Alternative formats and communication supports available upon request. Please contact accessibility@brantford.ca or 519-759-4150 for assistance.

Date	July 5, 2022	**Report No.** 2022-304	
To	Chair and Members Committee of the Whole - Operations		
From	Inderjit Hans, P. Eng., PMP General Manager, Public Works Commission		

1.0 Type of Report

Consent Item	[ ]
Item For Consideration	[X]

2.0 Topic Transit Fleet Electrification Feasibility Study [Financial Impact: 2022 - None]

3.0 Recommendation

A. THAT Report No. 2022-304, titled Transit Fleet Electrification Feasibility Study BE RECEIVED; and

B. THAT following the completion of the Transit Optimization Study staff BE DIRECTED to update the Battery Electric Bus (BEB) Feasibility Study to reflect the expected changes to Transit service levels, routing and fleet and REPORT BACK to Council.

4.0 Executive Summary

Fleet and Transit Services are committed to the City's Corporate Climate Change Action Plan (CCAP) to become Net Zero by 2050. This commitment includes converting vehicles and equipment to battery electric where possible when resources, technology, and funding are available in order to achieve the City's goals in reducing greenhouse gas (GHG) emissions.

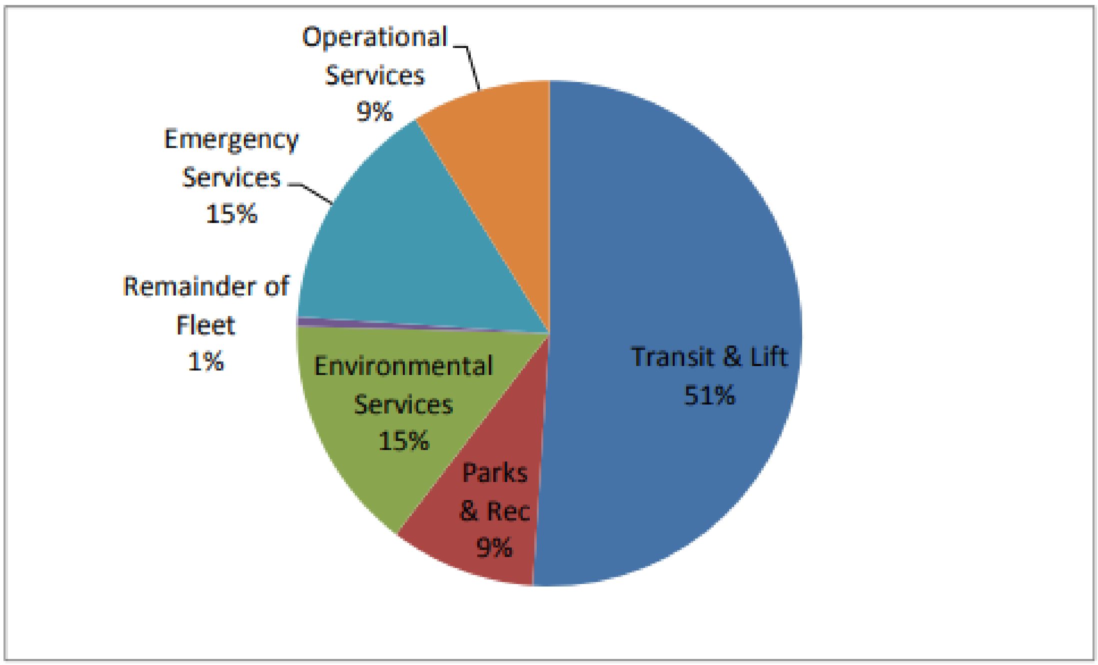
The Battery Electric Bus (BEB) feasibility study recently completed by IBI group included the following components; a facility assessment, energy modeling of the current routes, greenhouse gas assessment, an electrical service and charging analysis, and a review of the total cost of the transition. These components have been consolidated into the Battery Electric Bus Implementation Plan and Cost Report (Appendix A), and includes the following conclusions. With the transit optimization study forthcoming staff recommends updating this information, as required, in order to capture any service updates that may result from the optimization study:

