TO:	**CITY BUILDING COMMITTEE**
SUBJECT:	**BARRIE TRANSIT ALTERNATIVE FUEL STUDY**
WARD:	**ALL**
PREPARED BY AND KEY CONTACT:	**T. GREEN, SUPERVISOR OF COMPLIANCE AND CUSTOMER SERVICE, EXT 4179**
SUBMITTED BY:	**B. FORSYTH, DIRECTOR OF TRANSIT AND PARKING STRATEGY**
GENERAL MANAGER APPROVAL:	**R. JAMES-REID, EXECUTIVE DIRECTOR – ACCESS BARRIE**
CHIEF ADMINISTRATIVE OFFICER APPROVAL:	**M. PROWSE, CHIEF ADMINISTRATIVE OFFICER**

RECOMMENDED MOTION

1. That the conversion of the City's Transit fleet to battery electric buses (BEB), be endorsed in principle.

2. That a full-time equivalent position be approved and funded beginning in November 2021, for the purpose of developing and executing both the pilot program and implementation plan for transit's fleet conversion, at an estimated total cost of $150,000 per year for salary and associated costs.

3. That an additional Capital Project in 2021 for the purchase of 1 conventional BEB and accompanying charging infrastructure for a total project cost of $1.7M, which will be funded from Federal Gas Tax Reserve, be approved, with staff making every effort to leverage funding from upper levels of government when those programs become available to reduce the commitment from the Federal Gas Tax Reserve.

4. That the City of Barrie join Canadian Urban Transit Research and Innovation Consortium (CUTRIC) and that the membership fees be funded through the Transit and Parking Strategy Departmental Operating Budget.

5. That staff be authorized to submit applications for grants that would reduce capital expenditures or enhance capital projects associated with BEB's and a report or memo be presented, as appropriate, prior to the execution of any agreement associated with the acceptance of such grant.

PURPOSE & BACKGROUND

6. In 2019, Council declared a climate emergency in the City of Barrie. The declaration initiated that key departments would begin investigating ways of reducing the City's carbon emissions, with a goal of net-zero carbon emissions by the year 2050.

7. Council provided direction, as part of the 2020 Business Plan, whereby they advanced the Transit Alternative Fuel Study from 2022 to 2020 with the objective to include recommendations on the timing and methods to introduce alternative fuel buses to the transit service.

8. This report lays out a pathway to prepare for the future adoption of alternative fuel technologies, including investigating alternative fuels to propel the fleet, lower vehicle emissions, and achieve overall operational efficiencies and modernization.

ANALYSIS

9. In 2020, WSP Canada Inc. was retained to develop an alternative fuel study for both transit and corporate fleets. This committee report will focus on the transit component of the study.

10. The objective of the study was to perform an assessment of the available and applicable alternative fuel technologies that are suitable for the City's existing transit fleet. It includes:
    a) A review of the alternative fuel technologies currently available in the Canadian marketplace, including a detailed technical and regulatory review for the technologies identified;
    b) A high-level gap assessment of the different technologies, including infrastructure and routing implications, along with a scenario-based deployment plan;
    c) An assessment of the business cases for adopting the various technologies to determine costs and environmental benefits associated with each technology, as well as their social benefits;
    d) A risk identification and engagement summary to highlight potential risks in adopting alternative fuel technologies, their implications and potential mitigation measures related to adoption and;
    e) Recommendations on potential approaches for the City to employ in support of the future adoption of alternative fuel vehicles.

11. As a part of the study, several workshops were conducted with staff and other internal stakeholders across the corporation. The goal being to gain input on and various perspectives on future growth, service levels, climate change, financial implications, and social impacts. These workshops and engagement activities included the following:
    a) Alternative Fuel Technology Risk Assessment
    b) Internal Stakeholder Review
    c) Utilities Engagement
    d) Peer Review
    e) Technical Review of the Operating Contract

12. The Transit Alternative Fuel Study Report is attached to the agenda and the following sections are highlights from the report.

Current State

13. Barrie Transit's current fleet asset inventory consists of 63 vehicles including 46 conventional transit buses and 17 specialized transit vehicles. The current transit garage was constructed as part of a 20-year P3 design-build-operate contract. The facility was completed in 2015 and permits the indoor storage of all existing fleet. Designed to accommodate up to 88 vehicles, the facility is beginning to approach indoor storage capacity.

14. The facility and service contract were built on the premise that the service provider would be operating and maintaining both the fleet and a facility designed specifically for diesel or gasoline fuelled fleet until 2035.

