Item 5.4

Transit Operational Review Comprehensive Report

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Call for Applications – Public Transit, and Green Energy Stream of Investing in Canada Infrastructure Program (ICIP)

Motion

Moved by Councillor Green, seconded by Councillor O'Quinn, to approve the funding application for EV Transit Maintenance Facility and Zero Emission Buses for $56,850,000 under Investing in Canada Infrastructure Program (ICIP); and, to authorize staff to move forward on the acquisition and all necessary documentation of the appropriate lands from Build Nova Scotia related to the Transit Facility Needs, as described in the Issue Paper dated January 24, 2023.

Discussion:

Some of the items discussed were as follows:

- Proposed new building and site
- Electric Bus requirements
- Elimination of funding for fossil fuel busses
- Charging stations and storage
- Modifying bus routes to accommodate battery life

Following discussion, the Mayor called for the vote.

Motion Carried

Cape Breton Regional Municipality
320 Esplanade
Sydney, NS B1P 7B9

To: **Mayor Clarke and Council**

Submitted by: **John Phalen, Director of Public Works**

Date: **July 9, 2025**

Subject: **Transit Operational Review**

Background
In January 2023, a report was presented to Council regarding a call for applications under the Green Energy Stream of the Investing in Canada Infrastructure Program, focused on public transit. To support this initiative, the Cape Breton Regional Municipality (CBRM) engaged HDR Consulting Ltd. to conduct a comprehensive review of the transit system in order to better identify and define its needs.

CBRM staff have been actively working toward improving transit services and will continue to provide regular updates and present priorities to Council.

Recommendation
That CBRM Council receive and accept the transit review report as submitted.

Transit Operational Review Comprehensive Report

Cape Breton Regional Municipality

May 10, 2024

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1 Introduction and Background

The Cape Breton Regional Municipality (CBRM) has undertaken a comprehensive review and analysis of municipal public transit services to inform a Zero Emissions Bus (ZEB) fleet transition plan and the preliminary design of two key infrastructure upgrades required to support this plan – a purpose-built Transit ZEB Maintenance Facility and Community Transit Hub. This report summarizes the Transit Operational Review, and is comprised of the following technical memoranda:

- Policy Framework
- Consultation and Stakeholder Engagement
- Transit Services Review and Design
- Fare Structure Review
- E-Bus Technology Review
- E-Bus Transition Strategy
- Financial Implications
- Organizational Review

The following sections highlight some of the key background considerations that guided the study.

1.1 Climate Change

Climate change is one of the most pressing issues of our time. It is a global emergency that demands urgent action, and this project demonstrates CBRM's commitment to the province, country, and the world in tackling this emergency head-on. In parallel to this study, provincial initiatives to transition to clean energy sources will align well with this transit initiative to significantly reduce emissions from the transportation sector. The provincial Environmental Goals and Climate Change Reduction Act sets the most ambitious climate change goals in the country – to reduce greenhouse gas emissions by 53% below 2005 levels by 2030 and achieve net-zero emissions in Nova Scotia by 2050. And while not explicitly mentioned in CBRM's 2014 Municipal Climate Change Action Plan, this project remains of critical importance to achieving CBRM's climate change mitigation goals.

1.2 The Transit Planning Context

CBRM is the second largest municipality in the Province of Nova Scotia with a population of 94,000 spread over 2,470 kms; this is down by 11% compared to 106,000 population when the 2011 Transit Cape Breton Handi-Trans review was undertaken. This population is distributed over several communities. The most heavily populated urban center being the former city of Sydney (population ~ 22,000).

In the mid-1990s, Transit Cape Breton carried a high of 1,250,000 annual passengers. The 2011 Transit Cape Breton and Handi-Trans review noted the ridership at a low of 300,000. This was attributed in large part to the loss of approximately 500,000 students trips annually when they transferred to yellow school bus operations. Due to the loss of transit ridership, service was reduced significantly due to budget constraints.

