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CLEANER
VEHICLES & FUELS
THE WAY FORWARD

思匯 CIVIC EXCHANGE

THE ASIA FOUNDATION
亞 洲 基 金 會

GLOSSARY

AC:	alternating current
AQOs	Air Quality Objectives
BEV	Battery Electric Vehicle
CH_4	Methane
CLP:	China Light &Power
CNG:	Compressed Natural Gas
CO:	Carbon monoxide
CO_2:	Carbon dioxide
CRT:	Continuous RegenerativeTrap
DC:	Direct current
DOC:	Diesel Oxidation Catalyst
EFB	Environment & Food Bureau
ESB	Economic Services Bureau
EMSD:	Electrical & Mechanical Services Dept
EPD:	Environmental Protection Dept
EU	European Union
FB	Finance Bureau
FCV:	Fuel Cell Vehicle
FRT	First Registration Tax
FSD	Fire Services Department
GDI	Gasoline Direct Injection
GHG	Greenhouse Gas
GM	General Motors
GPS	Global Positioning System
HEV	Hybrid Electric Vehicle
HGV	Heavy Goods Vehicle
HKE	Hong Kong Electric
HKIVE	Hong Kong Institute of Vocational Education
HSU	Hartridge Smoke Units
ICE	Internal Combustion Engine
IRD	Inland Revenue Department
ITS	Intelligent Transport Systems
Km	Kilometre
KV	Kilo-volt
L	Litre
LFG	Landfill gas
LNG	Liquefied natural gas
LGV	Light Goods Vehicle
LPG	Liquefied petroleum gas
MGV	Medium Goods Vehicle
NG	Natural gas
NGO	Non Government Organisation
NGV	Natural gas vehicle
Ni-Cd	Nickel Cadmium (battery)
Ni-MH	Nickel Metal Hydride (battery)
NOx	Oxides of nitrogen
N_2O	Nitrous oxide
PLB	Planning & Lands Bureau
PLB	Public Light Bus
RSP	Respirable Suspended Particulates
SOx	Oxides of sulphur
TB	Transport Bureau
TD	Transport Department
THC	Total hydrocarbons
ULSD	Ultra low sulphur diesel
ULSP	Ultra low sulphur petrol
V	Volts
VOC	Volatile organic compounds

THE PROBLEM

- Air quality in Hong Kong has deteriorated significantly. Road based vehicles are the primary cause of street level pollution, producing smoke, particulates and chemicals in quantities that regularly exceed health standards.

THE SOLUTION

- To help achieve acceptable air quality and reduce road transport related pollution, Hong Kong needs to design an effective, overarching and long-term strategy for introducing cleaner fuels and vehicles.

THE PROCESS

- Although Government has introduced some useful measures, the public sector is just one of the many stakeholders affected by the problem and involved in the solution. All stakeholders from the public, private and civil sectors must be involved in reaching consensus on a way forward. There must be a concurrence of opinion and a network of partnerships to ensure that a comprehensive strategy can be developed and effective action taken.

THE INITIATIVE

- Civic Exchange and The Asia Foundation, with support from Lee Hysan Foundation, have taken the initiative to design and guide the consensus-building process. Three steps have been taken thus far: an international literature review; meetings with stakeholders from the transport community; and a Cleaner Vehicles & Fuels Workshop.

THE RESULTS

- On May 18 2001, the Cleaner Vehicles & Fuels Workshop convened over 90 participants from a wide range of sectors who worked together to gather ideas and to reach consensus on how to improve vehicle emissions. They developed Action Plans in 5 specific areas:

  - New technologies: Hong Kong should develop and implement short-term, intermediate and long-term policies that remove the barriers to the introduction of all cleaner vehicles and fuels, with the ultimate goal of achieving zero emissions from transportation, probably by means of hydrogen-powered fuel cell vehicles.
  - Regulation and planning: Hong Kong should create an overarching government department or Energy Commission to coordinate and unify responsibility for energy policy, currently fragmented over several agencies, and to develop a cleaner vehicles and fuels infrastructure.
  - Incentives: Hong Kong must adopt performance-based incentives to promote the cleanest vehicles and to develop the supply, storage and delivery of cleaner fuels.
  - Education and training: Hong Kong must develop an integrated education and training strategy that targets drivers, the public and the local media.
  - Infrastructure and research & development: Hong Kong must promote effective leadership in research and development. By forming partnerships among the public, private, civil and academic sectors, Hong Kong can become a regional center for research and development of cleaner vehicles and fuels for the benefit of itself, mainland China and all of Asia.

INTRODUCTION

Air quality in Hong Kong has deteriorated significantly in recent years. Health standards are regularly exceeded and visibility has noticeably worsened. Much of Hong Kong's air pollution is generated by road based vehicles. Which of us has not seen a smoke-belching bus, put hand or handkerchief over mouth and nose, or felt chest tighten and eyes water?

Government has introduced a number of useful measures to reduce emissions. It has tightened standards and required testing. It has introduced cleaner fuels for taxis and provided subsidies for retrofit devices. However, to achieve acceptable air quality and reduce emissions that cause road transport related pollution, Hong Kong needs an effective long-term strategy for introducing cleaner fuels and vehicles.

In recent years, other countries have reduced air pollution levels by promoting cleaner technologies that control or eliminate internal combustion emissions. But these technologies need to be reviewed in terms of efficacy, vehicle performance, safety, cost, availability and applicability to Hong Kong's particular context. A practical strategy needs to be developed that is acceptable to all the various stakeholders, from government leaders and politicians to transport operators, from oil and fuel companies to environmental organizations, from academic researchers to vehicle manufacturers. Inviting the constructive engagement of all these diverse constituencies and achieving consensus on the way forward are the keys to defining an effective action plan.

The Asia Foundation[1] and Civic Exchange[2] have taken the initiative to guide and coordinate this project. To date, three important steps have been taken.

- First, Civic Exchange conducted a review of the international literature on alternative technologies in development or in operation, including: cleaner diesel and petrol, LPG, biofuels, natural gas, battery electric, trolleybuses, hybrid and fuel cell vehicles. Civic Exchange reviewed each technology for its effectiveness in reducing polluting and greenhouse gas emissions, costs, safety aspects, vehicle performance, infrastructure requirements, status worldwide and availability and applicability to Hong Kong. (See Appendix 1 for results.)

- Second, to ascertain current and future limitations to introducing these alternative technologies to Hong Kong, Civic Exchange met with some 60 stakeholders from the transport community including: bus companies, transport operators and associations, government, vehicle suppliers and manufacturers, oil companies, academics, public interest and green groups and proponents of alternative technologies.

- Third, on May 18, 2001 Civic Exchange and The Asia Foundation held a Cleaner Vehicles & Fuels Workshop. Some 90 stakeholders with different interests in the road transport industry attended. The purpose of this bilingual workshop was to bring together a cross-section of the transportation community in Hong Kong, as well as international experts, to gather ideas and begin discussions on how to reduce vehicle emissions in Hong Kong. The Workshop exposed its participants to a range of different perspectives, encouraged frank discussion of the issues and impediments, achieved consensus on a variety of topics and generated a series of Action Plans. The Workshop proved to be a unique example of how the public, private and civil sectors can work together to design an effective way forward.

CLEANER VEHICLES AND FUELS

THE WAY FORWARD

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August 2001

CLEANER VEHICLES & FUELS

THE WAY FORWARD

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1 EXECUTIVE SUMMARY

Vehicles are the primary cause of street level pollution in Hong Kong. To reduce transport related pollution and improve roadside air quality Hong Kong needs to design an effective strategy for introducing cleaner fuels and vehicles. Civic Exchange, in partnership with The Asia Foundation has conducted a 7-month study on cleaner fuels and vehicles to try and build consensus on an effective way forward. This involved an international literature review, meetings with stakeholders from the transport community and a multi-stakeholder workshop on 18 May 2001.

The cleaner technologies reviewed included cleaner diesel and retrofit technologies, cleaner petrol, Liquefied Petroleum Gas, ethanol, biodiesel, battery electric vehicles, hybrid vehicles, trolley buses, natural gas and fuel cell vehicles. Some of these are near-term solutions while others are still in the development stage. The pros and cons of each technology were reviewed in terms of effectiveness in reducing polluting and greenhouse gas emissions, costs, safety aspects, vehicle performance, infrastructure requirements, status worldwide and applicability to Hong Kong. Many of these technologies are being used, tested or considered in Hong Kong. In very broad terms, the cleaner the technology, the higher the direct cost, although this does not take into account the avoided health and social costs of pollution. Sound policy making should include these avoided costs to give the full picture.

At the Cleaner Vehicles & Fuels Workshop over 90 participants from a wide range of sectors gathered ideas and developed action plans on how Hong Kong can reduce vehicle emissions. The recommendations can be grouped into 5 categories: New Technologies; Regulation and Planning; Incentives; Education and Training; and Infrastructure and Research & Development.

The workshop participants believed that Hong Kong needed to develop and implement short and long-term policies for the introduction of cleaner vehicles and fuels. It was agreed that Hong Kong should not just pursue a single technology but open itself to competing low emission technologies to capture maximum benefits. The ultimate goal should be zero emissions from transportation, probably by means of hydrogen-powered fuel cell vehicles, and intermediate enabling technologies should be encouraged. Hong Kong should position itself to become a leader in cleaner transport technologies but it can only do so if competing technologies are encouraged.

