Effectiveness of Current Trolley System

Recommendation:

That the September 21, 2006, Corporate Services Department/Transportation Department report 2006COM010 be received for information.

Report Summary

This report outlines the effectiveness and energy efficiency of Edmonton Transit's fleet in meeting environmental standards, and the impacts and potential best practices for increased efficiency.

Previous Council/Committee Action

At the May 16/17, 2006, Transportation and Public Works Committee meeting, the following motion was passed:

"That Administration prepare a report for Transportation and Public Works Committee no later than September 19, 2006, outlining:

a) the effectiveness of the City of Edmonton's current trolley system and the alternatives that are emerging for energy-efficient public transportation systems, including how they comply with national environmental standards and the City of Edmonton's Enviso (environmental management) system;

b) the impact on the trolley system if all new capital expenditures for trolleys, other than those necessary for safety purposes, are suspended until the 2008 trolley system review is completed;

c) potential best practices and estimated costs for increased efficiency, environmental and safety management of the City's transit fleet and supportive infrastructure.

Report

Responses to Questions

a) the effectiveness of the City of Edmonton's current trolley system and the alternatives that are emerging for energy-efficient public transportation systems, including how they comply with national environmental standards and the City of Edmonton's Enviso (environmental management) system;

Environmental Effectiveness – Current Trolley System

- Use is limited to specific routes.
- Provides lowest emissions at street level of all public transportation systems.
- Expensive purchase price (in relation to other buses).
- Expensive to maintain (overhead wires, etc.).

Alternatives for Energy Efficient Public Transportation Systems

- Clean Diesel Bus – produces 90% less emissions than previous generation of diesel buses.
- Diesel-hybrid Electric Bus – alternative to standard diesel bus for a growing number of cities. New technology still being evaluated.

- Battery-electric Bus – difficulties with need to recharge battery while vehicle is in-service – and long-range travel not possible without increasing vehicle weight.
- Fuel cell – emerging technology not expected to be available for 20-25 years.

Effectiveness -- Environmental Standards

- Edmonton Transit's bus fleet adheres to the *Canadian Environmental Protection Act (CEPA)* On-Road Vehicle and Engine Emission Regulation. Bus engines meet *CEPA* regulations at the time of manufacture.
- In 1995, the City of Edmonton committed to the Federation of Canadian Municipalities (FCM) Partners for Climate Protection Program (PCP) and the Voluntary Challenge and Registry (VCR) with 132 other Canadian cities. The FCM PCP and VCR programs require 20 per cent reduction in greenhouse gas emissions below 1990 levels. Canada's commitment to the Kyoto Protocol, which requires six per cent emissions reductions below 1990 levels, is now under review by the federal government.
- The current transit fleet, made up of GM, trolley and New Flyer low floor buses, ranges in age from one to 30 years. Emissions standards have improved dramatically in this time frame, particularly since 1992. Older buses still in service are subject to the emission standards in effect at the time of their manufacture. Newer models comply with the latest standards resulting in a wide variation in regulated emissions within the fleet. See Attachment 1 for information on the specific regulated emissions of the Edmonton Transit diesel fleet.
- The transit fleet also complies with ETS environmental aspects under ENVISO, the City of Edmonton's environmental management system which maintains the City's Environmental Policy (C512). These aspects include prevention of pollution, continual improvement in emissions reductions, and meeting or exceeding regulatory and voluntary emissions regulations. Older GM buses rate lowest on these aspects compared to the current New Flyer fleet, trolley buses and the soon to be delivered, diesel-electric hybrids.
- Trolley buses continue to provide the lowest emissions at street level. The City's FCM PCP program commitment requires that greenhouse gases produced in the generation of electrical power be included in the City's emissions inventory.

Information regarding Emerging Engine Technologies and Alternative Fuels is provided in more detail in Attachment 1.

b) the impact on the trolley system if all new capital expenditures for trolleys, other than those necessary for safety purposes, are suspended until the 2008 trolley system review is completed;

- The trolley system will not be impacted appreciably by suspending capital expenditures until 2008.

