TORONTO TRANSIT COMMISSION
REPORT NO.

MEETING DATE: February 18, 2009

SUBJECT: TROLLEY BUS SERVICE REVIEW

ACTION ITEM

RECOMMENDATION

It is recommended that the Commission forward this report to the City of Toronto and to Metrolinx, noting that:

- this report discusses the potential for re-introducing electric trolley bus service in Toronto, primarily as a means of reducing greenhouse gas (GHG) emissions;

- trolley buses consume less energy, and produce lower emissions, than either diesel or hybrid buses;

- locally, at street level, GHG emissions from trolley bus services are essentially zero, and there are GHG-free sources of electrical energy (wind, solar, etc.) to power trolley buses, so trolley bus services could, in theory, operate with zero GHG emissions;

- trolley buses are more attractive from the standpoint of air quality, noise, ride quality, the ability to negotiate steep grades, and their ability to accelerate in heavy traffic;

- trolley buses are less attractive because they have less flexibility or adaptability for route alterations or extensions or longer-term diversionary operation due to road disruptions;

- the high cost of investment in infrastructure, including both electrical sub-stations for converting high-voltage alternating current (AC) to low-voltage direct current (DC), as well as the overhead traction power system, results in the unit costs of service delivery being much higher for trolleys than for either diesel or hybrid buses;

- the implied value (cost) per tonne of GHG emissions achievable through the operation of trolley buses (about $1,840 per tonne) is considerably higher than values currently assumed for GHG reductions in most benefits case analyses (as, for example, Metrolinx studies, which use $40 per tonne);

- if trolley bus service were to become more attractive, as a result of situations such as the doubling of diesel fuel costs and a matching increase in ridership on trolley bus routes, then the incremental cost of converting current TTC services to trolley

bus operation, and the implied value per tonne of GHG emissions, would still be very high relative to hybrid and diesel buses; and

- there would be a large capital investment requirement to re-introduce electric trolley buses in Toronto, but such an investment could be considered by the City as a means of advancing the environmental objectives of the City's *Climate Change Action Plan* and *Sustainable Transportation Initiative*.

FUNDING

This report has no effect on the TTC's operating or capital budgets.

BACKGROUND

At its meeting of May 14, 2008, the Commission endorsed a communication from TTC Chair Adam Giambrone requesting that staff examine the feasibility of offering trolley bus service on some of the City's busiest routes that are not included in the Transit City Light Rail Plan. This report responds to that request.

DISCUSSION

TTC staff retained Richard M. Soberman to prepare an overview of the costs, benefits, and opportunities for re-introducing trolley bus service in Toronto. His report is attached as Appendix 1.

Trolley buses are quieter and environmentally-friendlier than fossil-fuel vehicles. At street level, their greenhouse gas (GHG) emissions are essentially zero. However, overall emission benefits depend upon how the required electrical energy is produced at source. Trolley buses also offer a superior ride quality, and are capable of higher acceleration, particularly on grades.

The main disadvantages of trolley bus service pertain to capital costs and service flexibility. Significant capital investment is required for electrification, namely, sub-stations and overhead traction power systems. The purchase price of trolley buses is higher than for comparable-size conventional buses, but their economic service lives are also much longer. Trolley buses are "tethered" to their overhead power systems, so they are less flexible to allow extension of trolley bus routes into new transit service areas in the short term, or to divert off-route for a prolonged period in response to road work or disruptions.

This report assesses the benefits and costs of re-introducing trolley bus service in Toronto, by considering a hypothetical network of four routes: 29 DUFFERIN, 63 OSSINGTON, 52 LAWRENCE WEST, and 90 VAUGHAN. This network would focus on the Wilson Bus Garage -- which already has access to electric power supply -- as a maintenance and storage facility.

The same number of 'clean' diesel, hybrid, and trolley buses has been assumed for all four routes. The same labour costs for operation, as well as unit bus maintenance costs have also been assumed for all three technologies, based on information obtained from other cities

which operate and maintain trolley buses. In addition, the analysis assumes that most electrical energy will derive from renewable sources of energy supply, leading to zero GHG emissions for the trolley bus alternative.