The workshop participants identified the top priority regulatory action as the creation of an overarching government body, such as an energy commission, which would coordinate and unify responsibility for energy policy, currently fragmented over several agencies. Closely linked to this is the development of cleaner vehicle and fuel infrastructure. Hong Kong must ensure ample supply and storage of cleaner fuels, especially those enabling technologies such as natural gas. Any infrastructure investments must have built in flexibility to ensure their future usefulness. The Energy Commission should also oversee research and development. With sufficient funding Hong Kong can become a centre for research and development of cleaner vehicles and fuels, by forming partnerships with the private sector and academics.

Government decisions profoundly affect the price of vehicles and fuels, and cleaner vehicles technologies have been effective in other parts of the world only through the introduction of government incentives or mandates. The workshop participants agreed that those vehicles with the best environmental performance, irrespective of age, type or model, should receive the best fiscal incentives.

Lastly, education and training is key to developing support for a cleaner vehicle and fuel industry. Proper training and certification of Hong Kong's repair mechanics is a key initiative, which must be coupled with life long training to keep up with evolving technology changes, and public support for their important role. An integrated awareness strategy needs to be developed that targets drivers, the public and the local media, without which long-term consumer pressure to stimulate change will be compromised.

There is an urgent need to involve stakeholders in the policy making process on cleaner vehicles because they have the experience and insights to share as well as legitimate interests and concerns. The detailed Action Plans contained in this report were developed during a one day workshop, indicating that it is possible to achieve a useful and productive outcome in a relatively short time. This report is an important first step toward achieving a consensus on the way forward.

2 SCOPE OF THE PROBLEM AND CURRENT CONTROLS

2.1 AIR POLLUTION IN HONG KONG

Depending on the time of year, roughly 50% of Hong Kong's poor air stems directly from pollutants generated in Hong Kong – primarily from vehicles. Roadside concentrations of Respirable Suspended Particulates (RSP)[3] and oxides of nitrogen (NOx)[4] regularly exceed health standards known as Air Quality Objectives (AQOs)[5]. The 24-hour AQOs were exceeded 93 times in 1999 alone. There is also a growing regional ozone[6] problem with a 50% increase in levels since 1990. Recent studies have shown NO_2, RSP and ozone all increase the risk of mortality, cardiovascular and/or respiratory cases in Hong Kong. These studies support the common sense conclusion that Hong Kong must reduce the levels of these pollutants in ambient air.[7]

In Hong Kong, road based vehicles account for 47% of RSP, 87% of Volatile Organic Compounds (VOCs)[8] and 32% of NOx emitted by all sources. Diesel and petrol vehicles are the primary cause of street level pollution.[9] Diesel vehicles account for nearly 98% of RSP and 80% of nitrogen dioxide (NO_2) from diesel and petrol vehicles combined. The main vehicle types responsible for the majority of emissions of RSP, NOx and VOCs are shown in Figure 1.

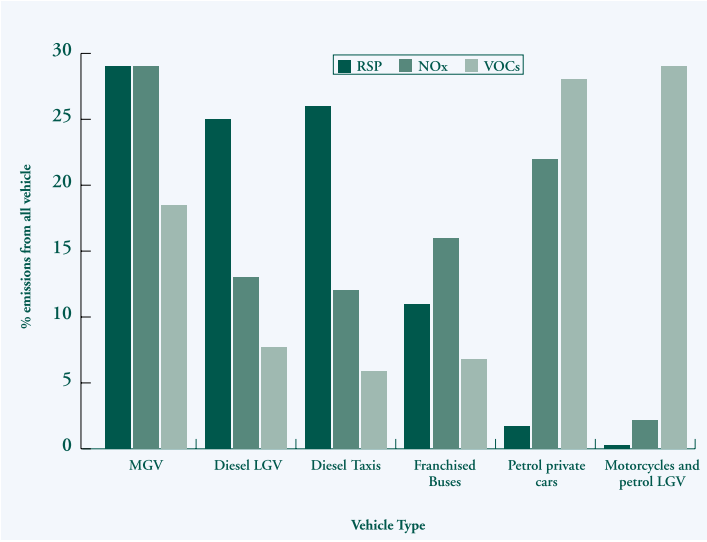


Figure 1: Percentage emissions of pollutants from different vehicle types in urban areas in 1997.[10]

The Government estimates that Hong Kong should be able to meet its current AQOs by 2005, assuming no increase in ambient, regional air pollution levels and no increase in vehicles. Both assumptions are unrealistic. Trends suggest that cross-border pollution is increasing.[11] Moreover, the number of vehicles is on the rise. Under Transport Department's high growth scenario, by 2016, private cars could increase by 300%, goods vehicles by 100% and cross-boundary traffic by 400%. Under this scenario, all monitoring stations will report much worse air quality due simply to the increase in vehicle numbers.[12] Even under a low growth scenario, there will continue to be non-compliance with the AQOs, and daily average concentrations of RSP will increase at all locations.[13]

2.2 GREENHOUSE GAS EMISSIONS

Several greenhouse gases (GHGs) contribute to global climate change. Road vehicles emit carbon dioxide (CO_2) as well as two other important GHGs, methane (CH_4) and nitrous oxide (N_2O).[14]

The transport sector in Hong Kong consumes more energy than any other single sector, and over twice that of industry. In 1998, the latest figures available, transport accounted for 36% of primary energy consumed in Hong Kong.[15] Diesel oil accounts for nearly a quarter of the total annual emissions of CO_2 although this does not include illegal or untaxed sources of diesel which could be significant.[16] With a doubling of the vehicle fleet predicted by 2016 (the Transport Department's worst case scenario), CO_2 emissions will rise accordingly unless there is a dramatic increase in vehicle fuel efficiency.

In line with the December 1997 Kyoto Climate Change Convention, many developed countries are now considering strategies to reduce emissions of greenhouse gases. For example, the European Commission aims to reduce CO_2 emissions from new cars sold in the European Union to an average of 120g/km, a reduction of about a third from the current average, through voluntary commitments by European vehicle manufacturers, fiscal measures and fuel economy labelling.

Hong Kong's per capita emissions of greenhouse gases are low compared to many developed countries, probably due to short commuting distances, a low percentage of car ownership and a well-developed mass transport system.[17] Hong Kong currently has no policy to reduce GHGs, but this is likely to change.[18] Because of the global impact of GHGs, it makes no sense to reduce tailpipe emissions of GHGs without addressing upstream emissions. Any strategy to reduce GHGs from vehicles must take into account the entire GHG lifecycle from well to wheels. This includes emissions during production, processing and distribution of fuel, and vehicle manufacture and operation, even if these processes occur outside Hong Kong.

2.3 CURRENT CONTROLS

In 1999, Chief Executive Tung Chee Hwa announced a number of measures to reduce vehicular pollution, including changing taxis from diesel to LPG, and allocated HK$1.4 billion to achieve these measures. Government's current control program for vehicle emissions comprises:

- Tighter fuel and emission standards. Hong Kong adopts European (Euro) engine standards, and newly registered vehicles in Hong Kong must meet Euro 3 (or 2 in some cases) standards.
- Introduction of cleaner fuels such as liquefied petroleum gas (LPG) for taxis and Ultra Low Sulphur Diesel (ULSD).
- Provision of subsidies for in-use light duty diesel vehicles (less than 4 tonnes) retrofit devices to reduce particulate emissions and for the purchase of new LPG taxis.
- Annual emission tests for in-use vehicles. Transport Department (TD) tests the smoke density of 10% of in-use vehicles on a random basis as part of its annual licensing, using a free acceleration test. TD has one chassis dynamometer for light and heavy goods vehicles. TD also tests LPG taxis for carbon monoxide (CO) and hydrocarbons and commercial petrol vehicles for CO and smoke as part of their annual license renewal. Private cars over 6 years old must undergo an annual inspection which includes an emissions check.

- Random emission tests. Vehicles emitting excessive (over 60 HSU) black smoke, if caught by the police, are subject to a $1000 fine. If spotted by an EPD spotter, the vehicle is summoned for testing. Chassis dynamometers have been used to test vehicles below 5.5 tonnes and were extended to heavy duty vehicles in December 2000. These provide a more accurate measure of emissions over the whole driving cycle than a simple acceleration test.

These current measures to control air pollution are important first steps. Traffic and demand management are also obvious considerations, which Government must address. But reversing present trends and effectively reducing vehicular pollution will require a comprehensive strategy including:

1. Proper maintenance of in-use vehicles.
2. Introduction of cleaner vehicle and fuel technologies.
3. Increasingly stringent emissions standards for new vehicles.

3 ALTERNATIVE CLEANER TECHNOLOGIES

Table 1 provides a summary of the relative merits of various cleaner vehicles and fuels technologies. Read from left to right, the table documents technologies from those that are currently available to fuel cells, which may not be available for 10-15 years. (See Appendix 1 for detailed information on the various technologies and Appendices 2-4 for a more detailed comparison of their benefits and limitations.) The table shows that in general, the cleaner the technology, the higher its cost, although that cost does not take into account the health and social costs of pollution.