- That Brantford Transit pursue an end-of-life replacement timeline for the current fleet (14 years);
- That Brantford Transit purchase first-generation BEBs with auxiliary diesel heaters for resiliency purposes in extreme cold weather, while considering pursuing heat pump technology as the technology becomes available on the North American market;
- Brantford Transit install initial charging equipment indoors, in a configuration that supports charging buses either stationary or as dedicated charging stalls for buses to rotate through, and that Brantford Transit decide which charging approach to implement based on observed performance of BEBs.
- That in the medium-term, the City of Brantford investigates options for a new or relocated facility for transit operations, given the space constraints at the existing garage.

In order to transition to BEBs over 14 years there would be an increase of capital funding of approximately $30.8 million, above current costs. Increases in capital costs are a result of the higher purchase price of BEBs, and the infrastructure required for charging. The cost of a single conventional BEB is approximately $1,302,000 compared to $600,000 for a diesel bus. Annual operating expenses will decrease by moving away from fossil fuels, and the decreased maintenance cost associated with BEBs. All operational savings are based on 2021 fuel prices and a detailed breakdown of costing is provided in Section 10 of this report. Following the optimization study there is potential for fleet numbers to change due to changes in service levels. Operational and maintenance costs would need to be reassessed at that time.

There is a potential GHG avoidance of 24,341 T of CO2e over the 14 years of the replacement project (equivalent to 989 cars taken off the road). Once the transition is complete and the 48 fossil fuel buses (31 conventional, 17 specialized) are replaced with a BEB fleet, up to 3,228 T of CO2e could be avoided annually. GHG emissions from the Corporation totaled 15,426 T of CO2e in 2019. . Emissions from Fleet account for 44% of the total corporate emissions. Figure 1 below shows a breakdown of the fleet emissions by department and shows that Brantford Transit and Brantford Lift account for 51% of all fleet emissions, or 22% of the total corporate emissions. Transitioning to BEBs will eliminate nearly all emissions (96% reduction) accounted for by Transit and Lift, reaching the corporate emission reduction targets for 2030, 2040 and net zero emissions target in 2050.

Figure 1: Fleet Emissions by Department



At this time staff recommends that the information in this report be received and that once the optimization study is complete and there is a better understanding of the ultimate transit fleet numbers and routing, staff report back with an updated BEB implementation plan that encompasses any service updates identified within the optimization study.

5.0 Purpose and Overview

The purpose of this report is to present a point in time analysis of the requirements to transition the transit fleet to BEBs. The Brantford Transit Electric Bus Needs Assessment and Feasibility Study as completed by IBI Group (Appendix A), outlines a transition plan, including the costing, GHG impact and timeline for the conversion of the transit fleet to BEBs based on current transit service levels. Following the upcoming transit optimization study, the information contained in the Brantford Transit Electric Bus Needs Assessment and Feasibility Study will be used as a starting point for the development of a transit service improvement plan which will include the transition to BEBs. This information will also be useful when undertaking the optimization study

6.0 Background

In December 2019, Brantford City Council declared a Climate Emergency, committing the City, in principle, to becoming carbon neutral by 2050. With this declaration, staff was directed to work with the Environmental and Sustainability Policy Advisory Committee (ESPAC) to develop a carbon reduction strategy, evaluation framework, and reporting mechanism.

The Corporate Climate Change Action Plan (CCAP) and Climate Lens Assessment Report (Report No 2020-472 “Corporate Climate Change Action Plan and Climate Lens Assessment”) approved on November 24, 2020 provided a plan for reducing GHG emissions emitted by the Corporation of the City of Brantford. This includes any emissions produced by any City owned or managed assets including buildings, fleet, water and wastewater treatment facilities, street lights and traffic signals, and emissions from landfill.