- An overhead line crossover re-construction at the 76 Avenue/114 Street intersection was planned, but could be delayed until completion of the new trolley and hybrid bus review. It would not impact services to citizens as trolley bus operation on Route 7 has been suspended during SLRT construction until the end of 2008. The cost of this reconstruction is approximately $290,000.
- Trolley wires on 111 St. between 57 Ave. and Southgate Transit Center will not be restored. The impact on service is and trolley operations is negligible as currently there is only one trolley bus operating on this route and it will not be necessary when LRT begins operation from Southgate. Savings from the capital budget is $1.5 M.

c) potential best practices and estimated costs for increased efficiency, environmental and safety management of the City's transit fleet and supportive infrastructure.

- MES conducted a survey of transit authorities across Canada and the U.S. to identify trends and industry practices relating to efficiency and environmental/safety management. The survey report is provided in Attachment 2, but some key points are highlighted below:
  - Fleet standardization is a common practice to minimize maintenance costs, training, tooling and parts inventory. Standardization is accomplished in various ways including standardization of major components and systems, standardization of make and model, and multi-year purchase contracts.
  - Replacing buses on a regular, planned basis means quicker compliance of fleets with current environmental and safety regulations. Most U.S. authorities have replaced their pre-1992 two-stroke diesel engines with cleaner engines. Canadian authorities are well behind. Edmonton has 220 of the two-cycle GM diesel buses, 24% of the total bus fleet, as compared with the survey average of 26%. However, Edmonton's fleet is significantly older than the other authorities, averaging 29 years compared to 20 years. At the present rate of replacement, the last of these units will be replaced by 2012.
  - Conventional diesel buses with engines meeting the latest (2007) emissions standards are considered the best compromise between life-cycle costs, and environmental factors in most jurisdictions. Diesel-electric hybrid buses provide better fuel economy and lower greenhouse gas emissions, but lifecycle costs have not yet been determined. Compressed Natural Gas (CNG) buses, once considered the leading technology for reducing exhaust emissions, have lost favour due to higher maintenance and fuelling infrastructure costs. The use of ultra-low sulphur diesel fuel has helped develop exhaust treatment

technologies that provide comparable emissions levels.

- Only seven transit authorities are operating trolleys in North America. Most are holding the trolley fleet size constant.
- Diesel fuel is the most commonly used fuel in the transit industry. It is followed distantly, by CNG and biodiesel. Diesel is expected to remain the standard fuel in the industry for the foreseeable future. Currently, Edmonton is evaluating the viability of using biodiesel in its fleet.
- Most Canadian transit systems aim for an 18-year life cycle for their vehicles. Some are considering a shorter 12-15 year cycle to avoid the need for a mid-life refurbishment and thereby decrease life-cycle costs. Bus replacement cycles are highly influenced by the availability of funding. In the U.S. buses are replaced on a 12-year cycle using federal funding programs.
- Currently, the City funds 35 replacement buses per year, resulting in a 22-year replacement cycle. Eight more buses per year must be funded at a cost of $3.2 million to achieve an 18-year life cycle.
- The most significant environmental aspect of the City's transit fleet is its exhaust emissions. **One old GM bus emits the same hydrocarbons and NOx as 29 new 2007 diesel buses.** The most effective way to improve Edmonton's environmental stewardship would be to accelerate the replacement of our 220 old GM buses with new, clean, energy efficient low floor buses.
- A major aspect of supporting infrastructure is the bus garage. Present garages were built to house 740 buses. Garage operations become less efficient when more buses are crowded into the garages. At present 806 buses are being squeezed into the garages and 40 more are being stored in temporary tent structures. The survey indicated that, with the exception of one other transit authority, all have adequate bus storage.

- The survey indicated there are no commonly agreed-upon 'best' practices in the transit industry. However, there are common practices such as standardization, lowering life cycles, accelerating the replacement of the older buses, evaluating hybrids, having adequate garage space, and using Ultra Low Sulphur Diesel as primary fuel.

