policy changes required to allow small, independent power producers to contribute to the grid.

[109] The Director of Audit recommended that the Government should develop a long-term energy policy strategy.

worldwide NOx and approximately 8% of SOx emissions.[110] This significant source of emissions requires control.

In Hong Kong, local and ocean-going marine vessels are estimated to account for about 11% of NOx emissions and 7% SOx emissions[111], the third major contributor of air pollutant emissions following power stations and vehicles. However, these estimates may understate the problem since they are extrapolated from international data, rather than monitoring here in Hong Kong. These emissions are likely to increase further since the Government aims to encourage growth in vessel calls to further raise Hong Kong's profile as a major international port and shipping centre.[112]

The Marine Department conducts periodic seaworthiness surveys[113] of licensed local commercial vessels and fishing vessels, which includes an engine running test.[114] However, Hong Kong has no emission standards for local marine vessels. International emission standards only apply to ships of 400 gross ton or above, although NOx limits exist (but are not yet in force internationally) for recently built, large-engines.[115] The international method of checking for NOx and SOx is to check the engine parameters and bunker record book respectively.

Even though harbour vessels use marked diesel oil that is 0.5% sulphur, and big ocean going vessels use bunker fuel that is from 3% to 3.59% sulphur,[116] since these fall below the proposed international marine sulphur limit,[117] the Marine Department is unwilling to reason to review the local standards. Officials believe that emissions from vessels can easily disperse in the open and because people are less likely to be affected, higher emissions can be tolerated.

The Marine Department's perfunctory attitude towards environmental protection is evidenced by its prosecution of merely 9 vessels for excessive smoke in the past three years. While the propulsion engines of marine vessels are less prone to overloading, which causes smoke, than vehicles on land vessels in Hong Kong waters daily belch thick black smoke. This is usually caused by poorly maintained engines and smoke from fast ferries rapid acceleration. Part of the problem is that Marine Department only has 20 patrol craft, which have other duties, and so depend largely on complaints from members of the public. The Secretary for Economic Services has stated that "*there have not been too many complaints and prosecutions, which makes me think that the problem is not really that serious*."[118]

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[110] ABS (1999), *Guidance Notes on the Prevention of Air Pollution from Ships*, American Bureau of Shipping, New York.

[111] Planning, Environment & Lands Bureau (1999), *Clean Air for Hong Kong*, http://www.pelb.gov.hk/cleanair.

[112] Hong Kong had 13,000 local vessels in 1999. In 1999 the arrivals of ocean-going vessels and river-trade vessels were 37,580 and 115,330 respectively, Marine Department, personal communication.

[113] Apart from the inspection of safety equipment and hull structure, engine-running tests are also conducted. In addition, the main engine and gearbox are required to be stripped down for inspection every 2-4 years, depending on class of vessel. Marine Department, personal communication.

[114] Under the Merchant Shipping (Launches and Ferry Vessels) Regulations and Merchant Shipping (Miscellaneous Craft) Regulations (Cap 313).

[115] The limit applies to engines constructed after January 1,2000, with an output of more than 130 KW.

[116] Marine Department, personal communication, 4/5/00. The Hong Kong Shipowners' Association figures are 1-3%, depending on the origin of the fuel oil.

[117] International regulations are being proposed to limit the maximum content to 4.5%. Annex VI of the Marpol 73/78 (Regulations for the Prevention of Air Pollution from Ships).

[118] Follow up response to Legco question. Legislative Council sitting 16/6/99.

The Secretary's comments underscore the real problem, that the Department only considers environmental protection a concern when the public complains, and not its duty to the public. It is the Department's responsibility to the public to establish marine emission standards and to enforce them. The MARPOL Convention[119] provides useful guidance for establishing marine emission standards and measures to abate marine exhaust emissions. Appendix 5 also summarises measures adopted in other countries to control marine emissions.

Nor must the Department rely solely on punitive measures to enforce emission standards. In Sweden, for example, fairway dues are reduced for ships with catalytic converters or that burn low sulphur fuel.[120] Moreover, the Department should explore requiring alternative, cleaner burning fuels in Hong Kong waters, such as ULSD or biodiesel, both of which can be used in current engines with modifications. As in the US and UK, ocean going vessels can be required to burn cleaner fuel when in local waters, and use the bunker fuel only when out at sea. The time is ripe for marine emission controls in Hong Kong. Already, responsible operators in Hong Kong, such as New World First Ferry, plan to eliminate excessive smoke during acceleration by using catamarans with computerised electronic engines that control the fuel injection more precisely.

