Legislative Council Panel on Transport

<u>Feasibility Study on Introducing Trolleybus System in Hong Kong</u>

INTRODUCTION

The consultancy study on the feasibility of introducing trolleybus system in Hong Kong (the Study) has been completed. This paper informs members of the key findings of the Study and the next steps to be taken by the Administration.

BACKGROUND

2. The Study was commissioned by Transport Department in 2000. The scope of the Study covers the following –

(i) operational feasibility;
(ii) design and operational features;
(iii) financial viability;
(iv) environmental implications as compared with diesel bus operation;
(v) broad regulatory, institutional and legislative framework; and
(vi) priority areas for further work or studies.

3. As part of the Study, the consultant has conducted three case studies to assess the operational and financial feasibility and the environmental implications of operating trolleybuses as compared with diesel buses in different operating environments in Hong Kong. The selected areas for the case studies are –

(i) the Central-Wan Chai Corridor which is a built up area with high traffic;
(ii) Aberdeen which is an existing built-up area with medium traffic; and
(iii) South East Kowloon Development (SEKD) which is a new development area.

4. The key findings and proposals of the Study are summarised in paragraphs 5-18 below.

SUMMARY OF KEY FINDINGS AND PROPOSALS OF THE STUDY

Technical and operational feasibility

5. Trolleybuses would be technically and operationally feasible in most circumstances in Hong Kong, but the feasibility of their operation in busy urban areas and in tunnels has yet to be established. There are important technical and operational issues to be resolved for trolleybus operation in these areas, in particular –

(i) trolley vehicles: the preferred vehicle type for Hong Kong is an air-conditioned, low-floor double-deck trolleybus. This new vehicle type would need to be designed. For manufacturers to be sufficiently interested to develop a new vehicle type, a minimum order of about 40-50 buses would be necessary;

(ii) vertical clearance: the recommended normal height for trolley wires is 6 metres. This exceeds the vertical clearance of many over-bridges constructed in accordance with Government standard clearance of 5.1 metres. There is a possible need for speed restrictions under this clearance in order to reduce the risk of dewirements. As for temporary structures and overbridges which provide Government standard clearance of 4.7 metres, the operation of double-deck trolleybuses would not be possible. Measures like temporary diversion, use of auxiliary engines, or temporary substitution by diesel buses would be required and these measures could be difficult and costly;

(iii) traffic impact: the constraint that trolleybuses could operate only within the reach of their trolley booms from the trolley wires, their inability to overtake one another without passing loops, and the possibility of dewirement would contribute to potential traffic delays especially in congested urban corridors;

(iv) depot location: trolleybus depots should be as close to the trolleybus network as possible to avoid the stringing of wires with no revenue-earning operation, thereby adding to the cost;

(v) hanging signs: repair or construction work on hanging signs directly above trolleybus wires (which, unlike tram wires, have both positive and negative overhead wires) would be dangerous. Legislation for relocating or removing such signs and compensation of owners would have to be considered;

(vi) fire-fighting: solutions have to be developed to prevent the trolley wires and traction poles from blocking the access of aerial ladders; and

(vii) infrastructure support: the planting of traction poles and underground feeder cables in busy urban areas could cause problems and solutions to them could be costly and time-consuming.

6. No single issue would stand in the way of trolleybus operation. However taken together they present important risks which would be greatest if trolleybuses were to be introduced in busy urban areas.

Financial viability and fares

7. Based on the three case studies, capital investment for trolleybus system is about 80%-210% higher than that for a comparable diesel bus system and the trolleybus fares would need to be about 24%-65% higher in order to achieve financial viability (i.e. 13% post tax internal project rate of return), assuming the "best case" scenario (where the routes most suitable for conversion are selected for study) and no elasticity of demand. There is also the pre-requisite that competition from other transport modes should be controlled or restricted, which will be particularly difficult to achieve in existing built-up areas where such competition already exists.

Annex A

8. The levels of fare premium required in respect of the three case studies are summarised below (details in Annex A) –

(i) Aberdeen: conversion of the existing network of domestic bus routes to trolleybus routes would require an additional 42-52% fare premium over diesel bus fares which could achieve financial viability;

(ii) Central-Wan Chai Corridor: conversion of a network of bus routes to trolleybus at similar fares would barely be able to meet the operating costs, let alone covering financing costs. Fares would need to be 54-65% higher;

(iii) SEKD: fares would need to be 24-33% higher; and trolleybus viability would be very sensitive to the level of competition from other modes.

