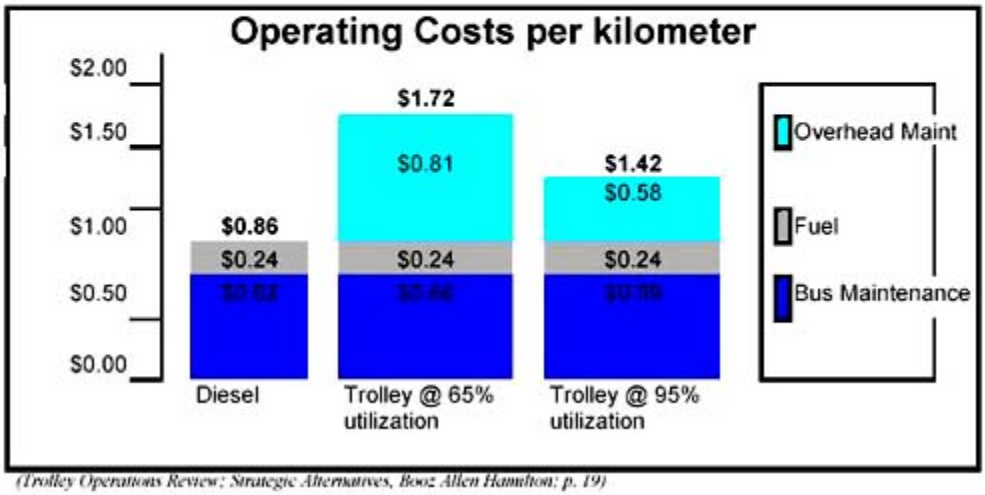
The Consultants' Study An Engineer's Commentary on Operating Costs

The following is a sample of a variance analysis on the cost per kilometre figures for trolleybuses vs. diesels that are presented in the Booz Allen Hamilton study. A variance analysis should be part of any thorough study. The fact that the Booz Allen Hamilton report did not perform such analyses suggests its conclusions regarding future costs cannot be taken as facts, but rather as opinions based on one set of assumptions. The analysis below is merely intended to show that very different figures could reasonably be adduced based on the same base data contained in the Booz Allen Hamilton report. Other variants are certainly possible.

The Report includes the following diagram comparing trolley and diesel bus cost/km figures:

What are operating costs of trolleybuses compared to diesels?

At the current rate of usage, trolleys cost $1.72 per kilometer to operate whereas diesel buses cost $0.86 per kilometer to operate. A significant portion of the difference in total operating costs between the two vehicle types is the proportion of costs associated with maintenance of the overhead electrical system that provides power to trolleys.



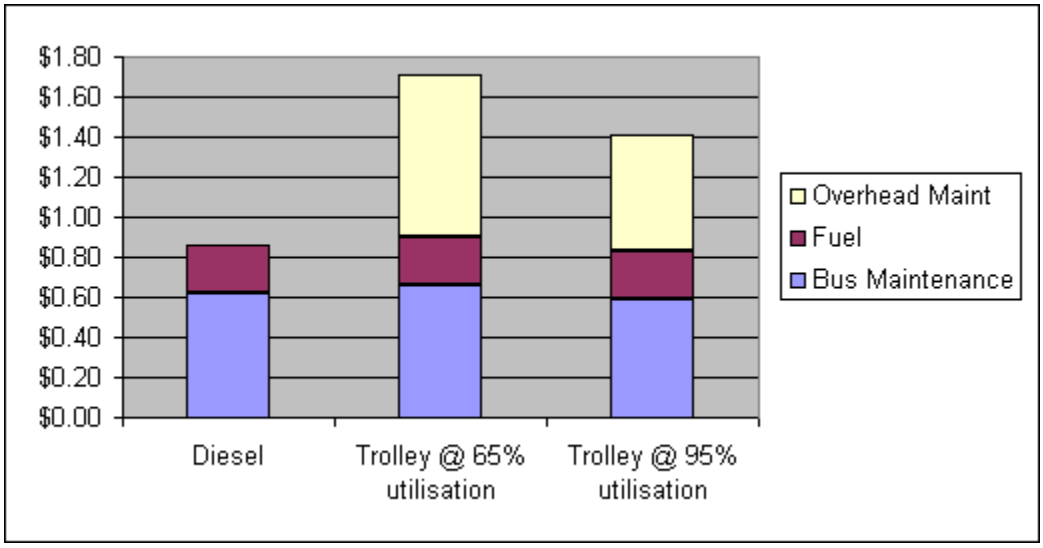
(Trolley Operations Review; Strategic Alternatives, Booz Allen Hamilton; p. 19)