Recommendation: (a) Marine Department should step up enforcement action again smoky vessels. (b) All Marine Department craft and public ferry areas should advertise a complaint telephone hotline for the public to encourage more reporting of smoky vessels. (c) The Marine Department should conduct a comprehensive review of technical, financial and legislative means to reduce emissions from vessels. (d) Monitoring of air pollution in ferry terminals, at container terminals and anchorages should be conducted by Marine Department to establish impacts of marine emissions.

20. Aircraft

Aircraft are a major source of air pollution. The principle emissions include the greenhouse gas carbon dioxide[121] and nitrogen oxides as well as sulphur oxides, soot, carbon monoxide and volatile organic carbons. It is projected that the global passenger air travel will grow by 5-6% per year between 1990 and 2015, and the total aviation fuel use by 3% per year over the same period. Global aviation emissions will consequently almost double over the next 15 years.

20.1 Means of control

(a) Aircraft and Engine Technology Options

Technology advances have improved aircraft fuel efficiency by 30-40% and hence reduced

[119] International Maritime Organization. *The Prevention of Air Pollution from ships*. Annex VI of MARPOL 73/78, 1998.

[120] Sweden levies shipping fairway and port dues according to ships' emission levels of nitrogen and sulphur oxides. The Swedish Maritime Administration will reimburse up to 40% fairway dues to ships with catalytic converters and will also reduce shipping dues for ships that consume fuel with a sulphur content of less than 0.5%. These incentive measures for ship owners have cut emissions of NOx and SOx from marine traffic at Swedish ports by 75%. Emission reductions can be certified in accordance with MARPOL standards, and issued an International Air Pollution Prevention (IAPP) Certificate. Sweden in addition has a NOx limit certification that must be renewed every three years.

[121] It is estimated that approximately 3.5% of global warming caused by greenhouse gas emissions can be attributed to aviation, and this is predicted to increase to 4-17% by 2050. Intergovernmental Panel on Climate Change, "Aviation and the Global Atmosphere", 1999

emissions per passenger-km.[122] Through engine and aircraft design improvement, a 20% improvement in fuel efficiency is projected by 2050, in relation to the aircraft produced today.[123] In the US, NASA is developing new engines that could reduce NOx by 70% by the middle of this century.[124] When a new aircraft type is registered in Hong Kong, the engine manufacturer needs to provide Civil Aviation Department with engine emission test data. CAD adopts International Civil Aviation Organisation standards.[125]

(b) Fuel Options

In Hong Kong and worldwide, aircraft use aviation fuel, known as Jet A-1, as a source of fuel. This has a maximum total sulphur content of 0.3%. Reducing the sulphur content of aviation fuel will reduce SOx emission and sulphate particle formation. In the long-term, the use of fossil fuel should be replaced by cleaner alternatives. As jet aircraft requires fuel with a high density, other fuel alternatives, such as hydrogen, may be viable in the long term.[126]

(c) Operational Options

Improvements in air traffic management and other operational procedures could reduce aviation fuel burn by between 8 and 18%. For example, improvement in air traffic management can help solve the problems of holding (aircraft flying in a fixed pattern waiting for permission to land), inefficient routings, and sub-optimal flight profiles, and hence reduce aviation fuel burn and consequently excess emissions.[127]

Other operational measures to reduce the amount of fuel burned per passenger-km, without impairing safety, include increasing load factors (carrying more passengers or freight on a given aircraft), eliminating non-essential weight, optimizing aircraft speed, limiting the use of auxiliary power (e.g. for heating, ventilation), and reducing excess taxiing.

(d) Regulatory and Economic Options

In pace with a rapid growth in the aviation industry, more stringent aircraft engine emissions regulations are essential. The International Civil Aviation Organizations has begun work to assess the need for standards for aircraft emissions at cruise altitude to complement the existing Landing and Take-off Cycle (LTO) standards for NOx and other emissions.[128]

At present, fuel used in international aviation is not normally taxed. The OECD estimates that a phased-in series of increases in aviation fuel charges, rising by 2-5% per year over a period of 10 years, will lower energy intensity at least 3.5% per year and thereby reduce CO2 emissions as much as 30% in 2020.

