CITY COUNCIL
AGENDA REPORT

Subject: ELECTRIC BUS REPORT AND GREENTRIP FUNDING

Recommendation(s)

That the results of battery powered electric buses pilot related to the 2015 Business Case Tran-0004 be approved and that Administration proceed with procurement once approved GreenTRIP funding has been received.

Purpose of Report

This report provides the outcomes, conclusions and recommendations related to Electric Bus Testing conducted by St. Albert Transit (StAT).

Council Direction

On September 2, 2014, Council passed the motion that testing and evaluation of electric buses continue and that recommendations be brought forward to Council to support the purchase of electric buses, after testing was completed. (C424-2014).

Preliminary results of the electric bus tests were brought forward to Council in March 23, 2015, but at that time not all buses slated for trial/testing were available. Since that time, another manufacturer's bus was also tested and evaluated.

Background and Discussion

In the Capital Region, StAT became the first Municipal Transit to introduce low floor buses and the first to introduce articulated buses. With a history of looking for improved ways of managing Transit and its operations, and a City Council that supports changes that offer better service and greener futures, StAT has been testing a new technology, "Battery Powered Electric Buses". With the opportunity to obtain GreenTRIP funding, real cost savings and lower emissions, the future for electric buses throughout the industry looks promising.

Evaluations Results

In summary, based on the average of StAT'S tests and that of Altoona tests, the electric bus results met or exceeded expectations and bus requirement needs.

"Attachment 1" provides detailed test results for two different electric buses and how each model compares to each other. A number of key criteria were evaluated through the testing. They included:

1. Charging - The actual charging of the buses matched the specifications as outlined by the manufacturers and the length of time required to charge the buses would more than adequately meet the operation requirements for transit.
2. Range - the range covered by the buses varied with the battery technology employed with at least one model, as tested meeting the required, specifications.
3. Environmental Impacts – During the test period, the electric power buses showed a reduction of 51% in green house gas emissions compared to diesel buses. Electric bus had an overall fuel economy diesel equivalent of 20.46 mpg. Conventional diesel buses average 3.86 mpg, making the electric bus just over five (5) times more energy efficient.
4. Mechanical issues – there were no mechanical issues
5. Operational and life cycle cost analysis – "Attachment 2" provides greater detail and background information related to costing. Below is a brief summary of the analysis. The costing considered a number of criteria and assumptions which included:
    - US dollar exchange rate
    - Latest/updated price of diesel fuel used
    - Latest price for energy used
    - Maintenance costs
    - Green TRIP funding related to capital

Costs for Entire Life Cycle Per Bus (18 years)

	Diesel Bus (does not qualify for GreenTRIP funding)	**Electric Bus** (with GreenTrip Funding)	**Cost Difference**	**Electric Bus** (w/o GreenTRIP
Capital Cost	$550,000 (CAD)	$394,675 (CAD)	$155,325 (CAD)	$928,000 (CAD)
Fuel/Energy	$476,280	$80,280	$396,000	$80,280
Maintenance	$286,000	$205,000	$81,000	$205,000
Total cost life of bus (18 yrs)	**$1,312,280**	**$679,955**	**$632,325**	**$1,213,280**
Total cost /yr	$72,900	$37,775	$35,130	$67,400

In conclusion, there is a significant cost saving by purchasing electric buses vs. diesel buses. The anticipated savings is estimated at $35,130/bus per year. (Utilizing GreenTRIP funding for the initial purchase). There will also be less maintenance, resulting in less downtime of buses which should translate into more reliable transit service. There is a significant reduction is green house gas emissions by over 50% which will contribute to the achievement of City Council's Goal of reducing total corporate greenhouse gas emissions by 20% below 2008 levels by 2020. In addition this study has shown that there are different

technological approaches to building battery powered electric buses which Administration proposes to evaluate through the Request for Proposal process.

Stakeholder Communications or Engagement

Part of the testing included feedback from transit users riding the electric buses; feedback from bus drivers and transit maintenance staff was also gathered and included in the final evaluation. Stakeholder feedback was very positive.