The Report asserts that "The trolley system has been -- and will continue to be -- more expensive to operate and maintain than equivalent diesel service". The analysis below attempts to bring out that the Report's analysis of even current costs is biased because it does not compare like with like [it buries significant detail in fleet averages] and that its prediction about future costs favouring diesels is based on a set of assumptions that may well be wrong.

Current cost/km data as per diagram as above:

	Diesel	Trolley @ 65% utilisation	Trolley @ 95% utilisation	
Bus Maintenance	$0.62	$0.66	$0.59	Note that the Consultant's chart contains apparent arithmetic errors that may be due to rounding errors.
Fuel	$0.24	$0.24	$0.24	
Overhead Maint	$0.00	$0.81	$0.58	
Total	$0.86	$1.71	$1.41	
Utilisation	100%	65%	95%	

Plotting this data:-



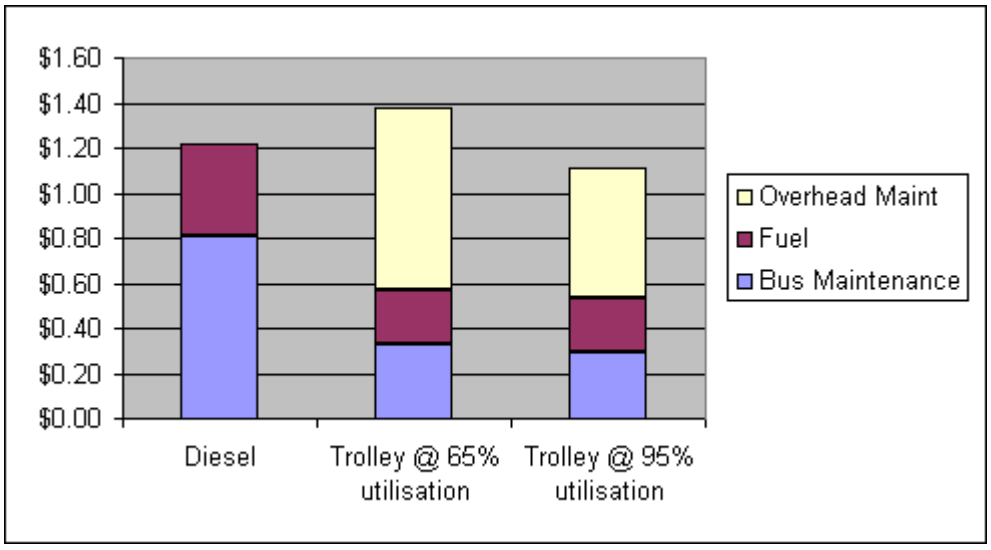
The Report effectively compares old trolleybuses with new diesel buses despite the fact that the old trolleybuses are very much cheaper to maintain than older diesels. Also trolleybuses are used on heavily trafficked coridors and the maintenance and fuel costs of diesels on such corridors are likely to be significantly higher than fleet averages. The data below adjusts the Report data to compare new trolleybuses with diesels and recognise higher fuel and maintenance costs for diesels when used to replace trolleybuses. Fuel cost data is based on actual Edmonton data from CASA/ETS tests.

