Report of the Alternative Fuel Light Bus Trial

Monitoring Committee of the Alternative Fuel Light Bus Trial
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CONTENT

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1. Introduction

1.1. The air pollution problem in Hong Kong is acute. The respirable particulates and nitrogen oxides from vehicle exhaust are the major source of the air pollution in urban area. Emissions from diesel vehicles account for 98% of the respirable particulates and 75% of the nitrogen oxides from the entire vehicle fleet respectively. In addition, 75% of the ambient respirable particulates and 80% of ambient nitrogen oxides in urban area are due to diesel vehicles. The Government has formulated a set of comprehensive measures to reduce the pollution from diesel vehicles. One of the measures is to replace the existing diesel vehicles with cleaner fuelled vehicles if feasible.

1.2. An interdepartmental working group launched a one-year trial of LPG taxis in November 1997. The objective was to explore the feasibility of replacing existing diesel taxis with LPG ones. Findings of the trial indicated that LPG taxis could meet the demands of local taxi operation and the public also supported the Government to introduce LPG taxis to improve the serious air pollution problem in Hong Kong. In the 1999 Policy Address, the Government announced a proposal to provide financial assistance to encourage diesel taxi owners to replace their diesel taxis with LPG ones. The LPG taxis grant scheme commenced in 2000, and by the end of May 2001 more than 8,000 diesel taxis had been replaced with LPG ones.

1.3. The 1999 Policy Address also proposed to launch a trial of LPG light buses to study the feasibility to replace diesel light buses, and $5.05 million was allocated for the trial scheme.

1.4. Subsequently, the Government consulted the trade representatives of public light bus and school light bus and obtained their full support to launch the trial. Since a supplier was able to provide electric light buses for the trial,

the Government and the trade were of the view that electric light buses should be included in the trial scheme.

1.5. On selecting light buses for the trial, the light bus trade opined that public light buses were more suitable than private light buses for the trial because they travelled more mileage. Moreover, since the public light buses had fixed routes, it would be easier to compare the performance of the trial vehicles under different environments, such as steep roads and long trips.

2. Arrangements of the Trial

2.1. A preparatory committee for the trial was set up in December 1999 which comprised representatives from green and red light buses, school buses and government departments. The committee was tasked to work out the trial arrangements which included renting suitable vehicles for the trial, selection of trial routes, invited the light bus trades to act as fleet managers, other trial arrangements, etc. Its terms of reference and membership list are in Appendix 1.

2.2. Based on the experience gained from the LPG taxis trial, the committee agreed the performance of the alternative fuelled vehicles could be fully tested if the trial was carried out during hot summer, rainy and windy season and bad weather conditions. If the vehicles could demonstrate that they could perform reliably under these conditions, the trial period could be shortened. The committee agreed that the trial should be set for a period of six months initially and would be extended when necessary.

2.3. The preparatory committee after discussion with all potential suppliers of alternative fuelled light buses, obtained consent from three LPG light bus suppliers (including Nissan, Ford and Toyota) and one electric light bus supplier (Vicmax Corporation) to provide LPG and electric light buses for the trial. The vehicles were either made available by leasing terms or by sponsorship. For leasing vehicles, the rental of each vehicle was $240,000 for a period of six-months. The rate included routine maintenance and repair, insurance and the provision of charging facilities. A total of 11 LPG and 4 electric light buses participated in the trial in which one LPG light bus and two electric light buses were sponsored by the suppliers in the form of free rental. Details of the suppliers and the number of vehicles provided by them are given in Appendix 2.

2.4. Since these light buses were specially made for the trial, the Transport Department exempted some of the light buses from meeting the statutory requirement of not exceeding 4 tonnes in design weight. However, all trial light buses had to meet the requirements of Transport Department, Electrical

& Mechanical Services Department and Environmental Protection Department in terms of vehicle safety, gas safety, exhaust and noise emission standards respectively and paid all licence fees and taxes before they could be registered and run on the road.

[Supporting services for vehicles on trial: gas-filling, charging and repairs]

2.5. At the beginning of the trial, there were totally 5 LPG filling stations in Hong Kong. The number of filling stations increased to 12 at the later stage of the trial. Moreover, the Transport Department issued special Restricted Area Vehicle Permits to two LPG red light buses on temporary basis to facilitate their refuelling at the nearby filling stations. The locations of the LPG filling stations, the commencement dates of operation and the selling prices of LPG are given in Appendix 3.

2.6. Since the maximum capacity of the battery of the electric light buses was limited to a travel range of about 80 to 100 kilometers, battery charging facilities needed to be set up within the area of trial routes. In this trial scheme, the electric light buses supplier installed the battery charging facilities at the green light bus terminals. The physical appearance of a charger is in Appendix 7. Due to the technical restraints in laying power cable wiring, not all the green light bus terminals were suitable for the installation of chargers. With the assistance of the two local power companies, the Transport Department examined the feasibility of setting up chargers at terminals of the 24 green light bus routes. The result showed that 15 routes were not suitable for the setting up of chargers at the terminals. The electric light buses were not tested for red light bus operation because the red light buses have no fixed terminal.

2.7. As maintenance services were provided by the vehicle suppliers, all trial light buses were sent to the suppliers' workshops for maintenance. Such an arrangement would ensure that all data were captured, so as to help the trade to understand the maintenance requirement of these alternative fuel light buses. Moreover, in accordance with the Gas Safety Ordinance, the fuel system of LPG vehicles must be repaired in designated workshops while other repair work could be carried out in ordinary workshop.

[Selection of Fleet Manager]

2.8. In April 2000, the Transport Department, in the form of open tender, invited experienced green and red light buses operators to apply as fleet managers to manage and operate the LPG or electric light buses in the same way as their diesel light buses fleet.

2.9. In order to test the suitability of each type of light buses operated under the unique local driving conditions, the trial routes had to meet the following criteria:

- more steep and uphill sections along the route;
- passing through tunnels;
- longer route journey;
- passing through busy and more polluted areas;
- more frequent vehicle start/stop for passenger boarding and alighting; and
- a higher patronage of passengers.

2.10. After drawing lot, six green light bus routes and one red light bus route were selected for this trial. Individual LPG and electric light buses were also assigned to different trial routes by drawing lots. Details of the routes under trial are given in Appendix 4.

2.11. Every successful fleet manager was required to provide a diesel light bus to run on his trial route in parallel for comparison, and pay the licence fees and daily operational expenses for the trial vehicles. In addition, under the licensing conditions, they were required to suspend the operation of the same number of diesel light buses so that the LPG or electric light buses could be registered as public light buses for the trial.

2.12. Upon selection of the trial routes and fleet managers, the tasks of the preparatory committee were completed. A Monitoring Committee comprised the fleet managers, representatives from the light bus trade, vehicle experts, vehicle suppliers and the departments concerned was set up to monitor the trial. Representatives from the oil companies and power companies were invited to attend the meeting. The committee monitored

the daily operation of the light buses and collected operational data, comments from passengers and fleet managers, vehicle repair and maintenance data, emissions data, etc. Please refer to Appendix 5 for the membership and terms of reference of the Monitoring Committee.

3. Details of the Trial

3.1. The trial was officially launched on 5 June 2000. Since some of the light buses for the trial could not arrive on time and their registration was delayed. These vehicles participated in the six-month trial by stages between 5 June and 15 July 2000. The two electric light buses sponsored by the supplier took part in the trial in August and September respectively.

3.2. The alternative-fuelled light buses completed the six-month trial starting from December 2000. The last data was collected on 31 January 2001. The actual trial period for the two electric light buses sponsored by suppliers were four and five months only. After the trial the vehicles were returned to the suppliers. The trial dates of all vehicles are given in Appendix 6.

3.3. During the trial, the fleet managers were responsible for collecting data on mileage travelled and fuel consumption, vehicle performance, drivers' comments and assisting in distributing questionnaires to passengers. The vehicle suppliers were responsible for collecting vehicle maintenance data and Environmental Protection Department was responsible to monitor all emission tests.

3.4. The Monitoring Committee held regular meetings to review the progress of the trial, verify and endorse the monthly operation data. The fleet managers reported any operational difficulties they encountered, the vehicle suppliers and the operators of LPG filling facilities responded to individual vehicle problems.

3.5. The mechanical design of LPG light buses was basically the same as that of the conventional diesel models except the engines and fuel systems had been designed to use LPG. Hence, driving characteristic of LPG light buses is the same as that of the existing diesel light buses. On the other hand, electric light buses are driven by motors and batteries. These vehicles are equipped with electricity regeneration device and their driving characteristics are different from that of the conventional diesel vehicles. As such, drivers of electric light buses had been trained by the suppliers to familiarize with the electric light bus and its driving method that would make the best use of

the vehicles. Please refer to Appendix 7 for detailed information and photos of the electric light bus.

4. Findings of the Trial of LPG Light Buses

[Fuel consumption]

4.1. During the trial, the total LPG consumption of the 11 LPG light buses was 220,628 litres while the total mileage travelled was 573,158 kilometres. The total diesel consumption of the 7 diesel light buses for comparison was 93,008 litres and the total mileage travelled was 451,223 kilometres. Based on the above data, an LPG light bus travelled 2.60 kilometres per litre of LPG while a diesel light bus on average travelled 4.85 kilometres per litre of diesel.