Background Information Attached

1. ETS Diesel Fleet Regulated Emissions and Emerging Engine Technologies
2. Transit Survey Results September 13, 2006

ETS Diesel Fleet Regulated Emissions and Emerging Engine Technologies

ETS Diesel Fleet Regulated Emissions **(per vehicle type and year of engine manufacture)**

(Source: Environment Canada)

1982 GM	**HC + NOx**	**CO**	**OPACITY**	**PM**
	10 g/bhp.hr	25 g/bhp.hr	15%	Not Regulated
1993 NFIL	**HC**	**CO**	**NOx**	**PM**
	1.3 g/bhp.hr	15.5 g/bhp.hr	5 g/bhp.hr	0.10 g/bhp.hr
1998 NFIL	**HC**	**CO**	**NOx**	**PM**
	1.3 g/bhp.hr	15.5 g/bhp.hr	4 g/bhp.hr	0.05 g/bhp.hr
2004 NFIL	**NOx + NMHC**	**CO**	**Not Applicable**	**PM**
	2.4 g/bhp.hr	15.5 g/bhp.hr	Incl. in NOx+NMHC	0.05 g/bhp.hr
2007 NFIL	**NMHC**	**CO**	**NOx**	**PM**
	0.14 g/bhp.hr	15.5 g/bp.hr	0.20 g/bhp.hr	0.01 g/bhp.hr

Notes:
GM = General Motors transit bus
NFIL = New Flyer Industries Ltd. transit bus
HC = Hydrocarbons
NOx = Nitrogen oxide
CO = Carbon monoxide
PM = Particulate matter
NMHC = Non-methane hydrocarbons
Opacity = A measurement of light passing through the exhaust stream. Maximum 15 percent.
g/bhp.hr = grams per brake horsepower-hour

Emerging Engine Technologies*

- **Diesel-hybrid electric bus** technology is technically viable for transit service and is now the alternative to the standard diesel bus for a growing number of transit properties. There has been a significant increase in orders from North American transit properties for diesel-hybrid electric buses, which are in commercial production. These diesel engines also meet the existing CEPA emission regulations. Vehicle cost, battery life, and longevity of components are being evaluated as this new technology is adopted by the transit industry.
- **Battery-electric buses** are not yet viable for most transit service applications. Recharging the battery is required while the vehicle is in-service and a sufficient range of travel is not yet possible without increasing vehicle weight.
- **Fuel cell** technologies are still in development and are expected to be in commercial production within the next 20 – 25 years.

*(Source: US Department of Transportation, Federal Transit Administration)

Alternative Fuels

- **Biodiesel** fuel is a renewable resource and is expected to be more readily available in the near future. The National Renewable Energy Laboratory in the United States reports an estimated 25

percent reduction in greenhouse gas emissions using 20 percent biodiesel (no change for nitrogen oxide; five percent reduction for particulate matter). Five and 20 percent biodiesel/low-sulphur diesel blends have been tested in Canada. Five percent biodiesel blends, which have shown to be most practical in Canadian temperatures and are supported by engine manufacturers, result in significantly less improvement than using a 20 percent blend.

- **Compressed Natural Gas (CNG)** is not currently a viable choice for the majority of transit properties. Adopting this technology involves significant infrastructure investments for equipment required to fuel buses. Other related issues with CNG include higher maintenance requirements for CNG engines, bus purchase cost premiums of up to $70,000 per vehicle and the lowest fuel economy of all internal combustion engines, based on tests conducted at Translink, Vancouver, BC.
- Environment Canada tested **ethanol-diesel blends** with Winnipeg Transit. They found an increase in hydrocarbons of 28 percent, an increase in nitrogen oxide (NOx) of 10.8 percent, and an increase in fuel consumption of nine and a half percent using ethanol-diesel blends. Environment Canada considers these increases to be statistically significant, indicating that further research is needed to explore this alternative fuel.

2006COM010

Attachment 2

City of Edmonton

Corporate Services Department

Transit Survey Results

September 13, 2006

Written by: Dennis Simcoe, Senior Project Manager, Mobile Equipment Services Branch

Executive Summary

A survey of transit authorities across Canada and the US was conducted to identify trends and industry practices to aid in the evaluation of the efficiency and environmental management of the City's transit fleet and supportive infrastructure. This report summarizes the finding of that survey.

Fleet standardization is viewed as beneficial technique, amongst most transit authorities, to minimize maintenance, training, and parts inventory. Standardization is being attempted in numerous ways including standardization of major components and systems, standardization of make and model, and multi-year purchase contracts. Each method has its benefits and limitations.