Current cost/km data as per diagram as above but with adjustments listed below/overleaf:-

	Diesel	Trolley @ 65% utilisation	Trolley @ 95% utilisation
Bus Maintenance	$0.81	$0.33	$0.30
Fuel	$0.41	$0.24	$0.24
Overhead Maint	$0.00	$0.81	$0.58
Total	$1.22	$1.38	$1.12
Utilisation	100%	65%	95%

Diesel Maintenance up lift = 30%
Diesel fuel uplift = 69%
Trolley maintenance reduction = -50%

Plotting this data shows that modest and reasonable changes to the data more fairly representing diesel and [new] trolley comparisons shows trolleybuses as coming out slightly ahead of diesel on running costs at 95 % utilisation [many other systems achieve very close to 100% so 95% **should** be readily achievable].

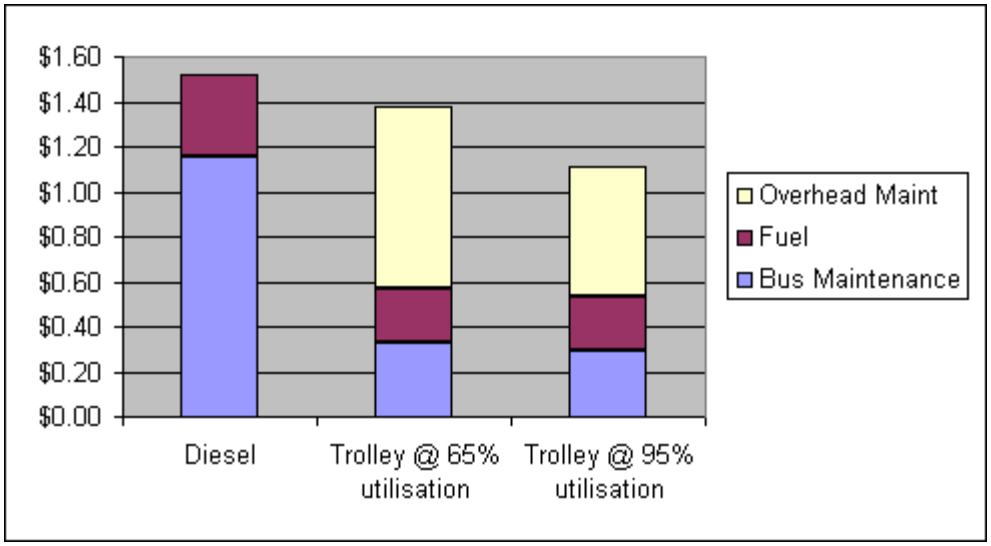


Looking to the future meeting exceedingly stringent post 2007 emission targets may require diesel electric hybrid technology. Such vehicles are likely to cost as much as trolleybuses but incur much higher maintenance costs than current diesels because of the need to frequently replace batteries. Fuel consumption may be modestly less, although in the long-term fuel costs are certain to rise. Recalculating the above figures to reflect this gives:-

Battery replacement costs per km based on available data = $0.35

	Diesel	Trolley @ 65% utilisation	Trolley @ 95% utilisation
Bus Maintenance	$1.16	$0.33	$0.30
Fuel	$0.36	$0.24	$0.24
Overhead Maint	$0.00	$0.81	$0.58
Total	$1.52	$1.38	$1.12
Utilisation	100%	65%	95%

Plotting this data shows that post 2007 diesels could have no capital cost advantage over trolleybuses but yet have very much higher running costs.



It should not be assumed that trolleybus utilisation cannot exceed 100%. The 100% figure above represents all current scheduled trolleybuses journeys being worked by trolleybuses i.e. no diesel substitution. If the number of scheduled trolleybus journeys is increased, this would raise trolleybus utilisation beyond 100% and further improve trolleybus costs relative to diesel. Potentially perhaps, future trolleybus operating costs could be half those of future diesel. Retaining the trolleybus system would be a very prudent decision.