In 2020, Fleet and Transit Services submitted report 2020-420 “Continuation of Clean Diesel Bus Replacement Until 2022” which advised that Fleet and Transit Services would continue purchase clean diesel options until such a time the Department was prepare to begin electrifying the bus fleet.

As part of the effort to reduce GHG emissions, funding was approved in the 2021 capital budget for a feasibility study to determine what would be required to convert the transit fleet to electric buses. Following the budget approval staff completed a Request for Proposals (RFP) to obtain a qualified consultant to conduct a feasibility study that will consider the various technologies available, required charging infrastructure, required upgrades to the existing Transit Service Centre (400 Grand River Avenue), and other key considerations.

7.0 Corporate Policy Context

The Corporate CCAP approved by Council in 2020 in Report #2020-472 “Corporate Climate Change Action Plan and Climate Lens Assessment” directly guides the work outlined in this staff report and gives staff guidance on emission reduction efforts for corporate activities.

Council Priorities # 4: There is high trust in the City through demonstrated progress in taxpayer affordability and value for money

Council Priorities # 7: The City is mitigating its environmental footprint and adapting to climate change

Public Works – 014: Green Fleet Policy

Corporate Energy Management Plan/Climate Change Action Plan

- Reducing fossil fuel energy consumption, GHG emissions are reduced
- Switching fuel sources to clean energy and electricity options

KMPG Service Review, reference 63 “Review the feasibility of electrifying the municipal fleet

8.0 Input From Other Sources

Input was received from the Business Support and Sustainability Department (Public Works) and the Finance Department.

9.0 Analysis

In recent years municipalities across the country have been transitioning to electric transit fleets. There are currently over 20 BEB implementation projects taking place across Canada mostly within larger municipalities. In Ontario transit services including, Toronto, York Region, Brampton and Ottawa, have already commenced with the deployment of BEBs within their fleets, while Waterloo Region, Hamilton, London, Guelph, and Kingston are all anticipated to start transitioning to BEBs in the near future. The size of transit fleet in many of these municipalities is greater than Brantford Transit; therefore there is a benefit and opportunity for staff to monitor how transition to BEB’s moves forward in these municipalities and understand the lessons learned before moving forward in Brantford.

A full transition to a BEB fleet would be a multifaceted undertaking for Brantford Transit, as the capabilities of BEBs on the market and the infrastructure to support their operation differ from conventional fossil fuel powered buses.

9.1 Electrification Study Components

The Brantford Transit Electric Bus Needs Assessment and Feasibility Study consisted of five components which have been consolidated into the final Battery Electric Bus Implementation Plan and Cost Report (Appendix A). Each component examined a different aspect of the transition process and are detailed in this section;

1. Facility Assessment
2. Route Modeling
3. Greenhouse Gas Emissions Assessment
4. Electrical Service and Charging Analysis
5. Total Cost of Ownership

9.1.1 Facility Assessment

The Facility Assessment examined the current state of the Brantford Transit Service Centre at 400 Grand River Ave., inclusive of space, constraints, electrical service, and transformer capacity. The assessment provided a high level overview of the technologies available and examined the best BEB practices for transit that municipalities are currently utilizing. This also included a gap analysis which identified areas that may present a challenge to the implementation of a fully electric transit fleet.

The Facility Assessment concluded that the current space and electrical service available at 400 Grand River Ave. could support the electrification of up to 12 BEBs. An expansion of up to 27 BEBs could be accommodated but would require the installation of a General Service Pad-Mounted Transformer. To replace the entire transit fleet with BEBs, a customer-owned substation would be required, and both outdoor charging opportunities and/or facility expansion will require further consideration.

The concept of moving to a new transit yard in order to address the shortcomings of the current facility was not included within the scope of this study and therefore not detailed within the study. This option is currently being explored internally by City staff as a possible solution to address the limitations identified.