Alternative Technology Overview

15. An initial high-level analysis was conducted to identify the technologies that are available in the marketplace. Four technologies were found to be available for adoption for transit vehicles (compressed natural gas (CNG), BEB, diesel-hybrid and hydrogen). The technologies were reviewed from an economic, social, and environmental perspective. The risks of each technology were carefully assessed, and a total cost of ownership model was constructed to examine the cost of owning each type of vehicle technology.

BATTERY ELECTRIC BUS (BEB)

16. The market for BEB's has been rapidly evolving over the past decade with continuous improvements being made in terms of both energy storage/density (kWh per kilogram), as well as reducing battery cost ($/kWh). It is expected that BEB's will comprise over 67% of the global bus fleet by 2040.

17. BEB's provide an option that enables dramatic reduction in the greenhouse gases (GHG) and Criteria Air Contaminants (CACs) emissions of the fleet, as they have zero tailpipe emissions (excluding any auxiliary diesel heater options), and their carbon footprint is directly proportional to the electrical grid they are connected to.

18. BEB's are expected to have lower routine maintenance costs in comparison to diesel buses. BEB's have fewer components and less moving parts than a diesel bus, an advantage that will likely result in reduce maintenance and part costs over the lifecycle of the vehicle. However, this is unproven at this time as no BEB has been in operation for a complete lifecycle in North America.

DIESEL-HYBRID

19. Diesel-hybrid buses offer a way to transit agencies to reduce between 10-30% GHG emissions without assuming some of the risks associated with operating BEB's. When comparing to diesel buses, historical data shows that diesel-hybrid buses are on average 11% more expensive to maintain on a per km basis and can have up to a 60% premium on the capital purchase price.

20. Due to limited GHG reductions, less efficient powertrain systems, and higher operating costs, diesel-hybrid buses were excluded from further evaluation for the purpose of this study.

NATURAL GAS (CNG)

21. CNG vehicles operate in a similar manner to gasoline vehicles with a spark ignition system and internal combustion engine. The main difference being the pressurized fuel system and storage tanks in which the natural gas fuel is stored on-board the vehicle.

22. CNG is becoming a widely adopted fuel alternative in transportation. Except for the fuelling components, CNG buses are similar to diesel buses, allowing for similar operations and maintenance activities.

HYDROGEN

23. Hydrogen fuel cell buses use compressed hydrogen gas, stored on-board the bus, to fuel and generate power for the electrical powertrain system that propels the vehicle. The hydrogen is released into the fuel cell, ultimately creating an electrical current that is either used or stored in an on-board battery. Hydrogen has a higher energy content and as a result, has a greater operating range than BEB's.

24. Hydrogen buses produce environmentally friendly emission bi-products, notably water vapour (steam). While the buses themselves produce zero-emissions, the lack of supply and fuelling infrastructure often results in the requirement that fuel be transported by truck (likely diesel), thereby negating the reduction or elimination of GHG emissions.

25. Hydrogen fuel cell technology has been in use since the early 2000's but due to high capital and operating costs, training qualifications, infrastructure requirements and fuelling limitations, the technology has not yet matured into a feasible fuel technology.

26. Detailed system changes, charging technologies, market overviews, industry trends, and training & tooling requirements for all investigated technologies (BEB, Diesel Hybrid, CNG/RNG, Hydrogen) can be found in Section 3 of the Alternative Fuel Technology Summary Report

27. Following the initial stage investigation and based on the preliminary costing model and environmental impact assessment, CNG and BEB's were selected as the two technologies for further analysis, as a part of a full fleet conversion scenario roadmap.

Operational Range Assessment

28. Another major consideration for alternative fuel propulsion technologies are the operating range that come with limited on-board energy supplies. This specifically applies to BEB's and Hydrogen fuelled buses. Diesel-hybrid and CNG fuelled vehicles have demonstrated daily operating ranges of 500km's or greater which exceed Barrie Transit's daily operating requirements.

29. WSP completed a modelling exercise to simulate the performance of BEB's with varying battery pack sizes using City of Barrie topography and weather conditions, as well as Barrie Transit ridership and routing data. These simulations were created to determine energy efficiency (kWh/km) and battery state-of-charge (SOC) over time. Based on the current state of the technology, Barrie Transit would need to replace 1.3 BEB's buses for every 1 diesel bus to maintain the same service levels. The study assumes that by 2030, with the evolution of the technology, the ratio would drop to 1:1 BEB's to 1 diesel bus.

30. A general comparison of the propulsion technology ranges using a combination of OEM specifications, Altoona Test results and data on fuel economy are compared in Section 6 of the Alternative Fuel Technology Report. Also are included are implications of the analysis, which were further explored as part of the scenarios in Section 8.