[122] OECD, 1997, http://www.globalpolicy.org/finance/alternat/aviation/at1_30.htm.
[123] ICPP(1999), *Aviation and the Global Atmosphere*, Intergovernmental Panel On Climate Change.
[124] Hozman D. *Plane Pollution.* Environmental Health Perspectives, Vol 105, No. 12, 1997
[125] Civil Aviation Department, personal communication.
[126] ICPP (1999), *Aviation and the Global Atmosphere,* Intergovernmental Panel On Climate Change.
[127] Civil Aviation Department, personal communication.
[128] Ibid.

Appendix 1: Main pollutants of health concern, sources and control[129]

Pollutant	Health Effect	Main sources	Exceeds health standards
Sulphur dioxide	Respiratory illness, reduced lung function; morbidity and mortality rates increase at higher levels	Power stations, diesel vehicles, marine vessels, fuel combustion, aircraft, cement plants, incinerators	No
Total Suspended Particulates (TSP)	Resirable fraction has effects on health	Diesel vehicles, road dust, power stations, marine vessels, fuel combustion, cement plants, aircraft, incinerators	Yes
Respirable Suspended Particulate (RSP)	Respiratory illness; reduced lung function; cancer risk; morbidity and mortality rates increase at higher levels	Diesel vehicles, power stations, marine vessels, fuel combustion, cement plants, incinerators, aircraft, soil erosion, transboundary air pollution	Yes
$PM_{2.5}$	The sub-fraction of RSP considered to be of greatest health concern.	Most combustion processes	Probably
Nitrogen Dioxide	Respiratory irritation; increased susceptibility to respiratory infection; lung development impairment	Power stations, diesel vehicles, marine vessels, fuel combustion, aircraft, cement plants, incinerators, transboundary air pollution	Yes
Carbon Monoxide	Impairment of coordination; deleterious to pregnant women and those with heart and circulatory conditions	Petrol and diesel vehicles, power stations, marine vessels, aircraft, industry	No
Photochemic a 1 oxidants (as ozone)	Eye irritation; cough; reduced athletic performance; possible chromosome damage	A secondary pollutant formed by photochemical reaction between NOx and VOCs	Yes
Lead	Affects cell and body processes; likely neuropsychological effects, particularly in children; likely effects on rates of incidence of hear attacks, strokes and hypertension	Leaded petrol industrial sources, paint	No
Volatile Organic Compounds (VOCs)	Eye and skin irritation, sneezing, coughing. Some are carcinogenic causing leukaemia	Evaporative and unburnt emissions from petrol and diesel vehicles, petrol terminals, cargo tanks and filling stations, dry-cleaners, paint works, printing works, landfill gases, natural sources	N/A

[129] Adapted from EPD

Appendix 2: Other Cleaner Fuels & Technologies to Reduce Pollution

(a) Biodiesel

Biodiesel is a fuel made from various vegetable oils, and sometimes mixed with regular diesel,[130] or with unleaded petrol as an octane booster. for unleaded petrol. Ethanol is commonly produced from grains. Biodiesel is a renewable resource since its carbon emissions from engine combustion are recycled by vegetation to produce more vegetable oils. Overall emissions are lower since its combustion produces no sulphur, although NOx emissions may be higher in some engines. Another drawback is that the emissions smell like fried food, although this effect can be minimized with addition of a catalytic converter, can be used to reduce smell and significantly reduce emissions. Finally it is also more expensive than regular diesel although biodiesel can be made from recycled restaurant waste cooking oil/grease.[131]

(b) Natural Gas

Natural gas or methane is a clean burning fossil fuel. Compressed Natural Gas (CNG) or Liquified Natural Gas (LNG) are both composed of methane, the only difference is the form in which the natural gas is in - compressed (under pressure) or liquefied (refrigerated). Because it's a liquid, a greater volume of LNG can be stored in a small space and is therefore more compact and suitable for longer journeys. However, it tends to be more expensive than CNG. Landfill gas (or methane) is also an option for use in vehicles.

The technology is mature. Worldwide over one million natural gas vehicles are in use, and have a long established record in Europe, Canada, New Zealand and Australia.

The Beijing Municipal Administration Commission has been given a mandate by the Beijing People's Municipal Government to develop and implement a plan to convert vehicle fleets from gasoline/diesel to natural gas (NGV program).[132] Planned vehicle conversions will require the construction of 100-200 NG stations in Beijing over the next few years. Beijing intends to convert its entire public fleet, consisting of 5,400 large buses, 10,000 microbuses and 60,000 taxis to alternative fuels over the next several years.