9.1.2 Route Modeling

The Route Modeling component provided a comprehensive technical review of Brantford Transit's and Brantford Lift's existing services and their compatibility with BEB operations. Batteries available for BEBs store less energy per unit than a tank of diesel in a traditional bus. As a result, full-size BEBs currently on the market tend to have a lower maximum driving range between charges, compared with a diesel buses driving range between fueling. In order to cover all scheduled passenger service, buses would need to rotate in and out of service for midday charging, and would therefore need to be relieved by recently recharged buses. The study provides an overview of modifications to individual bus service schedules that would be required to achieve full BEB compatibility.

The current transit fleet is made up of thirty one (31) conventional diesel buses and seventeen (17) specialized vehicles. In order to continue providing the current levels of service, a total fleet size of thirty nine (39) conventional BEBs and fourteen (14) specialized BEBs would be necessary under the energy consumption scenarios modelled. However service levels and fleet size may be impacted by changes to service resulting from the upcoming optimization study. Once the optimization study is complete and opportunities for improvements to the existing route network and service schedules are identified the number of BEBs that would be required in order to match future needs can be assessed.

9.1.3 Greenhouse Gas Emissions Assessment

The Greenhouse Gas Emission Assessment examined the impact on GHG emissions across three (3) different vehicle replacement time lines starting in 2024:

1. 2024 flash replacement (replacing the entire fleet simultaneously, this scenario was examined to show the immediate impact of replacing all transit vehicles. However this option is not viable as detailed in 9.1.5)

2. 2030 accelerated replacement (replacing the fleet over 6 years)

3. 2037 end-of-life replacement (replacement coinciding with standard 12-year replacement cycle for conventional buses

and 7-year replacement cycle for specialized buses) (Study Recommendation)

The end of life replacement timeline recommended in the study allows for a transition period with overlap in initial BEB purchases to allow for retraining and any troubleshooting associated with initial deployment.

All direct and indirect GHG emissions linked to the manufacturing and operation, were evaluated as part of the study. The analysis shows that once the fleet has been fully converted to BEBs, GHG emissions related to operating are anticipated to decrease by as much as 96% for the conventional fleet and 97% for the specialized fleet.

9.1.4 Electrical Service and Charging Analysis

The Electrical Service and Charging Analysis used the findings from the Facility Assessment and Route Modelling Report to investigate alternative scenarios for charging. Various facility and equipment constraints were accounted for and the requirements for infrastructure procurement and upgrades were identified.

Different timing/phasing options for installing charging equipment were considered. Phasing installation using a capital investment and implementation plan with a series of decision points will enable Brantford Transit to scale BEB operations without incurring wasteful costs. This provides opportunities to adapt investment decisions to optimize financial and operational advantages based on performance data as it becomes available.

The analysis examines three scenarios using different charger layouts and operational workflows.

- Indoor stationary charging: after being cleaned and serviced, buses would remain parked in storage/charging spaces for the duration of the overnight period (Study Recommendation).
- Indoor batch charging: after being cleaned and serviced, buses would be sorted into storage lanes without chargers. At planned times groups of buses would be driven into the

charging lanes and charged simultaneously as batches. After charging, buses would be removed and parked in storage lanes reserved for buses that are ready for pull-out.

- Outdoor individual charging: after being cleaned and serviced, buses would be parked indoors. Overnight, buses would be driven outdoors and charged, then returned to indoor storage in lanes reserved for buses that are ready for pull-out. This analysis assumes that an outdoor charging setup is relatively unconstrained for space, based on Brantford Transit having access to the backlot previously occupied by Brantford Power storage. Chargers would be arranged to allow free access.

For Brantford Lift, charging was assumed to take place outdoors for all scenarios, due to space limitations within the current facility. This represents a suboptimal but necessary condition to achieving electrification of the conventional fleet.

The study did identify constraints with setup and layout within the existing garage. As a result of these limitations it is recommended that options for a new or relocated transit operations facility be investigated.