Adoption and Implementation Scenario

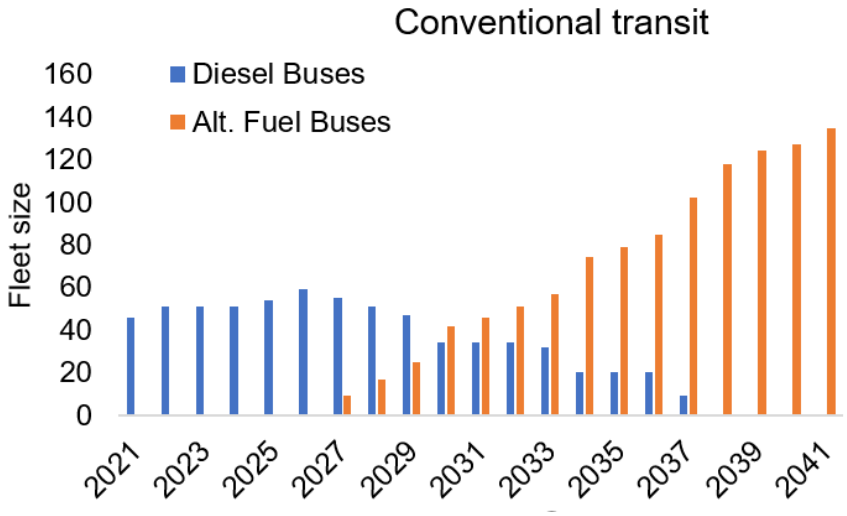
31. In alignment with the 2019-2041 Transit Asset Management Plan as a guiding document, WSP was able to identify adoption and implementation scenarios, including key considerations for both fleet and facility infrastructure for both CNG and BEB technologies.

32. A summary of the details for the scenario is provided in Appendix A. The scenarios project that fleet conversion begins in 2027 with the full fleet converted by 2038. These defined scenarios were meant to characterize what adoption may look like but should not be considered firm implementation roadmaps, as technologies evolve at a different rate than what is assumed in this study.

33. As staff continues to refine the conversion plan, it is important to ensure that the plan is aligned with the future adoption of the City's GHG Reduction Strategy.

34. Both technologies followed similar adoption scenarios, capturing both growth and replacement fleet. Figure 1 displays what a phased replacement scenario may look like for Barrie Transit's conventional fleet. Consideration is given to both growth vehicles and replacement of existing fleet with the adopted technology at end of life:

Figure 1:



35. Based on the current garage capacity, the provided scenario would require a facility expansion by 2026. Following the same scenarios, a second transit garage facility would be required within 7-10 years due to replacement ratios, growth planning, spatial constraints (equipment) and fuelling considerations. The BEB scenario would require a secondary facility by approximately 2033 and CNG would require it by 2036.

36. Based on discussions with the local utility company, the current infrastructure at 133 Welham Rd would be able to accommodate between 5 and 7 BEB's, without needing to upgrade the utility infrastructure.

37. Additional details pertaining to facility upgrade requirements, including equipment and fuel supply can be found in Section 9 of the Alternative Fuel Technology Summary Report.

Cost Analysis

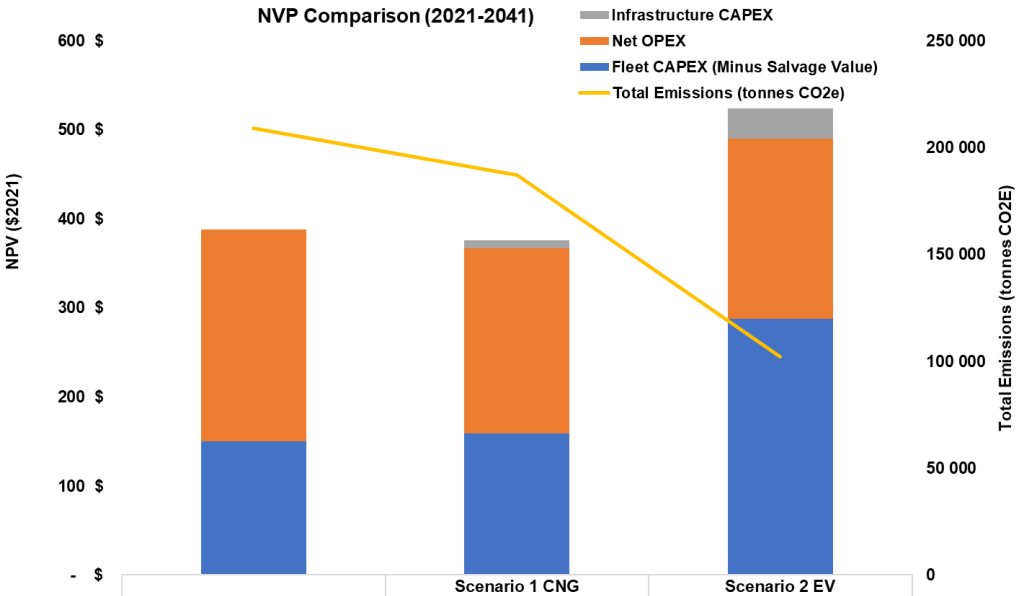
38. Models were created to provide a financial context of each identified scenario following the fleet conversion timelines. The models were structured into financial forecasts to output the annual capital (CAPEX) and operating (OPEX) expenditures in year-of-expenditure (YOE$), as well as in net present value (NPV) terms (2021$) and totals for the forecast period, assuming an inflation rate of 2.1%. Inputs for those models took the following key areas into consideration:

- General Financial Inputs (i.e. inflation, discount rate, forecast period)
- Fleet Asset Inventory (40ft transit buses, para-transit cutaway buses and para-transit vans)
- Infrastructure Capital Expenditures (i.e. fueling stations, BEB charging stations).
- Infrastructure Operational Expenditures (i.e. fuel station maintenance)

- Fleet Capital Expenditures (i.e. vehicle procurements)
- Fleet Operational Expenditures (i.e. vehicle maintenance, electricity, fuel, specialized tooling and training)
- Environmental (i.e. GHG emissions in tonnes of CO2e)

39. A cost comparison spanning from 2021 to 2041 for CNG and BEB was modelled against business-as-usual (BAU). The models used a number of input parameters (as detailed in Appendix B) and equipment costs (as detailed Appendix C). In both scenarios, fleet procurement and operating expenses remain the key cost drivers (Figure 2).

Figure 2:



	BAU	Scenario 1 CNG Conversion (2021-2041)	Scenario 2 EV Conversion (2021-2041)
Infrastructure CAPEX	- $	9 $	34 $
Net OPEX	238 $	208 $	202 $
Fleet CAPEX (Minus Salvage Value)	150 $	159 $	288 $
Total Emissions (tonnes CO2e)	209 124	187 309	102 263

Projected Emissions Reduction

40. The use of BEB vehicles versus business as usual diesel (BAU) or CNG provides many benefits, however the most prevalent is the elimination of tailpipe emissions that typically emit GHG's and other harmful air contaminants into the environment. In the scenario studied and when compared to BAU (diesel), BEB's would reduce emissions up to 51% over the next 20-year timeframe, while adopting CNG would reduce emissions by up to 10%.

41. At the end of the scenario period and once full fleet conversion had occurred, BEB's would reduce emission levels by 80% when compared to BAU and CNG by 16%. It should be noted that to meet net-zero by 2050, it is likely that additional measures will be necessary to achieve this goal.

42. Additional information regarding environmental and social impacts can be found in Section 10.2 of the Alternative Fuel Summary Technology Report.

Peer Review

43. As a part of the alternative fuel engagement, a number of peer municipalities, associations and institutions were consulted to gather feedback with regards to experience with alternative fuel technologies and vehicles. Pertinent information with regards to transit fleet vehicles can be found in Section 4 of the Alternative Fuel Technology Summary Report.

44. Notable highlights include:

- The Toronto Transit Commission (TTC) has the largest fleet of alternative fuel vehicles (60 BEB)
  - The TTC is currently engaged in a pilot program with 60 BEB's from three different manufacturers. This is the largest pilot of BEB vehicles in North America.
  - Given the early nature of the technologies and phased approach, the TTC has identified numerous challenges, including:
    - Electrical infrastructure challenges when upgrading/modifying existing facilities
    - Range limitations of vehicles
    - Deployment flexibility
    - Lack of interoperable charging infrastructure for initial BEB's
    - Inefficient and inadequate supply chain
    - Overall technology maturity and reliability

- Calgary Transit began transitioning their diesel buses to CNG in 2015 (~230 buses) but have recently begun investigating pilots for BEB's
  - Calgary Transit began introducing CNG vehicles to their fleet approximately 5 years ago and have received excellent feedback from riders/residents. Notably, the transition to a local fuel source that supports the regional economy

- Abbotsford Transit is still investigating alternative fuel technologies, having conducted a Green Fleet Strategy study in 2019
  - Abbotsford Transit has identified it will focus on electric vehicles wherever possible as CNG was considered not to be an economically or environmentally viable option
  - Abbotsford has not begun to procure any alternative fuel fleet at this time but plans to over the next 20 years to align with corporate targets

45. The other current trial or pilot on-going in the Ontario marketplace is through the Pan-Canadian Battery Electric Bus Demonstration and Integration Trial (via CUTRIC). This project is the first in the world to design, develop and integrate BEB's with charging systems that can interoperate interactively despite being made by different manufacturers.