Natural gas can be used for light and heavy duty vehicles. However, as with LPG, it requires significant investment in new infrastructure, although the fuel itself is cheaper than standard diesel.

In terms of air quality benefits, natural gas results in a reduction in all pollutants, including carbon dioxide compared to standard diesel. Reductions of NOx and particulates compared to diesel heavy duty vehicles are 60% and 90% respectively. In warm climates, emissions of un-burnt methane would provide an additional source of hydrocarbon emissions.

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[130] In Germany and most of Europe, it is produced from rapeseed oil and is used in a mixture of 20% biodiesel to 80% fossil diesel (known as RME 20).

[131] Tax policy can lower biodeisel's relative price. Germany has a tax policy from 1 April 1999 resulting in biodiesel costing less than fossil diesel. One company in Hong Kong has proposed importing biodiesel from Germany for use in public light buses. Another company has proposed producing biodiesel from waste cooking oil and greasetrap waste.

[132] Bloomberg. Alternative Fuel Systems Inc. in cooperation with Hydro Quebec and Kraus Group Inc to expedite large-scale natural gas conversion project in Beijing. 8/2/99.

As with LPG, there are also safety concerns about storage and transportation. Currently the only source of natural gas in Hong Kong is that supplied to Black Point Power Station, although landfill gas could also be used. A LNG plant is due to be built in Shenzhen in 2003.

While the first conversions of diesel buses to CNG incurred some problems[133], the technology is still improving.[134] Compared to LPG, CNG is more expensive but LPG is not practical for larger vehicles. CNG is suitable for single decker buses but for double decker buses and heavy trucks travelling long distances LNG would be more appropriate.

(c) Reformulated gasoline

Reformulated gasoline was developed by the US Environmental Protection Agency (US EPA) in cooperation with the oil and engine manufacturing industries. It is a cleaner burning petrol which has lower amounts of certain compounds that contribute to air pollution. It does not evaporate as readily as conventional petrol and contains chemical oxygen additives, commonly known as oxygenates (e.g. ethanol and MTBE[135]). Under the Clean Air Act in the US, nine cities with the worst levels of ozone pollution are required to use reformulated gasoline although many cities use it voluntarily. It produces 15-17% more pollution than conventional petrol.[136]

It can be used in place of conventional petrol and is used in vehicles and marine engines.

(d) Electric vehicles (EVs) and Hybrid vehicles

EVs use electricity to drive motors. They have no emissions and are very quiet. Toyota' EVs use regenerative braking systems that retrieve electricity from the kinetic energy generated when the vehicle decelerates or brakes. Ford has developed electric vehicles equipped with nickel-hydride batteries that have a range of 100 miles.

The technology is still developing although over 100 European cities have signed a deal to buy electric vehicles. More expensive than standard vehicles, the main constraints are the range of the battery and the need for battery changing/recharging stations. Battery waste may also be a problem.

Hybrid vehicles are diesel or gasoline-electric vehicles, which can use either petrol or an electric motor. An onboard battery is charged by the conventional fuel engine as well as by the action of braking the car. Fuel efficiency is double and exhaust emissions are one-tenth that of typical petrol engineered vehicles.

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[133] According to the US General Accounting Office, CNG buses typically cost 15-25% more to purchase than diesel buses and maintenance is more costly. http://www.clevescene.com/issues/2000-01-27/news.html/printable_page.

[134] A trial in Southampton, UK of 16 first-generation CNG buses proved popular with passengers though fuel consumption and CO2 emissions were higher. This has been addressed in more recent innovations, including lightweight storage cylinders and fitting with catalysts. Hampshire County Council, "Summary of Achievements of Thermie Project ENTRANCE", January 1998. http://www.hants.gov.uk/scrmxn/c23674.html.

[135] MTBE has raised concern in the US because of potential contamination of groundwater. In Hong Kong MTBE is limited to no more than 10%. Typical levels in Hong Kong's Unleaded Petrol is less than 5%. EPD, personal communication.

[136] http://www.epa/gov/otaq/rfgboats.htm

The technology is recently developed nevertheless commercial vehicles on now on sale in Japan.[137] Gasoline-electric private vehicles and diesel-electric trucks/buses are both available. The fuel economy is boosted by 100%, and engine efficiency by 80%. Hybrid vehicles show a significant reduction in all pollutants compared to standard diesel and gasoline engines. Hybrid vehicles are well suited to Hong Kong since they are small, accident-safe and durable. They are not yet competitively priced but the Government could improve their pricing and promote these relatively non-polluting vehicles by waiving their first-time registration fee.