The study concluded that, with the current transit fleet and service levels, initial charging equipment could be installed indoors, in a configuration that supports either stationary charging or rotating batch charging. A decision on charging layout could be made at a later date based on early performance data of the BEBs. Initial operations would use stationary charging to avoid additional labour cost while BEB performance and the potential for a new transit operations facility are evaluated.

9.1.5 Cost of Ownership

The Cost of Ownership examined the anticipated costs associated with transition to a fully electric bus fleet. The study considers nine alternative scenarios, as a combination of three alternative replacement timelines and three charging infrastructure configurations.

The three alternative replacement timelines considered are:

A. 2024 Flash cut replacement - replacing the entire fleet simultaneously

B. 2030 Accelerated Replacement - replacing the fleet over 6 years

C. 2037 End of Life Replacement - replacement coinciding with standard 12-year replacement cycle for conventional buses and 7-year replacement cycle for specialized buses (Study Recommendation)

The three charging infrastructure configurations are (details are in section 9.1.4):

A. Indoor stationary charging (Study Recommendation)

B. Indoor batch charging

C. Outdoor batch charging

Costs included within the total costs of ownership are:

- Capital Costs: purchasing new vehicles and installing infrastructure.

- Operating Costs: changes to energy costs from switching to electricity, and maintenance needs including labour and parts.

- Administrative Costs: employee re-skilling, as well as some ongoing costs associated with regular retraining.

Scenarios which involved a flash cut or accelerated replacement schedule incur the lowest total costs, but also come with risks. BEB technology is still not at a fully mature state of development in North America. Risks of technical challenges associated with an immediate or accelerated conversion are high, and provide little or no opportunity to collect data, establish best practices, or expose staff to the new technologies prior to transition. These concerns are exacerbated by the fact that BEB orders are facing an anticipated backlog of 18 to 24 months due to accelerating demand and overarching global supply chain challenges.

Due to these challenges, the study does not recommend scenarios which use the flash cut or accelerated replacement timeline. This leaves the end of life timeline as the preferred scenario.

The end of life timeline provides an opportunity to collect performance data and refine the technical requirements based on data and lessons learned. If changes need to be made to procurement schedules or specifications, the relatively low cost benefit of the accelerated scenario would quickly be eclipsed by the cost of midstream changes.

In terms of charging infrastructure configurations, stationary charging incurs the lowest cost due to savings in labour. Although it should be noted that in the early stages of rollout the indoor stationary charging and the indoor batch charging scenarios start with the same equipment, before eventually diverging in year 4 of the implementation. The study recommends proceeding with an initial charger layout that supports either indoor option, followed by a decision at a later date on which final approach to pursue.

9.1.6 Study Conclusions

The study makes the following conclusions regarding the transition to BEBs that will be carried forward when the optimization study is complete and the future of transit fleet is reassessed:

i. That Brantford Transit pursue an end-of-life replacement timeline for the current fleet;

ii. That Brantford Transit purchase first-generation BEBs with auxiliary diesel heaters for resiliency purposes in extreme cold weather, while considering pursuing heat pump technology as the technology becomes available on the North American market;

iii. That Brantford Transit installs initial charging equipment indoors, in a configuration that supports charging buses both stationary or as dedicated charging stalls for buses to rotate through and that Brantford Transit decide which charging approach to implement based on observed performance of BEBs.

iv. That in the medium-term, the City of Brantford investigates options for a new or relocated facility for transit operations, given the space constraints at the existing garage.

9.2 Funding Sources

On March 26, 2019 the Minister of Infrastructure announced the launch of the Investing in Canada Infrastructure Program (ICIP) – Public Transit stream. Eligible municipalities, located outside of the Greater Toronto and Hamilton Area (GTHA), are able to nominate their most critical public transit projects. This stream will fund construction, expansion, and improvement of public transit networks. The cost share for the program is 40% Federal, 33.33% Provincial, and 26.67% Municipal.