46. Participants in this trial include multiple Canadian universities, as well as Translink (Vancouver), Brampton Transit and York Region Transit (YRT). In total, the three agencies have deployed 18 BEB's and seven charging units to test and acquire data to further innovation and research in the alternative fuel sector.

47. The goal of the CUTRIC trial is to expand the project to include more than 200 BEB's across numerous municipalities between 2022-2024 in a national joint procurement using an innovative funding and financing solution with the Infrastructure Bank of Canada. At the time of writing this report, details of a funding model has not yet been provided publicly.

Procurement

48. The City of Barrie, along with dozens of other Ontario transit agencies are members of the Transit Procurement Initiative (TPI), led by Metrolinx. The Metrolinx TPI group has dedicated resources leading joint transit procurement initiatives, allowing member agencies to leverage their expertise and skillset, as well as engage and share knowledge throughout the process. The procurement of transit vehicles is an extremely involved and complex process, where the City of Barrie has relied on the TPI group's skillset through this program for over 15 years, specifically in the development, implementation, and oversight of the process.

49. As of 2021, TPI has not yet developed the specifications for BEB procurement. Given the early nature of the technology, TPI is still monitoring the marketplace and will begin developing a joint procurement initiative based on industry best practice once suitable routing demands, battery size, charging options and motor specifications can be identified. TPI has indicated it expects this process to begin between 2022 and 2025 for both specialized and conventional vehicles, with procurement expected to begin in 2025.

50. If Council directs staff to proceed with a pilot program, staff will investigate other joint procurement opportunities in the short term, and if these opportunities are not available or appropriate, staff will undertake its own procurement.

Next Steps to Adoption

51. Considering the environmental, social, operational, and costing impacts of each technology, it is recommended that the implementation of BEB's will be required to meet environmental goals while offering benefits to ridership, residents, and the Barrie community.

52. As adoption of BEB's are still in the infancy stage for the transit industry and with the expected continued evolution of the technology over the coming decade, a program of this scale and significance will require a dedicated internal resource(s) with the applicable skillset to manage and monitor an adoption and transition program. This resource will work with key stakeholders in the development of a detailed framework and provide continued monitoring and oversight through the various stages of the program.

53. To support the transition to the BEB technology, staff have identified the following broad steps and associated actions that are required to develop a plan and strategy towards implementation:

Action: Participate in Industry Association Working Groups

54. The Transit and Parking Strategy Department has already begun working with Industry Association partners and will continue to do so as opportunities present. Whether intradepartmental, interdepartmental, or external associations, these working groups will be key to establishing operating standards and technical specification for municipal operations relating to the mitigation of GHG emissions.

55. Staff have worked informally with CUTRIC through membership in both the Canadian Urban Transit Association (CUTA) and the Ontario Public Transit Association (OPTA). CUTRIC is a socially responsible non-profit organization that spearheads, designs, and launches technology and commercialization projects that advance next generation zero-carbon mobility and transportation solutions across Canada.

56. The data and experience gathered by current membership (that includes dozens of Canadian Transit Agencies and industry partners) of CUTRIC's Pan-Canadian Trials will be critical input into decisions with respect to the deployment of similar technology in Barrie. Staff are planning to formally join CUTRIC by paying the annual membership fee (estimated at $1,000 annually).

Action: Alignment with Corporate Plans

57. Utilizing the yet to be determined, Net Zero Carbon targets (to be adopted in the Fall 2021), the Transit and Parking Strategy Department will begin adjusting operational procedures and procurement direction to better align with corporate goals.

58. Staff will work with various stakeholders to ensure the BEB technology is factored into corporate plans, including but not limited to the City's Transportation Master Plan, Asset Management Plans, GHG Reduction Strategy, and Development Charges Background Study.

Action: Initiate Additional Plans/Studies

59. Additional studies will be required to develop a solid longer term implementation plan, including but no limited to detailed facility assessment, utility assessments, resilience strategy, and operational planning studies.

60. One of the more important discussions to be held is with the local utility with respect to power/fueling requirements and potential funding opportunities. Specifically, if BEB's are selected, discussions will need to be held with the utility provider to discuss facility and roadside grid capacity, costs, demands and infrastructure needs. Transitioning to full fleet electrification will require an assessment to ensure sufficient power delivery at the current garage facility, considering both current and future growth plans.