Implications of Recommendation(s)

It is anticipated that the following implications might be the result of purchasing electric buses;

a) Financial:
As outlined in “Attachment 2”, when combining fuel and maintenance figures together along with GreenTRIP funding, the data shows that over the life of the vehicle, the total savings to the City is estimated at $632,325 per bus. In fact without GreenTRIP funding there is still a significant saving of almost $100,000. This round of purchasing for electric buses will be funded with the assistance of GreenTRIP. Future bus purchases will be re-evaluated to determine whether the City continues with this initiative into the future.

b) Legal / Risk:
No legal risk at this time.

c) Program or Service:
As the electric buses are more widely seen and utilized by the residents of St Albert, StAT should see more satisfaction based on:
- Reduction of noise
- Reduction of pollution (increased air quality)
- Possibly an increase in riders (on the routes with electric buses) as residents will feel this contributes to a more sustainable future.

d) Organizational:
StAT currently has electrical service levels in the building to support up to five (5) stationary / overnight chargers. Depending on how the bus routes were configured, StAT could support up to ten (10) electric buses without any electrical upgrades.

Alternatives and Implications Considered

If Council does not wish to support the recommendation, the alternative would be to continue with the purchase of diesel buses. However, the City’s GreenTRIP application specified electric buses and there is no guarantee funding would be approved for something different.

Strategic Connections

a) Council's Strategic Outcomes and Priorities (See Policy C-CG-02)
- CULTIVATE ECONOMIC PROSPERITY: A diversified, robust and resilient economic foundation to support growth and community service delivery.
  Electric buses would demonstrate not only within the Capital Region but within the Province that St Albert remains a leader through being the early adopter of this new technology.
- CULTIVATE A GREEN COMMUNITY: A healthy natural environment for future generations that preserves and promotes enjoyment, conservation and responsible development.
  Electric buses would solidify St Albert as a green community through the reduction of Greenhouse Gas Emissions. Electric buses will contribute to reducing community carbon footprint by providing a low carbon alternative to single occupancy vehicles. The community target approved by City Council is a 6% reduction in 2008 levels by 2020.
- CULTIVATE EXCELLENCE IN GOVERNMENT: A responsive, accountable government that delivers value to the community.
  Electric buses have a lower cost per km or per passenger over the life of the vehicle than our current diesel fleet.
- CULTIVATE SUSTAINABLE INFRASTRUCTURE AND SERVICES: A growing community that has balanced development and management of civic facilities, transportation networks and related services.
  Electric buses will help StAT manage our transportation plan with more options. These new buses are quieter and may be smaller allowing us to service the tighter traffic and streets of residential areas.

b) Long Term Plans (e.g. MDP, Social Master Plan, Cultural Master Plan, etc.)
- The purchase of electric buses is consistent with Transit's Long Term department Plan and the City's Environmental Master Plan.

c) Corporate Objectives (See Corporate Business Plan)
- Attract and retain high quality employees
- Deliver programs and services that meet or exceed our standards
- Exercise strong fiscal management
- Ensure our customers are very satisfied

Attachment(s)

1. StAT Electric Bus Tests
2. Cost Analysis

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General Manager Approval:	*Glenn Tompolski, General Manager, Infrastructure Services*
City Manager Signature:	Date:

StAT Electric Bus Tests

StAT tested two 12m electric buses. The first test was the BYD bus. The test bus went on the same regular bus routes that our diesel buses service. There were no mechanical issues during the test, and overall the bus performed as expected. In total the BYD bus travelled 2,935 kms and operated for 128 hours during this test period.

BYD Electric Bus

Charging:
The BYD bus used a total of 3,056 KWH of power with a maximum daily use of 269 KWH and an overall average of 156 KWH during this evaluation period.
The maximum time required to charge the BYD bus during this evaluation period was 3hrs 43min, this was from a charged state of 31% to a complete charge of 100%. The average rate of charge was approximately 1 minute per KWH which would indicate a 6hr charge would be required for a totally depleted system.

Range:
The average power consumption during the evaluation period was 1.01 KWH / km. The longest distance the electric bus traveled between charges was 184 kms which used 156 KWH (about 57% of total capacity). Based on our results the maximum range of the BYD bus should be at least as much as reported in their literature (250 kms).

Environmental impacts:
The BYD bus average power consumption of 1.01 KWH / km is estimated to generate approximately 0.66 kg of CO^2 / km (counting GHG generated from Alberta's electrical power grid) as compared with an average of 1.28 kg of CO^2 / km generated by a diesel bus, a reduction of about 51% in greenhouse gas emissions compared to a diesel powered bus.

New Flyer Electric Bus

Charging:
The New Flyer bus used a total of 2,310 KWH of power with a maximum daily use of 102 KWH and an overall average of 75 KWH during this evaluation period.