9. Apart from restricting competition from other transport modes, there may be other measures to improve the financial viability of trolleybuses e.g. cross-subsidy of trolleybus services from diesel bus services (by covering both services in a single franchise) or of trolleybus power supplies from general electricity supplies (by integrating the former with the existing wider electricity system).

Environmental implications

10. Trolleybuses produce no tailpipe emission. The replacement of diesel buses by trolleybuses could bring benefits in terms of air quality improvement at street level.

11. In Aberdeen and Central/Wan Chai, the case studies show that when the current plans to improve the environment are in place (including the use of ultra low sulphur diesel (ULSD), fitting of continuous regenerating traps, gradual replacement of older buses by Euro III buses, and replacement of diesel taxis by liquefied petroleum gas (LPG) taxis), there would be significant reduction in tailpipe emission at the roadside by 2011 (as compared with 1997, the year in which latest figures are available) even without using trolleybuses. With the replacement of diesel buses by trolleybuses as envisaged in the case studies, the additional reduction in particulates and hydrocarbons would be small whereas the additional reduction in nitrogen oxides would be greater. Details are shown below –

	Reduction in tailpipe emission in 2011 when compared with emission level in 1997			
	Aberdeen		**Central/Wan Chai**	
	Reduction with diesel bus	Additional reduction with trolleybus	Reduction with diesel bus	Additional reduction with trolleybus
Particulates (PM_{10})	65%	0.5%	85%	1%
Nitrogen oxides (NO_x)	39%	4%	44%	6%
Hydrocarbons (HC)	32%	2%	45%	2%

12. For the SEKD case study, there is no base data for 1997 to reflect the reduction that would be brought about by the planned improvement measures. By comparing the tailpipe emissions under a diesel bus scenario and a trolleybus scenario in 2016 when SEKD will reach full development, the reductions in emissions are –

	Reduction in tailpipe emission in SEKD in 2011 with the use of trolleybuses instead of diesel buses as tested <u>in the SEKD case study</u>
Particulates (PM_{10})	1 to 5%*
Nitrogen Oxides (NOx)	9 to 20%*
Hydrocarbons (HC)	2 to 5%*

* *The range corresponds to high and low traffic forecasts.*

Annex B Detailed figures are given in Annex B.

13. Trolleybuses would bring benefits in noise reduction. The magnitude of such benefits would depend on the traffic mix and volume, and ambient noise levels.

14. Visual impact of the overhead trolley wires and traction poles could be an issue, depending on the public's perception. Proper attention to design would be important.

Regulatory, institutional and legislative framework

15. The franchise options (e.g. vertical integration of trolleybus operation and power distribution, horizontal integration of trolleybus and diesel bus operation, or separate franchises) would depend on factors such as the network size, the possibility of cross subsidy and the need for operators to share the overhead. In the event that trolleybuses would replace existing diesel buses, the implications for the franchise of existing bus companies would also need careful examination.

16. Legislative amendments to the Road Traffic Ordinance (Cap. 374) and the Public Bus Services Ordinance (Cap. 230) would be necessary to enable the operation of a trolleybus system on the road. The Study also proposed that a new ordinance should be enacted to cater for the construction, safety and franchising of the power distribution system for the trolleybus system.

Study Proposals

17. The Study concluded that, in view of the advancement in bus technology and the availability of alternative technologies, it is important to evaluate the most appropriate and cost-effective ways of improving the roadside environment before committing to the introduction of trolleybuses in

Hong Kong. If a decision is taken to pursue the trolleybus option, it would be desirable to conduct a pilot scheme to gain on-road service experience. Such a scheme should comprise a reasonably sized trolleybus network in a suitable location where it would be feasible to achieve financial viability.

18. Congested urban corridors are not recommended as suitable locations for a pilot scheme. If a new development area is selected for the pilot scheme, the first step would be a detailed evaluation of the various environmentally friendly transport modes to ascertain whether trolleybuses would be the best option. The Study estimated that it would take about 5 years to implement a pilot scheme.

THE ADMINISTRATION'S ASSESSMENT

Government's objective

19. It is the Government's transport objective to provide transport infrastructure and services in an environmentally acceptable manner to ensure the sustainable development of Hong Kong. To alleviate the environmental impact of transport activities, we have adopted a multi-facet approach –

- better integration of transport and land use planning;
- better use of railways as the backbone of our passenger transport system;
- better public transport services and facilities;
- better use of advanced technologies in transport management; and
- better environmental protection.

