

## Case Study 2 – Clean Vehicle Fuel

### 1. Context

Hong Kong's road transport systems allow the smooth flow of traffic to service the needs of this vibrant city. Private vehicle ownership is about 5% i.e. one private vehicle per 20 persons; hence there is much dependency on alternative road transport methods such as public buses and taxis to transport people to and from work and other daily activities.



*Figure 1. Hong Kong on the Move*

The following Table 1 highlights the composition of vehicles used by members of the public:

Type	Number
Private cars	345,000
Motor cycles (including motor tricycles)	33,000
Taxis	18,000
Buses, public and private	13,000
Light buses, public and private	6,000

*Table 1. Vehicles on Hong Kong's Roads (2004)  
Source: Census and Statistics Department*

### 2. Air Pollution Problem

Motor vehicles are a major cause of street level air pollution. Due to Hong Kong's tall buildings, the roads often form corridors along which pollutants such as particulates and NO<sub>x</sub> are trapped and unable to circulate.

To control air pollution from motor vehicles, the Government has introduced programmes with the aim of reducing particulate emissions by 80% and nitrogen oxide emissions by 30% by the end of 2005 through:

- Adopting tighter fuel and vehicle emission standards;
- Adopting cleaner alternatives to diesel where practicable;
- Controlling emissions from the remaining diesel vehicles with devices that trap pollutants;
- Strengthening vehicle emission inspections and enforcement against smoky vehicles; and
- Promoting better vehicle maintenance and eco-driving habits.

Two key target areas are taxis and public light buses. Both of these types of vehicles run on diesel fuel. In finding cleaner alternatives to the latter, liquefied petroleum gas (LPG) was identified as an alternative fuel.

### **3. Solution**

#### ***Liquefied Petroleum Gas***

LPG is a natural hydrocarbon fuel made up of propane and butane. About 60% of the world's supply of LPG comes from the separation of natural gas products and the remainder is a by-product from the refining of crude oil. In the past, LPG was considered as waste and flared off - now it is recognised as a major energy source.

LPG itself is a clear and odourless liquid when under pressure, but reverts to its component gases at atmospheric pressure. This means that LPG can be easily and conveniently stored in liquid form whereby it is 250 times denser as a liquid than as a gas mix. Hence the amount of fuel that can be stored in a relatively small space is substantial.

When combusted, LPG emits a similar amount of CO<sub>2</sub> to diesel but considerably less than petrol. Compared with the latter, vehicles running on LPG emit about 20% less CO<sub>2</sub>. The real benefits however are realised when compared with diesel. One diesel car is equivalent to 20 and 120 LPG cars with regard to NO<sub>x</sub> and particulates respectively. LPG engines in general are also quieter than diesel engines and, therefore, possess an added bonus in reducing traffic noise.

### **4. Implementation**

#### ***Conversion of Vehicles to LPG***

Subject to space limitations, most petrol and diesel engine vehicles can be converted to run on LPG (see Figure 2). The common method is the Single Point system which introduces the fuel at a single point, normally a mixer attached to the throttle body. Depending on the vehicle, the LPG tank can be either located crossways behind the rear seats, in the well beneath the boot floor where the spare wheel normally fits or in the boot space itself. Four-wheel drive vehicles offer further options for multiple tanks to be installed beneath the bodywork.

Because the burning of LPG causes drier and hotter conditions than when using petrol, “valve seat recession” can occur, hence additional upper-cylinder lubrication is often necessary.



*Figure 2. Typical Conversion of Vehicle to LPG*

Conversion to LPG has been shown to make no appreciable difference to the car’s performance. According to tests, the top speed may be marginally reduced and the acceleration times cut by a fraction of a second, but most drivers are unlikely to detect any difference.

In Hong Kong, the conversion of taxis and light buses took place as follows:

- To encourage a quick switch of diesel taxis to environmentally-cleaner vehicles, a one-off grant of \$40,000 was provided for each diesel taxi replaced with an LPG taxi. Commencing in August 2000, the programme was completed by the end of 2003 with nearly 100% conversion of taxis.



*Figure 3. A Converted Taxi*



*Figure 4. An LPG Light Bus*

In 2002, a one-off grant of \$60,000 was provided for each diesel public light bus that was replaced with an LPG one, together with exemption for each replacement vehicle from first registration tax. The scheme was applied to light buses over ten years old which would have been scrapped or reregistered anyway. In other words, the LPG buses were new versions rather than retrofits of old vehicles.