Range:
The average power consumption during the evaluation period was 1.23 KWH / km. The longest distance the electric bus traveled between charges was 83 kms which used 102 KWH (about 51% of total capacity). Based on our results the average maximum range of the New Flyer bus is calculated to be around (170 kms).

Environmental impacts:
The electric bus average power consumption of 1.23 KWH / km is estimated to generate approximately 0.80 kg of CO^2 / km (counting GHG generated from Alberta's electrical power grid) as compared with an average of 1.28 kg of CO^2 / km generated by a diesel bus, a reduction of about 44% in greenhouse gas emissions compared to a diesel powered bus.

Conclusion of Test Results:
Based on the test results the longest range is achieved by the BYD bus (they have a new proprietary iron phosphate battery which holds a larger charge). The new battery design of this bus means less frequent charging, so the energy consumption was lower on the BYD test bus as well. And finally because there are fewer charging cycles, the batteries on the BYD bus will last much longer. The tests showed that an electric bus will meet our operational requirements.

Cost Analysis

A. Energy Used in Electric & Diesel Buses

The battery powered electric bus has energy stored in rechargeable batteries and uses no internal combustion engine (except for small diesel fired heaters for onboard passenger comfort). The power from the batteries is fed into electric motors.

The Federal Transit Administration (FTA) is part of the U.S. Department of Transportation, and administers all transit funding and transit standards in the U.S. (including bus standards). All bus manufacturers are required to submit their various models of buses to the FTA testing facility to be considered for federally funded transit programs. The FTA site states:

> "FTA's New Model Bus Testing Program (often referred to as "Altoona Testing" due to the location of the primary test facility) tests new transit bus models for safety, structural integrity and durability, reliability, performance, maintainability, noise, and fuel economy..."

Some of StAT information is based on this U.S. FTA facility and their test results.

The energy consumption of test bus # one in St Albert was 1.01 KWH/km, of test bus # two it was 1.23 KWH/km. The average energy consumption from a BYD electric test bus in Altoona was 1.24 KWH/km, and the average of the Proterra electric test bus in Altoona was 1.06 KWH/km. This makes an overall average used for our calculations of 1.14 KWH/km (or 1.84 KWH/mile).

The formula used to compare diesel and electric bus fuel economies is:

$$FE_{MPGe} = (E_D \times 100) / FC_{EV}$$

Where:
FE_{MPGe} = Fuel Economy in miles per gallon diesel equivalent
FC_{EV} = Measured unadjusted electrical consumption [KWH/100Mile]
E_D= Energy content per gallon of diesel = 128,450 BTU/gallon = 37.64 KWH/gallon (US DoE, Alternative Fuels & Advanced Vehicles Data Center)

Based on the average of our tests and that of Altoona tests, the electric bus has an overall fuel economy diesel equivalent of 11.5 l/100km (20.46 mpg). Conventional diesel buses average 60.9 l/100km (3.86 mpg), making the electric bus just over five (5) times more energy efficient.

B. Factors Affecting Costs

StAT bus purchases are affected by the strength or weakness of the Canadian dollar. As the Canadian dollar falls, the price of imported buses rises, for example as of July 15, 2015 the exchange rate for the Canadian dollar against the US dollar was 0.773.

One year ago on the same day (July 15, 2014) the exchange rate was 0.931, a difference of $0.16.

This means that if a purchase price was quoted one year ago of $800,000, then today (with no price increases, only the exchange rate difference), we would now expect to pay $928,000.

The price of diesel fuel and electricity also affects the costs, but operational costs this time rather than capital costs as mentioned above. Natural Resources Canada shows diesel prices from one ago at $1.32/l. The average price across Canada now is $1.10/l ($0.22 or 17% lower).

Electricity costs tend to fluctuate in Alberta more than most provinces. Currently we are paying around $0.09/KWH. But as can be seen from the graph attached (Appendix A) (from National Energy Board), Alberta still averages around $0.10 - $0.15/KWH over the ten (10) year period.

C. Cost Comparison of Energy Used

Based on our calculated average energy used for an electric bus of 1.14KWH/km and electricity costs of $0.09/KWH, the operational costs of 'fueling' the bus for an entire year should be approximately $4,460/yr.

Compared to a diesel bus with which average 60.9 l/100km (3.86mpg), and diesel costs of $1.00/l, the operational costs of 'fueling' the bus for an entire year should be approximately $26,460/yr. These costs are derived from our actual kms per year for our fleet.