Action: Service Provider Engagement and Contract Renegotiations

61. Like most transit service providers in the industry, the City's service provider has no previous experience with BEB's and will require a strong partnership from the City to introduce this technology into the fleet. This will include but is not limited to developing training and maintenance plans, managing change and a shift in culture, coordinating facility upgrades and expansions, operational service planning, SOP and policy development, and a re-negotiation of the service contract.

62. The language and mechanisms specifically related to the P3 operational contract can allow for a change of this magnitude to arise, although the steps to reach such an agreement and incorporate a new technology will require some heavy contract renegotiations to specified terms and conditions. Pending direction from Council, staff will begin those discussions with the service provider to ensure the process is completed in a fair, transparent and equitable manner.

Action: Pilot Development and Deployment

63. Given the infancy of BEB's within transit and the on-going evolution as the technologies mature, as well as service contract implications, it would be a benefit for the City to consider piloting the selected technology. This will be a key step in developing an understanding of the technology in our specific operating context and towards the development of a long-term implementation plan.

64. It would be expected that any procurement by way of a pilot, both vehicles and infrastructure, would be in addition to any existing fleet to ensure service reliability. As early adopters, consideration would also need to be given to ensuring that staff, both City and contractor, can have the opportunity to train and learn the new equipment, infrastructure, and operational services.

65. Staff will be recommending the procurement and purchase of one conventional vehicle and one charger for the initial pilot program. Pending Council approval in June 2021, and following additional research, procurement, and manufacturing, the goal would be to have the vehicle delivered and ready for service in 2023.

66. There are very limited options for specialized BEB vehicles in the marketplace at this current time. As the technology presents itself, staff can look to integrate options for a specialized vehicle pilot program in future capital budgets.

Action: Funding Applications

67. Given the continued focus from all levels of government on the need to address Climate Change, there will likely be opportunities to leverage funding from various programs to assist with financial impacts from these changes. Staff will continue to monitor and research opportunities when they become available for the City of Barrie.

Action: Implementation Plan

68. The development of a long-term implementation plan will consider all the above action items and will be a constantly evolving document to guide the city in the conversion of transits fleet. The transition of the entire fleet will include further decisions with respect to the rate of conversion and charging options. The evolution of the plan will be on-going and staff will continue to report back to Council, as needed.

ENVIRONMENTAL AND CLIMATE CHANGE IMPACT MATTERS

69. The following environmental and climate change impact matters have been considered in the development of the recommendation:

a) Supporting the adoption of an alternative fuel fleet program will enable future climate change mitigation action and reducing GHG emissions.

ALTERNATIVES

70. The following alternatives are available for consideration by General Committee:

Alternative #1 General Committee could alter the proposed recommendation by accepting the study and approving the adoption of CNG as the technology of choice.

Although this alternative is available, this alternative would not result in sufficient GHG emissions to meet Barrie targets by 2050.

Alternative #2 General Committee could decide to hold on a decision to move forward with a recommended alternative fuel vehicle solution.

Although this alternative is available, this alternative would delay efforts to work towards net-zero targets.

FINANCIAL

71. The key financial takeaway from the results presented in the adoption and implementation scenario is that the CNG adoption scenario shows an overall saving compared to BAU of $13.2M over the 20 years, representing about 3.2% savings over the total BAU cost. The BEB adoption scenario shows an additional expense of $135.9 million compared to BAU, which represents a 35% expenditure increase. However, the BEB scenario enables an emission reduction that are in more alignment with the goal of becoming Net Zero.

72. The costs associated with conversion of the fleet, and the associated charging infrastructure will be incorporated into future capital and operating budgets as the conversion is phased over time.

73. The costs associated with a full-time position to develop and coordinate the plan is estimated at $150,000 per year. This report recommends the position begin in November 2021 and therefore this cost would be prorated for the last two months of 2021 (up to $25,000 required in 2021). The costs for 2021 can be absorbed within the departments budget and the annualized costs will be included as part of the 2022 Business Plan.

74. The capital costs associated with the pilot program is estimated at $1.7M ($1.2M for one BEB and $500K for charging infrastructure) and will be funded from Federal Gas Tax Reserve.

75. It is anticipated that funding programs from senior levels of government to support the transition to alternative fuel vehicles will become available in the near future. In early 2021 the federal government announced they will be providing a $2.5B funding program for the integration of electric buses between 2021 and 2025. Details of the program have not yet been released, however having Council provide direction to staff to begin planning for BEB, as well as a providing staff with the authority to apply for such grants will only benefit the City in potentially leverage funding through these types of programs.