What does the Study say, What Doesn't it say?

The study says the system comprises 140km of overhead wire, 4,600 support poles and 8 power substations. 3,700 of the poles are "joint use poles" which also hold street lighting and other fixtures.

A new trolley substation was built at Rossdale in 2000 at a cost of $2 million, and there have been many upgrades to the trolley system recently. The study didn't consider capital investments.

The study identifies the replacement of some trolley support poles as a capital cost. [Street lamp poles in many areas are also being replaced]. This begs the question: If 3,700 of the trolley poles also support street lighting, how is this cost being shared? Is the entire cost charged to the trolley system?

The study says trolleys comprise 7.4% of all buses in service and serve 8.4% of all bus stops, representing a small portion of the ETS system.

Whether the trolley system is small or large isn't a significant factor in determining its utility value. Small [ELF] mini buses form an even smaller portion of the fleet. At 37 vehicles, the LRT fleet is also smaller than the trolley fleet, and it serves only 10 stops, less than 1% of all stops in the transit system. Both of these sub-systems are highly valued by citizens and commuters. If we used the percentage of stops served or percentage of the fleet to measure of their worth, we should have abandoned both mini buses and LRT long ago.

More important in determining the value of any part of the transit system is the number of passengers it serves or can serve. Location in relation to activity centers and areas of denser population are considerations also. LRT connects important destinations, mini buses serve seniors centers and shopping malls where big buses can't enter. Trolleybuses serve the denser city core and connect with activity centers and LRT, serving lots of passengers. Denser downtown development means more people benefit from quality of life advantages [e.g. low noise levels] associated with trolleys.

The study says operating costs, calculated in cost per km, are higher for trolleys than for diesels, and will remain so even if trolley usage is increased.

The study doesn't actually evaluate future operating costs, so there is no basis for this future projection. It looks at past cost comparisons, and doesn't present a complete picture of these. Cost per km doesn't take into account the work a vehicle does, for example in stopping for passengers, accelerating and operating in heavy stop-and-go traffic. An express or suburban bus that makes few stops and hauls few passengers will naturally have a lower cost per km than a popular bus route in the busy downtown that makes a lot of stops. But the popular downtown route will be more viable financially because it hauls more passengers, thereby earning more revenue.

One would naturally expect the cost per km to be lower on the diesel system because it has many express and suburban runs that cover many kilometres

with fewer stops. The trolley system operates mainly in the more congested city core. In order to be able to determine how well trolleys do in covering the costs of their operation, one needs to know more than cost per km. A cost per passenger or cost per passenger km comparison is required. Looking at cost per hour would also be useful since City Council allocates transit service in terms of service hours.

An accepted methodology for comparing two investment scenarios is a discounted cash flow [DCF] analysis. If properly done, a DCF analysis would allow one to compare the costs associated with trolleys and diesels over the long-term in a more balanced manner, taking into account cost factors that are not directly related to vehicle mileage.

The study says trolleybus maintenance costs are similar to diesels over the long run. It says trolleys cost more to maintain in 2002 than diesels, and then concludes trolleys will continue to cost more to maintain than diesel buses.

None of these conclusions are substantiated by the data in the study. The data actually show the most expensive buses to maintain are 9 to 11-year-old [6V92] diesels. They cost 1.53 per km in 2002, vs. only 0.72 for a 21-year-old trolley. Diesel buses of comparable age to the trolleys averaged 0.11 more per km for maintenance over the three years examined. The figures also indicate that maximizing trolley usage would make trolleys the least expensive vehicles to maintain of all the buses 10 years of age and older. This obvious error casts doubt on the study's reliability.