4.2. The above fuel consumption figures were average of the whole 6 month trial period. In hotter months, the fuel consumption of an LPG light bus and a diesel light bus was 17% and 10% more than that in colder months respectively. The increase was likely due to the use of more air-conditioning during the hotter months. Please refer to Appendix 12 for details.

4.3. The total fuel cost of the LPG light buses were $733,397 with an average $1.28 per kilometre. For diesel light buses, the fuel cost was estimated from the pump price of diesel and the diesel consumed during the trial period because the fleet managers did not provided their actual fuel cost for the diesel light buses. The estimated fuel expenditure was $582,423 with an average $1.29 per kilometre. According to the light bus trade, they had bulk purchase discount and the actual fuel cost would be lower.

4.4. There is currently no duty on auto-LPG. During the trial period, the selling price of LPG varied from station to station. In the 5 dedicated LPG filling stations, the selling prices were set under contracts between the operators and the Government and ranged from $2.01 to $2.04 per litre, whereas in converted LPG filing stations, the prices were $2.72 and $3.88 per litre.

4.5. During the trial period, the duty for motor vehicle diesel was $2.00 per litre whereas the duty for ultra low sulphur diesel fuel was $1.11 per litre. Ultra

low sulphur diesel was introduced for use by motor vehicles in July 2000. In September, only ultra low sulphur diesel was available in all petrol filling stations. Ultra low sulphur diesel was cheaper than ordinary diesel fuel when it was first introduced. In the early stage of the trial, price of ultra low sulphur diesel was $6.35 per litre, and was reduced to $5.84 per litre at the later stage of the trial. According to light bus trade, bulk users such as Green Minibuses would receive about 15% discount on pump price. As a result, the actual diesel fuel costs for the light buses were $5.40 and $4.96 per litre in the beginning and at the later stage of the trial respectively.

4.6. Based on the aforementioned fuel consumption rate and the fuel prices at the conclusion of the trial (LPG at $2.01 to $3.88 per litre, diesel at $5.84 per litre), the fuel cost of an LPG light bus ranged from $0.77 to $1.49 per kilometre versus that of diesel light buses was $1.20. If the 15% bulk user discount was taken into consideration, the diesel light bus fuel cost would become $1.02 per kilometre. For fuel expense alone, LPG light buses patronizing the dedicated LPG filling stations (price at $2.01 and $2.04 per litre) would save $0.25 to $0.43 per kilometre. However, for light buses which refuelled at other converted stations (LPG price at $2.72 and $3.88 per litre), their fuel expense would be from $0.15 per kilometre lower to $0.47 per kilometre higher than that of the diesels. Please refer to Appendix 8 for more details.

[Operation and reliability]

4.7. During the six-month trial, the trial vehicles experienced hot summer and rainy season. They were operated as usual and without problem.

4.8. In the trial, a total of three LPG light buses were involved in traffic accidents. Although these three light buses had sustained heavy damage, their fuel systems remained intact. Inspection by Government department confirmed that the design of the fuel system of the LPG light buses is safe and reliable. Please refer to Appendix 9 for the damage of the compartments of the vehicles concerned. Apart from the traffic accidents, the fleet manager of light bus JR2445 reported a suspected LPG leakage when waiting for

passengers. However, after inspection on site by Fire Services Department and follow up examination by the vehicle supplier, no sign of gas leakage was detected.

4.9. Regarding the LPG light bus reliability, light buses JN7865 and JR1589 were found to have water pump leakage and light bus JP6187 had engine computer problem that required urgent repair. In addition, the spark plug housing and cylinder head of light bus JN7865 were damaged and needed additional repairs because of human error in maintenance procedures. The other 8 LPG light buses operated normally.

4.10. The fleet managers reported that the average daily mileage of the LPG light buses was 302km which was similar to other diesel light buses operated similarly in the same route. As three LPG light buses had accidents and took some time for repair, the monthly average operation days were less than that of the diesel vehicles.

[Vehicle repairs]

4.11. According to the information provided by the LPG light buses suppliers, the monthly regular maintenance costs of LPG light buses of different models were about $1,800, $2,700 and $1,700 with an average of $2,092 per month. The unscheduled repairs related to the engine system and not related to engine system were about $192 and $1,438 per month respectively (excluding accident repairs). Since the monthly regular maintenance data of diesel light buses provided by the fleet managers either had no detailed and itemized breakdown or were incomplete, no comparison of maintenance costs between LPG and diesel light buses could be made. According to the information provided by Toyota Motor Company, the repair requirements of their LPG and diesel light buses were similar. The Chief Engineer of the company also pointed out that the repair requirements and durability of the two models of light buses were the same. Please refer to Appendix 13 for the LPG light bus repair schedules.

4.12. It should be noted that the repair on the fuel system of the LPG light buses must be carried out in the approved LPG vehicle repair workshops.

[Emissions]

4.13. All the LPG light buses on trial had to undertake an emission test every month. The tests were monitored by EPD staff. All the LPG light buses except one passed the tests with emissions much lower than the limits. The LPG light bus JN7865 was found to have exceeded the emission standard during the test in October. Inspection found that its catalyst was damaged. The vehicle supplier looked into the problem and advised that the catalyst used was too small.

4.14. The 7 diesel light buses for comparison also undertook smoke test using chassis dynamometer from October to November. Except two vehicles having test results that were close to the statutory limit, the remaining 5 passed the smoke test. The results are given in Appendix 10. It was noted that light buses meeting Euro II emission standard had lower smoke levels than those meeting Euro I. The two diesel light buses emitting excessive smoke were serviced after the test.

4.15. Comparing the pollution levels of the light buses, although the trial LPG light buses are designed to meet Euro II emission standard, they emit 87% less carbon monoxides and 51% less hydrocarbons and nitrogen oxides than the Euro III diesel light buses, and the particulate and smoke emissions are eliminated. LPG light buses are a cleaner alternative in the foreseeable future. Replacing diesel light buses by LPG ones will help to reduce the air pollution caused by respirable suspended particulates and nitrogen oxides in Hong Kong. Please refer to Appendix 11 for the emission comparison of the two types of vehicles.

[Comments of the fleet managers]

4.16. The fleet managers summed up their daily operational experiences on the LPG light buses and reflected the following comments to the Monitoring Committee:

Comments	Measures/responses of vehicle suppliers
Toyota and Nissan models	
Capacity of the LPG cylinder was too small	Manufacturer would consider to enlarge the LPG cylinder
Fuel consumption was more than the diesel counter parts	Manufacturer would study to improve the design
Ford model	
Insufficient horsepower	New model would have a larger engine and passenger compartment and an improved design
Vehicle type was too small and the space of passenger compartment was inadequate	
Double tyres should be used at rear axle	
Electric door opening outwards might hit passengers	

4.17. The fleet managers also voiced out their concerns:

- LPG light bus suppliers should provide more efficient and fuel economy engines.
- Whether a duty was levied on auto-LPG would significantly affect the feasibility of the local operation of LPG light buses.
- Since there was no price control on the non dedicated LPG filling stations, the LPG prices of some non-dedicated stations at convenient locations might be higher.
- The existing supporting infrastructure for LPG light buses including gas filling stations and approved repair workshops were far from adequate.
- Whether the price of LPG light bus would be too high.

5. Findings of the Trial of Electric Light Buses

[Electricity consumption]

5.1. The total electricity consumption of the four electric light buses was 109,267 kilowatt-hours and the total mileage was 111,163 kilometres with an average 1.02 kilometres per kilowatt-hour. The difference of the electricity consumption of electric light buses between cold and hot months was about 6%. A chart showing the variation in fuel cost of the different light buses is in Appendix 12.

5.2. The price of electricity slightly varied due to geographic location and consumption. Prices were as follows:

Power Company	Electricity price Per kilowatt-hour(per unit)	Remarks
China Light and Power Company Limited	$0.968	First 5,000 kilowatt-hours
	$0.958	After the first 5,000 kilowatt-hours
Hong Kong Electric Company Limited	$0.943	Flat rate

5.3. Based on the data collected from the trial, fuel cost of electric light bus ranged from $0.92 to $0.95 per kilometre, which was cheaper than diesel light bus by about $0.27 per kilometre. In addition to the expenses of electricity charging, the suppliers of the electric light buses stated that they would charge the vehicle owners in future a fixed monthly fee for the rental of batteries and charging facilities. The suppliers estimated that the monthly rent would be $6,000. If the fixed rental cost at $0.65 per kilometre was added to the electricity cost for electric light buses, the fuel cost would range from $1.57 to $1.60 per kilometre. However, if the battery was sold to the vehicle owners, only the per kilometre battery maintenance

cost of about $0.14 would be changed and the per kilometre cost of battery charging and maintenance would become $1.07 to $1.09. The cost of the battery from the supplier was about $220,000 with a 4-year warranty. The supplier also indicated that the options for battery rental or purchase had already included the costs of setting up charging facilities at the light bus terminuses for the free use by the light bus owners as well as the recycle of the waste batteries. Please refer to the comparison of the fuel costs given in Appendix 8.