For this hypothetical network, costs and emissions are compared for diesel, hybrid, and trolley bus service in Table 1 and Figures 1 and 2.

Table 1: Comparison of Diesel, Hybrid and Trolley Bus Costs (excluding costs of bus maintenance and labour operation) for Illustrative Four-Route Network

Item	Units	Bus Technology		
		Diesel	Hybrid	Trolley
Route length (1 way)	km	41.8	41.8	41.8
No. of Buses		77	77	77
Annual Vehicle-km	veh-km (1,000s)	6,193.00	6,193.00	6,193.00
Capital Costs	$1,000			
Vehicles		38,577	54,131	70,840
Electrification				303,555
Maintenance Facility				15,000
Total		38,577	54,131	389,395
Incremental (relative to diesel)			15,554	350,818
Annual Costs	$1,000			
Energy		4,469	3,799	1,325
Overhead Maintenance				1,254
Sub Total (Operation)		4,469	3,799	2,579
Debt service				
Buses		3,300	4,631	4,608
Electrification				19,747
Maintenance Facility				976
Sub Total (amortization)		3,300	4,631	25,331
Total Annual Costs	$1,000	**7,769**	**8,429**	**27,910**
Unit Costs	$/passenger	0.29	0.31	1.03
Total Annual GHG	tonnes	10,969	9,324	0
Implied Value of GHG	**$1,000/tonne**	**0**	**401**	**1,836**

Figure 1: Comparative Capital Costs for a Four-Route Network Under Alternative Bus Technologies

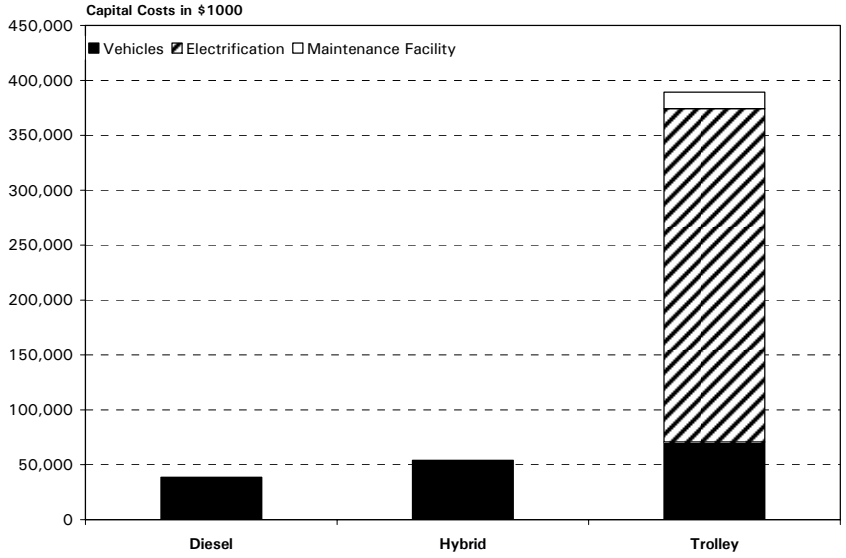

Figure 2: Comparative Annualized Costs for a Four-Route Network Under Alternative Bus Technologies