Environmental dimension

20. Based on the findings of the Study, the reason for pursuing the introduction of trolleybuses would solely be environmental as trolleybuses do not offer a higher quality of passenger service than buses. The additional reductions of emission that could be achieved by trolleybuses, which are set out in paragraphs 11-12 above, would be small in existing built-up areas whereas they would be greater in new development areas. With the advancement of bus technology and after-treatment devices and the use of cleaner diesel, the gap between trolleybuses and diesel buses in terms of environmental performance is narrowing. Indeed, research and development is being conducted in other places on newer bus technology to improve the environment. Trolleybuses may not be the only choice in the years to come.

Financial viability and fares

21. The biggest problem is that trolleybus system costs a lot more than diesel bus system and trolleybus fares need to be much higher than diesel bus fares. Regarding possible cross-subsidy to improve the financial viability, there is no strong case nor merit for any cross-subsidy from general electricity supplies to trolleybus power supplies. It is difficult to see why electricity users would subsidise transport users. The possibility of cross-subsidy from other transport mode to trolleybuses in the form of a single franchise would have impact on the fares of the other transport mode involved. The public acceptability of the resulting increase in these fares would have to be considered carefully.

22. As for the possible need for restricting competition from existing transport modes, this is not in line with our philosophy of allowing healthy competition between different transport modes. Based on the results of the Study, there is not a strong case to restrict such competition to ensure the financial viability of trolleybus operation.

Private Sector Initiative

23. Citybus Limited (Citybus) has just commenced a depot trial of running a prototype air-conditioned double-deck trolleybus converted from an existing diesel bus. The converted vehicle is also equipped with an auxiliary diesel power unit to give limited off-wire capacity. It will be tested in both on and off-wire modes to ascertain energy consumption levels under loaded conditions and simulated passenger service conditions and to determine componentry life. Transport Department has been in contact with Citybus on the progress of the scheme and will examine the results of the trial when they are available.

WAY FORWARD

Existing built-up areas

24. In view of the important technical and operational risks mentioned in paragraphs 5-6 above and the financial viability and fare problem mentioned in paragraphs 7-8 and 21-22 above, we would not pursue the introduction of trolleybuses in existing built-up areas. Since railways are more efficient and environmentally friendly mass carriers, we should continue to accord priority to the development of railways to make them the backbone of our transport system. However, if a transport operator puts forward proposals for introducing trolleybuses, we would keep an open mind

and consider them carefully taking into account the likely impact on the existing bus franchises.

New development areas

25. On the other hand, we would explore the merits of introducing a pilot trolleybuses scheme vis-a-vis other environmentally friendly transport modes in a new development area. In the light of the Study findings, we will study the merits of implementing a pilot trolleybus scheme in SKED vis-a-vis other environmentally friendly transport modes to determine the best choice of transport mode for this new development area.

Transport Bureau
June 2001

Feasibility Study of Introducing a Trolleybus System in Hong Kong
- Assessment of Financial Viability

- The capital investment (at 2000 prices) required for a trolleybus system is some 80%-210% higher than that for a comparable diesel bus system:

Table 1

Case Studies	**Aberdeen**	**Central/Wan Chai**	**SEKD**
Fleet size	47 (8 routes)	134 (10 routes)	70 (5 routes)
Total capital investment **- for diesel bus system** **- for trolleybus system** *(% difference over diesel bus system)*	 $144M $373M-$420M *(159%-192%)*	 $406M $1,136M-$1,270M *(180%-213%)*	 $268M $483-$553M *(80%-106%)*

- The case studies show that in order to be financially viable, trolleybus fares have to be 24%-65% higher than diesel bus fares and competition with other transport modes would have to be restricted. The key findings of the financial analyses are given below:

Table 2

	Diesel Bus	**Trolleybus**	**% Difference of Trolleybus fares over Diesel bus fares**
Aberdeen			
Fare at 13% project IRR	$3.3	$4.7-$5.0	42%-52%
Central/Wan Chai			
Fare at 13% project IRR	$3.7	$5.7-$6.1	54%-65%
SEKD			
(i) High competition[1]			24%-33% (Remarks : Fares should be regarded as illustrative only.)
Fare at 13% project IRR	$5.0	$6.6-$6.7	
(ii) Moderate competition[2]			
Fare at 13% project IRR	$3.4	$4.2-$4.5	
(iii) No competition[3]			
Fare at 13% project IRR	$1.8	$2.2-$2.4	

- The figures above should be interpreted with caution because:

(a) the fare differentials already represent the "best case" scenarios since the routes

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1 *This assumes that a substantial number of direct external diesel buses are allowed to be operated in SEKD and as a result trolleybuses would carry only 50% of the internal SEKD trips.*

2 *This assumes that some direct external diesel buses are allowed to be operated in SEKD and as a result trolleybuses would carry only 75% of the internal SEKD trips.*

3 *This scenario is for reference purpose. It is unrealistic to assume implementation of the no competition scenario where SEKD fare is assumed to be $1.8.*

selected in the case studies in the urban areas are financially more promising and an optimistic patronage is assumed in SEKD; and

(b) elasticity of demand has not been accounted for. Higher trolleybus fares would lead to drop in patronage, depending on the availability of other alternative modes.