[Operation and reliability]

5.4. During the four to five-month trial, the four electric light buses had experienced the hot summer and rainy season. They operated normally with no problem.

5.5. During the trial, the fleet managers and the vehicle supplier could not arrange staff to carry out overnight slow charging, all the trial electric light buses adopted quick charging during day time. Due to frequent quick charging, battery balance and maintenance charging needed to be performed in the workshop every 4 days in order to maintain the battery's efficiency. Furthermore, fleet managers reported that the light bus service schedule was affected due to the time taken for the battery charging during operation hours.

5.6. According to the trial data, electric light buses ran an average of 184 kilometres daily. At the beginning of the trial, every quick battery charging could support a travelling range of 20 to 40 kilometres. The range was improved to 30 to 50 kilometres at the later stage of the trial. The light buses required 4 to 8 quick charges everyday and the time taken was 20 to 30 minutes each time. The vehicle supplier explained that the main reason for the improvement in range per quick charge was that the drivers were able to operate the vehicles at the best economy mode. Moreover, the supplier had carried out more frequent balance charging of the batteries to maintain its efficiency.

5.7. The suppliers believed that the drivers had not fully utilized the electricity regeneration device when decreasing speed and had failed to adjust the accelerator pedal according to road conditions effectively. These two factors would speed up and increase the consumption of electricity, resulting in lower vehicle range and higher increasing travelling cost. The suppliers had tuned up the vehicles to restrain the accelerating speed, but this affected their performance in going up steep roads. The suppliers stated that they would work out other possible measures to improve the performance of vehicles.

5.8. The first electric light bus BG9133 running on route no. 4C/5 had experienced six breakdowns in July and required urgent repairs. After checked by the supplier, it was found that an unsuitable fuse had been used in the manufacturing process. In September to November, electric light buses BG9133, JS3684 and JR951 required to replace 4 fuses, reset the circuit breaker 2 times and replaced an inverter. Furthermore, the fleet manager of route no. 48 reported the charger experienced 8 failures in September and affected the light bus operation. Upon investigation by the supplier, it was found that the problem was caused by the fault in the switch of the power supply and was not related to the charger. After the fault was rectified, the fleet manager reported that the light bus operation was satisfactory.

5.9. During the trial, one electric light bus was involved in a traffic accident. Moreover, in December when an electric light bus was on a trip, the cooling fan of the battery was overheated due to it being obstructed by an unknown object. The battery was damaged and released smoke which was finally put out by firemen. The emergency had not caused any injury to passengers nor other road users. After investigation, the supplier commented that the incident was highly unusual.

[Vehicle maintenance]

5.10. The average monthly regular maintenance fee of an electric light bus was about $1,580 which was only for the maintenance of batteries. The suppliers pointed out that should owners of electric light buses choose to pay a fixed

rental for batteries in the future, they do not have to bear the maintenance cost of the batteries.

5.11. As the mileage of the electric light buses had not reached the scheduled maintenance, no other maintenance cost was reported. According to the information provided by the manufacturer, the repair items required for the motor and transmission systems of electric light buses were less than those of the LPG and diesel ones. For the repair items of the car body and chassis, such as the brake system, steering system and suspension system, the requirements were similar as those of LPG and diesel light buses. The suppliers estimated that the monthly regular maintenance cost was $470 (excluding battery maintenance). The fee already included the regular maintenance of the motor control system and proprietary electronic parts

5.12. The cost of unscheduled maintenance of electric light buses was on average $1,117 every month. Those repairs related to the propulsion system were electrical and electronic parts, including the replacement of fuses and circuit breakers, the calibration of circuits and the repair of transformers, etc. The repair not related to the propulsion system were mainly on the vehicle doors, brakes and accessories to the car body. All the above repairs were carried out by the electric light bus supplier. However, the supplier expected that the light bus repair workshops would be capable to carry out the repairs.

5.13. The repair requirements of the electric light buses are given in Appendix 13.

[Emissions of exhaust]

5.14. Since the electric light buses are free of emissions, they were not required to undertake any test. As such, the use of electric light buses can significantly reduce the air pollution in urban areas.

[Comments of fleet managers]

5.15. The fleet managers had the following comments on the design and operation of electric light buses:

Comments	Measures/responses of vehicle suppliers
Insufficient power for going up steep roads	Alteration of rear gear to enhance the climbing power
Unsatisfactory vehicle suspension	Suspension systems of some vehicles had been improved
A quick charging could only provide 30 kilometres range	Manufacturer had increased the frequency of balancing the batteries, and provision of chargers at both terminals could be considered
The car body vibrates when the speed was over 60 kilometres	The transmission shaft causing vibration had been replaced

5.16. The fleet managers also expressed some of their concerns:

- The time-consuming charging had a significant impact on the light bus service.

- Many terminals of green light buses were not suitable for the installation of chargers. Even chargers could be set up, it was extremely difficult for several electric light buses to get charged at the same time. It was even harder to make arrangements for charging red light buses and, hence making it not feasible to use electric light buses.

- The short range of electric light buses had made them unsuitable for long distance routes.

6. Comments of Passengers

6.1. Passenger questionnaires were placed inside the compartment of the trial vehicles during the trial for collection of the passengers' comments on LPG and electric light buses.

6.2. A total of 116 questionnaires were collected. 85% of the respondents were of the view that the alternative-fuelled light buses were quieter and more comfortable; 93% thought that the alternative-fuelled light buses were more environmental friendly; 95% supported large scale introduction of alternative-fuelled light buses to improve our air quality.

6.3. In some replies, some requested the Government to introduce alternative-fuelled light buses as soon as possible and to reduce the operation costs of alternative-fuelled light buses. Some were willing to pay more to take an alternative-fuelled light bus but some commented on the designs of electric light buses and the smaller LPG light bus. Summary of the comments is given in Appendix 14.

7. Operation Income

[Monthly revenue provided by fleet managers]

7.1. The fleet managers pointed out that during the trial the vehicles needed more frequent refuelling or charging of battery due to insufficient LPG filling stations and vehicle design. This had a bearing on the light bus service and operation income. In addition, the revenue of the light buses of a particular model, which had a smaller compartment, was lower due to lower passenger patronage.

7.2. To substantiate their claim, fleet managers provided a comparison among the revenue of the LPG light buses, electric light buses and diesel light buses running on the same route. The relevant information is given in Appendix 15.

7.3. According to the information provided by the fleet managers, the service schedule of the LPG light buses had decreased by 1% to 24% and the operation loss was from 1% to 32%. Since the red light buses did not have detailed income record, the operation loss of the red light buses in Appendix 15 was based on the average patronage of passengers provided by the fleet managers.

7.4. The losses in service and income of electric light buses were from 25% to 58% and from 22% to 68% respectively.

7.5. The factors affecting the service schedules and income provided by the fleet managers were as follows:

- The LPG filling stations were far away from the trial routes.
- Compared with diesel light buses, the LPG light buses needed up to 3 times more gas refuelling everyday depending on the distance of the routes.

- The time taken for the journey to the filling station, waiting and refuelling were from 20 to 60 minutes.

- Although the smaller LPG light buses did not need frequent refuelling, they were less attractive in appearance, less comfortable and travelled at a slower speed, resulting in loss in passenger and income.

- Electric light buses needed frequent recharging and took 20 to 34 minutes each time, causing significant impact on the light bus service and income. Failing to set up chargers at both terminuses of the route also increased the charging time, affected the service and income.

[Analysis of operation income]

7.6. The operation loss figures in Appendix 15 are averages of the 6-month trial provided by the fleet managers. As some light buses were involved in traffic accidents or had undergone repairs and maintenance, their operating days were reduced. For the purpose of objective reporting of revenue, those months with significantly fewer operating days were excluded in the calculation.

[LPG light buses]

7.7. After the adjustment, the operation loss of green light buses was from 2% to 17%, depending on the location of the nearby LPG filling station.

7.8. Since the figured provided by the red light bus fleet manager were not supported by actual income record, no adjustment nor analysis could be made.

[Electric light buses]

7.9. For the electric light buses, the operation loss after adjustment was from 34% to 55%. The loss was greatest for route with longer travelling distance.

7.10. The results of the revenue loss analysis are given in Appendix 16.

8. Opinion of the Fleet Managers/Light Bus Trade

8.1. Upon the completion of the trial, the light bus trade representatives in the monitoring committee had expressed their view on the implementation of alternative fuel light buses. Their opinions were summarized in paragraphs 8.2 and 8.3 at their request.

8.2. The opinion and concerns of the fleet managers and trade representatives of the trial monitoring committee were as follows:

- Although LPG and electric light buses were technically feasible, both types of vehicles had drawbacks from the commercial operation point of view. For example, some of the LPG light buses had lower horsepower and smaller passenger compartment than the diesel light buses. The LPG storage tank was too small and the electric light buses needed frequent recharging etc. As such, subsidy should be provided for the successful implementation of alternative fuel light buses.