The City of Brantford's allocation totals $36 million under this program. Public Works has already accessed funding for four (4) projects totaling $13,883,000 outlined in Table 1. The remaining $22,117,000 is available for projects such as, bus fleet electrification.

Table 1: Public Transit Stream ICIP First Intake Submission

Project	Total Project Cost
Conventional and Specialized Bus Replacement	$9,988,000
Replacement of On Board Equipment on Conventional and Specialized Buses	$2,035,000
Bus Pad and Shelter Replacement Program	$825,000
Transit Centre Hoists, Bus Wash and Fuel Pump Upgrades	$1,035,000
First Intake Submission Total	**$13,883,000**

In addition to the available ICIP funding, staff will continue to seek additional funding and grant opportunities such as, the Zero Emissions

Transit Fund (ZETF), and the Canadian Infrastructure Bank Zero-Emissions Bus Initiative to offset costs throughout the life of the project.

Details of grant funding and ICIP funding will be included in capital request annually.

9.3 Next Steps

There are two (2) initiatives moving forward in 2023 which will help to reshape the way Brantford Transit delivers service to the public; new onboard technology, and a Transit Optimization Study.

Brantford Transit is currently in the process of replacing and updating onboard technology which includes; fareboxes, automatic vehicle location (AVL), computer aided dispatch, and passenger counters. These upgrades will enhance the customer experience through improved real time information, connectivity, and quality improvements to public transportation. The addition of the new technologies will improve the quality of ridership data, operational tracking, and performance data. This information will be used to inform service improvements and provide a quality service to riders.

At the June 7 Committee of the Whole – Operations meeting and City Council the same month, an amendment to a resolution was approved to direct staff to initiate the planned Transit Optimization Study by Q1 2023. This study will review all aspect of transit services and prepares both short and long term plans for the delivery of service. This study will determine the levels of transit service that are needed to effectively respond to the needs of residents and business, and recommend service improvement options where appropriate.

Both initiatives have the potential to reshape the way that public transit is delivered within Brantford. Changes and upgrades that may result from these initiatives include updated routes and service hours, changes to the service delivery model, and the required size of transit fleet.

In 2023 with improved data and the completion of the optimization study the future needs of Brantford Transit will become increasingly clear. At this time a strategy to transition the transit fleet to BEBs that properly accounts for future service plans will be fully developed.

10.0 Financial Implications

There is no funding being requested at this time as a result of this report. All costs associated with this report will be brought to the Estimates Committee at a later date.

In order to provide Council with a representation of what the costs are with transitioning to BEB's Table 2 assumes the transition to BEBs will begin in 2024 and estimates the impacts on the capital and operating costs over the 14 year transition period. The capital costs under a business as usual scenario, where no transition to BEBs occurs, are compared to the recommended BEB transition scenario (stationary charging, and end of life replacement cycle). Over the 14 year transition to BEBs capital funding would be required to increase by approximately $30.8 million. Increases in capital costs are a result of the higher purchase price of BEBs, and the infrastructure that would be required for charging. The cost of a single conventional BEB is approximately $1,302,000 compared to $600,000 for a diesel bus. Annual operating expenses will decrease due to switching away from fossil fuels, and the decreased maintenance cost associated with BEBs. Although the first year sees an increase due to training, and additional FTEs, operating cost decrease by a total of approximately $12.7 million over the 14 year transition. Once the transition is complete operational savings will be approximately $1.3 million annually. All operational savings are based on 2021 fuel prices. Additionally the table shows the annual reduction in GHG, compared to the fossil fuel fleet, in terms of both T of CO2e and the equivalent number of "cars off the road".