Table 1: Summary matrix comparing different cleaner vehicle technologies

	ULSD	Diesel Retrofit techno logies	Water blend diesel	Cleaner petrol	LPG	Ethanol	Biodiesel	Battery Electric	Hybrid	Trolley bus	Natural gas	Fuel Cell Vehicles
Applicability	All diesel vehicles	All diesel vehicles	All diesel vehicles	All diesel vehicles	Cars, minibus, LGV	All petrol vehicles	All diesel vehicles	Cars, minibus, LGV	Cars, minibus, LGV, SD bus	SD and DD buses	All vehicles	All vehicles
Effect on RSP	●	O	O	OO	OO	OO	OO	OOO	OO	OOO	OO	OOO
Effect on NOx	●	●	O	O	OO	●	●	OOO	OO	OOO	OO	OOO
Effect on VOCs	O	O	O	O	OO	O	O	OOO	OO	OOO	OO	OOO
Lifecycle green house gases	●	●	●	●	OO	●	OO	OO*	OOO	OO*	OO	OO*
Costs -vehicle -fuel	N/A $	$ N/A	N/A $	N/A $	$ $	N/A $	N/A $$	$$ $	$$ $	$$ $	$ $	$$$ $$$
Infrastructure costs	N/A	N/A	$	N/A	$$	$	$	$	N/A	$$($)	$$	$$$
Safety	C, F	–	C	F	F, E	–	–	–	Depends on ICE	–	F, E	Depends on ICE

* *highly dependent on how electricity or hydrogen is generated - can be higher or lower depending*

Key: • little or no reduction; O some reduction; OO good reduction; OOO significant reduction T = toxic C = carcinogenic E = explosive F = flammable ICE = Internal Combustion Engine; N/A = not applicable; $ economical ; $$ more expensive; $$$ most expensive

LGV = light goods vehicles SD = single decker DD = double decker ULSD = ultra low sulphur diesel

To assess the applicability of each technology in Hong Kong, we must better understand the nature of each alternative, its current status and any barriers to implementation.

3.1 CLEANER DIESEL & RETROFIT TECHNOLOGIES

What is cleaner diesel?

Over the years, improvements in diesel engine[19] and fuel standards have reduced polluting emissions significantly. In Hong Kong, Euro 3 has been the emission standard for light duty vehicles since January 2001, and Euro 3 will also be adopted for heavier vehicles by October 2001.

Cleaner diesel fuels include Ultra Low Sulphur Diesel (ULSD), water-blend diesel and synthetic diesels. ULSD has a lower sulphur content (less than 50ppm or 0.005%) than regular diesel, and will be required for even the cleanest engines to comply with future Euro 4 standards. ULSD allows the use of diesel catalytic converters to reduce emissions further.

Emulsified water-blend diesels containing up to 20% water also reduce emissions of NOx and particulates. They can be used directly in a diesel engine. A synthetic diesel fuel, Fischer-Tropsch (F-T) diesel, produced from natural gas, coal or biomass, also boasts a very low sulphur and aromatic content.

What are cleaner diesel retrofit technologies?

Diesel retrofit technologies are devices that can be fitted to existing diesel vehicles. These include particulate traps, diesel oxidation catalysts (DOCs) and NOx reduction devices.

Diesel particulate traps reduce emissions by filtering particulates from the exhaust stream. The collected particulates must be burnt or washed off. A more sophisticated particulate trap is the Continuous Regenerative Trap (CRT) which continuously oxidizes diesel soot particles to CO_2, thus regenerating the filter. Diesel oxidation catalysts (DOCs) oxidize waste gases like carbon monoxide and gaseous and liquid hydrocarbons that are adsorbed onto carbon particles into CO_2 and water.

However, none of these retrofit technologies reduce NOx significantly. Only NOx control retrofit technologies, such as the NOx storage catalyst, will enable diesel vehicles to meet Euro 4 NOx standards. Other promising technologies are not yet commercial.[20]

Current status

ULSD was introduced in Hong Kong with a concessionary duty in July 2000. It is now the only diesel available at filling stations. The Environmental Protection Department is considering introducing diesel with an even lower sulphur content (<10ppm) at some point.[21]

The Government has also offered subsidies of HK$1,300 for particulate traps and DOCs retrofitted onto older light duty diesel vehicles, although in the case of the former, taxi drivers in Hong Kong have had trouble finding legal, safe disposal sites for the waste water that results from washing the traps. Government is also considering a similar scheme for medium and heavy-duty diesel vehicles once a suitable DOC has been selected. Other diesel fuels or retrofit technologies under trial include a water-diesel blend and CRTs for franchised buses. The bus companies have committed to buying CRTs for their pre-Euro 2 fleets.

Barriers to implementation

The chief barrier to widespread use of ULSD is competition from cheaper, higher sulphur diesel, including diesel from mainland China and local industrial diesel. Cross border vehicles continue to use high sulphur diesel due to the much lower costs. (The exception is Guangzhou, which mandates the sale of low sulphur diesel within the city boundaries.) Industrial diesel, which has a higher sulphur content, is also widely used: illegally for mobile vehicles and legally for stationary vehicles such as those at construction sites. The former is an enforcement problem, the latter could be solved by harmonizing the standards between vehicular and industrial diesel.

Cost is the prinicipal barrier to installing DOCs for medium and heavy goods vehicles. The larger the vehicle, the larger and costlier the DOC required and the higher the subsidy. Maintenance is also a key constraint for all diesel technologies, since even Euro 3 engines will deteriorate if not maintained properly.

3.2 CLEANER PETROL

What is cleaner petrol?

Cleaner petrol generally describes petrol with lower levels of sulphur (less than 50ppm) and carcinogenic aromatics (less than 35%) or petrol which contains oxygenates,[22] high octane additives that reduce aromatics and carbon monoxide emissions. The benefits of cleaner petrol are magnified with advanced technologies, such as Gasoline Direct Injection (GDI) engines and NOx storage traps.

Current status

In Hong Kong, most private passenger vehicles and motorcycles and some light goods vehicles are petrol-driven. Since 1992, all new petrol cars must have a catalytic converter. Since 2000, petrol cars over 6 years old must have an annual emissions test, in part to detect possible deterioration or damage to the catalytic converter. While not the main target of Government emission controls, petrol vehicles are the single biggest vehicular source of VOCs. (See Figure 1.)

The petrol currently available in Hong Kong is equivalent to Euro 3 standards (150ppm sulphur, 42% aromatics). In Europe Ultra Low Sulphur Petrol (ULSP) with only 50ppm sulphur is now widely available, and many countries offer a concessionary duty to encourage its use. Cleaner petrol improves the useful life and efficacy of the catalytic converter and also facilitates the adoption of fuel economy measures such as GDI.

Barriers to implementation

There is no source of ULSP in Hong Kong and no Government policy to introduce it before the EC officially introduces it in 2005.

3.3 LIQUEFIED PETROLEUM GAS (LPG)

What is LPG?

LPG is a mixture of propane (C_3H_8) and butane (C_4H_{10}). Auto-LPG in Hong Kong contains 20-30% propane and 70-80% butane; the same as that used for domestic purposes. LPG is extracted from natural gas directly or as a by-product of oil refining. It is a gas at ambient temperature and pressure but is stored as a liquid under moderate pressure (4-12 bar) in a closed system, so no fuel vapors are vented during filling or operation. It can be used in most vehicle types either in dedicated models or bi-fuel engines, although the latter are not permitted in Hong Kong.

Current status

Since the beginning of 2001, all new taxis are required to operate on LPG, and by 2006 all taxis will run on LPG. As incentives to use LPG, Government has subsidized the purchase of new taxis, adopted concessionary duties for LPG and waived the land premium for new LPG filling stations. Government has just completed a trial of LPG minibuses and is considering the feasibility of extending the use of LPG to light goods vehicles.

Barriers to implementation

Presently, there is a shortage of reasonably convenient LPG filling stations, but with new construction now underway, there should be sufficient LPG filling stations to service all taxis and public light buses (PLBs). More stations will be required if Hong Kong's light goods vehicles also convert to LPG. One considerable barrier is that the Tsing Yi bulk storage facility lacks sufficient capacity to supply all of Hong Kong's taxis and PLBs, and developing a new storage site is a lengthy and costly process. Finally, expanding LPG use means that Hong Kong must examine the safety risks of more bulk LPG tankers travelling through the urban areas.

3.4 ETHANOL

What is ethanol?

Ethanol (CH_3CH_2OH) is a liquid, biodegradable fuel produced from corn, barley or wheat which is fermented and distilled into a pure (200 proof) product. It has a higher octane rating than petrol but a lower cetane rating than diesel. It is generally used as a blend with petrol to boost octane and reduce pollutant emissions, and in the US is known as E-85 and E-10 (respectively 85% and 10% denatured ethanol). The use of additives has also enabled the development of ethanol-diesel blends (10% or 15% ethanol).[23]

Current status

There is no current supply of ethanol blend fuels in Hong Kong, although one local company is looking at the feasibility of importing a diesel-ethanol blend from the US.

Barriers to implementation

To switch the existing petrol fuelling and distribution infrastructure to E-85 would require extensive changes and investments. A change to E-10 would be relatively simple, but before changing to ethanol, Hong Kong must study its impact on vehicle performance and emissions, especially its potential to increase ozone production.

3.5 BIODIESEL

What is biodiesel?

Biodiesel is a liquid, biodegradable fuel made from the transformation of virgin vegetable oils (such as soy and rapeseed), animal fats or even recycled restaurant cooking oils. It has similar physical properties and engine performance to petroleum diesel. It can be used as a fuel directly in diesel engines or mixed with diesel (usually 20% biodiesel).