Like the operating cost analysis, one can also identify problems with the method used for the maintenance cost analysis. The study only examines maintenance costs over the last three years. It calculates an average maintenance cost for a diesel fleet consisting of almost 50% new vehicles, and compares this average directly against the maintenance cost for 20+ year-old trolleys. Naturally diesels come out cheaper because there are so many new buses in the diesel fleet. "Life cycle costing" is the method fleet operators prefer for making comparisons; looking at the life cycle costs of trolleys and diesels of similar ages would have provided a more informative comparison. This could form part of a discounted cash flow [DCF] analysis.

The study says that because of dramatic improvements in diesel engine controls [spurred by impending 2007 exhaust regulations], trolleys no longer will offer advantages in "area wide" emissions.

The study devotes much analysis to "area wide" emissions, but the crucial issue in deciding the trolley or diesel question is actually pollution along major arterials, in high density core areas of the city and in public areas such as bus stops and even inside buses. In other words, it is street-level or localized pollution, not "area wide" emissions. Whether a power plant 100 km away emits a fraction more or less pollution to run electric trolleys compared to diesels is hardly significant when the diesels emissions are released into the streets, in close proximity to hundreds of people. Environment Canada states there is no safe level of exposure to particle emissions and recommends avoiding exposure wherever possible. In its cursory look at local impacts, the study says passengers waiting at bus stops are exposed to particle levels 40

times higher than ambient levels. If these levels are unsafe, then even the reduced levels from newer diesel engines must be considered unsafe. Reducing the emissions from diesel buses by a factor of 4 would still leave passengers at stops exposed to particulate levels 10 times higher than ambient levels. One wonders about exposure levels inside the buses themselves.

Emissions from vehicles operating in real world conditions often vary considerably from test data used for federal certification. New diesel buses may not be as 'clean' in reality as the standard promises.

The study says trolleybuses produce lower noise levels than diesels under most conditions.

Diesel buses produce noise levels in excess of 80 db, but passing trolleybuses are barely audible above ambient noise levels. A special exemption clause [covering heavy vehicles] was required in the City's noise bylaw to permit the operation of diesel buses in residential areas. Edmontonians have voiced concerns about diesel bus noise in the past.

Parkallen residents, for instance, recently rejected plans for a transit center in their community as part of LRT expansion because of the noise impacts from diesel buses. A noise impact assessment evaluating the number of noise peaks per weekday above 80 db that would result in each affected community from a trolley to diesel conversion would be useful to be able to quantify the noise impacts to citizens. In areas served by trolleys, replacing them with diesels adds anywhere from ~25 to 500 such noise peaks per weekday, depending on service levels.

The study says new trolley acquisition cost is arguably the biggest disadvantage vs. motorized buses. New trolleys cost about twice as much as diesel buses, mostly because the market in North America is intermittent.