LINKAGE TO 2018–2022 STRATEGIC PLAN

76. The recommendation(s) included in this Staff Report support the following goals identified in the 2018-2022 Strategic Plan:

- ☒ Fostering a Safe and Healthy City
- ☒ Offering Innovation and Citizen Driven Services
- ☒ Improving the Ability to Get Around Barrie

77. The continued advancement towards the adoption of Alternative Fuel technologies will support a strategic direction in ensuring the department can continue to meet service demands of residents and riders, while doing so in an environmentally responsive manner as the City expands, grows, and changes.

Appendix A

Scenario Fleet Adoption Plans

Plan Aspect	CNG Transition	BEB Transition
Year of introducing the technologies	2027	2027
Facility Expansion Year	2026	2026
Year by which 100% is converted	2038	2038
Year when a new facility is required	2036	2033
Phase description at the existing and expanded facility	**Phase I:** The first compressor and the redundant compressors are installed first in 2026 along with the remaining supply. **Phase II:** the last compressor in 2030 (Phase II).	**Phase I:** The incoming switchgear and first substation is installed in 2026, along with 28 x 150 kW DC charging cabinets. **Phase II:** The second substation and 28x 150 kW DC charging cabinets are installed in 2029. **Phase III:** The last substation and 23x 150 DC charging cabinets and 46 dispensers are installed in 2031.
Fleet size at the existing and expanded facility	105x 40ft + 25 specialized vehicles	95x 40ft + 25 specialized vehicles
Fleet size at the new facility by 2041	30x 40ft	60x 40ft
Total OPEX and CAPEX between 2021-2041 compared to BAU	- 12.7 million (-3.2%)	+$135.9 million (+35 %)
Total OPEX and CAPEX between 2021-2041 compared to BAU with carbon tax	-19.2 million (-4.4%)	+$114.0 million (+26.0%)
Emissions saved compared to BAU between 2021-2041	10%	51%
Emissions saved compared to BAU between in 2041	16%	80%

APPENDIX B

Bus Lifecycle Cost Input Parameters

CNG

Input/Assumption	Value			Source
	40ft Transit	Cutaway-Specialized	Van-Specialized	
Vehicle Lifecycle	12 years	7 years	5 years	Barrie Transit AM Plan
Annual Usage	77,509 km/year	30,500 km/year	20,000 km/year	Barrie Transit Data
GHG Bus Purchase	$650,000	$185,000	$54,000	Barrie Transit AM Plan
CNG Vehicle Purchase	$700,000	$210,000	$65,000	Clean Energy ($50,000 premium over diesel bus); Peer Agency ($25,000 premium over diesel chassis); US EPA MV1 Van Report
GHG Vehicle Fuel Economy	55.2 L/100km	33.6 L/100km	15.5 L/100km	Historical Barrie Transit data; US EPA MV1 Van Report
CNG Bus Fuel Economy	55.2 DLe/100km	33.6 DLe/100km	18.1 DLe /100km	Assumption, same as diesel, based on dLe units; US EPA MV1 Van Report
GHG Bus Maintenance	0.5 to $1.5/km	0.30 to 1.10 $/km	0.50 to 0.90 $/km	Based on historical Barrie Transit data and industry averages.
CNG Bus Maintenance	95% of Diesel Bus Maintenance cost			WSP Bus Asset Management Lifecycle Data Analysis Diesel vs. CNG
Salvage Value (SV)	1%			Assume scrap value, percentage of purchase cost
Emission Factor for CNG Heavy-Duty Vehicles	2.20 kg CO2e/L			Calculated using GHGenius for Ontario, Wheel-to-Wheel
Emission Factor for Diesel Heavy-Duty Vehicles	2.65 kg CO2e/L			Calculated using GHGenius for Ontario, Wheel-to-Wheel
Emission Factor for Gasoline Vehicles	2.50 kg CO2e/L			Calculated using GHGenius for Ontario, Wheel-to-Wheel
Diesel and Gasoline fuel cost	0.97$/L or $0.53/km	0.97$/L or $0.32/km	0.97$/L or $0.15/km	Historical Barrie Transit data
CNG	0.5 $/DLe or $0.28/km	0.5 $/ DLe or $0.17/km	0.5 $/ DLe or $0.09/km	Change Energy Services