Although there was a population decrease since the 2011 study, Transit Cape Breton use has now increased from a recent low 360,000 in 2017 to 1,300,000 in 2019, eclipsing the high of 1,250,000 reached in the mid-1990s. The significant enrollment of international students at Cape Breton University has had a profound and positive impact on Transit use. This is a story similar to other small communities across Canada as they struggle to meet the public transit demand from international students who are, after all, used to transit as a mode of choice in their country of origin. With the in-person classes anticipated to return to Cape Breton University in Fall 2022, transit use can reasonably expect to meet and exceed the all-time pre-pandemic high reached in 2019.

1.3 Innovative Transit Solutions to Meet Community Needs

The current hourly service is challenged to meet the growing Transit Cape Breton and Handi-Trans demand, which will trigger the need to improve service. Improving service can come in many forms and can be one or more of the following:

- Reallocating existing resources so that existing budgets are maintained,
- Increasing service frequency and hours of operation using existing conventional and specialized accessible transit,
- Introducing low-cost forms of service delivery such as on-demand transit with smaller vehicles (Transit best practices),
- Maximizing the inter-operability between Transit Cape Breton and Handi-Trans to eliminate unnecessary duplication of service (Transit industry trend), and
- Introducing customer-friendly smart card and mobility payment systems to reduce passenger boarding times, increase transit revenues and reduce revenue management system costs.

Regardless of the public transportation solutions developed, the Municipality's commitment to GHG reductions will be addressed through the introduction of a zero-emissions fleet and a Net Zero Transit Maintenance Facility. In this study, the Project Team compared the existing business as usual (BAU) model with that of EV options that are available, providing CBRM staff and Council with the information it needs for the decision-making process, and to know what the next steps and schedule will be in order to make things happen.

1.4 Reinforcing Transit as an Essential Service

Understanding the challenges that Transit Cape Breton faces as they aim to deliver high quality, cost- effective, and innovative transit services within a very challenging operating environment is critical to the success of the system. On top of this, COVID-19 has done transit agencies no favours, but this study presents an opportunity to reinforce the need for transit as an essential service providing mobility to all.

1.5 Zero Emissions Fleet Transition Plan

Planning CBRM's transition from conventional to electric vehicles from the very start will help to avoid the pitfalls of the "scaling zone". A well-thought-out road map is required, based on thorough analysis to provide the right data to make good decisions, resulting in less wasted time and investments. Further, it will help in gaining public and political support by showing all stakeholders that there is a comprehensive plan in place not only for the short term but also for the long term.

CUTRIC's Fleet Electrification Analysis Report identifies that only two weekday routes (Routes 4 and 11) can be successfully operated using existing Battery Electric Bus technology with 40' buses and depot-only charging, assuming the worst case heavy duty-cycle. Considering depot and en-route opportunity charging, all routes that CUTRIC modelled are feasible on the weekday heavy duty-cycle with the exception of Route 1 (Glace Bay), Route 5 (North Sydney / Sydney Mines) and Route 9 (New Watford). CUTRIC's report also identified the top 5 locations for opportunity charging, and we understand that 3 of the 5 locations are located in Downtown Sydney. The site for the new Community Transit Hub will need to be determined recognizing that it will need to incorporate electric bus charging stations, parking and ride facilities, and support an electric shuttle that will connect to the new Nova Scotia Community College (NSCC) Marconi Campus.

1.6 Report Structure

This report is structured in sections corresponding to the key sequential activities undertaken throughout this study, as follows:

1. Introduction and Background
2. Policy Framework
3. Transit Service Review and Design
4. Review of Current and Project Ridership
5. Fare Structure Review
6. E-Bus Technology Review
7. E-Bus Transition Strategy
8. Organizational Review
9. Conclusions and Recommendations

2 Transit Service Review

2.1 Levels of Service / Peer Review

The current hourly service is challenged to meet the growing Transit Cape Breton and Handi-Trans demand, which will trigger the need for service improvements. To identify cost-efficient options for improved service levels, the project team undertook a thorough analysis of service performance metrics against industry standards. A list of comparable Canadian transit agencies that can provide a useful comparison was established. The peer comparison was based on Canadian Urban Transit Association (CUTA) Fact Book (2020) data and focused on the following standard units of transit system measurement:

- Service area population
- Annual hours of operation
- Annual ridership
- Hours of service per capita
- Passengers per operating hour
- Ridership per capita
- Average fare
- Operating cost per hour
- Municipal cost per capita
- Revenue to cost ratio

Based on this assessment, useful performance indicators were identified to track and targets to aim for as a proxy for overall health of the system and develop a set of service standards. The final recommendations include a set of performance indicators to monitor the system, and a set of clearly defined service standards and principles that are transparent to the public and define a commitment to providing the appropriate level of service.