Current status

An independent trial of various biodiesel types and blends is currently being undertaken by the University of Hong Kong. Four companies are currently trying or intending to market biodiesel in Hong Kong, one using imported rapeseed-based biodiesel from Germany and three using waste vegetable oil as feedstock.

Barriers to implementation

Government has not sanctioned the use of biodiesel. It is considering adopting the European biodiesel standard, which will help to ensure the quality of biodiesel once it becomes available. If permitted by the Government, biodiesel may require significant investments in infrastructure. Under its current classification as a flammable substance under the Dangerous Goods Ordinance, biodiesel must be distributed from a filling station, like petrol, although some contend that due to its relatively high flash point, it could be distributed like motor oil from garages. Biodiesel, which is not taxed as a fuel, already costs more than USLD and other fuels: an additional barrier. Factoring in costs of a biodiesel infrastructure would render it even more expensive.

> Under an agreement with the New Jersey Board of Public Utilities, the New Jersey Department of Transportation will begin using biodiesel fuel (as a 20% blend) in its diesel powered vehicles and be reimbursed for the incremental costs. The DOT has a fleet of 1,100 medium and heavy-duty vehicles. The project is funded using federal funds resulting from legal settlements with oil companies from the oil crisis of the 1970's. www.biodiesel.org

3.6 BATTERY ELECTRIC VEHICLES (BEVS)

What are BEVs?

BEVs use electrical energy, stored in a battery on-board the vehicle, and convert it to traction by the use of an electric motor. BEVs therefore emit no pollution from the tailpipe. Motors can be direct current (DC) or alternating current (AC). AC induction allows the use of brushless motors, which are easier to maintain and which have increased efficiency and twice the specific power of DC motors. The most common batteries used include lead acid, nickel-cadmium (Ni-Cd) and nickel metal hydride (Ni-MH). Lead-acid is the cheapest but has a relatively low energy density. Ni-Cd and Ni-MH batteries have higher energy density, thus improving performance and range (110km for Ni-MH) but are more expensive. Some external electricity source is required for recharging the batteries in the vehicle or, alternatively outside the vehicle, if the exhausted battery pack is swapped for a replacement.

Current status

There are only 56 BEVs registered in Hong Kong, despite the Government's waiver of the First Registration Tax since 1996. A few companies, like Cathay, CLP, Hong Kong Electric and Goldpeak, have BEVs (minibuses or cars) for in-house use. Other BEVs include demonstration models at Hong Kong's universities.

Barriers to implementation

The main constraint is the high capital cost of a BEV, even though its lifetime costs may compare well to conventional vehicles due to cheaper electrical fuel and maintenance. The limited range and lack of recharging stations for BEVs also limit their applications to predictable and regular routes and niche applications such as hotel shuttles, postal vehicles and government fleet vans. Any serious use of BEVs would require construction of a recharging infrastructure.

3.7 TROLLEYBUSES

What are trolleybuses?

A trolleybus is a bus which uses electricity from overhead wires to drive an electric motor, air conditioning and lighting. It has zero tailpipe emissions and is much quieter than a diesel bus. Since it moves on tyres, a trolleybus is more flexible than a tram. Trolleybuses are in operation in over 340 cities in Asia, America and Europe, including 25 cities in China.

Current status

Citybus is currently running a 6 month trial at Wong Chuk Hang on a converted double decker bus to check reliability, durability, performance and costs. The Government conducted a one year study on trolleybuses, a paper on which was released in June 2001.[24] The Government intends to explore the merits of introducing a pilot scheme in a new development areas, such as South East Kowloon Development but has ruled out their use in congested urban areas.

Barriers to implementation

Trolleybuses require an extensive network of overhead wires, and the high cost of such an infrastructure is the main constraint. Land must also be allocated for substation construction although these can be relatively compact.

3.8 HYBRID ELECTRIC VEHICLES (HEVS)

What are hybrid electric vehicles?

A HEV combines both an electric motor and a battery with an internal combustion engine (ICE). It combines the range and convenience of an ICE but has significantly lower tailpipe emissions due to partial electric operation and the greater fuel economies of electric traction. No external recharging of the battery is required, although it can be done. Most commercial hybrids now available operate on petrol or diesel, although other fuels such as natural gas can be used.

Two types of hybrids exist. “Series” hybrids use a small ICE, operating at a constant speed, to charge the battery, which in turn drives the electric motor. This operates at optimum efficiency and emissions performance, but requires a larger, heavier battery. “Parallel” hybrids have both an ICE and battery, either of which can operate the car. The engine is smaller and tuned for optimal efficiency with the battery pack to provide extra power for start-up or acceleration. City driving can come exclusively from the electric motor. It tends to have more power and a smaller battery than a series hybrid or a conventional BEV.

Figure 2: Series Hybrid System

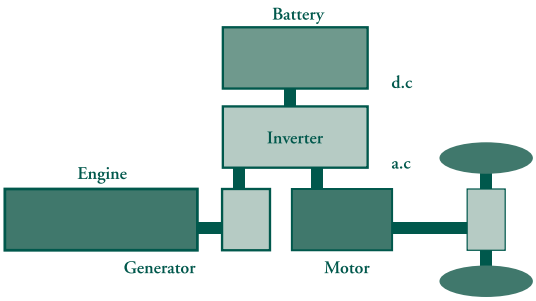
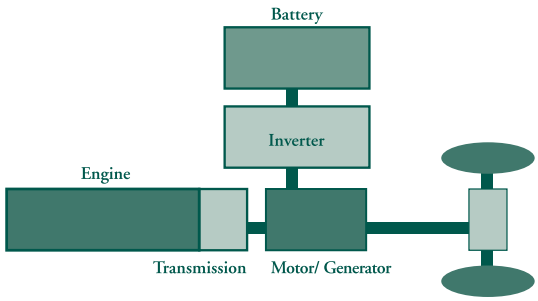


Figure 3: Parallel Series Hybrid System



Current status

There are currently no demonstration or research models of hybrids available in Hong Kong, although one individual has registered a hybrid passenger vehicle with the Transport Department.

Barriers to implementation

The main barrier is the high cost of hybrids relative to conventional ICE models. Toyota is currently selling its Prius in the United States at a loss, even though its price is US$30,000. In Hong Kong, there is also a lack of interest amongst dealers in promoting hybrids to the public.

> The New York Metropolitan Transit Authority has placed a US$77 million order for 200 full-sized diesel hybrid buses for New York City. Ten earlier generation hybrid buses have been in regular use in New York City since 1998 and have proven to be low polluting, reliable and economical to operate and repair. www.baesystems.com

3.9 NATURAL GAS

What is natural gas?

Natural gas (NG) is 80-99% methane (CH_4) gas, with small amounts of propane and other hydrocarbon gases depending on the source. NG is produced either from gas wells or in conjunction with crude oil production or from landfill gas or biogas. It can be used in an internal combustion engine (ICE), hybrid vehicle or fuel cell vehicle. It is usually stored on the vehicle as compressed natural gas (CNG) or as liquefied natural gas (LNG), which is pure methane. CNG is stored onboard at high pressures in high strength steel or lighter composite cylinders, but these require 2-4 times the space of a conventional diesel fuel tank for the same range. LNG is stored at -160 degrees C in specially designed insulated containers. LNG is best suited for larger vehicles because the higher energy density of LNG allows a longer range.

Current status

Hong Kong's sole supply of NG fuels CLP's Black Point power station. By contract, the Government allows CLP to only use the NG to generate power although CLP proposes to fuel some of its fleet vehicles with the gas.

Hong Kong also produces significant quantities of landfill gas (a mixture of natural gas, carbon dioxide and impurities) from its 3 strategic landfills and 13 old landfill sites. Nearly half of this gas is currently being flared-a complete waste-even though, sometime in the next decade, these sites will produce an estimated 1.5 million cubic meters of landfill gas per day.[25]

Another future source of NG will be Shenzhen's planned LNG plant, due to be operational in 2005. The Shenzhen plant will supply Hong Kong Electric's (HKE) new gas-fired power plant on Lamma Island and will provide an alternative source of NG for vehicles.

To distribute new sources of NG, Hong Kong could adapt Towngas's extensive distribution network[26] to a common carrier system. The Government undertook public consultation[27] on this possibility a few years ago but has issued no decision.

Barriers to implementation

The lack of a storage and distribution infrastructure is perhaps the biggest barrier to NG vehicles in Hong Kong. Even if the Government allows CLP to use some of its NG for vehicles, in the short to medium term, only fleet operators will be able to afford storage with their bulk use. Government may be reluctant to invest in distribution infrastructure until a competitive source of NG becomes available, either from Shenzhen or from landfills. The barriers to converting landfill gas to NG include storage, the costs of processing and cleaning the landfill gas, and obtaining EPD approval to utilize the gas.

Four waste management facilities in the US have innovative programs to use landfill gas as fuel for refuse trucks, resulting in major emission reductions for NOx, RSP and CO_2. One facility in California is initiating a program to convert landfill gas to Liquefied Natural Gas (LNG) which will be used to fuel refuse collection trucks.

Yokohama, Japan has 36 refuse collection trucks fuelled by natural gas which cost approximately the same to operate as diesel trucks and reduce emissions significantly.

In the long term, a HKSAR-wide NG distribution infrastructure would facilitate the wider use of gas vehicles. To achieve this, the Government would have to decide whether to proceed with a common carrier system, and, if so, how to compensate Towngas for the conversion.

3.10 FUEL CELL VEHICLES (FCVS)

What are fuel cell vehicles?