StAT currently maintain our buses for 18 yrs, so our annual operational saving of energy used will be $22,000/yr x 18 yrs for a total energy savings of $396,000.

D. Maintenance Cost Savings

Since there is no internal combustion engine or a transmission there will be some maintenance savings over the life the electric bus too. These savings are:

- Regular oil changes / services = $11,000 over the life of the bus
- Engine rebuild = $40,000 over the life of the bus
- Transmission rebuild = $10,000 over the life of the bus
- Engine injectors, DPF cleaning and changes, other engine related regular maintenance = $20,000 over the life of the bus

The total maintenance savings are estimated to be $81,000 over 18 yrs.

E. Total Cost Savings

Using the new estimated capital cost of the electric bus and our current diesel bus, with some price adjustment for inflation and lower CDN dollar, the calculations are:

Electric bus
$928,000 Capital cost
+ $80,280 total energy operational costs (18 yrs)
+ $205,000 Regular maintenance & repairs (brakes, tires, heating, etc)

= $1,213,280 over the life of the bus

Diesel bus
$550,000 Capital cost
+ $476,280 total energy operational costs (18 yrs)
+ $81,000 Diesel specific maintenance costs
+ $205,000 Regular maintenance & repairs (brakes, tires, heating, etc)

= $1,312,280 over the life of the bus

A difference of $99,000 over the life of the bus.

Note:
Original calculations were based on diesel prices of $1.15l and capital costs of the electric bus of $800,000 (before the CDN dollar fall). If these figures were again used, the figures would be:

Electric bus = $1,085,280 over the life of the bus
Diesel bus = $1,414,451 over the life of the bus

A difference of $329,171 over the life of the bus.

F. Total Savings with GreenTRIP funding

Electric bus
$394,675 Capital cost
+ $80,280 total energy operational costs (18 yrs)
+ $205,000 Regular maintenance & repairs (brakes, tires, heating, etc)

= $679,955 over the life of the bus

Diesel bus
$550,000 Capital cost
+ $476,280 total energy operational costs (18 yrs)
+ $81,000 Diesel specific maintenance costs
+ $205,000 Regular maintenance & repairs (brakes, tires, heating, etc)

= $1,312,280 over the life of the bus

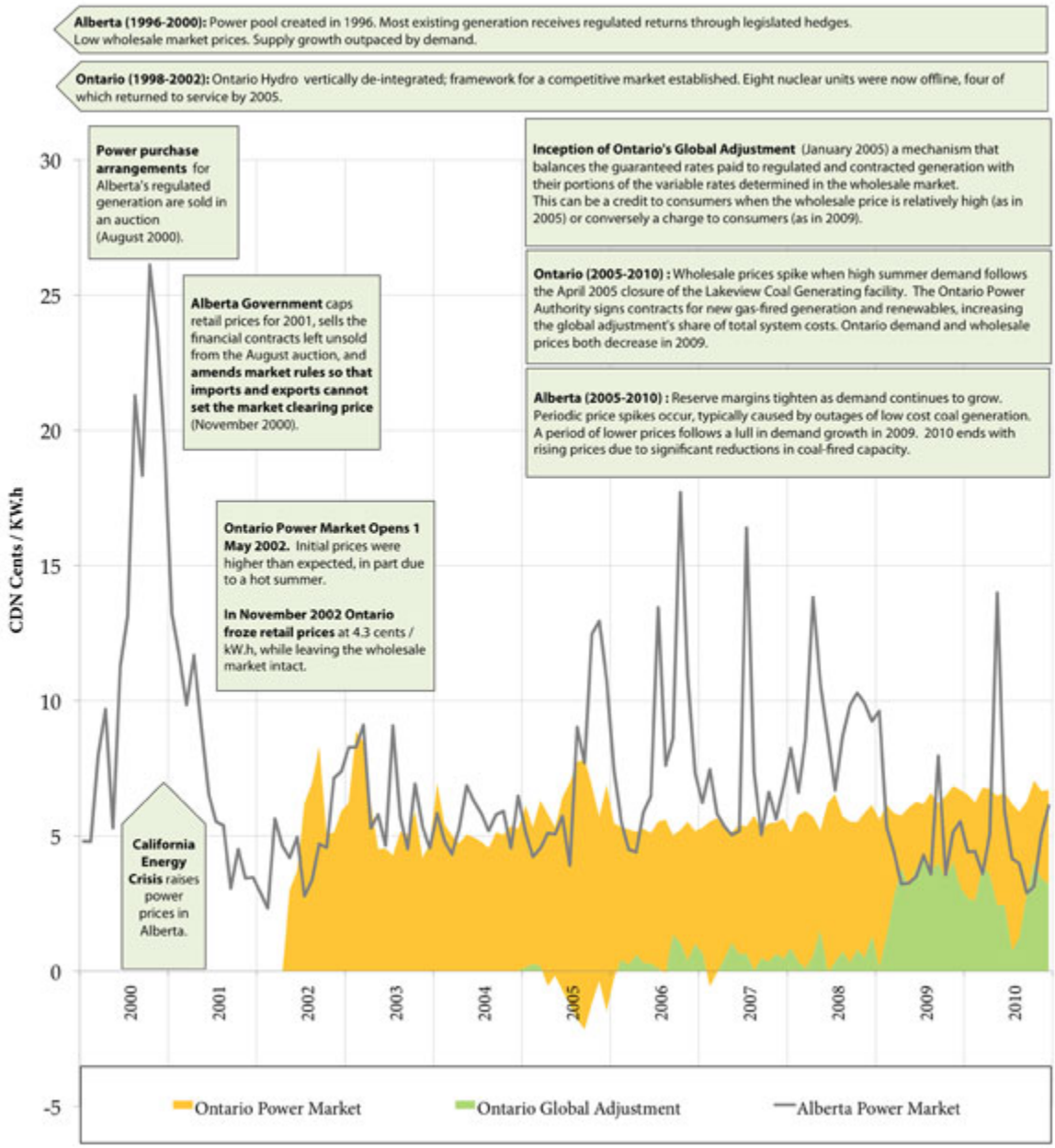
A difference of $632,325 over the life of the bus x each bus.