All of the US authorities have replaced or are completing the replacement of their pre-1992 2-stroke engines with cleaner 4-stroke engines, but Canadian authorities are well behind. One Ontario fleet currently has the highest percentage of 2-stroke engine buses at 44.2% of its fleet compared to the survey sample average of 26.1%. Edmonton is ranked 6th amongst the surveyed properties with 24.3%. A further examination of the age of the pre-1992 2 stroke buses showed Edmonton to have the oldest buses with an average age of 29.0 years compared to the survey sample average of 20.3 years. There is no certainty amongst the authorities as to when this replacement will be complete, since it is dependant on the availability of funds.

Edmonton and one other property are the only two surveyed with overcrowded storage facilities. Edmonton currently stores 806 buses in facilities designed to accommodate 740 buses. 40 buses are stored in temporary tent structures. The total number of Edmonton Transit fleet is 846 units including 29 community buses and 49 trolleys. This results in poor air quality periods during the initial deployment of the day.

Hybrid buses currently are being viewed as a popular alternative to the conventional diesel bus, but with a high purchase price, most authorities cannot afford to incorporate them into their fleets. Hybrid buses are also an alternative to the CNG buses, which are either being phased out or maintained at their existing level due to the increased maintenance requirements, compared to conventional diesel buses, and high fueling infrastructure costs. The 2007 clean diesel bus is being purchased as an alternative to the diesel-electric hybrid bus and the CNG bus because of the reduced engine emissions for 2007 and their lower purchase costs.

With only seven transit authorities operating electric trackless trolley bus fleets in North America, most authorities are maintaining their trolley fleets at the same size or in some cases reducing the fleet size. These trends result in sporadic purchases of trolleys only on a replacement basis.

Diesel fuel in the form of ultra low sulfur diesel, which was legislated in Canada as of June 2006, is the most common fuel in the industry with the use of CNG and biodiesel in specific niche areas. Diesel is expected to remain the standard fuel in the industry in the foreseeable future by the majority of authorities.

Some transit authorities are considering shortening of the 18 year life cycle to reduce maintenance and operating costs of the fleet. At the current replacement rate of 35 buses per year, Edmonton's life cycle would be 22 years. To achieve the industry accepted life cycle of 18 years, 43 buses per year would need to be purchased. Some authorities are suggesting the life cycle should be in the range of 12 to 15 years. Currently, bus refurbishment is a common practice amongst transit authorities to ensure the bus operates safely to the full life cycle, but the extent and frequency of the refurbishments varies amongst the authorities. Life cycles of buses are highly influenced by the funding structure given to the transit authorities from the province and or state they are in.

The results of this industry practices survey have confirmed that there are no commonly agreed upon 'best' practices for the transit industry. However, there are common practices such as standardization, lowering of life cycles, accelerated replacement of the older buses, evaluating hybrid buses, having adequate garage space, and using ultra low sulphur diesel fuel as primary fuel that most of the properties are implementing in one form or another to meet local market and operational needs.

Introduction

In July 2006, Mobile Equipment Services Branch conducted a survey with the purpose of finding the best practices on a variety of topics such as standardization practices, fuel choices, emission and environmental practices, life cycle and replacement practices for transit operating authorities. This survey was conducted by telephone to eleven transit authorities in Canada and six in the US. The results are to provide information in the City's decision-making in the areas of efficiency and environmental management for the Transit's fleet and supportive infrastructure.

Eighteen transit authorities were contacted from July 2006 to August 2006, seventeen transit authorities responded. The results are summarized below:

Fleet Standardization Practices

Fleet standardization practice is the process of simplifying the fleet to reduce maintenance repair times, reduce parts inventory and minimize training requirements. Fleet standardization is seen as favorable amongst all transit authorities, and most transit authorities with the exception of a few are attempting it. Standardization is being accomplished by the majority of authorities through several techniques including purchasing vehicles with specifications that include standardized components and systems, purchasing a specific make and model of equipment, and developing multi-year purchase agreements from a single vendor. However, each method of attempting to standardize has its limitations and drawbacks. Standardization on major components and systems still results in non-standard items. Multi-year purchase agreements results in larger batches of one style or model of bus as long as the manufacture is capable of building to one's specification. Most purchasing groups are unable to recommend purchasing a specific make and model of bus due to competition bylaws and requirements.