Fuel cells combine hydrogen and oxygen to produce water (the reverse of electrolysis). Chemical energy is converted directly to electricity with no combustion. Fuel cells produce zero or extremely low emissions, depending on the fuel used to produce the hydrogen. Fuel cells need to be stacked to produce enough electricity to operate a FCV.[28] The weight and volume of fuel stacks can impair the FCV function.

There are several fuel cell types but most FCVs use a fuel cell which runs on hydrogen, either pumped directly into the FCV or produced on-board from hydrogen-rich fuels such as methanol, natural gas or petrol.

Hydrogen, which exists as a gas, has a high energy density: it is a powerful, potential vehicle fuel. But FCVs will become commercially available only when the problems of on-board hydrogen storage and lack of hydrogen infrastructure are overcome. Hydrogen can be produced commercially from steam reforming of natural gas or direct electrolysis of water. Both of these processes would require another energy source, which ultimately could be renewable.

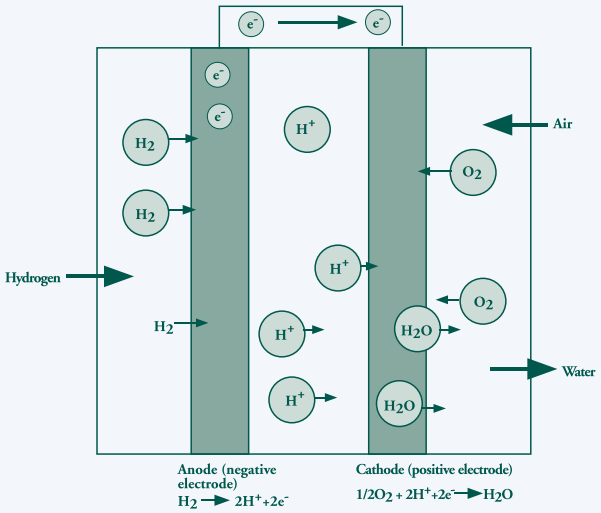


Figure 4: Schematic of a fuel cell.

Another potential fuel for FCVs is methanol. Methanol can be from any carbon source (natural gas, coal, landfill gas, sewage) and has fewer on-board storage problems than hydrogen. A fuel cell which runs directly off methanol is under development but is still experimental.

Current status

No FCVs are available in Hong Kong, although the first fuel cell for electricity generation is likely to be installed in the Science Park. Cheung Kong Infrastructure, which has shares in a Canadian hydrogen company, is interested in demonstrating hydrogen FCVs in Hong Kong.

Barriers to implementation

The high cost and low availability of FCVs are the main barriers. Other barriers include the lack of a fuelling infrastructure, depending on the fuel used to generate hydrogen. Hong Kong needs to study and develop a policy and standards on hydrogen.

4 CLEANER VEHICLES & FUELS WORKSHOP: ACTION PLANS

At the Cleaner Vehicles & Fuels Workshop, held on May 18, 2001, some 90 participants from a wide range of sectors in Hong Kong including government, transport operators and associations, oil companies, vehicle manufacturers, utility companies, technology providers, researchers, and green groups met at the Academy of Medicine in Wong Chuk Hang. (See Appendix 5 for a list of participants.) The day was devoted to achieving the following objectives:

1. To gather ideas on how to pursue ways to improve vehicle emissions.
2. To develop action plans to take vehicle emissions strategies forward.
3. To provide a network for ongoing development of strategies.

Although obviously relevant, pollution from Guangdong and other forms of transport (rail, sea, air) were deemed outside the scope of the discussion.

The workshop employed a systematic and analytical approach to addressing and solving problems. Participants were encouraged to listen, to appreciate other points of view and to think creatively so that all possible ideas and options could be considered.

The workshop identified key issues and concerns, presented expert opinions and encouraged questions and answers. Then the participants were divided into small focus groups that were encouraged to think creatively about how to improve vehicle emissions for 5 vehicle types: passenger cars, taxis, light goods vehicles and minibuses, medium and heavy goods vehicles, and buses. The ideas identified in the creative thinking sessions fell into 5 broad categories:

1. New technologies
2. Regulation and planning
3. Incentives
4. Education and training
5. Infrastructure and research & development

These categories were used to frame Action Plans, and the results of each group discussion were presented to the collective workshop.

The Action Plans outlined by the participants are presented in Tables 2-6. These represent the consensus of a diverse group of stakeholders, with supplementary suggestions on how to carry the recommendations forward by Civic Exchange. The process of reaching consensus was in itself a valuable exercise. The participants not only developed detailed plans, but they also formed a network of all involved stakeholders in the public, private and civil sectors, and that consensus network will lay the foundation for effective implementation in the future.

4.1 NEW TECHNOLOGIES

The workshop participants concurred that Hong Kong should develop and implement short-term, intermediate (5-10 years) and long-term policies that remove barriers to the introduction of all alternative vehicles and fuels. The ultimate goal should be zero emissions from transportation, probably best effected by the use of hydrogen-powered fuel cell vehicles. As soon as possible, Hong Kong should foster all existing cleaner technologies that reduce emissions. At the same time, it should encourage intermediate enabling technologies and fuels such as natural gas that require infrastructure which could ultimately be converted to hydrogen for fuel cell vehicles. It was agreed that Hong Kong should not just pursue a single technology, but should open itself to competing low-emission technologies. Moreover, Hong Kong should consider niche technologies for specific problems or fleets, for example, electric vehicles for short-hop fleets such as hotels and school buses.

On the furthest horizon, participants envisioned that Hong Kong could become a leader in cleaner transport technologies, as it has in using ULSD in Asia. While it is often assumed that Hong Kong is too small to be a leader in cleaner transport technologies, Singapore has claimed just such a leadership role. Hong Kong also needs to consider the wider benefits of developing a clean vehicles and fuels industry, including the obvious health and amenity benefits as well as investment opportunities, jobs and technology exports. Many transport technology solutions developed for Hong Kong may be applicable to high density urban centers typical of many larger Chinese cities.

> Singapore recently announced a “Transport Innovation Development Scheme” in which new generation vehicles such as fuel cell and hybrid vehicles can be brought into Singapore for test-bedding and development purposes with a waiver of the usual taxes and Certificate of Entitlement. They also launched an international program to bring together car makers, research institutes, fuel industry members and other parties to make the city a testing ground for new types of “green” vehicles and accelerate the process of commercialization and market adoption. Speech by Mr Yeo Cheow Tong, Singapore Minister for Communications & Information Technology. 30 May 2001.

The Cleaner Vehicles Task Force was set up by the UK Government in November 1997 to bring together government ministers and representatives of the oil industry, vehicle manufacturers, fuel suppliers, transport executives and other associations with an interest in road transport issues. The Task Force addressed measures to encourage people to build, buy and use vehicles which are more fuel-efficient, less polluting, quieter and less resource intensive. The Task Force also set out to explore ways of improving the environmental performance of existing vehicles. The Task Force published its final report "The Way Forward" in 2000.

At its first meeting in 1998, the Cleaner Vehicles Task Force set out an ambitious work program to develop a package of practical solutions to put cleaner vehicles on the road now and in the future. The Task Force's work fell into three main areas: the steps to an effective market transformation, the role for technology and the role of fleets. The Task Force also outlined ways to disseminate information about the environmental impacts of road vehicles. The Task Force has published a number of detailed and authoritative reports. www.roads.detr.gov.uk/cvtf/index.htm

Table 2: Action Plan for New Technologies

SHORT-TERM ACTIONS				
ACTION	WHAT	WHEN	WHO	HOW
Encourage vehicle dealers to import alternative technology vehicles.	Create incentives for bringing cleaner vehicles into Hong Kong.	ASAP	TD, Finance Bureau, Customs & Excise Dept, vehicle dealers and manufacturers	Expedite type approvals and/or waive costs for procuring type approvals for low emissions vehicles. Waive custom duties, if any, and import fees for low emissions vehicles.
Encourage scrapping of older vehicles which tend to emit more pollutants.	Create incentives to scrapping older vehicles and disincentives (or outright prohibition) to retaining them.	ASAP	TD, EPD, Legco	Ban all vehicles of a certain age or that are unable to achieve established emissions levels. Pay incentive premiums for people to retire diesel vehicles at 8-10 years, like those presently applied to petrol vehicles. Increase annual license fee for older vehicles.
Introduce biofuels and make them widely available.	Set standards for biodiesel, create and implement a plan for biodiesel distribution. Encourage importation of biodiesel and local production of biodiesel from waste vegetable oils and animal fats.	ASAP	TD, EPD, Fire Services Dept, EFB, biofuel proponents, oil companies	Set quality standards. Relax Fire Safety Ordinance classification for biofuels and allow distribution from mechanics garages like motor oil. Waive duties associated with importing biodiesel. Provide incentives for local biodiesel production, especially using waste oils.