Conclusions of Cost Analysis

The cost savings were much larger when we started this process, when both our dollar and the price of diesel were higher. However we know that diesel prices will not stay this low for the long term. If we look at historical numbers the price of diesel has gone up 37% in the last 10 years (U.S. dept of Energy). So the potential savings in energy costs will only increase with the electric bus over time.

Nevertheless even with the unfavourable exchange rate and low diesel prices, the savings are still favourable. And in fact the savings are quite substantial with the GreenTRIP funding in place. As mentioned previously this round of purchases for electric buses will be largely funded with the assistance of GreenTRIP. However; future electric bus purchases will have to be re-evaluated to determine whether the City continues with this initiative into the future.

Appendix A


Alberta (1996-2000): Power pool created in 1996. Most existing generation receives regulated returns through legislated hedges. Low wholesale market prices. Supply growth outpaced by demand.
Ontario (1998-2002): Ontario Hydro vertically de-integrated; framework for a competitive market established. Eight nuclear units were now offline, four of which returned to service by 2005.
Power purchase arrangements for Alberta's regulated generation are sold in an auction (August 2000).
Alberta Government caps retail prices for 2001, sells the financial contracts left unsold from the August auction, and amends market rules so that imports and exports cannot set the market clearing price (November 2000).
Ontario Power Market Opens 1 May 2002. Initial prices were higher than expected, in part due to a hot summer.
In November 2002 Ontario froze retail prices at 4.3 cents / kW.h, while leaving the wholesale market intact.
California Energy Crisis raises power prices in Alberta.
Inception of Ontario's Global Adjustment (January 2005) a mechanism that balances the guaranteed rates paid to regulated and contracted generation with their portions of the variable rates determined in the wholesale market. This can be a credit to consumers when the wholesale price is relatively high (as in 2005) or conversely a charge to consumers (as in 2009).
Ontario (2005-2010) : Wholesale prices spike when high summer demand follows the April 2005 closure of the Lakeview Coal Generating facility. The Ontario Power Authority signs contracts for new gas-fired generation and renewables, increasing the global adjustment's share of total system costs. Ontario demand and wholesale prices both decrease in 2009.
Alberta (2005-2010) : Reserve margins tighten as demand continues to grow. Periodic price spikes occur, typically caused by outages of low cost coal generation. A period of lower prices follows a lull in demand growth in 2009. 2010 ends with rising prices due to significant reductions in coal-fired capacity.
CDN Cents / KW.h
30
25
20
15
10
5
0
-5
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Ontario Power Market
Ontario Global Adjustment
Alberta Power Market