- The infrastructure for LPG and electric light buses was not sufficient to support light bus operation and would affect the light bus services and income. The existing LPG filling stations were far away from most of the light bus routes whereas the traveling range of electric light buses were too short to serve the demand during peak hours.

- From the commercial operation point of view, the gas consumption of LPG light buses was high which caused more refuelling and dead mileage to and from the filling stations. For electric light buses, their traveling ranges were too short to support the peak hour demand, and insufficient charging facilities caused long recharging time. As the use of these two types of alternative fuel light buses would result in loss of services and income, auto-LPG must be maintained at a stable low price and permanently duty free. Since the rental cost of electric light bus battery would result in a higher operating cost than diesel light bus, electric light bus suppliers should sell their battery and provide extended warranty.

- The maintenance cost data provided by the LPG light bus suppliers was higher than the average maintenance cost of diesel light buses experienced by the trade. The maintenance requirements of older LPG light buses were also difficult to be estimated as all the trial light buses were new vehicles. The time taken for the maintenance of LPG light buses by the vehicle suppliers were longer than that if the vehicles were maintained in other garages. Insufficient LPG maintenance workshops and mechanics would result in higher maintenance cost if LPG light buses were used on a large scale. Regarding electric light buses, sufficient facilities should be provided for battery maintenance and balance charging if they were to be used on a large scale.

8.3. In relation to the future implementation of alternative fuel light buses, the fleet managers and trade representatives of the trial monitoring committee would like to put down their requests as follow:

- Since the use of alternative fuel light buses would incur recurrent losses, one off grant similar to that of LPG taxis would not be practicable. Any proposed scheme must ensure that the trade will not suffer from recurrent losses due to the switch.

- Auto-LPG should be permanently duty free and the price must be maintained at a low level for the implementation of LPG light buses.

- The seating capacity of light buses should be increased to 24 in order to offset the recurrent operating losses due to the use of alternative fuel light buses. It would also facilitate the trade to implement high quality light bus services and fare concession scheme.

9. Conclusion

9.1. Based on the results collected during the trial, the Monitoring Committee has reached the following conclusions and suggested Government to thoroughly consult the trade before implementation.

LPG light buses

[Fuel cost]

- LPG light buses if refuelled at dedicated LPG filling stations, the per kilometre cost is $0.77 to $0.78, which is lower than the per kilometre cost of $1.02 to $1.20 for diesel light buses. However, if LPG light buses were refuelled at non-dedicated filling stations, the per kilometre cost is $1.05 to $1.49, which is higher than diesel light buses.

[Operation and reliability]

- The performance of the light buses meets the operation requirement of light bus trade.
- Due to the small storage capacity of LPG tank or long journey to the LPG filling stations, LPG light buses may require more refuelling than diesel light buses by up to 3 times per day which resulted in up to 21% loss in service and up to 17% loss in income.
- To cope with the light buses operation, some of the LPG light bus models require improvement in engine efficiency and/or larger LPG storage tank to reduce number of gas refuelling

[Vehicle maintenance]

- The repair on the fuel system of LPG light buses must be carried out in approved LPG vehicle workshop.
- The maintenance requirements of LPG light bus engine and fuel system are comparable with those of diesel light buses.

[Exhaust emission]

- Compare with diesel light buses, LPG light buses do not emit respirable suspended particulates, have lower nitrogen oxides, carbon monoxide and hydrocarbons emissions, and free from black smoke problem.

Electric light buses

[Fuel cost]

- The per kilometre electricity cost is $0.92 to $0.95 which is lower than that of diesel light buses. However, if battery rental is included, the total per kilometre cost will be $1.57 to $1.60, which is high than that of diesel light buses.

[Operation and reliability]

- The electric light buses and chargers experienced malfunctions in the early stage of the trial. The reliability had improved at the later stage of the trial.
- Only quick charge mode was used during the trial period. As the normal traveling range covered by each quick charge was 30 to 50 kilometres, multiple recharges were required each day.
- The long time taken for battery recharging caused loss in service up to 58% and loss in income up to 55%.
- Physical constraints on site at the light bus terminuses have limited the feasibility of setting up electricity chargers at all light bus routes.

[Vehicle maintenance]

- The battery of the electric light buses requires frequent maintenance.
- There are less mechanical items that needed regular maintenance than diesel light buses. On the other hand, there are more electronic parts that require maintenance. The vehicle supplier commented that regular garages were capable to perform the repair and maintenance.

[Exhaust emission]

- Free from exhaust emissions.

- END -

Appendix

Membership and Terms of Reference of Preparatory Committee for the Trial of Alternative Fuelled Light Bus

Official Members	Non-official members
Planning, Environment and Lands Bureau (Chair)	**Trade Representative of Green Public Light Bus:**
Transport Bureau	Yan Yan Ho Motors Limited
Government Land Transport Agency	Sai kung P.L.B. (Maxicab) No.1 & 2 Co. Ltd.
Fire Services Department	Aberdeen Maxicab Service Co. Ltd.
Transport Department	Chit Fai Motors Co. Ltd.
Electrical and Mechanical Services Department	
Environmental Protection Department	**Trade Representative of Red Public Light Bus:**
	The Kowloon P.L.B. Chiu Chow Traders & Workers Friendly Association
	P.L.B. General Association
	Tuen Mun P.L.B. Association
	HK KLN & NT Public Maxicab Light Bus Merchants' United Association
	Trade Representative of School Bus：
	Private Hire Car for Young Children Association
	Expert：
	Professor C.C. Chan
	Dr. W.T. Hung

Terms of Reference

1. Set the Scope of Trial and Planning.
2. Assist setting up the Monitoring Committee of the Trail.
3. Hand over the preparation work to the Monitoring Committee after its establishment.

Vehicle Suppliers and Number of Vehicles supplied for the Trial

Supplier / Manufacturer	Type of Vehicle	Quantity	Remarks
Crown Motors Limited / Toyota Motor	Coaster LPG light bus	8	Rent by Government
Honest Motors Limited / Nissan Motor	Civilian LPG light bus	1	Sponsored by Supplier
Wallace Harper & Co. Ltd. / Ford Motor	Transit LPG light bus	2	Rent by Government
Vicmax Corporation / Vicmax Electric Motor	Zen Electric light bus	4	2 rent by Government 2 sponsored by Supplier

Appendix 3

Location of LPG Filling Stations

As at 31.1.2001

LPG Supply Company	Site	Started Operation on	LPG Price $／litre
Caltex Oil Hong Kong Ltd.	Tai Po Road, Shatin Heights	1997	3.88
	Pok Fu Lam Road, Hong Kong	June 2000	3.88
Shell Hong Kong Ltd	8 Kai Fu Road, Kowloon Bay	1997	3.88
CRC Petrol Filling Station Co., Ltd.	53-67 Tsing Yi Road, Tsing Yi	1997	3.88
	12 Yuen On Street, Siu Lek Yuen, Shatin	October 2000	2.72
	Kam Tin Road, Shek Kong, Yuen Long	October 2000	2.72
	Yuen Chau Chai, Tai Po	October 2000	2.01
	Wai Lok Street, Kwun Tong	October 2000	2.01
	Fung Mat Road, Sheung Wan	November 2000	2.01
ECO Energy Co., Ltd.	Ngo Cheung Road, Kowloon West	October 2000	2.04
	Junction of Fung Yip Street and On Yip Street, Chai Wan	November 2000	2.04
	Fung Yip Street, Chai Wan	1997	2.38

Trial Routes

Route		Type of Route	Make & Model	Registration Mark
[5]/ [4C]	Aberdeen-Causeway Bay/ Aberdeen-Causeway Bay (via Aberdeen Tunnel)	Green bus	Toyota Coaster LPG Light Bus	JN6854
			Vicmax Zen Electric Light Bus	BG9133
[Red bus]	Mong Kok-Oi Man	Red bus	Toyota Coaster LPG Light Bus	JN7274
			Ford Transit LPG Light Bus	JP6187
[1A]	Sai Kung-Choi Hung	Green bus	Toyota Coaster LPG Light Bus	JN7929
			Nissan Civilian LPG Light Bus	JN7865
[47M]	Chai Wan MTR-Siu Sai Wan	Green bus	Toyota Coaster LPG Light Bus	JN9241
			Ford Transit LPG Light Bus	JR1589
			Vicmax Zen Electric Light Bus	JS9947
[58]/ [59]	Aberdeen-Sai wan/ Aberdeen-Wong Chuk Hang	Green bus	Toyota Coaster LPG Light Bus	JR2445
			Vicmax Zen Electric Light Bus	JR951
[481]	Tsuen Wan-Fo Tan	Green bus	Toyota Coaster LPG Light Bus	JR1279
			Toyota Coaster LPG Light Bus	JR2381*
[48]	Kowloon Bay-Shun Lee Tsuen	Green bus	Toyota Coaster LPG Light Bus	JR746
			Vicmax Zen Electric Light Bus	JS3684

*Note： JR2381 served Route 58 from 15 July to 26 July and Route 481 after 27 July

Membership and Terms of Reference of the Monitoring Committee for the Trial of Alternative Fuelled Light Bus

Official Member

Transport Department (Chair)
Environment and Food Bureau
Transport Bureau
Electrical and Mechanical Services Dept.
Fire Services Department
Government Land Transport Agency
Environmental Protection Department

Non Official Member

Fleet Manager：
PLB General Association
Peace Base Investments Ltd.
Sai Kung PLB (Maxicab) No. 1 & 2 Co. Ltd.
Koon Wing Motors Ltd.
Aberdeen Maxicab Service Co. Ltd.
Fine Luck Ltd.