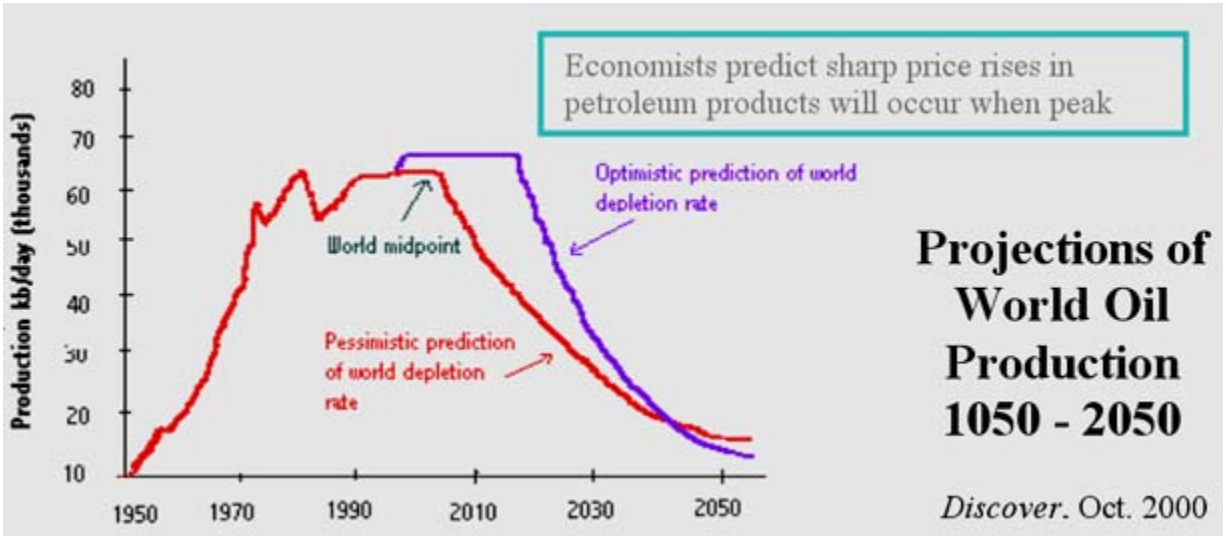
Edmonton needs less than 50 trolleybuses - the study says 49. By the time the trolleys need to be purchased in 2008, the replacement of the old GM diesel fleet will have been largely completed. Currently, the City buys about 40-50 diesel buses per year. 25 trolleys would involve about the same annual expenditure. Spreading an order of 49 trolleybuses over two years will not require annual funding above and beyond what is currently spent on diesel buses. The higher per unit cost of new trolleybuses therefore should not pose a problem.

New Flyer Industries of Winnipeg is due to complete an order of trolleybuses for Vancouver by the end of 2007. With an assembly line in place, this manufacturer would be in a position to turn out trolleybuses for Edmonton and to offer a competitive price. Because of the timing of Edmonton's order, the fact that North American manufacturers are not regularly producing trolleybuses should not be a problem.

The study says petroleum prices are forecasted to remain stable. Diesel fuel costs will likely increase by 2 cents per litre in 2007 due to ultra low sulfur requirements.

This statement contradicts recent experience. For the past three years, the City has had to add several million dollars to the budget to cover rising diesel fuel costs for the transit fleet. Petroleum prices are governed by the world market, and history indicates this market is anything but stable. Power for trolleys, on the other hand, is bought on contract over a longer term. Price stability over the contract's term is guaranteed, and the City is likely to be able to negotiate a "good deal" because it owns the power company.

Petroleum refiners actually predict a price rise of 0.20 per US gallon or about 0.05 per litre on diesel fuel due to the 2007 low sulphur requirements. But beyond this, prices are forecast to rise sharply sometime in the next two decades, as world petroleum production peaks [see graph below]. Could this jeopardize the long-term sustain ability of diesel powered public transport? Should Edmontonians give up their trolley system based on a gamble that economists might be wrong about oil price rises?



The study says it will cost $369 million to phase out the trolleys and $389 million to continue with trolleys over the next 6 years. [The latter figure includes a brand new trolley fleet].

The calculations used to arrive at these figures depend entirely on how many buses are purchased. The "keep trolleys" scenario includes 15 more diesel buses than the trolley phase out scenario, at a cost of about $7.5 million. If the intent is to use these 15 vehicles only as occasional spares, an alternative to purchasing 15 new buses would be to retain 15 old ones as the older fleet is retired. This would reduce the capital cost difference down to around $12 million. Another $3 million could be eliminated by ordering 46 trolleys instead of 49. This would allow the "industry standard" spare ratio of 15% rather than the higher spare ratio of 25% that the consultants used.

One premise of this study is that future emissions standards will make diesel buses 'cleaner', but one detects uncertainty about what technology will be used. At one point, the study says "sophisticated engine controls, particulate traps, NOx reduction catalysts and ultra low sulphur diesel fuel" will enable the standards to be met [p.34]. On another page [p.38], it suggests hybrid [diesel-electric] buses may be the

industry's choice to meet post-2007 standards. The long-term performance, reliability and maintenance costs of both of these technologies are largely unknown, but because they are more sophisticated, one might expect such costs to be higher. The hybrid bus, for instance, uses about 40 batteries which have to be replaced about every two years. The study does not evaluate maintenance cost implications for future fleets at all, but presents only the above capital cost assessment.