Year	First Generation Bus Purchases		Annual Costs (2023 Present Value, 000s)			Annual GHG Emissions Savings (tonnes CO2-equiv.) - Operating Only	
	Conventional	Specialized	Business As Usual	Stationary Charging, End-of-Life Replacement		tonnes CO2-equiv.	"Cars off the road"
			Capital	Capital	Operating(+/-)		
2024	4	5	$2,748	$7,102	$205	455	140
2025	4	4	$758	$6,583	($253)	634	194
2026	4		$3,202	$4,939	($630)	989	303
2027	3		$1,298	$3,567	($675)	1222	375
2028			$0	$0	($663)	1223	375

2029	4		$1,947	$5,209	($728)	1576	483
2030	3	5	$2,510	$5,517	($1,229)	1687	517
2031			$0	$0	($1,205)	1687	517
2032	4		$1,947	$4,939	($1,244)	2039	625
2033			$0	$0	($1,212)	2043	626
2034			$0	$0	($1,173)	2043	626
2035	5		$3,245	$6,128	($1,266)	2520	772
2036	5		$3,245	$6,128	($1,302)	2996	918
2037	3		$1,947	$3,567	($1,312)	3228	989
Total	**39**	**14**	**$22,847**	**$53,679**	**($12,687)**	**24341**	

All figures included in the report from IBI are estimates based on a combination of academic and industry research and observed costs from past IBI Group projects.

Under the above conditions the budget in the first year of transition would require an addition $4,354,000 in capital and $205,000 in operating above the business as usual scenario.

11.0 Climate and Environmental Implications

As indicated in the Corporate CCAP, electrification of the corporate fleet is prioritized due to the potential of GHG reductions. GHG emissions from the Corporation totaled 15,426 T of CO2e in 2019. Emissions from Fleet account for 44% of the total corporate emissions. Brantford Transit and Brantford Lift account for 51% of all fleet emissions, or 22% of the total corporate emissions.

By phasing out fossil fuel buses over 14 years, using the end of life replacement timeline as recommended in the study, there is a potential operating GHG avoidance of 24,341 T of CO2e over the lifetime of the replacement project (equivalent to 989 cars taken off the road). The replacement of 48 fossil fuel buses (31 conventional, 17 specialized) with BEBs, has the potential to reduce operating GHG emissions by up to 3,228 T of CO2e annually. This will help put Fleet and Transit Services on the path to reaching the corporate emission reduction targets for 2030, 2040 and net zero emissions target in 2050.

Electric buses not only produce significantly fewer emissions than diesel or hybrid buses, but they are also better for local air quality and street noise. Electric buses are quieter, cleaner and better for the local environment.

12.0 Conclusion

Despite the overall low cost of maintaining Business-as-Usual, this approach fails to meet federal emissions reductions targets or the City's climate emergency declaration. In order to make progress towards the 2050 net zero emissions targets included in the city's Climate Change Action Plan, Brantford Transit will need to transition away from fossil fuel buses towards BEBs.

The Battery Electric Bus (BEB) feasibility study recently completed by IBI group gives a point in time account for transitioning the current Brantford Transit fleet and service to BEBs. The study concludes that the best path forward towards full electrification is to use an end of life replacement time line for replacing the buses, and to install the infrastructure needed for either a stationary or batch charging strategy.

Following the onboard technology upgrades and the transit optimization study in 2023 a clear vision of the future needs of Brantford Transit will be established. Once this is completed, staff will be able to begin to bring forward a long term strategy that include both capital and operating request for service improvements and a transition to a fully electric transit fleet.

Inderjit Hans, P. Eng., PMP
General Manager, Public Works Commission

Prepared By:

Brad Smith, Transit Planner, Fleet & Transit Services

Attachments (if applicable)

Appendix A- Battery Electric Bus Implementation Plan and Cost Report

In adopting this report, is a by-law or agreement required? If so, it should be referenced in the recommendation section.

By-law required	[ ] yes [X] no
Agreement(s) or other documents to be signed by Mayor and/or City Clerk	[ ] yes [X] no
Is the necessary by-law or agreement being sent concurrently to Council?	[ ] yes [X] no