Trade Representative of Public/Young Children Private Light Bus:
The Kowloon PLB Chiu Chow Traders & Workers Friendly Association
Yan Yan Ho Motors Ltd.
Tuen Mun PLB Association
HK KLN & NT Public & Maxicab Light Bus Merchants' United Association
Chit Fai Motors Co. Ltd.
Private Hire Car for Young Children Association

Vehicle Supplier：
Honest Motors Ltd.
Crown Motors Ltd.
Wallace Harper & Co. Ltd.
Vicmax Corporation Ltd.

Expert：
Professor C.C. Chan (Hong Kong University)
Dr. W.T Hung (The Hong Kong Polytechnic University)

Invited to attend：
CLP Power Hong Kong Ltd
Caltex Oil Hong Kong Ltd.
Mobil Oil Hong Kong Ltd.
Shell Hong Kong Ltd.
Hong Kong Electric Ltd.
CRC Petrol Filling Station Co. Ltd.
Eco Energy Co. Ltd.*
Hong Kong Society for Rehabilitation

*Joined in October 2000

Terms of Reference

1. Report to Government all matters concerning the Trial of Alternative Fuelled Light Bus.
2. Arrange, execute and monitor the operation of the Trial of Alternative Fuelled Light Bus.
3. Provide advice and assist to solve any problem from the Fleet Managers and Vehicle Suppliers in the trial period.
4. Collect public opinions on the introduction of the use of Alternative Fuel in Light Buses.
5. Prepare report for the Trial of Alternative Fuelled Light Bus.
6. Provide opinion on technical matters related to the introduction of LPG or Electric Light Bus.

Trial Periods of all the Vehicles

Route		LPG/Electric Light Bus	Make/Model		Date started	Date completed
[5]/ [4C]	Aberdeen-Causeway Bay/ Aberdeen-Causeway Bay(via Aberdeen Tunnel)	JN6854	Toyota	Coaster	5.6.2000	4.12.2000
		BG9133	Vicmax	Zen	3.7.2000	2.1.2001
[Red Bus]	Mong Kok-Oi Man Tsuen	JN7274	Toyota	Coaster	6.6.2000	5.12.2000
		JP6187	Ford	Transit	24.6.2000	22.12.2000
[1A]	Sai Kung-Choi Hung	JN7929	Toyota	Coaster	7.6.2000	6.12.2000
		JN7865	Nissan	Civilian	7.6.2000	26.11.2000
[47M]	Chai Wan MTR-Siu Sai Wan	JN9241	Toyota	Coaster	13.6.2000	12.12.2000
		JR1589	Ford	Transit	15.7.000	14.1.2001
		JS9947	Vicmax	Zen	12.9.2000	31.1.2001
[58]/ [59]	Aberdeen-Sai Wan/ Abeadeen-Wong Chuk Hang	JR2445	Toyota	Coaster	15.7.2000	14.1.2001
		JR951	Vicmax	Zen	27.7.2000	26.1.2001
[481]	Tsuen Wan-Fo Tan	JR1279	Toyota	Coaster	15.7.2000	14.1.2001
		JR2381*	Toyota	Coaster	27.7.2000	14.1.2001
[48]	Kowloon Bay-Shun Lee Tsuen	JR746	Toyota	Coaster	15.7.2000	7.1.2001
		JS3684	Vicmax	Zen	30.8.2000	3.1.2001

*Note：JR2381served Route 58 from 15 July to 26 July and then Route 481 after 27 July.

LPG Light Bus

車廠 Make	Toyota
型號 Model	Coaster (LPG)
引擎類別 Engine Type	**直列** 4 **汽缸** 4-cylinder, in-line
汽缸容積 (公升) Cylinder Capacity (L)	4.104
最大馬力 Max. Power	85 kW @ 3600 rpm
最大扭力 Max. Torque	306 Nm @ 1600 rpm
石油氣缸容積 (公升) LPG Tank Capacity (L)	90

車廠 Make	Ford
型號 Model	Transit (LPG)
引擎類別 Engine Type	**直列** 4 **汽缸** 4-cylinder, in-line
汽缸容積 (公升) Cylinder Capacity (L)	1.998
最大馬力 Max. Power	84 kW @ 5500 rpm
最大扭力 Max. Torque	170 Nm @ 2700 rpm
石油氣缸容積 (公升) LPG Tank Capacity (L)	116

車廠 Make	Nissan
型號 Model	Civilian
引擎類別 Engine Type	**直列** 6 **汽缸** 6-cylinder, in-line
汽缸容積 (公升) Cylinder Capacity (L)	4.169
最大馬力 Max. Power	90 kW @ 3600 rpm
最大扭力 Max. Torque	270 Nm @ 2000 rpm
石油氣缸容積 (公升) LPG Tank Capacity (L)	126.5

Electric Light Bus

車廠 Make	Vicmax
型號 Model	Zen
引擎類別 Engine Type	**電池推動電力馬達** Battery Powered Electric Motor
最大馬力 Max. Power	75 kW
最大扭力 Max. Torque	419 Nm
電池類別 Battery Type	**鎳鎘** Nickel-Cadmium
電池容量 Battery Capacity	140 amp-hr

LPG Filling Station

Battery Charger

Shun Lee Estate, Sau Mau Ping

Nam Ning Street, Aberdeen

Appendix 8

Fuel Cost of Diesel, LPG and Electric Light Buses

	Fuel Consumption (Km/Litre) (A)	Fuel Price ($/Litre) (B)	Fuel Cost per Km ($/Km) (B/A)	Remarks
Diesel Light Bus	4.85	5.84 (4.96)	1.20 (1.02)	Fuel Station Price (Less 15%)
LPG Light Bus	2.6	2.01 to 2.04	0.77 to 0.78	Dedicated LPG Station Price
	2.6	2.72 to 3.88	1.05 to 1.49	Converted LPG Station Price
Electric Light Bus (Fuel Consumption calculated by Kilowatt-Hour)	1.02	0.943 to 0.968	0.92 to 0.95 (1.57 to 1.60)	Electricity cost varies according to district and quantity consumed (plus $72,000 for annual rental of Battery. i.e. approx. $0.65/Km)

[Note] Cost calculation is based on the price in January 2001

Appendix 9

LPG Light Buses Damaged due to Traffic Accidents

Exhaust Emissions Test Results of Diesel Light Buses

Test Route	Registration Mark	Year of Manufacture	Mileage* (Km)	Date of Test	Smoke reading/ Limit (HSU)	Power Reading/ Lower Limit (KW)
5	EG2823	1999	202,419	29.11.2000	8 / 50	72 / 50
Red Bus in Mong Kok	HY9521	1998	70,841	26.10.2000	7 / 50	64 / 50
1A	HW6445	1998	308,030	25.10.2000	5 / 50	73 / 50
47M	JP2271	2000	84,834	20.10.2000	50 / 50	75 / 50
58	GM1344	1995	136,179	29.11.2000	36 / 50	39 / 35
481	GM3724	1995	497,842	30.11.2000	13 / 50	40 / 35
48	HE7335	1997	542,360	21.10.2000	49 / 50	44 / 35

* According to the report from Emission Test Centre.

Monthly Exhaust Emissions Test Results of LPG Light Buses

Reg. Mark	Date started	Date Completed	June 2000		July		August				September			
							Before service		After service		Before service		After service	
			HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)
JN7929	7.6.2000	6.12.2000	5	<0.001	1	0.004			5	0.005	1	0.011	1	0.009
JN6854	5.6.2000	6.12.2000	0	<0.001	126	0.009			4	0.026	6	0.027	4	0.022
JN7274	6.6.2000	5.12.2000	0	<0.001	2	0.002			3	0.004	7	0.006	7	0.015
JN9241	13.6.2000	12.12.2000	5	<0.001	3	0.003			1	0.019	5	0.008	0	0.011
JR1279	15.7.2000	14.1.2001			0	0.001	1	0.012	0	0.009	9	0.013	6	0.017
JR2445	15.7.2000	14.1.2001			1	0.007	[Note 2]				1	0.011	0	0.010
JR746	15.7.2000	14.1.2001			4	0.006	[Note 2]				9	0.013	3	0.005
JR2381	15.7.2000	14.1.2001			0	0.004	0	0.040	0	0.060	5	0.005	3	0.004
JP6187	24.6.2000	23.12.2000	5	0.004	2	0.005	2	0.005	2	0.001	5	0.001	10	0.005
JR1589	17.7.2000	14.1.2001			5	0.003	18	0.004	4	0.003	6	0.002	5	0.001
JN7865	7.6.2000	6.12.2000			23	0.007			77	0.003	245	0.063	57	0.027