June 2001

Feasibility Study of Introducing a Trolleybus System in Hong Kong
- Environmental assessment

Detailed comparisons of total tailpipe emissions between diesel bus scenario and trolleybus scenario in the three case studies are given in the following tables:

Table 1 : Aberdeen case study
Comparison of total tailpipe emissions in 1997 and 2011
(with or without trolleybuses)

Emissions (grams/hour)	**1997**	**2011 (with diesel buses)(1)**	**2011 (with 47 diesel buses replaced by trolleybuses)(1) (2)**	**2011 Additional reduction due to trolleybuses**
Particulates (PM_{10})	14,785	5,189 *(65% reduction)*	5,132 *(65.5% reduction)*	0.5%
Nitrogen Oxides (NOx)	92,909	56,570 *(39% reduction)*	52,593 *(43% reduction)*	4%
Hydrocarbons (HC)	28,532	19,363 *(32% reduction)*	18,929 *(34% reduction)*	2%

Note (1) *The 2011 scenarios assume the current plans to improve the environment are in place (including the use of ULSD, fitting of continuous regenerating traps, gradual replacement of older buses by Euro III buses, replacement of diesel taxis by LPG taxis).*

Note (2) *The case study has examined the scenario where 35% of the diesel buses operating in the study area in terms of bus-km operated would be replaced by trolleybuses. If all the diesel buses in the study area are to be replaced by trolleybuses, it would result in further additional reduction of 0.5% for PM_{10}, 8% for NO_X and 4% for HC. However, such a wholesale replacement is not feasible in the foreseeable future.*

Table 2 : Central/Wan Chai case study
Comparison of total tailpipe emissions in 1997 and 2011
(with or without trolleybuses)

Emissions (grams/hour)	**1997**	**2011 (with diesel buses)(1)**	**2011 (with 134 diesel buses replaced by trolleybuses)(1) (2)**	**2011 Additional reduction due to trolleybuses**
Particulates (PM_{10})	4,549	664 *(85% reduction)*	640 *(86% reduction)*	1%
Nitrogen Oxides (NO_X)	29,765	16,542 *(44% reduction)*	14,878 *(50% reduction)*	6%
Hydrocarbons (HC)	7,841	4,276 *(46% reduction)*	4,092 *(48% reduction)*	2%

Note (1) *The two 2011 scenarios assume the current plans to improve the environment are in place (including the use of ULSD, fitting of continuous regenerating traps, gradual replacement of older buses by Euro III buses, replacement of diesel taxis by LPG taxis).*

Note (2) *The case study has examined the scenario where 17% of the diesel buses operating in the study area in terms of bus-km operated would be replaced by trolleybuses. If all the diesel buses in the study area are to be replaced by trolleybuses, it would result in further additional reduction of 2% for PM_{10}, 12% for NO_X, and 4% for HC. However, such wholesale replacement is not feasible in the foreseeable future.*

Table 3 : South East Kowloon Development case study
Comparison of total tailpipe emissions in 2016[(1)]
(with or without trolleybuses)

(a) **LOW total traffic scenario** (i.e. 50% of design capacity and 10% Heavy Goods Vehicles)

Emissions (grams/hour)	2016[(2)] (with all diesel buses)	2016 (with all trolleybuses)	2016 Reduction due to trolleybuses
Particulates (PM_{10})	498	474	5%
Nitrogen Oxides (NOx)	8,567	6,889	20%
Hydrocarbons (HC)	3,500	3,314	5%

(b) **HIGH total traffic scenario** (i.e. 100% of design capacity and 20% Heavy Goods Vehicles)

Emissions (grams/hour)	2016[(2)] (with all diesel buses)	2016 (with all trolleybuses)	2016 Reduction due to trolleybuses
Particulates (PM_{10})	1,653	1,629	1%
Nitrogen Oxides (NOx)	19,618	17,940	9%
Hydrocarbons (HC)	8,034	7,849	2%

Notes : (1) No present day situation is available for comparison purpose.
(2) Assuming the current plans to improve the environment are in place (including the use of ULSD, fitting of continuous regenerating traps, gradual replacement of older buses by Euro III buses, replacement of diesel taxis by LPG taxis).