2.1.1 Peer Review

Meeting the diverse access and connectivity needs of a service area is the difficult yet critical mission of every transit agency. Fulfilling this mission becomes even more challenging when transit-supportive factors that facilitate cost-effective transit operations by generating sufficient ridership are not present. Among others, these include density, compact service areas that are walkable, and a rich mix of land uses and origins/destinations in the service area. While not alone, CBRM faces the challenge of using limited resources to meet the needs of a population dispersed throughout a large service area. In order to identify opportunities for improvement in the form of efficient operations and investment of resources that are attainable for CBRM, the Project Team identified a group of ten peer transit systems with similar-sized service areas and service area populations throughout Canada. The Project Team then collected a set of meaningful metrics to look for patterns among the various systems faced with similar conditions in how they choose to allocate resources and provide transit service. This peer review should be carefully interpreted since local conditions vary significantly from one municipality to another across Canada. For this reason, information from peer systems has been used for order-of-magnitude comparisons only.

The peer agencies identified for this component of the operational review consist of:

- Lethbridge, AB
- Moncton, NB
- Grand Prairie, AB
- Sarnia, ON
- Fredericton, NB
- Niagara Falls, ON
- Sault Ste. Marie, ON
- Saint John, NB
- Belleville, ON
- Charlottetown, PE

2.1.2 Methodology and Data Sources

This review uses data from the same dataset used to produce the Canadian Urban Transit Association's (CUTA) 2019 Canadian and Ontario Transit Fact Book for Conventional and specialized transit systems. All metrics discussed are based on the definitions provided in this resource. The year 2019 was selected since it is the most current year of service prior to the Covid-19 pandemic.

2.1.3 Conventional Transit Peer Review

Table 1 provides a comparison of key statistics for the CBRM transit system peer group. This table, like all other graphs and tables in this peer review, is organized in order of population density to account for this variable among peers when used for comparisons. **Figure 1** through **Figure 9** graphically illustrate several primary indicators derived from the data in Table 1 and each is preceded by a discussion about the indicator, specifically the relevance and meaning of the comparison's results for CBRM's transit system service and operations. All graphs show specific indicators for CBRM and each of the peer transit systems as well as the median among all indicators.

2.1.4 Comparison of Municipalities

Table 1 below presents key statics of peer Municipal transit agencies, for comparison with Transit CB.

Table 1: Peer Municipality Transit Statistics (CUTA, 2019)

Transit System	Municipal Population	Service Area Population	Total Population Within Service Area Population	Service Area (square km)	Population Density (people per square km)	Revenue Vehicles	Revenue Hours	Revenue Kilometres	Riders	Net Operating Cost Per Capita
Lethbridge, AB	101,482	101,482	100%	121	841	48	113,190	2,567,085	1,485,889	$392.82
Moncton, NB	116,940	116,940	100%	231	505	40	129,025	2,259,528	2,495,189	$65.30
Grande Prairie, AB	91,391	78,438	86%	169	465	25	42,187	878,124	435,977	$92.72
Sarnia, ON	74,779	74,779	100%	167	448	22	63,112	1,336,086	1,718,574	$62.30
Fredericton, NB	57,500	57,500	100%	132	436	27	60,811	1,723,440	946,766	$61.30
Niagara Falls, ON	88,071	88,071	100%	212	415	37	107,791	2,559,117	2,590,032	$59.93
Sault Ste. Marie, ON	73,300	69,900	95%	224	313	28	81,799	1,952,647	1,894,661	$28.41
CBRM, NS*	93,694	54,856	59%	207	265	21	52,989	1,319,813	1,300,000	$50.62
Saint John, NB	127,400	102,760	81%	495	208	46	97,721	1,962,937	1,138,792	$88.22
Belleville, ON	50,716	50,716	100%	247	205	16	56,942	1,002,040	1,207,077	$63.39
Charlottetown, PEI	49,000	49,000	100%	250	196	15	24,709	590,000	754,021	$79.51

** Provided by Transit CB*

Figure 1 shows the population density for all peer systems, which is calculated by dividing the service area population by the service area. Peer group densities range from 841 people per square km to 196. At 265 people per square km, CBRM has a lower population density than the median of 415 people per square km. This key metric significantly impacts CBRM's opportunities for providing efficient operations as it essentially means that vehicles in the system must travel longer distances to reach each potential rider. This figure is even lower when considering the size of the municipal area within which the service area population is dispersed, as only 9% of the municipal area is included in the transit system's service area.