Table 2: Action Plan for New Technologies. (contiuned)

SHORT-TERM ACTIONS				
ACTION	WHAT	WHEN	WHO	HOW
Encourage heavy goods vehicle (HGV) fleets to use biodiesel and/or ULSD.	HGVs power requirements limit the use of alternative fuels other than diesel or biodiesel. Study applicability and implement switch. Work with Guangdong to encourage adoption of standards and fuels.	ASAP	EPD, TD, HGV owners associations	Continue and expand demonstration program for HGVs with both biodiesel and USLD. Prevent the use of high sulphur mainland diesel by law. Establish a petrol station at border selling ULSD or biodiesel cheaper than mainland diesel.
Encourage fleet operators to implement diesel retrofit technologies.	Set comprehensive emissions standards for existing diesel vehicles. Subsidize diesel retrofit technologies from several manufacturers.	ASAP	TD, EPD, fleet operators	Establish well-equipped testing centers, operated or licensed by the government, similar to those in US and other countries. Create incentives and subsidies for purchase of diesel retrofit technologies.
Apply clean petrol technologies to all vehicles.	Encourage use of cleaner petrol or ethanol additives	ASAP	TD, EPD, IRD, oil companies, biofuel promoters	Provide incentives for introduction of cleaner petrol. Test ethanol for ozone-producing potential.
INTERMEDIATE ACTIONS				
ACTION	WHAT	WHEN	WHO	HOW
Encourage importation and market for alternative fuels.	Plan and develop alternative fuel/energy sources, and create distribution networks. Enter into long term contracts to procure reliable “clean” fuel sources.	Over next 5 years	ESB, EFB, Planning and Lands Bureau, TD, EPD, oil and energy companies, vehicle manufacturers	Conduct comprehensive study of cleaner fuels, especially electric, NG. Study current distribution networks and estimate cost of conversion and/or new distribution sources. Contract for supply and distribution of cleaner fuels. Plan for eventual conversion to hydrogen.
Discourage private passenger cars.	Increase price of owning and operating private cars, which add to pollution and traffic congestion.	Over next 5 years	TB, TD, Customs, Inland Revenue Department, EPD	Raise taxes on private vehicles. Tie level of tax to level of vehicle emissions. Increase parking prices. Increase price of fuel, especially most polluting ones.

Table 2: Action Plan for New Technologies (contiuned)

LONG-TERM ACTIONS				
ACTION	WHAT	WHEN	WHO	HOW
Plan for early introduction of fuel cell vehicles operating on hydrogen.	Plan for infrastructure that can support hydrogen fuel cell vehicles.	Begin now.	TD, Planning and Lands, EPD, Central Policy Unit, Towngas, CLP.	Establish long term energy policy including policy on common carrier system for natural gas. Plan natural gas carrier system for eventual conversion to hydrogen either by establishing conversion units at filling stations or as part of larger hydrogen energy distribution system.

4.2 REGULATION

Workshop participants identified their top priority regulatory action to be the creation of an overarching government department or commission on energy (including clean fuels), which would coordinate and unify responsibility for energy policy. Currently, Hong Kong's energy policy is fragmented over several agencies.[29] This fragmentation hampers the creation of a coordinated long-term policy. But the experience of other countries shows that merely setting up a new government bureau is not sufficient. Energy policy is so fundamental to the fabric of society that it falls within the jurisdiction of several regulatory agencies and cannot be completely taken from them and placed in a new Department of Energy. Whatever department or commission Hong Kong creates must recognize these overlapping interests and jurisdictions and set up a mechanism for concerted cross-government action.

> The US Energy Policy Act of 1992 (EPACT) was enacted to stimulate the research, development and accelerated introduction of alternative fuel technologies in the US. The objective of EPACT is to reduce the nation's dependence on imported petroleum by pursuing renewable and domestically produced energy resources. Under EPACT, the Department of Energy has established programs to promote energy diversity and the displacement of crude oil-based motor fuels.

Table 3: Action Plan for Regulation and Planning

ACTION	WHAT	WHEN	WHO	HOW
Create a Department of Energy or Energy Commission.	Plan for future energy needs and manage demand and supply on a large scale by establishing an energy policy and coordinating with other relevant government agencies to plan and build an infrastructure for introduction of alternative fuels and vehicles.	Near future	A government taskforce or external consultant to propose the Energy Commission, with public consultation to set terms of reference.	The new Energy Commission to coordinate with ESB, EMSD, TD, EFB, PLB, EPD and other relevant agencies.
Relax government type specifications for alternative vehicles.	Allow fast track type approvals for cleaner vehicle models. Waive the costs of applying for type approval for zero emission vehicles, and reduce costs for low and ultra low emission vehicles.	ASAP	TD	TD to issue policy establishing preferences for cleaner vehicle models based on transparent performance criteria. Inform vehicle manufacturers throughout world and distributors in HK of the preference.

Table 3: Action Plan for Regulation and Planning (contiuned)

ACTION	WHAT	WHEN	WHO	HOW
Broaden government specifications for public vehicles (buses, taxis, minibuses).	Allow more models and manufacturers to compete for public vehicle contracts. Discourage monopoly by a single supplier that can raise price for new vehicles (as occurred with LPG taxis).	ASAP	TD, taxi associations, light bus and minivan associations, franchised bus companies, vehicle dealers and manufacturers.	Learn what vehicles are available worldwide. Directly allow certain models or create specifications broad enough to accommodate more than one model and manufacturer.
Set goals for large fleet operators to have a fixed percentage of cleaner vehicles	Develop stringent legislation applying to government and private sectors that will force scrapping of polluting vehicles by a future date certain.	Now	EFB, EPD, TB, TD, Legco, private fleet operators.	Draft legislation, set definitions of “large fleet” operator and consult those affected.
Develop comprehensive traffic management.	Design a comprehensive plan to reduce congestion, including electronic road pricing, dedicated pedestrian areas, utilizing IT to minimize trips and optimize routes.	Now and into the future	TB, TD, PLB, EPD	Study options for traffic management. Release ERP study for public review and discussion of its adequacy. Adopt scheme and implement plan.
Ban or restrict idling engines.	Develop legislation to control, with provisions for stationary vehicles such as cement trucks.	ASAP	EPD, Legco	Draft legislation for consideration. Work with police to ensure enforcement. Encourage public to report violators.

4.3 INCENTIVES

The workshop participants agreed that government action profoundly affects the price of vehicles and fuels, whether conventional or alternative. The government imposes obvious direct costs such as custom duties on vehicles and fuels, vehicle registration taxes and licensing fees. Many more costs are indirect, such as high land premiums. The government also subsidizes transport both directly and indirectly. One direct subsidy is the current concessionary duty on ULSD to artificially lower its pump price below that of conventional diesel. Indirect subsidies for the current ICE based transport system include Hong Kong's entire scheme of roads and its continued maintenance, an enormous subsidy for continued use of relatively polluting fuels and vehicles.

The retail prices of alternative fuels and vehicles are generally more expensive than prices of conventional ones, due in part to institutionalized subsidies for conventional technologies and the additional research, development and processing costs for new technologies. If Hong Kong wants to reduce vehicular pollution, it must plan and implement a coordinated system of incentives and disincentives to reduce the costs of less polluting vehicles and fuels. Cleaner alternative technologies have been effective in other parts of the world only through the introduction of government incentives or mandates.

> The Mobile Source Air Pollution Review Committee, a cross-sector government committee in California, has awarded US$17.2 million in 2001 for clean vehicle projects, including alternative fuel transit buses and heavy duty vehicles. The funding is awarded to proposals that reduce air pollution from mobile sources and that help offset the higher cost of clean-fuelled heavy duty trucks, transit buses, street sweepers and construction vehicles. The funding for the program comes from a percentage of motor vehicle registration fees. www.msrc-cleanair.org

Hong Kong must adopt performance-based incentives to promote the cleanest vehicles, irrespective of age, type or model. One example is a sliding scale of fees with a complete waiver for the cleanest vehicles and higher fees for the most polluting vehicles. The same concept could be tied to waivers of the First Registration Tax.

> Since 1st March 2001, all brand new cars in the UK (registered on and after 1st March 2001) have been taxed on the basis of their CO_2 emissions. New cars are placed into one of four tax bands, with rates within those bands varying according to their fuel types. Under the new system, a very large number of more fuel-efficient new cars are paying less - in some cases by as much as £70 (HK$760).
>
> Also, as of 1st March, the reduced rate of Vehicle Excise Duty (VED) for existing cars (registered before 1st March 2001) was extended from the current threshold of 1,100cc to cars with engines up to 1,200cc – giving a £55 cut to owners of an extra 2.2 million smaller cars.
>
> In his 2001 Budget, the Chancellor of the Exchequer announced a proposal that, as of July 2001, the reduced rate of VED for existing cars would be extended from the threshold of 1,200cc to cars with engines up to 1,549cc – giving a £55 (HK$600) cut to owners of over 5 million additional smaller cars. http://www.dvla.gov.uk/newved.htm and http:/www.hm-treasury.gov.uk

Other fiscal incentives suggested by workshop participants include:

Capital

- Waive or reduce land premiums for filling stations or distribution points (as was done for LPG).
- Provide direct grants towards costs of new ultra low emission/no emission vehicles (as was done for LPG taxis).
- Provide tax credits for trade in of older vehicles of all types (as is done for passenger cars over 10 years old).
- Provide direct grants for retrofit technologies (as was done for particulate traps/DOCs for LGVs).

Operation

- Waive or reduce duty on cleaner fuel (as was done for ULSD and LPG).
- Waive or reduce Annual License Fees for cleaner vehicles.
- Base duty on energy content rather than volume for all fuels.
- Waive duty for fuel for certain vehicles (as is done for franchised buses).
- Provide preferential parking fees or spaces for cleaner vehicles.
- Base road pricing on vehicle performance with a lower charge for cleaner vehicles.