Emission Standard： Carbon monoxide(CO) - 1%
Hydrocarbons(HC) - 300ppm

Reg. Mark	October 2000				November				December				January 2001			
	Before service		After service		Before service		Before service		Before service		Before service		Before service		Before service	
	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)
JN7929	8	0.008	10	0.006	11	0.008	1	0.011	28	0.012						
JN6854	152	0.018	11	0.024	20	0.048	39	0.034	91	0.067	19	0.008				
JN7274	18	0.009	10	0.005	[Note 1]		8	0.009	17	0.015	11	0.018				
JN9241	12	0.011	12	0.012	5	0.007	7	0.014	37	0.059						
JR1279	9	0.071	8	0.006	[Note 2]				20	0.011	12	0.006	10	0.061	10	0.008
JR2445	6	0.007	12	0.004	11	0.014	8	0.008	9	0.007	10	0.006	15	0.004	5	0.005
JR746	22	0.010	5	0.026	22	0.032	17	0.007	13	0.010	5	0.006	10	0.007		
JR2381	12	0.01	0	0.007	27	0.007	8	0.005	8	0.015	20	0.006	[Note 1]		4	0.007
JP6187	38	0.002	0	0.001	3	0.002	16	0.006	20	0.011	13	0.010				
JR1589	30	0.002	30	0.001	7	0.002	8	0.002	9	0.003	7	0.006				
JN7865	78	0.054	62	0.057	507	0.131	[Note 2]									

[Note 1]：Not tested because test equipment failure.
[Note 2]：Not tested because the vehicle under repair.

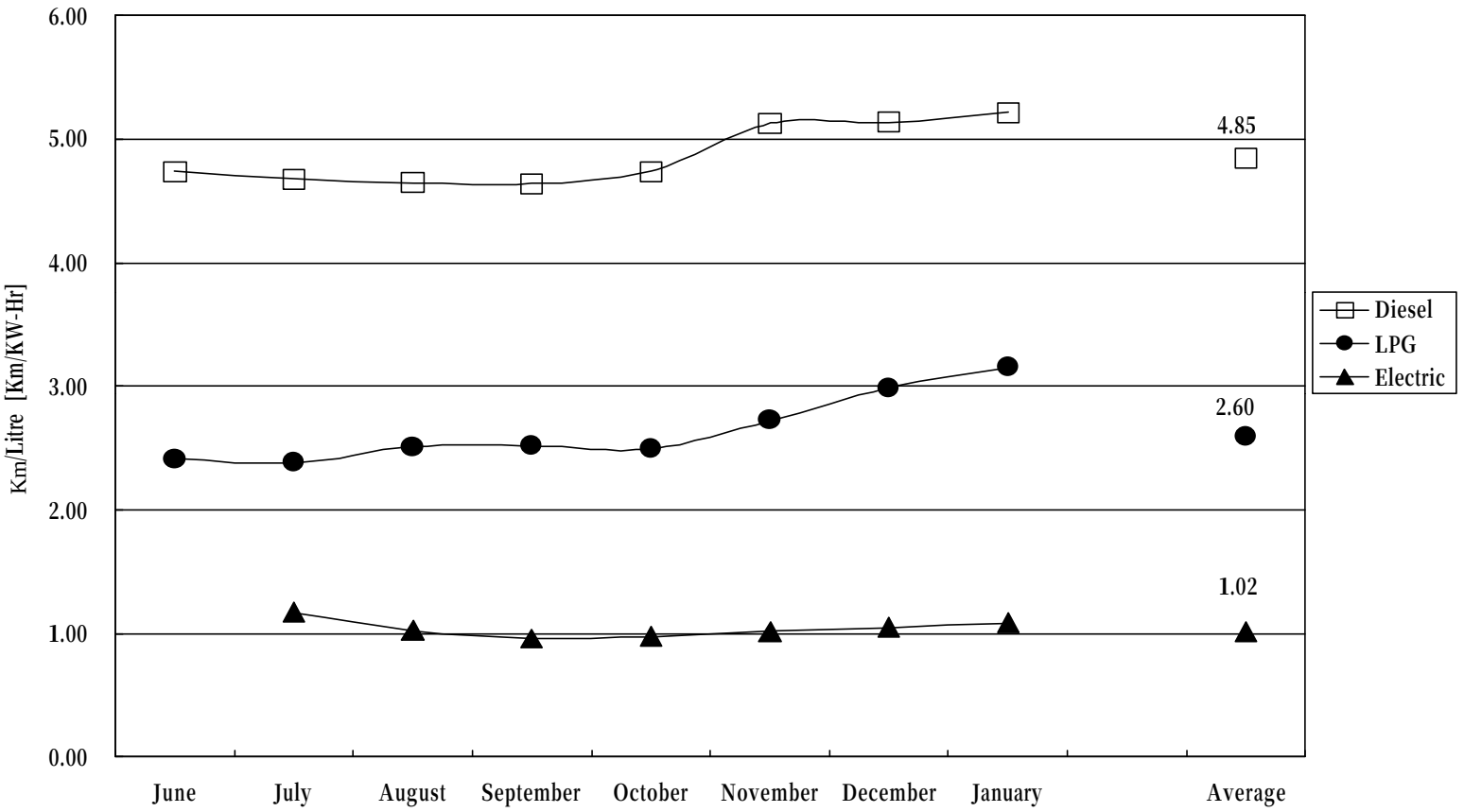
Appendix 11

Comparison of Exhaust Emissions between LPG and Diesel Light Buses

	LPG Model	Relevant Emission Standards	Euro III Diesel Model	Relevant Emission Standard
	(g/Km)			
Hydrocarbons + Oxides of Nitrogen	0.379	0.7	0.779	0.865
Carbon Monoxide	0.08	5.0	0.62	0.95
Particulate	Very low	NA	0.06	0.1
			(Absolute units of light absorption)	
Smoke	Very low	NA	0.68	1.0

	Pollutant Reduction Percentage of LPG Light Bus Compared with Euro III Diesel Model
Hydrocarbons + Oxides of Nitrogen	51%
Carbon Monoxide	87%
Particulate	Very low emission from LPG Model
Smoke	No black smoke from LPG Model

Comparison of Monthly Fuel Consumption for Diesel, LPG and Electric Light Bus



Appendix 13-1

Nissan Civilian W41 LPG Light Bus Regular Service Schedule

Maintenance Schedule			Monthly	6 months
Engine	1	Change engine oil and filter	X	X
	2	Clean / change air filter	X	X
	3	Drain tar in vaporizer	X	X
	4	Check LPG piping for looseness, damage & leakage	X	X
	5	Clean and adjust spark plug	X	X
	6	Check & adjust ignition timing	X	X
	7	Adjust valve clearance	X	X
	8	Check & adjust fan belt	X	X
	9	Check & adjust idling speed	X	X
	10	Check engine mounting	X	X
	11	Check exhaust pipe & its mounting	X	X
	12	Check and top-up coolant	X	X
	13	Top-up windscreen wiper fluid	X	X
	14	Engine emission test (HC & CO)	X	X
Power Train	15	Check & adjust clutch pedal free play	X	X
	16	Check clutch fluid Leakage of master & slave cylinder	X	X
	17	Check gearbox oil level & leakage	X	X
	18	Change gearbox oil	O	X
	19	Check universal joint & splines for wear	X	X
	20	Grease Universal joints	X	X
	21	Check differential oil level & leakage	X	X
	22	Change differential oil	O	X
Axle	23	Check wheel hub bearing for wear	X	X
	24	Check wishbone ball joint, bush & pin	X	X
	25	Check shock absorber for leakage & damage	X	X
	26	Check axle linkage for damage, looseness & excessive play	X	X
Wheel & Tire	27	Check wheel nuts looseness	X	X
	28	Check tire inflation and wear condition	X	X
Steering	29	Check power steering fluid level	X	X

Steering	30	Check & adjust steering wheel free play	X	X
	31	Check steering linkage for damage looseness	X	X
	32	Check wheel alignment if necessary	X	X
Brake	33	Check & adjust brake pedal free play	X	X
	34	Check brake fluid level & leakage	X	X
	35	Clean & dedust wheel brake	X	X
	36	Adjust wheel brake & hand brake	X	X
Electrical	37	Check electrolyte level, specific gravity	X	X
	38	Check function of starter motor	X	X
	39	Check alternator function	X	X
	40	Check all lights, horn, instrument gauges	X	X
	41	Check windscreen wiper & cleaner	X	X
	42	Check air conditioner performance	X	X
Other	43	Lubricate grease point of front axle, rear axle, propeller	X	X
	44	Vehicle cleaning	X	X