The province of Quebec purchases buses for all provincial transit authorities based on a single specification and tender. This practice results in a better price for each authority, but at the cost of potentially different vendors each year. Ontario transit authorities are following a similar trend as Quebec, in that they are currently developing a provincial standard bus specification as a minimum guideline. Other authorities, not attempting to standardize, are purchasing with yearly tenders based on best price using specifications with standardized performance requirements.

There is no common practice amongst the transit authorities with respect to the purchase agreements. Six authorities are currently engaged in multiyear purchase contracts. Some authorities have expressed interest in pursuing a multiyear agreement, but have been prevented from doing so due to purchasing bylaws. The remainder of the authorities currently purchase from yearly tenders. The advantage of a multiyear contract is that it promotes fleet standardization practices to the fullest extent; whereas, yearly contracts promote the best purchase price for the fleet vehicles. All authorities surveyed are using

a RFP process, but evaluation processes vary from negotiated contracts to low bids to lifecycle cost analyses.

From the maintenance and operations perspective, all transit authorities preferred standardization practices. The improvements of standardization have been recorded in reduced maintenance repair times for repeated tasks, reduced training requirements for both maintenance and operations, and reduced parts inventory levels due to standardized components. Operations also stated that standardized fleets do not require the frequent route changing because of having different types of buses in the fleet.

Emissions and Environment Practices

A 'greener' fleet was important to all transit authorities. This was indicated by the purchases that are currently being made ranging from new 'clean diesel' buses, diesel-electric hybrid buses, compressed natural gas (CNG) buses, and electric trolleys to replace the aged fleets. Some authorities are not mandated to purchase green technology or do not have emission reduction targets to achieve.

To incorporate new technology and cleaner alternatives into the fleet, all authorities agreed that the identification of new technology was more of a communication process through the bus and component manufacturers, transit conferences, tradeshows, publications and interagency discussions. Once the technology has been deemed viable through the above communication network, the methods that the transit authorities follow to incorporating new technology varies. Some authorities only incorporate time proven technology. While other transit authorities follow the process of testing a sample of vehicles. Once the test is complete, an evaluation of the results will determine if the new technology should be incorporated into the standard specification or not.

All Canadian transit authorities have started the replacement of the pre-1992 2-stroke diesel engines such as the 6V71 in the GM New Look and Classic buses. As indicated in Figure 1, the chart shows the variation in the percentage of the fleet that is 1991 vintage and older. All the US authorities have replaced or are completing the replacement of these older engine vehicles. Edmonton is ranked 6th amongst the 13 authorities based on the fleet percentage of pre-1992 engines remaining in their fleet. There is one Ontario authority with the largest percentage of pre-1992 engines in their fleet at 44.2% and it has currently planned to replace 6 buses, or 5-6% of the fleet, per year until 2011 to alleviate this collection of older buses Edmonton is currently ranked 6th amongst the authorities surveyed. Most authorities are working to replace these buses, but it is dependant on the availability of funds from their respective municipalities as to when it will be completed.

The average age of the pre-1992 vintage buses is illustrated in Figure 2. Edmonton has the oldest buses with an average age of 29.0 years. One eastern Canadian property has the newest buses at 15.3 years. A summary comparison of Edmonton to the survey sample average is compiled in Table 1. Edmonton is ranked 6th of 13 for overall percentage of pre-1992 buses in the fleet, but Edmonton has the oldest pre-1992 buses of the authorities surveyed. As for the average age of the fleet, Edmonton is ranked 10th of 12 authorities

providing fleet data with an average age of 12.2 years. Most authorities are purchasing buses on a regular frequency to maintain a balanced fleet age distribution, with the exception of Edmonton and one other city, For Edmonton, this period of not purchasing from 1982 to 1993 has resulted in a backlog of older units that have very high emissions. Only two US properties have undertaken re-powering their 2-stroke buses to newer engine technology to reduce emissions, but this is not a trend followed by any other authorities.