The study estimates that a 40 foot diesel bus will cost about $500,000 after 2007 because of the added emissions equipment. It uses this figure to project future capital costs for diesel buses. But if hybrid technology is needed to meet post-2007 standards, the capital cost of a new diesel bus could increase to $700,000 - almost as much as a new trolley. The study does not take this into account in a "margin of error". If future emission standards require hybrids at $700,000 a piece, the capital cost difference between keeping trolleys and going all-diesel narrows considerably. The capital cost assessment is thus really just a "guess" that falls apart if any of the assumptions it is based on are not met.

City Council puts brakes on Plan to Scrap Trolleys

Decision preserves quality of life for core neighborhoods and downtown

In an 8 to 5 vote July 27th, Edmonton City Council rejected an administrative proposal to terminate trolley bus service this summer, allowing 46 core neighborhoods to continue to benefit from the quiet and emission-free operation of electric trolleys. An extension of the trolley system to Northgate is to be considered in the 2006 budget. A new low floor trolley bus as well as a hybrid diesel-electric bus are to be acquired for testing and evaluation, and an assessment of new trolleys, hybrids and other technologies is to be presented to Council in 2008, in time to replace the trolley fleet by 2010.

Various community leagues, residents and organizations, including the ***Citizens for Better Transit***, have repeatedly asserted that the trolley's benefits of low noise and zero in-street pollution offset their incremental costs when they are used on busy routes and in high density core areas of the city. According to transit schedules, Inglewood and Westmount residents, for example, would have been subjected to the noise and pollution from 300-400 more diesels passing by each weekday, had trolley service been terminated.

Much of the trolley vs. diesel debate centred on costs. Arguments to abandon trolleys cited the expenditure of maintaining overhead wires. However, over a ten year period, it would cost as much to take the wires down as it would to maintain them, making claims of operating savings by abandoning trolleys dubious. $12 million in recent investments in the system would be lost. If diesel fuel costs continue to rise the way they have in each of the past three years, any financial gains from abandoning trolleys would indeed be short lived.

Although Council's decision does not commit to new trolleys just yet, critics of the motion drew attention to the cost of new trolley buses—at twice the price of new diesels. Edmonton will need to look at renewing its trolley fleet within the next six years. A consultants report released in January—highly criticized

for oversights and analytical errors—examined only one high cost scenario for keeping trolleys. The **ETS Advisory Board** recommended an alternate scenario that would allow renewal of the trolley fleet without spending more over a ten year period than the city would spend on new diesel buses to replace the trolleys. But to benefit, the city would have to act soon. While new trolleys cost more, they typically last about 1/3 longer and have lower maintenance requirements despite consistently heavy service conditions. There is also evidence that well run trolley services attract more riders than diesel buses, increasing revenue. European cities have demonstrated a business case for trolleys on this basis.

Edmonton's trolleybus system has suffered from a lack of commitment in recent years. Paring down trolley service has driven up operating costs. At the July 27th meeting, Councillor Bryan Anderson made a motion directing administration to maximize the cost-benefit of operating the trolley system. This could mean staggering summer road construction projects to minimize interference with trolley operations, as noted by City Manager Al Maurer.

Citizens for Better Transit **applauds the vision shown by Edmonton councillors to retain the trolley system as an option not only for today, but for the future. The flexibility of electricity as an energy source and its relative stability compared with the eventuality of sharp diesel price increases make trolleys a wise choice for a city that already has a sizeable investment in this technology. And there is simply no arguing the benefits of low noise and zero emissions in 46 core neighborhoods!**