(e) Fuel Cells

Fuel cells work by taking hydrogen and oxygen and putting them through a chemical reaction to produce electricity and water. There is no combustion. They produce a supply of electricity to power an electric motor, with water coming out of the exhaust pipe. Since hydrogen is volatile and hard to handle, hydrogen is typically carried in the form of methanol. There are a number of prototypes but the technology is still developing into a commercial vehicle.

Toyota and Daimler Chrysler (who announced introduction by 2004 of its first model) have both developed private vehicles that run on a self-contained fuel cell. Vehicle prototypes are available but advances in hydrogen storage technologies are still needed. The most likely solution will be use of existing hydrocarbon fuels in the existing gasoline distribution network.

[137] Toyota has just launched a 2nd-generation Prius for the Japanese market, and will hit the US market next month, priced at round US$20,000. Sales to Europe will begin in September.

Appendix 3: Other Emission Control Technologies Available

Type of product	Name of product	Type of vehicle	Emissions reduction	Impacts on fuel efficiency	Method of installation	Cost (HK$)	Infrastructure, tax, legal requirements	Other remarks
Fuel Catalyst	Fitch Fuel Catalyst*	All petrol and diesel	RSP 16% NOx 11% SO2 95% CO 55% Black smoke 83% CO2 32%[138]	5-12% savings	Installed in line or pellets in petrol tank	580-870	No	Also results in reduced carbon build up, easier starting, reduced maintenance
Fuel Treatment (uses magnets to increase fuel combustion rate)	WB-1 (WuBin) Overflow High-Efficiency Fuel-Economizing Purifier	All petrol and diesel	RSP 80% NOx 66.1% CO 47.8% Black smoke 35.7% CO2 59.59%[139]	5-20% savings	Installed between filter of fuel tank output pipe and carburetor	~505	No	Can reduce carbon deposit in engine cylinder.
Fuel Treatment	GOLET, Purifier-Energizer	All petrol and diesel	RSP, NOx, CO, Black smoke, CO2:Reduces all by 50-83%[140]	5-20% savings, depending on vehicle condition	Installed on fuel oil pipeline	Cost: 1,000 Retaile price unknown	No	
Filter	Smoke-FilterTM	Diesel vehicles	Black smoke: 30% Reduces particulates[141]	No effect	Installed in exhaust pipe; re-fill water upon evaporation	~1200	No	

* Endorsed by overseas agency

[138] Source: tests at HK Polytechnic Institute; Australian Postal Authority; U.S. Air Force; State-run laboratory in Barcelona; Center for Research Emissions Research and Analysis (U.S. EPA recognized).
[139] Source: tests at China Environmental Research Institute; China's Environmental Protection Bureau.
[140] Source: tests at the Harbin Technical University Vehicle Studies Institute (?)
[141] Source: tests at the University of Hong Kong, Department of Mechanical Engineering

Appendix 4: Control of Power Station Emissions

Best Practicable Means (BPM) to control emissions from power stations

The BPM includes using solid fuel with a maximum sulphur content of 1% (by weight) and a liquid fuel with maximum sulphur content of 0.5%. The emission limits are such that coal-fired burners will need to install flue-gas desulphurisation to reduce SO2 emissions, electrostatic burners to reduce particulates and low-NOx burners to reduce NOx.[142] However, retrofitting pre-1991 units with FGD or low-NOx burners is not always possible, so in some cases the power companies have been advised to shift the load to the more efficient burners.[143]

Table: Permitted maximum emission limits for NOX and SO2 specified in power station license conditions compared with actual emissions in 1998.[144]

Power Station	NOx Maximum emissions limit (kg/h)	SO2 Maximum limit emissions (kg/h)	NOx actual emission (1998) (tonnes)	SO2 actual emission (1998) (tonnes)
Castle Peak	2 880 (A1-A8) 250 (A23, A24) 5 650 (B1-B4)	2 600 (A1-!8) 200 (A23, A24) 5 060 (B1-B4)	Data not available	
Black Point	170 (gas-firing) 290 (distillate)	9.1 (gas-firing) 210 (distillate)	Data not available	
Lamma	861 (1-3) 1 120 (4,5) 616 (6)	1 330 (1,2) 1 351 (3) 1 778 (4,5) 1 77.8 (6)	14 434	23 233
Penny's Bay	195 (P1-3)	360 (P1-3)	Data not available	

[142] Lamma Power Station currently has 6 units with electrostatic precipitators and one with FGD; and Castle Peak Power Station has 8 units with electrostatic precipitators.