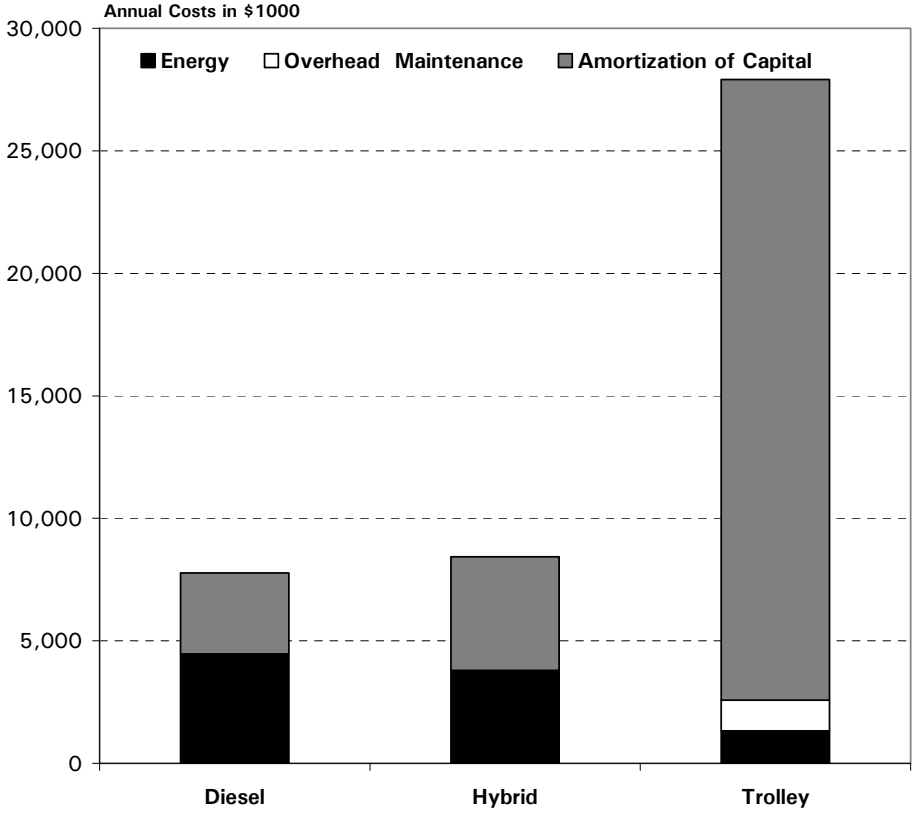

Table 1 also shows that the benefits of reduced GHG emissions are achieved at an average cost of about $1,840 per tonne (when compared with diesel buses), well above the $40 per tonne now used in various Metrolinx studies.

In summary, trolley buses consume less energy and produce lower emissions than either diesel or hybrid buses. They are also more attractive from the standpoint of air quality, noise, ride quality, acceleration and opportunities provided by central power generation to negotiate steeper grades.

The unit costs of service delivery with trolley buses are much higher than for either diesel or hybrid buses. The high cost of trolley bus service derives primarily from the fact that, in Toronto, entirely new infrastructure is required for electrification, as opposed to a situation in which there is an existing electrification network in need of refurbishment.

Even if diesel fuel costs, ridership, and frequency of service were all to double, the incremental cost estimates of converting the sample network to trolley bus operation still would be very high. The main cost disadvantages of trolley buses derive from the need for investment in electrification infrastructure (sub-stations and overhead power systems) which accounts for more than two-thirds of the total cost differential when compared to diesel bus operation. In addition, trolley buses offer less flexibility to both alter and extend routes to serve entirely new areas.

The implied value per tonne of GHG emissions ($1,840) achievable through the operation of trolley buses is considerably higher than values currently assumed elsewhere for GHG reductions (about $40 per tonne). The large differences in capital investment and the high implied cost per tonne for reducing GHG emissions raise the issue of the relative efficiency and potential of reducing GHG emissions from transit by other means, including:

- achieving the anticipated performance benefits of hybrid buses,
- the emergence of more cost-effective fuel cell buses,
- development, within the foreseeable future, of all-electric buses,
- expansion of bus services to new markets, and

The large capital investment in electrification required for new trolley bus service would be difficult to afford from TTC finances alone. However, the Commission should refer this report to Toronto City Council and Metrolinx for consideration as a separate initiative for achieving their GHG emission reduction goals.

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February 3, 2009
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Attachment: Appendix 1: *A Review of Trolley Bus Potential,* Richard M. Soberman, January, 2009