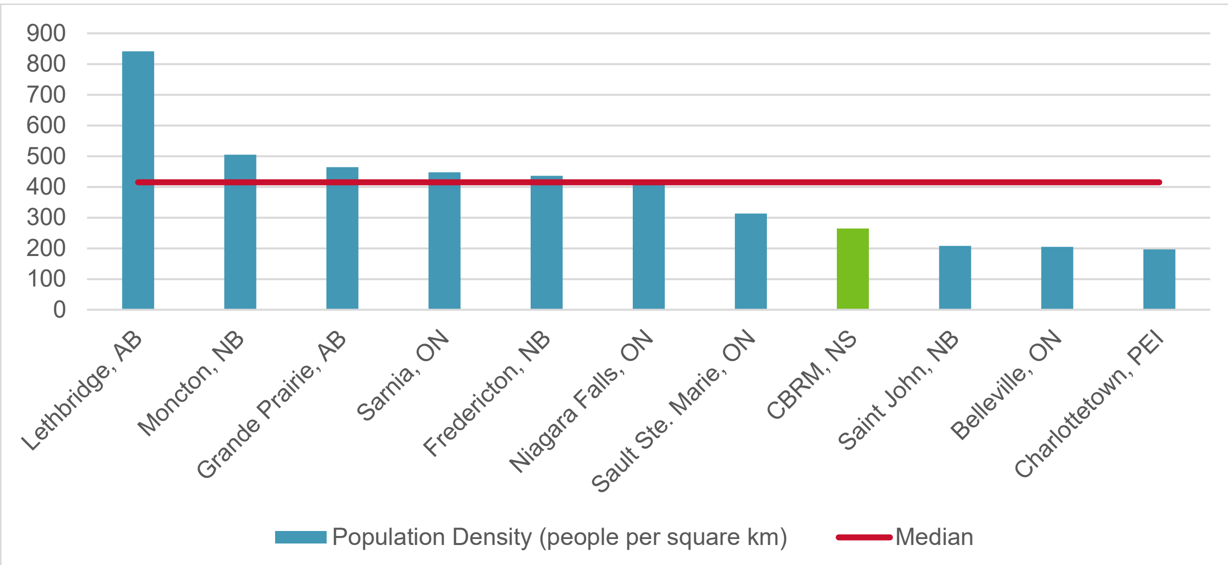

Figure 1: Population Density

CBRM has the lowest percentage of municipal population within the service area, with 59% of the population. **Figure 2** shows that many of CBRM's peers' transit service area includes their entire municipal population.