Table 4: Action Plan for Incentives

ACTION	WHAT	WHEN	WHO	HOW
Develop performance based incentives for cleaner vehicles.	Base incentives on emissions rather than fuel, age or type of vehicle.	ASAP	Various bureaus including Environment & Food, Economic Services, Transport, Finance, Health & Welfare, and Innovation & Technology Commission, Legco	Examine systems developed in other countries and methods of accurate emissions tests. Develop comprehensive regular testing program for petrol and diesel vehicles.
Encourage franchised bus operators to switch to cleaner buses.	Create incentives to expedite purchase of cleaner buses and use of cleaner fuels (Note: franchised buses currently pay no fuel duty.)	ASAP	EFB, TB, EPD, TD, Legco, FB	Study alternatives to conventional diesel buses, including costs and availability, and develop a proposal to Legco to subsidize cleaner buses. Set emissions standards that allow franchised bus operators to choose cleanest technology and subsidize the purchase or provide general tax waivers. Provide incentives to encourage operators to use cleaner fuels or retrofit technologies in older buses.

Table 4: Action Plan for Incentives (contiuned)

ACTION	WHAT	WHEN	WHO	HOW
Encourage switch to cleaner passenger vehicles, vans, lorries.	Allow waivers or reductions in the First Registration tax, annual license fees and fuel duties based on emissions levels of vehicles.	ASAP	EFB, TB, FB, EPD, TD, Legco	Assess import costs of alternative vehicles and devise schedule of new taxes to make competitive with conventional vehicles. Impose additional pollution tax on new conventional vehicles that fail to meet performance standards (or ban outright). Set a comprehensive schedule of tax or duty concessions tied to vehicle emissions levels.
Encourage the scrapping of old MGVs or HGVs	Subsidize the purchase of cleaner models of MGV or HGV as with LPG taxis.	ASAP	EFB, TB, TD, EPD, FB Legco	Assess costs and devise schedule of new taxes, duties and subsidies.

4.4 INFRASTRUCTURE AND RESEARCH & DEVELOPMENT

The workshop participants concluded that gas technologies, from LPG to CNG hybrids, would figure large in the next 5 to 10 years, and the goal is to introduce their use by essentially expanding on Hong Kong's conversion to LPG taxis. Hong Kong must begin now to ensure ample supply and storage facilities for NG or other enabling technologies. In the long term, however, fuel cells running on hydrogen, quite possibly from natural gas, were seen as the ultimate technology of the future, To accomplish these goals, Hong Kong needs to set a plan to ensure that the infrastructure investments it makes today will remain valuable tomorrow. This planning must be orchestrated through an Energy Commission. Two of the first infrastructure decisions that this Commission must address is whether and how to adopt a common carrier system and whether to convert the existing Towngas distribution network to NG.

The Energy Commission should also oversee research and development. A critical first step is the widespread development of vehicle emissions testing centers with the appropriate research support. But even more important is making Hong Kong a center for research and development of cleaner vehicles and fuels. Hong Kong is not a small market unto itself. The decisions that Hong Kong makes in adopting new technologies will influence what mainland China does. The Chief Executive, Tung Chee Hwa, recently stated that Hong Kong 'will amass capital to provide the mainland and the rest of the world with finance, trade, tourism, telecommunications and transportation services."[30] With sufficient funding for research and development, Hong Kong can use its unique geographic, economic and political position to bring cleaner and more innovative transport systems here, to mainland China and to all of Asia, for the health and economic benefit of Hong Kong people.

Hong Kong would do well to follow the lead of other governments and form partnerships with private enterprises and academics. Opportunities abound. For example, Hong Kong is home to an important battery manufacturer, and that presents an opportunity for joint development of electric vehicles for government fleets. Moreover, while fuel cells are widely acknowledged as the transport technology of the future, few universities in Hong Kong are researching fuel cells, and research is unrelated to transportation. With Government sponsorship and private enterprise partnering, Hong Kong could become a center for studying the applicability of a fuel cell economy to China and all of Asia.

A 21st Century Truck Program has been developed by a government and industry partnership in the US to increase energy efficiency, reduce pollution and improve safety in the trucking industry. The program establishes technical and performance targets and fuel efficiency goals for 2010. The trucking and supporting industries will develop and coordinate research to achieve these goals, making use of the nation's research universities. www.osti.gov/21stcentury_truck.pdf

The Fuel Cell Development Information Centre in Tokyo Japan was set up in 1986 to exchange information among its members on the research, development and demonstration of fuel cell technology and to accelerate the introduction and penetration of fuel cell products in the market. It currently has 173 corporate members and 46 universities, including organizations from other countries.

Table 5: Action plan for Infrastructure and Research & Development

ACTION	WHAT	WHEN	WHO	HOW
Encourage vehicle producers to provide training and support to independent repair shops.	Require vehicle suppliers to provide copies of detailed maintenance manuals to independent repair shops.	ASAP	TB, TD, EPD, Legco, vehicle suppliers/ manufacturers	Draft legislation to compel vehicle suppliers to release maintenance information pertaining to emissions reduction as a precondition to operating in Hong Kong. Provide funding to support efforts to develop a comprehensive public database of maintenance manuals.
Increase the number of LPG filling stations and/ or establish mobile stations.	Establish the infrastructure to better implement the LPG taxi scheme.	ASAP	PLB, Plan D, EMSD, TD, District Councils, transport operators, FSD	Locate more sites for LPG filling stations or provide temporary mobile stations. Involve the transport sector in the site selection.
Encourage Government's decision on common carrier system for NG supply.	Commit to a common carrier system for gas supply to forward the development of NG-powered alternative vehicles.	ASAP	ESB, EMSD, Towngas, CLP, HKE, Legco, vehicle manufacturers and dealers	Release results of consultation and current status/policy. Take proposal to Legco.
Identify and develop sites for NG distribution points.	Establish the necessary infrastructure for NG distribution.	ASAP	ESB, PLB, EMSD, CLP, landfill operators, vehicle manufacturers and dealers	Search for suitable sites for NG distribution. Encourage uptake of NG through possible waivers on land premiums or fuel duties. Consider switching government fleets to NG as demonstration vehicles and to create enough volume to warrant investment.
Identify ways that CLP's supply of NG and landfill gas can be used in NGVs.	Lift Scheme of Control restrictions on use of NG for vehicles.	ASAP	ESB, EPD, EFB, TB, TD, EMSD CLP, vehicle manufacturers and dealers, transport operators.	Reach agreement between ESB and CLP to allow use of a portion of CLP natural gas for vehicles.

Table 5: Action plan for Infrastructure and Research & Development (contiuned)

ACTION	WHAT	WHEN	WHO	HOW
Set up NG delivery system at suitable locations.	Plan for conversion to NG vehicles as intermediate stage.	1-10 years	ESB, EPD, EFB, TB, TD, EMSD CLP, vehicle manufacturers and dealers, transport operators	Undertake comprehensive study of likely refueling stations for NG. Identify fleets most likely to convert.
Develop NG quality standards.	Establish standards for NG use in vehicles both in Hong Kong and the mainland.	1-2 years	EMSD, EPD, FSD, CLP, Towngas, landfill operators, Guangdong authorities, Legco	Develop proposals and consult public. Propose and adopt standards following consultation.
Develop gas regulations and standards, especially safety.	Establish comprehensive standards exist for NGVs and distribution systems	1-2 years	EMSD, EPD, FSD, Legco	Propose and adopt standards and regulations following consultation.
RESEARCH & DEVELOPMENT				
Create a research and testing center for cleaner vehicles and fuels.	Establish an independent, standardized research and testing facility that will regularize the work now done on an ad hoc basis.	1-5 years	EFB, TB, EPD, TD, EMSD, FB, Academic institutions, international consultants	Develop systematic testing facilities for the development of cleaner vehicles and fuels, including state of the art testing equipment and sufficient funding for comprehensive studies.
Study and develop recharging systems for electric vehicles.	Develop the infrastructure needed to encourage electric vehicles.	1-5 years	Electric utilities, universities, Planning and Lands Bureau, TD, EPD, transport operators, large fleet operators.	Conduct study of potential uptake of BEVs and recharging/ infrastructure needs. Install recharging stations at strategic points.

4.5 EDUCATION AND TRAINING

The workshop participants agreed that new vehicles technologies will reduce emissions only if they are properly maintained. Proper training and certification of Hong Kong's dealer-linked and independent repair shops is one important education initiative. This initiative must be buttressed with life-long training for mechanics to ensure that they keep up with evolving technology changes, as well as public support for the important role mechanics play. Driver education in cleaner driving techniques is also important. Driver training, which shows people how to drive in a safer and more fuel efficient way, can cut fuel use by 10% to 30%. There also needs to be an integrated awareness strategy to educate the general public as well as the press about the affects of vehicle use on the local and global environment and the costs and benefits of cleaner technologies. Initiatives such as vehicle energy labeling, which is being undertaken by the Electrical & Mechanical Services Department, should be encouraged and extended.