BEB

Input/Assumption	Value			Source
	40ft Transit	Cutaway-Specialized	Van-Specialized	
Vehicle Lifecycle	12 years	7 years	5 years	Barrie Transit AM Plan
Annual Usage	77,509 km/year	30,500 km/year	20,000 km/year	Barrie Transit Data
GHG Bus Purchase	$650,000	$185,000	$54,000	Barrie Transit AM Plan
Electric Vehicle Purchase	$1,200,000	$300,000	$73,000	Clean Energy ($50,000 premium over diesel bus); LionM (High Level Estimate); Ford eTransit Van Quote (converted from USD to CAD) Wheelchair ramp installation (+$15,000 CAD est.)
GHG Vehicle Fuel Economy	55.2 L/100km	33.6 L/100km	15.5 L/100km	Historical Barrie Transit data; US EPA MV1 Van Report
BEB Bus Fuel Economy	1.92 kWh/km	0.83 kWh/km	0.42 kWh/km	WSP BOLT; OEM Published Range (200 km from 67 kWh with 20% safety)
Diesel Bus Maintenance	$0.73/km	0.30 to 1.10 $/km	0.50 to 0.90 $/km	Based on historical Barrie Transit data.
BEB Bus Maintenance	70% of Diesel Bus Maintenance cost			WSP Bus Asset Management Lifecycle Data Analysis
Salvage Value (SV)	1%			Assume scrap value, percentage of purchase cost
Emission Factor for Electric Heavy-Duty Vehicles	Varying from 0.031 kgCO2e/kWh in 2021 to 0.098 kgCO2e/kWh in 2041			IESO's 2020 Annual Planning Outlook
Emission Factor for Diesel Heavy-Duty Vehicles	2.65 kg CO2e/L			Calculated using GHGenius for Ontario, Wheel-to-Wheel
Emission Factor for Gasoline Vehicles	2.50 kg CO2e/L			Calculated using GHGenius for Ontario, Wheel-to-Wheel
Diesel fuel cost	0.97$/L			Historical Barrie Transit data
Diesel and gasoline fuel cost	0.97$/L or $0.53/km	0.97$/L or $0.32/km	0.97$/L or $0.15/km	Historical Barrie Transit data
Electricity	Administrative fee: 150.84$/month Electricity cost (including GA): 0.125$/kWh Demand cost: 8.9887 $/kW			Large Customer Rates, Alectra, 2021

APPENDIX C

Equipment CAPEX Breakdown

CNG

Station Component	Existing Facility + Expansion		New Facility
	Phase I	Phase II	Phase I
Equipment			
Dryer	$62,555	$62,555	$62,526
Compressor	$761,484	$380,742	$761,351
Ground Storage	$70,243	$0	$70,243
Priority Panel	$30,977	$0	$30,977
Fast Dispenser	$119,076	$0	$119,076
Slow Dispenser	$0	$0	$0
PCC Panel	$59,236	$0	$59,236
Building Modifications	$1,000,000	$0	$0
Auxiliary Equipment	$45,000	$0	$45,000
Backup power generators	$257,200	$0	$257,200
Utility Upgrade (Placeholder)	$2,000,000		
Civil and Installation			
Installation Budget	$685,280	$77,577	$385,297
Fences & Gates	$0	$0	$0
Jersey Barriers & Guardrails	$0	$0	$0
Site Preparation	$0	$0	$0
Paving & Landing Strips	$0	$0	$0
Surface Treatment (other than paving)	$0	$0	$0
Design and Execution Allowances			
Gas Service	$0	$0	$0
Electrical Service	$0	$0	$0
CATS, Training, Proj. Mgmt., & Engineering	$219,841	$0	$133,425
Approvals	$20,000	$0	$20,000
General Contractor Fee	$116,761	$0	$116,747
Contingency	$379,693	$0	$230,464
Owner Oversight & Admin. Fees	$0	$0	$0
Total	**$5,827,346**	**$520,874**	**$2,291,542**

BEB

Station Component	Existing Facility + Expansion			New Facility
	Phase I	Phase II	Phase III	
Equipment				
Transmission & Distribution (Including Alectra's Upgrades)	$8,400,000	$0	$0	$0
Entrance Switchgear	$250,000	$0	$0	$250,000
Power Distribution & Step-Down Transformation	$322,750	$322,750	$0	$645,500
Backup power generator	$964,500	$0	$0	$964,500
Charging Units	$1,113,543	$1,417,236	$2,125,854	$2,328,317
Substations	$700,000	$700,000	$700,000	$700,000
Other				
Architectural/Civil/Structural Modifications	$750,000	$0	$0	$0
Building System Modifications	$200,000	$0	$0	$0
Construction Management/Overhead/Project Delivery	$2,501,892	$2,281,124	$3,004,623	$3,705,194
Station Total				
Total	**$15,202,685**	**$4,721,110**	**$5,830,478**	**$8,593,511**