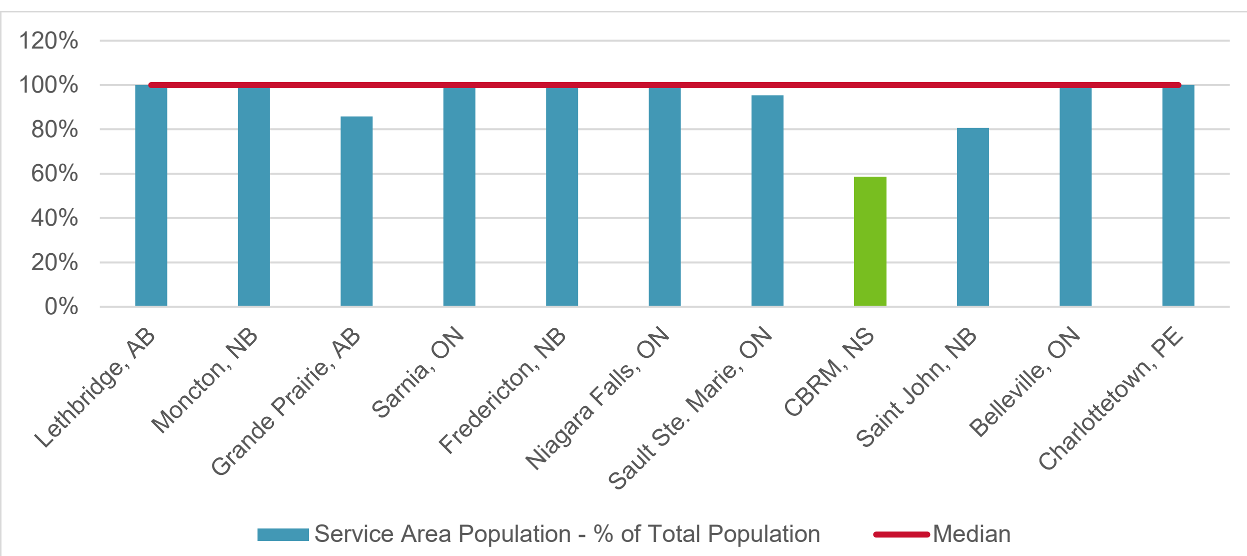

Figure 2: Percentage of Total Municipal Population within Service Area Population

Figure 3 shows annual revenue hours per capita, which is an indicator of investment per community member. CBRM's investment in the community in terms of service hours is below the median. In 2011, service hours per capita for CBRM was 0.4. The increase in service hours by 143% since then is a testament to the system's commitment to making service improvements in response to feedback and demand.

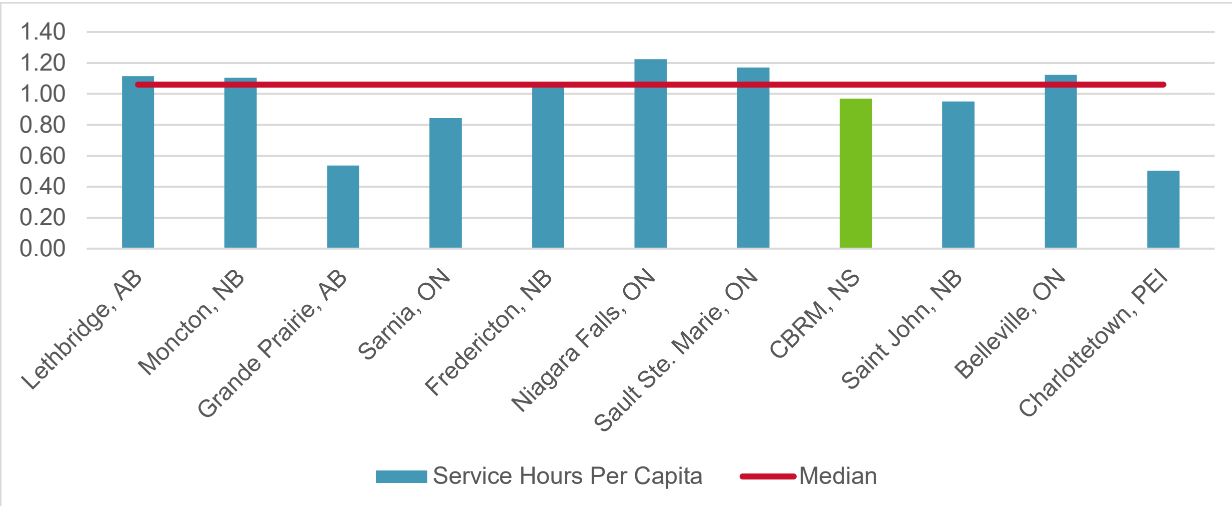

Figure 3: Service Hours Per Capita

If service hours per capita is an indicator of investment in the community, riders per capita **(Figure 4)** is the indicator of how well this investment is targeted and how well it is paying off. In essence, it is a measure of the effectiveness or usefulness of the transit system and how closely it matches the community's trip needs. The indicator is calculated by dividing the number of annual riders by the service area population. Annual riders per capita in the peer group ranges from 6 to 29, with a median value of 21. CBRM provides an annual 24 trips per capita, solidly above the median. When compared to 2011's annual 4.5 riders per capita, CBRM's increased investment in service hours by 450% has translated to an even greater increase in ridership of 533%.