Table 6: Action Plan for Education and Training

ACTION	WHAT	WHEN	WHO	HOW
Establish mechanic certification and/or refresher courses including training on emissions reduction.	Develop a program to qualify mechanics and to offer continuing professional development courses in alternative technologies and fuels.	Now and in future	Existing GovernmentWorking Group on Vehicle Maintenance Services, HKIVE, vehicle dealers and manufacturers, mechanic associations, shop owners, consumer protection groups.	Work with vehicle manufacturers, dealers and vocational training institutes to set standards and ensure adequacy. Create testing programs for certification. Launch a public information campaign to raise consumer awareness of mechanic certification and to raise public profile of certified mechanics.
Educate the public on importance of "green" driving measures and vehicle maintenance to reduce emissions.	Educate and test new drivers and commercial drivers on "green" driving techniques. Develop outreach to existing drivers including public education advertisements.	ASAP	TD, driving schools, consumer groups, HK Automobile Association	Make "green" driving part of driver's education programs and of driver's license renewal for commercial and private vehicle drivers. Launch a widespread publicity campaign that includes signage on buses and taxis, at petrol stations and along roads.
Launch a public information campaign on cleaner vehicles and fuels.	Promote public awareness of cleaner technologies and encourage public preference for them.	ASAP	Government, HK Automobile Association, bus companies, oil companies and petrol stations, taxi companies, advertising agencies, vehicle distributors.	Put signage at petrol stations, on buses, taxis and along roads. Distribute information pamphlets at goverment offices and vehicle distributors.
Demonstrate the benefits of alternative vehicles and fuels.	Promote public awareness of cleaner vehicles and public acceptance of them.	Now and ongoing	Government Land Transport Agency, vehicle dealers and manufacturers, alternative fuel promoters.	Switch government fleet to cleaner vehicles (except essential services) now available. Advertise the cleaner vehicle fleets; make them recognizable. Bring prototype cleaner vehicle like fuel cell buses to Hong Kong.

Table 6: Action Plan for Education and Training (contiuned)

ACTION	WHAT	WHEN	WHO	HOW
Use GPS and other new technologies to avoid traffic congestion.	Encourage private fleets (tour buses, hotel buses, etc.) to purchase GPS and utilize in trip planning	ASAP	Private sector, academic institutions, TD	Develop incentives for purchase of GPS. Encourage adoption of other traffic control/planning technologies.
Establish a forum dedicated to group facilitation, mediation and consensus-building.	Facilitate discussion of policies and issues with all stakeholders in order to achieve consensus on policy or issue resolution.	Ongoing	Non-profit NGOs, Government, facilitation and mediation experts	Raise public and private funds to hire trained facilitators and mediators and establish a forum that would train mediators in both government agencies and private sector and that could act as a clearinghouse for requests for mediation or facilitation from public or private sector.
Establish journalist training courses and briefing sessions.	Encourage journalists to cover “green issues” to promote public education	Now and ongoing	EPD, green groups, GIS	Provide background education for journalists as part of newsworthy stories (demonstration fleet introduction, adoption of new policies, etc.). Encourage journalists to report on environmental problems associated with old vehicle technologies.

5 CONCLUSION

Clearly, to alleviate road based air pollution, Hong Kong must incorporate infrastructure planning, research and development, an effective system of incentives, education and regulation into its future energy policy. This is a massive task and it underscores why Hong Kong must establish an Energy Commission to develop a clear, coordinated energy policy that points the way to future energy developments. Without such a policy, Hong Kong inevitably considers each energy source on a case by case basis, rather than as part of an overall, long-term plan.

The groundwork needs to be laid to encourage the introduction of all possible cleaner fuels and vehicles technologies as well as other emissions reduction products and services with a long-term goal to introducing zero emissions fuel cell vehicles. Such a program could prove to be a model for the region. Existing market and regulatory barriers frustrate the process. The challenge now is to design new regulations and to develop open minds and new markets.

There is an urgent need to involve stakeholders in the policy making process on cleaner vehicles and fuels because they have experience and insights to share as well as legitimate interests and concerns. Their interests need to be considered in order to ensure that the final policies have the support needed to facilitate implementation in the future. Government alone cannot achieve the consensus-building that is required.

The detailed Action Plans contained in this report were developed during a one day workshop. This indicates that by including all the stakeholders and properly managing the process, it is possible to achieve a useful and productive outcome. With more time, these Action Plans could be refined and developed.

Civic Exchange, in partnership with The Asia Foundation, has taken the initiative to bring together the data and the people. The Cleaner Vehicles & Fuels Workshop provided a forum for all interested parties to come together to address the problems, the constraints, the solutions and the visions. This report is the result of an important first step toward achieving a consensus on the way forward.

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ENDNOTES

1 The Asia Foundation is a non-profit, non-government organization headquartered in San Francisco with 14 field offices throughout Asia. Its mission is to advance the mutual interests of the United States and Asia.
2 Civic Exchange is a non-profit public policy research organization in Hong Kong.
3 Fine particulates with a diameter of less than 10 micrometres (a millionth of a metre). RSP causes respiratory illness, reduced lung function and increased cancer risk.
4 "NOx" collectively refers to nitrogen dioxide (NO_2), nitric oxide (NO), nitrous oxide (N_2O). NO_2 a brown gas, contributes to urban photochemical smog and acid rain. NO_2 causes respiratory irritation, increases susceptibility to respiratory infection and impairs lung development.
5 Hong Kong Air Quality Objectives are not legal requirements. When they are exceeded, there is no legal consequence. This differs from other countries where similar objectives are mandatory, which provides more impetus for governments, oil companies and vehicle manufacturers to act to reduce emissions and improve air quality.
6 Ozone is not a directly emitted pollutant but is formed from a photochemical reaction between Volatile Organic Compounds (VOCs) and NOx. It is toxic to humans at levels above 0.1ppm.
7 Wong C M, Ma S, Hedley A J, Lam T H (2001). Effect of Air Pollution on Daily Mortality in Hong Kong. Environmental Health Perspectives. Vol 109, No. 4, April 2001.
8 VOCs contribute to ozone formation, cause eye, respiratory and skin irritations, and can be carcinogenic.
9 In 1999, over 570,000 vehicles were registered in Hong Kong, 31% of which were diesel vehicles, including 18,000 taxis, over 12,000 buses, 6,500 light buses, 87,000 light goods vehicles (LGV) and 43,000 medium goods vehicles (MGV) and heavy goods vehicles (HGV). These are responsible for 61% of total vehicle mileage.
10 Planning, Environment and Lands Bureau (1999). Clean Air for Hong Kong. http://www.pelb.gov.hk/cleanair/index.htm
11 EPD and its Guangdong counterpart have just completed a joint 18-month study to identify the nature and extent of air pollution in the entire Pearl River Delta. Results should be available in 2001.
12 Wilbur Smith Associates Ltd, Third Comprehensive Transport Study. Strategic Environmental Assessment Technical Report. Study commissioned by the Transport Department, HKSAR Government. 10/99.
13 Ibid.
14 Both CH_4 and N_2O are more potent GHGs than CO_2. They are generally reported in terms of equivalent emissions of CO_2 and will be in this report. CH_4 is converted to its CO_2 equivalent by multiplying by 21, and N_2O is converted to its CO_2 equivalent by multiplying by 310.
15 EMSD Energy End Use Database. http://www.emsd.gov.hk/emsd/english/energy/database/index.html
16 Leung D Y C and Lee Y T (2000) Greenhouse Gas Emissions in Hong Kong. Atmospheric Environment, 34. 4487-4498.
17 Ibid.
18 An EPD study on greenhouse gas emissions is due to be published soon.
19 Recent diesel engine improvement technologies include the Direct Injection (DI) diesel engine, which increases fuel efficiency by 15%; exhaust gas recirculation (EGR), which reduces NOx on both heavy-and light-duty diesel engines; and the common rail injection system, which allows for reduction in engine noise and NOx emissions.
20 Selective catalytic reduction (SCR) and non-thermal plasma can reduce NOx by 80-90%. Marsh G, Hill N and Sully J (2000). Consultation on the Need to Reduce the Sulphur Content of Petrol and Diesel Fuels Below 50ppm – A Policy Makers Summary. Report for the European Commission.
21 The European Commission is considering introducing diesel with low sulphur (<10ppm) after 2005. Reducing the sulphur content further will enable more active emissions reduction devices to be used. Ibid.
22 In the US, MTBE is an oxygenate commonly used, but it has been found to contaminate groundwater.
Ethanol is being considered as an alternative.
23 Kenreck C, BetzDearbon. Presentation to EPD 17/10/00.
24 Transport Bureau (2001). Feasibility Study on Introducing Trolleybus System in Hong Kong. Paper to Legislative Council Panel on Transport. 22 June 2001. CB(1) 1575/00 – 01(03)
25 Lawrence Lau, EPD, Pers Comm.
26 Towngas is a mixture of 49% hydrogen, 28.5% methane (natural gas), 19.5% carbon dixide and 3% carbon monoxide. www.hkcg.com
The original pipework for towngas was designed for natural gas. It could be converted back to carry natural gas although this would need to be done in stages and would take several years.
27 EMSD (1997) Public Consultation Report On Feasibility Study of Introducing a Common Carrier System for Gas Supply in Hong Kong.
28 Each fuel cell generates over 1kW/L, but adequate acceleration and speed for a full-sized car requires about 50-65 kW or 150-200 cells at 350 watts.
29 Involved government agencies include Economic Services Bureau (energy supply), Electrical & Mechanical Services Department (energy efficiency and some vehicle/infrastructure safety standards), Environmental Protection Department (greenhouse gas emissions), Transport Department (transportation fuel), Customs & Excise Department (fuel duties), and the Fire Services Department (fire safety and other standards).
30 Tung Chee Hwa (2001). Address to the 54th World Newspaper Congress and 8th World Editors Forum. Hong Kong, 4 June 2001.