These buses have required at least one complete refurbishment to extend their lifecycles. Various refurbishment plans exist amongst authorities including as needed refurbishments based on major inspections to 6 and 12 year minor refurbishments to full refurbishments on a predefined interval usually 10 to 12 years. Ontario transit authorities also received provincial funding to refurbish and retain their GM buses for 6 additional years in 2000 – 2004.

Bus storage facilities and the air quality of those surveyed also indicated that only Edmonton and one other property are operating over the designed capacity, the remainder either have adequate storage or are able to store vehicles outdoors. Edmonton has the highest problem of overcrowding with a designed capacity for 740 buses, but actually storing 806 buses with storage of 40 additional buses in external tent structures. This results in poor indoor air quality during the peak times of the day.

The highlights of the new buses being purchased and considered by the various transit authorities are discussed below.

Diesel

A new interest has been generated in the diesel engine technology with the change in diesel engine emission regulations to be introduced in 2007. These new buses cited as the 'Clean Diesel' will provide a 90% reduction in Nitrous Oxides (NO_x) and Particulate Matter (PM) over 2004 diesels buses. This new reduced emission level makes this engine the cleanest diesel engine manufactured to date. This attribute combined with the lowest purchase price as compared to the other alternatives in the 40-foot bus category has resulted in continued purchases of the diesel bus. All transit authorities purchase a majority of their fleet as diesel buses with a few buses with alternative new technologies. All diesel buses delivered to transit authorities in 2007 will be equipped with clean diesel engines. These new engines require ultra low sulfur diesel (ULSD) fuel for the diesel particulate filter (DPF) to function properly.

Figure 1: Percentage of Pre-1992 Buses in Fleet

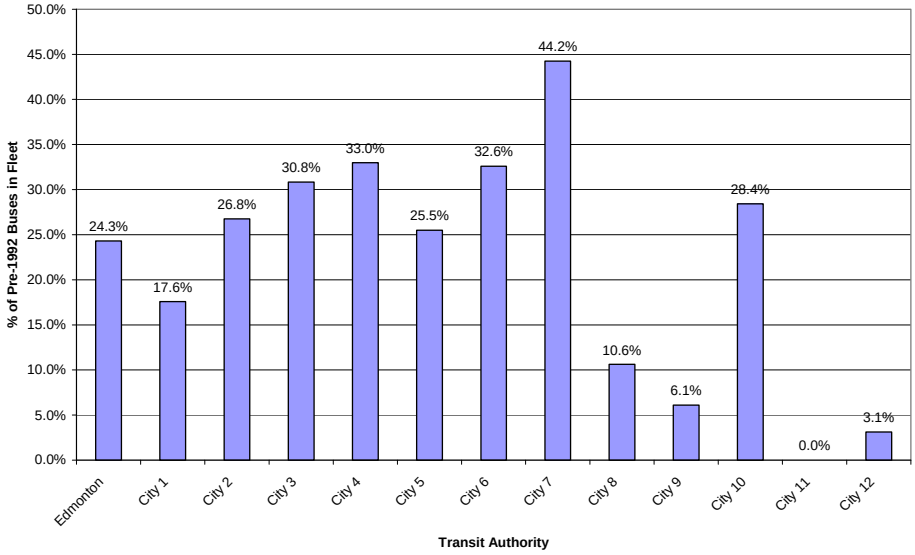
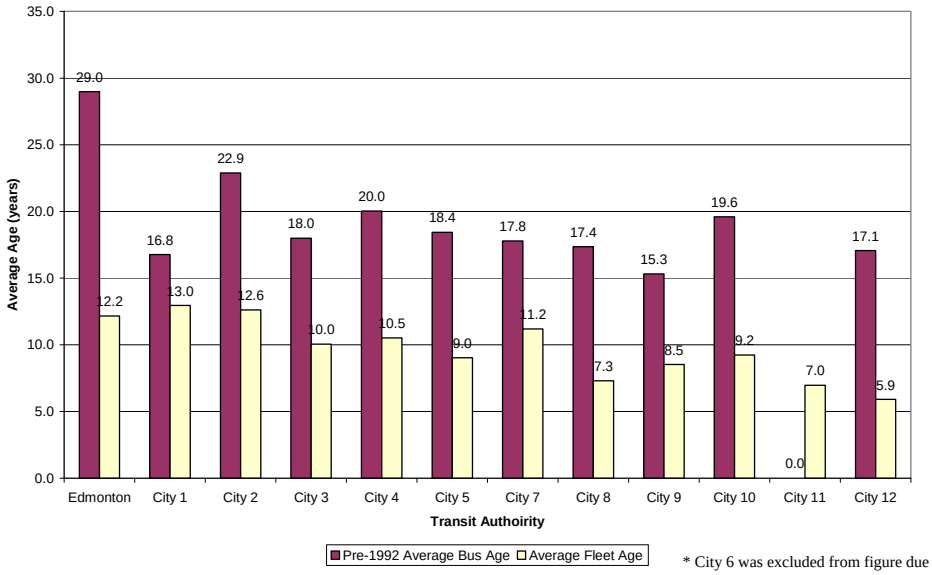