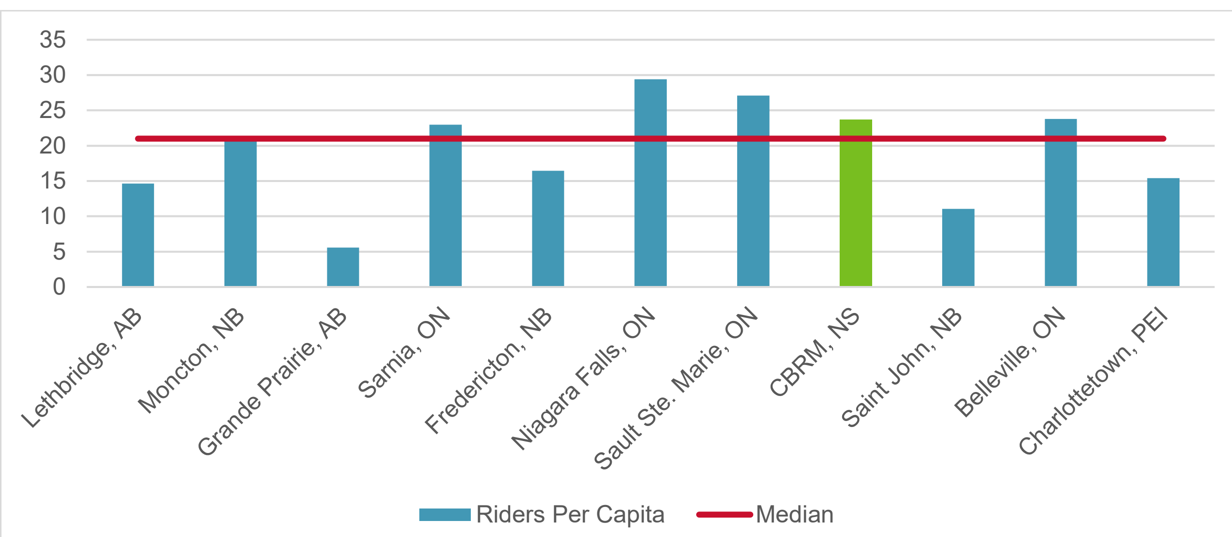

Figure 4: Annual Riders Per Capita

As shown in **Figure 5**, CBRM has higher riders per service hour than many of its peers with 25.0 riders per hour while the median Is 19.3. CBRM's higher ridership per service hour and ridership per capita show the effectiveness of the transit system.