### *Infrastructure*

LPG refilling capacity has increased substantially with the opening of many large dedicated stations. Currently, there are a total of 50 stations run by oil and gas companies which provide gas re-filling service for all LPG vehicles.

A typical example is the ECO Energy Company Limited, a wholly-owned subsidiary of Towngas, which was awarded a 21-year contract for the design, construction and operation of dedicated LPG filling stations in 2000. Towngas has invested more than HK\$90 million in the ECO sites in Chai Wan, Mei Foo, Tuen Mun, West Kowloon and Wan Chai (see Figure 5). These five strategically located ECO stations are open 24 hours a day and are serving more than 9,000 vehicles per day.



*Figure 5. LPG Filling Station*

## **5. Outcomes**

The conversion rate for taxis was much higher than the Government had originally envisaged. All 18,000 taxis in Hong Kong are now running on LPG. In addition by the end of 2004, nearly 80% of newly registered public light buses were LPG-based, representing about 50% of the total number.

The improvements in street level air quality have been marked. Compared with 1999 levels, the concentrations of particulates and NO<sub>x</sub> monitored at the roadside have fallen by 13% and 23% respectively in 2003.

Based on the Government's emission inventory, other data (see Table 2) show the drop in SO<sub>2</sub>, particulates and NO<sub>x</sub> from vehicles as follows:

	<b>SO<sub>2</sub> (tonnes)</b>	<b>Particulates (tonnes)</b>	<b>NO<sub>x</sub> (tonnes)</b>
1999	931	3,900	27,500
2000	755	3,590	27,800
2001	131	3,040	26,300
2002	120	2,800	25,500
2003	114	2,090	20,100

*Table 2. Emissions from Road Transport Sources  
 Source: Environmental Protection Department*

## 6. Cost Benefits

The cost benefits of LPG conversion are as follows:

Scenario 1: assuming taxi owner and minibus owner paid full vehicle cost

	<b>Taxi</b>	<b>Light bus</b>
Cost of replacement	HK\$ 200,000	HK\$385,000
Cost per litre of LPG	HK\$2.42 - \$2.92	HK\$2.42 - \$2.92
Km per litre of LPG	~6 km	~2.5 km
Cost per km	HK\$0.40 –\$0.60 / km	HK\$ 1.00 - 1.60 / km
Cost saving per litre LPG versus diesel	HK\$ 0.45 / km	HK\$ 1 / km
Breakeven number of km	~450,000	~ 385,000

Scenario 2: assuming taxi owner and minibus owner received subsidies from Government)

Subsidy for taxi = \$40,000

Subsidy for minibus = \$60,000

	<b>Taxi</b>	<b>Light bus</b>
Cost of replacement	HK\$ 160,000	HK\$ 325,000
Cost per litre of LPG	HK\$2.42 - \$2.92	HK\$2.42 - \$2.92
Km per litre of LPG	~6 km	~2.5 km
Cost per km	HK\$ 0.40 – 0.60 / km	HK\$ 1.00– \$1.60 / km
Cost saving per km LPG versus diesel	HK\$ 0.45 / km	HK\$ 1.20 / km
Breakeven number of km	~350,000	~ 270,800

Notes:

The breakeven number of km = (cost of replacement – subsidy provided by Government) divided by the cost of saving per litre LPG

The cost of LPG for public light buses will depend on the routing.

*Table 3. Cost Benefits of Using LPG*

## 7. Transferability

There are still some 2,000 light buses that have yet to convert to LPG. At this stage, conversion to LPG is not mandatory but encouraged by the Government.

Other opportunities include private vehicles. Overseas experience shows that LPG has become widely adopted by private car owners when a combination of conversion facilities and a network of LPG filling stations are available. Hong Kong has a number of advantages in both of these areas to meet the needs of vehicle owners, particularly organisations with large vehicle fleets, should they choose to use LPG. The Airport Authority has been testing an LPG vehicle with positive results.

## 8. Conclusions

LPG is a clean fuel alternative to diesel. The benefits of converting to LPG are both environmental and economic.

Lessons learnt include:

- The entire taxi population in Hong Kong now uses LPG with marked results in improved road side air quality. About 50% of light buses have converted and a further 50% have yet to do so; and
- Potentially, the opportunities for using LPG as an alternative fuel are not just for diesel-based vehicles but also for petrol versions.

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