Figure 2: Average Bus Age



* City 6 was excluded from figure due to lack of data

Table 1: Edmonton Comparison

	Pre-1992 bus % of fleet	Pre-1992 Avg. Bus Age	Average Bus Fleet Age
Edmonton	**24.3%**	**29.0 years**	**12.2 years**
Survey Sample Average	26.1%	20.3 years	9.3 years
Ranking (of 12)	6th	12th	10th

Diesel-electric hybrid

The current trend amongst the transit authorities surveyed indicated a strong interest in obtaining hybrid bus technology. Currently, 6 of the 17 properties surveyed have hybrid buses in service, in addition, Edmonton and one other property have made or are currently making purchases of diesel-electric hybrid buses.

Diesel-electric hybrid buses are manufactured in two configurations: Parallel and Series. Parallel configuration hybrids can use both the diesel engine and electric motor to power the bus, where as series configurations generally use smaller dedicated diesel engines only to produce electrical power that drive the electric motors. Sales of hybrids have been increasing since its inception in 1999. Several Transit Authorities expect to reduce fuel consumption by 20 – 40 % versus conventional diesel buses when deployed in frequent stop and go routes.

The drawbacks to the hybrid bus are the high purchase price if there is little or no government funding assistance. In addition, two US properties commented that the first batch of diesel electric hybrids had some maintenance issues regarding the battery and charging system that reduced their operational efficiency. However, a different US property has claimed that their hybrid buses have reduced maintenance requirements and increased the mean time between failures. Unanimously diesel-electric hybrids are seen as the cleaner choice versus the conventional diesel buses amongst transit authorities across North America. There are evaluations currently being performed to compare the benefits of the hybrid versus the new 2007 diesel buses

Compressed Natural Gas (CNG)

Most Canadian transit authorities with the exception of two are not considering purchasing CNG buses. This is due to difficulties with fueling infrastructure cost and maintenance requirements. Of the properties with CNG buses, the fueling infrastructure is currently operating at maximum capacity and the expansion costs are very high. The CNG buses maintenance requirements are more than that of a conventional diesel bus thus requiring more maintenance checks on a more frequent basis. Of the two exceptions, one is purchasing 50 new CNG buses from New Flyer in 2006 and another one is preparing a feasibility study of the CNG buses at their Council's request.

Trackless Trolleys

Only two Canadian properties and five US properties are currently operating trolleys in North America. Of these authorities, only one US property increased its trolley fleet. This increase was 32 dual mode trolley buses with diesel-electric generator for the airport tunnel route. One US city does not presently have an active trolley fleet due to maintenance facility upgrading and fleet replacement. Two US properties are planning on reducing their trolley fleets. The remainder of the authorities remained the same or experienced small reductions.

The survey indicated that the new trolleys are expected to have a life cycle of 15 – 20 years with a minimum of one structural refurbishment at mid life. All transit authorities agreed that the life-limiting component on the new trolley bus is the bus structure. It is also expected that as the fleet ages the electronic component obsolescence will require alternative parts sources, system retrofitting and in some cases in house manufacturing of new parts as with the old trolley buses.