X - Applicable O – Not Applicable

Ford LPG Light Bus Service Schedule

Fuel System Service Schedule

Kmx1000 / Item	1.5	20	40	50	60	80	100	120	140	150
High pressure injection test for leakage:										
Vaporizer and cut-off device	I	I	I		I	I	I	I	I	
All LPG piping	I	I	I		I	I	I	I	I	
Filter valve	I	I	I		I	I	I	I	I	
Fuel tank connection	I	I	I		I	I	I	I	I	
Fuel system joint	I									
Check filter/cut-off device	F			F			F			I*
Overturn restriction device function				I			I			I
Air filter		I*	I*	S	I*	I*	S	I*	I*	S
Spark plug		R	R	S	R	R	S	R	R	S
Spark-plug wire	I	I		C		I	C	I		C
Check computer analyzer	N	N	N	S	N	N	S	N	N	S
Drain tar in vaporizer		D	D		D	D	D	D	D	
Check idling speed governor	I	I	I		I	I	I	I	I	

Note:

I -Check function and test operator
I*- -Clean or replace if necessary
R -Replace
S -Including in standard service plan
F -Clean or replace if necessary (High pressure injection test for leakage after replacement)
C -Check resistance of spark-plug wire
D -Loose bolt to drain tar in vaporizer
N -Fault code function test

Monthly service schedule for other parts

Engine	1.	Check engine oil, coolant & intake air for leakage
	2.	Change engine oil & filter
	3.	Check engine mounting
	4.	Clean/change intake air filter
	5.	Change fuel filter
	6.	Check & adjust idling and accelerative speed
	7.	Adjust cooling fan belt tension and check for damage
	8.	Check coolant pump for leakage
	9.	Check and top-up coolant
	10.	Check noise emission and engine performance
	11.	Check engine cover and intake air line for looseness
	12.	Check radiator cap function
	13.	Clean radiator
Steering	14.	Check power steering fluid level
	15.	Check power steering performance
	16.	Check steering linkage for damage
Transmission	17.	Check driving system performance and leakage
	18.	Check gearbox oil leakage
	19.	Check vacuum & air piping for leakage
	20.	Check driving system electrical connector for damage
	21.	Check gear changer and linkage
	22.	Check overall performance of driving system
	23.	Check driving system linkage for looseness & normal operation
	24.	Grease driving system linkage
	25.	Check differential gear box for leakage

Transmission	26.	Check differential gear overall performance
Clutch	27.	Check & adjust clutch pedal free play
	28.	Check & top-up clutch fluid
Wheel & axle	29.	Check tire inflation and wear condition
	30.	Check wheel bolts looseness
	31.	Check wheel nuts looseness
	32.	Check linkage bolts looseness
	33.	Check wheel bearing looseness
	34.	Check axle bolts for looseness
Brake	35.	Check and adjust brake pedal free play
	36.	Check brake system leakage and function
	37.	Check brake fluid leakage
	38.	Top-up brake fluid if necessary
	39.	Check hand brake function
	40.	Adjust brake lining clearance
	41.	Check brake lining and drum wear & damage
	42.	Check brake fluid piping condition
	43.	Check brake efficiency
	44.	Clean & dedust brake drum
	45.	Check exhaust assist brake system
Suspension	46.	Check leaf spring damage & position
	47.	Check all mounting for looseness, crack & damage
	48.	Check shock absorber for leakage and damage
	49.	Check spring and bush condition
Electrical	50.	Check alternator function
	51.	Check battery fitting, electrolyte level & charge level

Electrical	52.	Check battery connection condition
	53.	Check lamp, horn, instrument board & direction indicator lamp
	54.	Check windscreen wiper function
	55.	Check starter motor performance
	56.	Check wire for damage & connector looseness
	57.	Check starter motor & alternator mounting
	58.	Check & top-up windscreen cleaner fluid
Air conditioning	59.	Check air conditioning performance
	60.	Check pipe joint looseness & tight-up
	61.	Clean radiator by compressed air or water jet
	62.	Clean refrigerator filter by compressed air or water jet
Body & Chassis	63.	Check body, Chassis, platform & paint for damage
	64.	Grease chassis, universal joint & transmission shaft link
	65.	Check auto door function
	66.	Check passenger seat mounting & safety belt normal function
	67.	Check emergency exit
Other	68.	Road test

Appendix 13-7

Ford Diesel Light Bus Service Schedule

Service Item	Work	Inspection before delivery of vehicle	Mileage (X 1000 Km)		
			1, 5	15, 30, 60, 75	45, 90
Fluid level	Check/top-up if necessary :				
	- Coolant	●	●	●	●
	- Engine oil	●	●	-	-
Auxiliary engine belt	Check condition/Adjust tension if necessary	-	-	●	●
Engine	Check radiator, fuel & brake fluid piping for leakage and damage	●	●	●	●
	Check & correct circuit	●	●	●	●
Air filter	Change	-	-	-	●
Valve clearance	Check/adjust	-	-	●	●
Engine	Change engine oil and filter	-	-	●	●
Underneath	Check exhaust pipe leakage & damage	●	●	●	●
Fuel filter	Change	-	-	-	●
Driving belt	Change	-	-	-	a

a –only at 90,000 Km

Toyota Coaster LPG Light Bus Service Schedule

Item			General Service (Every 10,000 Km or 1 month)	Thorough Service (Every 40,000 Km or 4 month)
Engine	1.	Engine oil & filter	R	R
	2.	Fuel filter	I	I/R
	3.	Air filter	I/R	I/R
	4.	Engine belt & belt tension	I	I
	5.	Radiator cap & cooling fan function	I	I
	6.	Radiator piping & connection	I	I
	7.	Engine coolant	I	I/R
	8.	Spark plug	I	I/R
	9.	Ignition timing	I	I
	10.	Idling speed & idle fuel ratio	I	A
	11.	Exhaust pipe and mounting	I	I
	12.	Fuel piping and joint	I	I
	13.	Carburetor pipe	I	I
	14.	LPG injection nozzle	I	I
	15.	Crankcase compulsory ventilation	I	I
Steering	16.	Steering wheel & Link	I	I
	17.	Universal joint & dust cover	I	I
	18.	Steering stub axle & cross rod linkage	T	T
	19.	Power steering fluid	I	I
	20.	Steering fluid hose & sealant	I	I
Suspension	21.	Leaf spring damage & deform	I	I
	22.	Shock absorber function & wear	I	I
Brake	23.	Brake pedal & hand brake free play	A	A
	24.	Brake drum & lining	I	I
	25.	Brake fluid	I	I/R

Brake	1.	Brake fluid piping and hose	I	I
	2.	Brake lining clearance	A	A
Transmission	3.	Clutch fluid leakage	I	I
	4.	Clutch oil	I	I/R
	5.	Clutch pedal free play	A	A
	6.	Gear box oil	I/R	I/R
	7.	Gear box oil leakage	I	I
	8.	Universal joint	I	I
	9.	Differential oil	I/R	I/R
Electrical	10.	Battery electrolyte & charge	I	I
	11.	All original electrical equipment	I	I
	12.	Air conditioner performance	I	I
Other	13.	LPG fuel tank mounting	I	I
	14.	Tire & inflation	I	I
	15.	Wheel bearing greasing	I/F	I/F
	16.	Road test	Need	Need

Note:
A - Adjust if necessary
I - Check
R - Replace
F - Top-up
T - Adjust to fit the standard

Toyota Coaster Diesel Light Bus Regular Service Schedule

Item \ Service frequency			Mileage (X 1000 Km)									
			1	10	20	30	40	50	60	70	80	Month
Basic Engine Part	1.	Valve clearance	-	-	A	-	A	-	A	-	A	24
	2.	Engine belt	-	-	I	-	I	-	I	-	I	24
	3.	Engine oil	Every 5000 Km or 6 month									
	4.	Engine oil filter	-	R	R	R	R	R	R	R	R	12
	5.	Coolant system hose and joint	-	-	-	-	I	-	-	-	I	24
	6.	Engine coolant	-	-	-	-	R	-	-	-	R	24
	7.	Exhaust pipe and mounting	-	-	I	-	I	-	I	-	I	12
	8.	Battery	-	I	I	I	I	I	I	I	I	12
Fuel & exhaust emission system	9.	Fuel filter	-	-	R	-	R	-	R	-	R	24
	10.	Water settle sump	-	I	I	I	I	I	I	I	I	12
	11.	Air filter	Check & clean every 10000 Km or 12 month Replace every 100000 Km or 120 month									
	12.	Engine idling speed	A	-	A	-	A	-	A	-	A	24
	13.	Smoke test	-	-	-	-	I	-	-	-	I	48
	14.	Fuel tank, piping & connection	-	-	-	-	I	-	-	-	I	24
Chassis & body	15.	Clutch pedal	I	-	-	-	-	-	-	-	-	-
	16.	Brake pedal & hand brake	Check at 1st 1000 Km and then every 5000 Km or 3 month									
	17.	Brake drum and lining	-	-	I	-	I	-	I	-	I	12
	18.	Brake fluid	I	I	I	I	R	I	I	I	R	I:6 R:24