[143] EPD, personal communication.

[144] Data from EPD licence conditions and Hong Kong Electric Company.

Appendix 5: Technical Measures to Control NOx and SO2 from Marine Vessels.

NOx Control

NOx in exhaust gas can be reduced in two ways. First, by design or operation changes to engine combustion process, such as the use of low NOx injectors, retarding injection timing and temperature control of the change air, which, depending on the type of engine and method used, can reduce emissions from 10% to more than 50%.[145]

Second, NOx emissions can be lowered without changing engine performance by improving fuel uptake and use. Options available, provided by the American Bureau of Shipping, include:

Exhaust Gas Recirculation (ERG)
A percentage of the exhaust gas is fed back into the inlet manifold resulting in reductions in NOx concentrations of the order of 50% for as little as 15% ERG utilization;

Fuel/Water Emulsion
The addition of fresh water to fuel and subsequent emulsification prior to injection into the engine can give reductions of produced NOx of up to 10% for each 10% of added water, up to a maximum of 50%;

Water Injection
As an alternative to fuel/water emulsion, fresh water can be directly injected into the engine giving reductions of produced NOx similar to that expected from the use of fuel/water emulsion with typical reported reduction of 20-50%;

Humid Air Motor (HAM) Technique
This is a method that reduces the produced NOx by humidifying the inlet air prior to its entry into the combustion chamber and reductions of the order of 50-80% have been recorded;

Selective Catalytic Reduction (SCR)
This is the most efficient method for NOx control, giving reductions in produced NOx of 80-95% when using injected area as a catalyst. Unlike the other options, this system is an after-treatment device, being totally dependent of the combustion process and hence potentially suitable for retrofitting to any existing engine.

SOx Control

Primary Control
Switching to low-sulphur bunker fuel improves engine combustion and reduces Sox emissions. The international maritime convention, the MARPOL, states at Annex VI, that a majority of ships will soon use fuel oil with a 1.5% m/m maximum sulphur content. Sweden is even more stringent and requires that fuel contain less than 0.5% sulphur by weight for passenger and railway ferry, and less than 1.0% by weight or less for cargo ships;

Secondary Control
This refers to some forms of exhaust gas cleaning system, such as exhaust gas scrubbing, which operate in a similar manner to those fitted as part of inert gas system.

[145] MAN B&W (1996), Emission Control: Two-Stroke Low Speed Diesel Engines, MAN B&W Diesel A/S; and IMO (1998), Annex VI of MARPOL 73/78, International Maritime Organization, London.

Table: Comparison of international control measures for marine emissions

Sweden	United States	MARPOL Annex VI
Marine emission standards	Marine emission Standards	Marine emission limits and regulations
Environmental differentiated fairway and port dues	Labelling system, based on exhaust emission level from marine vessels	Certificate system, based on the International Air Pollution Prevention (IAPP) Certificate
Financial reward for the installation of catalytic converters	Certificate system, based on the International Air Pollution Prevention (IAPP) Certificate	Continuous monitoring of emission and engine performance onboard
NOx Reduction Certificate stating the rebate level for which a particular ship has qualified	Annual, intermediate and renewal surveys and testing to ensure a continuous compliance with the regulations	Use of low-sulphur fuel
Unscheduled random controls, inspections and surveys to monitor the engines and emissions performance	Use of low-sulphur bunker fuel	Installation of exhaust gas scrubber
Use of low-sulphur bunker fuel	Installation of exhaust gas scrubber	Engine design and operational modification
Exhaust gas scrubbing	Modification of basic engine design, such as the use of low NOx injectors	Better maintenance of ship engine
Use of catalytic converters to reduce NOx emission	Operational modification, such as ignition retarded	Water Injection
Water injection into the combustion chamber for reducing NOx	Water Injections, such as Water/Fuel Emulsion and Combustion Air Humidification	Exhaust Gas Recirculation (EGR)
Humid Air Motor (HAM) techniques for achieving NOx reduction	Exhaust Gas Recirculation (EGR)	Selective Catalytic Reduction (SCR)
Improved combustion control, with development of fuel-injection engine control system	Selective Catalytic Reduction (SCR)	
Alternative fuels, with additives and mixing components		
Use of environmentally friendly engine		