The new trolley buses require minimal overhead system upgrades to incorporate the new technology, but one US property required major maintenance facility upgrades to service the new articulated trolleys due to the weight and size. In the event of overhead system failure, the larger fleets reduce bus service on all routes to maintain service on the trolley routes. No authority has adequate spare units to have a one-to-one ratio of spare diesel buses for their trolleys. Of the authorities contacted, none to date have removed/abandoned lines from service in the past 10 years. Several have added or moved lines for service at a cost of approximately $750,000 to $1,000,000 /km for a two-way service (4 overhead lines). The environmental advantage cited by the transit authorities of operating trolleys is the zero ground level emissions.

Fuel Choices

All transit authorities are required to move to ULSD due to 2007 emission regulations. Other fuels being used amongst the surveyed parties include diesel, CNG, biodiesel and electricity. Five transit fleets of the 17 surveyed are operating CNG buses. However, the number of CNG buses being operated by the Canadian authorities is reducing, while the American properties are maintaining and in some cases increasing their CNG fleets. Biodiesel has been implemented in several US authorities in a B5 (95% petroleum diesel and 5 % biodiesel) winter and B20 (80% petroleum diesel and 20 % biodiesel) summer blends in their diesel fleets.

Hythane (natural gas and diesel), biodiesel, CNG and hydrogen have been tested in different markets for viability. Currently, the authorities testing this technology have not chosen to implement any of these fuels. Biodiesel is currently the most popular with small trials in Canada. Most Canadian authorities state that adequate local biodiesel supply and cost are preventing a large scale implementation.

Of all authorities surveyed, none had considered or developed an action plan or mandate for when diesel is no longer a primary fuel. One US west coast city is the only one to have a goal of not purchasing diesel buses by the year 2020.

Life cycle and Replacement Practices

The current life cycle amongst Canadian transit authorities is 18 years, with the exception of one city with a 16-year life cycle. At the present replacement plan of 35 buses per year, Edmonton's replacement cycle would be 22 years. To achieve the current industry replacement life cycle of 18 years, 43 buses would have to be purchased per year. There

are some authorities recommending reducing the life cycle from 18 years to either 12 or 15 years to minimize the maintenance and refurbishment costs. The US authorities are required to keep the buses a minimum of 12 years as defined by the Federal Transit Administration (FTA) to receive their government grant funding. Ontario Transit properties, until the end of 2006, also receive provincial government funding for the purchase of buses and bus refurbishments. Most authorities tried to renew their fleets between 14 – 18 years, depending on the growth needs of their region and the availability of funding.

To achieve the full life cycle, most transit authorities are performing, at minimum, a single mid-life bus refurbishment. The extent of the refurbishment depends upon the findings of the maintenance inspection. This inspection covers the mechanical, electrical and structural conditions of the bus. Some authorities perform two overhauls at shorter intervals in an attempt to minimize the refurbishment costs.

All authorities are starting to sell their buses for salvage cost due to limited resale market as well some cited minimizing legal liabilities as reason for not reselling buses.

Conclusions

The following industry practices were identified from completing the survey. Fleet standardization is being attempted in many different methods including multi-year purchase contracts, annual purchases based on standardized components and systems, and in some cases direct purchasing of a particular make and model of bus. Canadian transit authorities are currently working to replace their older pre-1992 2 stroke engines, but the availability of funding is determining the timeline to when it can be completed. Edmonton has the oldest fleet of pre-1992 2-stroke buses amongst the authorities surveyed with an average age of 29.0 years. The clean diesel bus is being purchased as an alternative to the high costs of the diesel-electric hybrid bus and the CNG bus because the 2007 emission reduction regulations and low purchase price. Electric trolley bus fleets in North America are not increasing. They are only being replaced to maintain the existing fleet capacity, or in some cases, fleet size is being reduced slightly. Diesel fuel in the form of ultra low sulfur diesel is the most common fuel in the industry and it is expected to remain the standard fuel in the industry in the foreseeable future by the majority of authorities. The diesel bus life cycle is 18 years and the modern trolley bus life cycle is expected to be 15 – 20 years, but some consideration is being made towards reducing the diesel bus life cycle to 12 – 15 years to reduce operating costs due to increasing operating and maintenance costs of aged fleets. The results of this industry practices survey have confirmed that there are no commonly agreed upon ‘best’ practices for the transit industry, but rather a series of practices that are considered the most beneficial method based on their local market and operational needs.