Chassis & body	19.	Clutch fluid	I	I	I	I	I	I	I	I	I	I:6 R:24
	20.	Brake piping & hose	I	-	I	-	I	-	I	-	I	12
	21.	Power steering fluid	-	I	I	I	I	I	I	I	I	6
	22.	Steering wheel, link & gear box	I	I	I	I	I	I	I	I	I	6
	23.	Grease steering stub axle, drag, side & cross rod	Change or grease every 5000 Km or 3 month									
	24.	Grease front suspension rod sleeve	-	-	R	-	R	-	R	-	R	12
	25.	Grease transmission shaft	-	-	R	-	R	-	R	-	R	12
	26.	Universal joint & dust cover	-	I	I	I	I	I	I	I	I	6
	27.	Manual gear box oil	-	-	-	-	I	-	-	-	I	48
	28.	Differential gear box oil	-	-	I	-	R	-	I	-	R	I:12 R:48
	29.	Wheel bearing & grease universal joint	-	-	R	-	R	-	R	-	R	12
	30.	Front & rear suspension system	I	I	I	I	I	I	I	I	I	6
	31.	Tire & inflation	-	I	I	I	I	I	I	I	I	6
	32.	Light, horn, windscreen wiper & washer	-	I	I	I	I	I	I	I	I	6
	33.	Air conditioner/refrigerant	I	-	I	-	I	-	I	-	I	12

Note :
A – Check and/or adjust if necessary
I – Check & correct if necessary
R – Replace or grease

Vicmax Zen Electric Light Bus Service Schedule

	Service item		Period/mileage
Battery set	1.	Balance power charge	Use every 3,000 A-hr
	2.	Charge & top-up electrolyte	Every charge 1,000 A-hr
	3.	Check electrolyte circulation & tight battery connector	Every charge 1,000 A-hr
	4.	Check cooling system of battery set	Every charge 1,000 A-hr
	5.	Clean battery case	If necessary
Chassis	6.	Check & adjust brake system	Every 10,000 Km
	7.	Check & adjust hand brake	Every 20,000 Km
	8.	Check & adjust steering system clearance	Every 20,000 Km
	9.	Check power steering motor & pump	Every 20,000 Km
	10.	Check vacuum motor & pump	Every 20,000 Km
	11.	Check wheel bearing & suspension	Every 40,000 Km
	12.	Change brake fluid	Every 50,000 Km
	13.	Change differential gear box oil	Every 50,000 Km
Power train	14.	Check & clean cooling system	Every 15,000 Km
	15.	Check motor mounting	Every 30,000 Km
	16.	Change transmission fluid	Every 50,000 Km
	17.	Check step up transform voltage	Use every 2,000 hr
	18.	Check control device output voltage	Use every 2,000 hr
	19.	Check recharge control voltage	Use every 2,000 hr
	20.	Check MVD C control signal strength	Use every 2,000 hr
	21.	Check motor main shaft wear	Every 300,000 Km

Appendix 14

The Trial of Alternative Fuelled Light Bus

Summary of Passengers' Views on LPG / Electric Light Bus Collected by Questionnaire

Do you find that the alternative fuelled light bus is quieter and more comfortable than a diesel light bus ?	Yes	No	Same
	85%	3%	12%
Do you agree that alternative fuelled light bus is more environmentally friendly than diesel ?	Yes	No	No comment
	93%	1%	6%
Do you support using alternative fuelled light bus on a large scale ?	Yes	No	No comment
	95%	1%	4%

Other suggestion :

Support the introduction of alternative fuelled light bus	17
Alternative fuelled light bus is more environmental friendly	5
Support promotion of alternative fuelled light bus	2
Have comments on the design of light bus	20
Care of cost/ fee	7
Willing to pay more	1
Other	7

Note：116 copies of effective questionnaire collected

Operation Loss Data of LPG/Electric Light Bus (Comparison with Diesel Light Bus)

Information provided by Fleet Manager

Route	Diesel		LPG			Diesel	Electric		
	Daily Shifts/Runs	Refills daily (Time require for each refill)	Runs reduce daily	Average Operation Lost	Refills daily (Time require for each refill)	Daily Shifts/Runs	Runs reduce daily	Average Operation Lost	Recharges daily (Time require for each recharge)
[5] Aberdeen – Causeway Bay	3 / 27	2 (6 Mins)	11%	10%	3 (50 Mins)	2 / 18	33%	35%	6-7 (25-30 Mins)
[58] Aberdeen – Sai Wan	2 / 18	1 (6 Mins)	11%	8%	2 (20 Mins)	1.5 / 32 [Note 2]	25%	22%	4-5 (20-30 Mins)
[481] Fo Tan – Tsuen Wan (1)	1.5 / 14	1 (15 Mins)	21%	21%	2 (60 Mins)	NA			
[481] Fo Tan – Tsuen Wan (2)	1.5 / 14	1 (15 Mins)	21%	21%	2 (60 Mins)	NA			
[47M] Chai Wan MTR – Siu Sai Wan (1)	2 / 39	1/2 (30 Mins)	4%	1%	2 (30 Mins)	2 / 39	58%	68%	3 (120 Mins) [Note 3]
[47M] Chai Wan MTR – Siu Sai Wan (2)	2 / 39	1/2 (30 Mins)	1%	5%	1 (30 Mins)	NA			
[48] Shun Lee – Kowloon Bay	2 / 22	1 (10 Mins)	14%	5%	3 (40 Mins)	2 / 22	41%	45%	6 (25-30 Mins)
[1A] Sai Kung – Choi Hung (1)	3 / 21	1 (10 Mins)	14%	14%	4-5 (25-30 Mins)	NA			
[1A] Sai kung - Choi Hung (2)	3 / 21	1 (10 Mins)	14%	14%	3-4 (25-30 Mins)	NA			
[Red bus] Mong Kok – Oi Man (1) [Note 1]	2 / 29	2 (15 Mins)	24%	32%	2 (30 Mins)	NA			
[Red bus] Mong Kok – Oi Man (2) [Note 1]	2 / 29	2 (15 Mins)	10%	12%	1 (30 Mins)	NA			

Remarks:

1. Calculation was based on actual operation income provided by the fleet managers.

2. Operation loss and runs reduction were based on comparison with the diesel light bus running on the same days and shifts.

[Note 1] No actual operation income data for red bus, the operation lost is estimated by average number of passengers of each run.

[Note 2] This electric light bus operated in Route 59, round trips from Aberdeen to Wong Chuk Hang.

[Note 3] This electric light bus returned to maintenance depot for recharge of battery.

Adjusted Operation Loss Data of LPG/Electric Light Bus

(Comparison with Diesel Light Bus Having the same shift)

Route	Diesel			LPG			Diesel	Electric		
	Daily Shifts/Runs	Refills Daily (Time require for each refill)		Runs reduce daily	Average Operation Lost	Refills daily (Time require for each refill)	Daily Shifts/Runs	Runs reduce daily	Average Operation Lost	Recharges daily (Time require for each recharge)
[5] Aberdeen – Causeway Bay	3 / 27	2	(6 mins)	11%	10%	3 (50 mins)	2 / 18	33%	54%	6-7 (25-30 mins)
[58] Aberdeen – Sai Wan	2 / 18	1	(6 mins)	11%	8%	2 (20 mins)	1.5 / 32 [Note 2]	25%	34%	4-5 (20-30 mins)
[481] Fo Tan – Tsuen Wan (1)	1.5 / 14	1	(15 mins)	21%	17%	2 (60 mins)	NA			
[481] Fo Tan – Tsuen Wan (2)	1.5 / 14	1	(15 mins)	21%	15%	2 (60 mins)	NA			
[47M] Chai Wan MTR – Siu Sai Wan (1)	2 / 39	1/2	(30 mins)	4%	6%	2 (30 mins)	2 / 39	58%	55%	3 (20-34 mins) [Note 3]
[47M] Chai Wan MTR – Siu Sai Wan (2)	2 / 39	1/2	(30 mins)	1%	2%	1 (30 mins)	NA			
[48] Shun Lee – Kowloon Bay	2 / 22	1	(10 mins)	14%	6%	3 (40 mins)	2 / 22	41%	45%	6 (25-30 mins)
[1A] Sai Kung – Choi Hung (1)	3 / 21	1	(10 mins)	14%	6%	4-5 (25-30 mins)	NA			
[1A] Sai Kung – Choi Hung (2)	3 / 21	1	(10 mins)	14%	12%	3-4 (25-30 mins)	NA			
[Red bus] Mong Kok – Oi Man (1) [Note 1]	2 / 29	2	(15 mins)	24%	32%	2 (30 mins)	NA			
[Red bus] Mong Kok – Oi Man (2) [Note 1]	2 / 29	2	(15 mins)	10%	12%	1 (30 mins)	NA			

Remarks:

1. Calculation was based on actual operation income provided by the fleet managers.
2. Operation loss and runs reduction were based on comparison with the diesel light bus running on the same days and shifts.
3. For those months with loss in operation days due to accidental repairs, their monthly turnover were not included in the calculation (except red buses).

[Note 1] No figure of actual income for red bus, operation lost is estimated by average number of passengers of each run.

[Note 2] This electric light bus operated in Route 59, round trips from Aberdeen to Wong Chuk Hang.

[Note 3] This electric light bus returned to maintenance depot for recharge of battery.