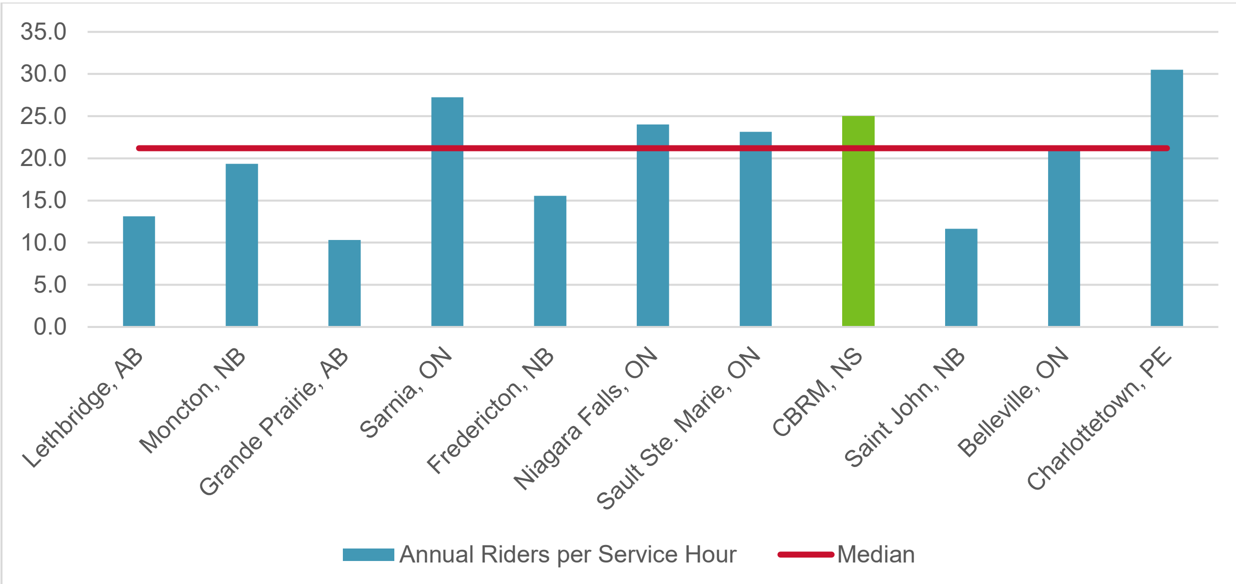

Figure 5: Annual Riders Per Service Hour

Net operating cost per service hour (**Figure 6**) ranges from $114 per service hour to $27 per service hour among the peer group. The median is $71 per service hour and CBRM is one of the lowest at $52 per service hour. This means that CBRM has a lower operating cost per hour than 80% of its peers, an indicator of the opportunity to provide cost-efficient service. The deviation from the median, however, may also indicate sub-optimal investment in operating resources from staffing to facilities.

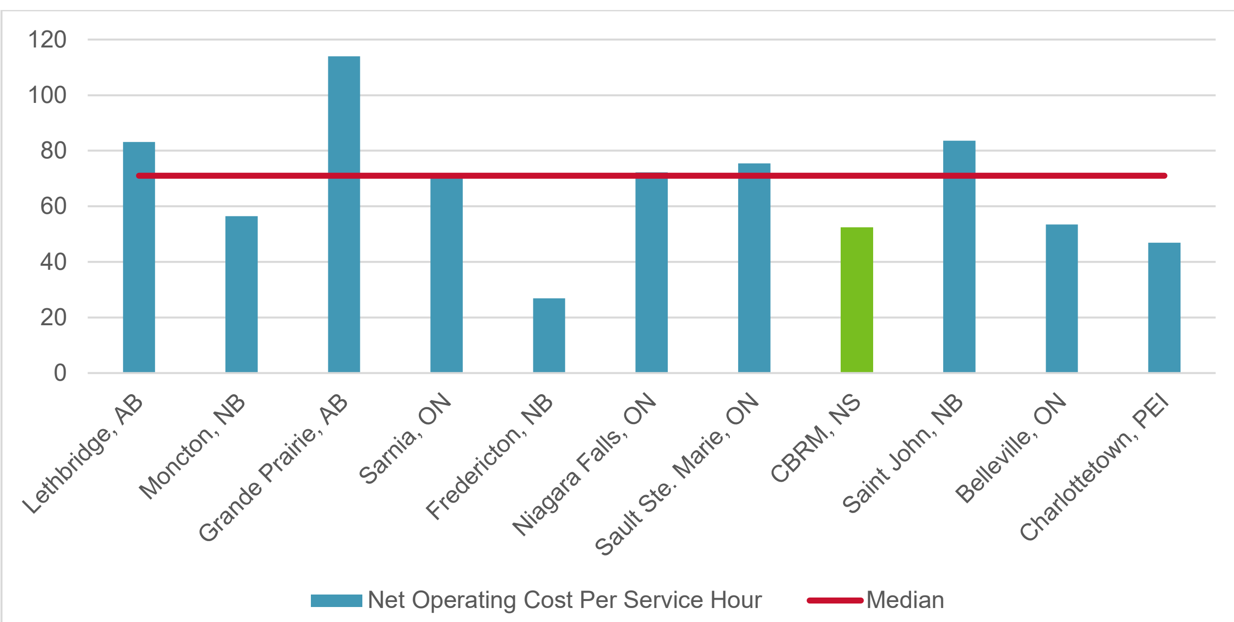

Figure 6: Net Operating Cost per Service Hour

Net operating cost per capita (**Figure 7**) is calculated by dividing the net operating cost by the service area population. Among the peer group, Lethbridge has the highest net operating cost at $93 per capita and Fredericton has the lowest at $28 per capita. CBRM is below the $61 per capita median at $51 per capita.

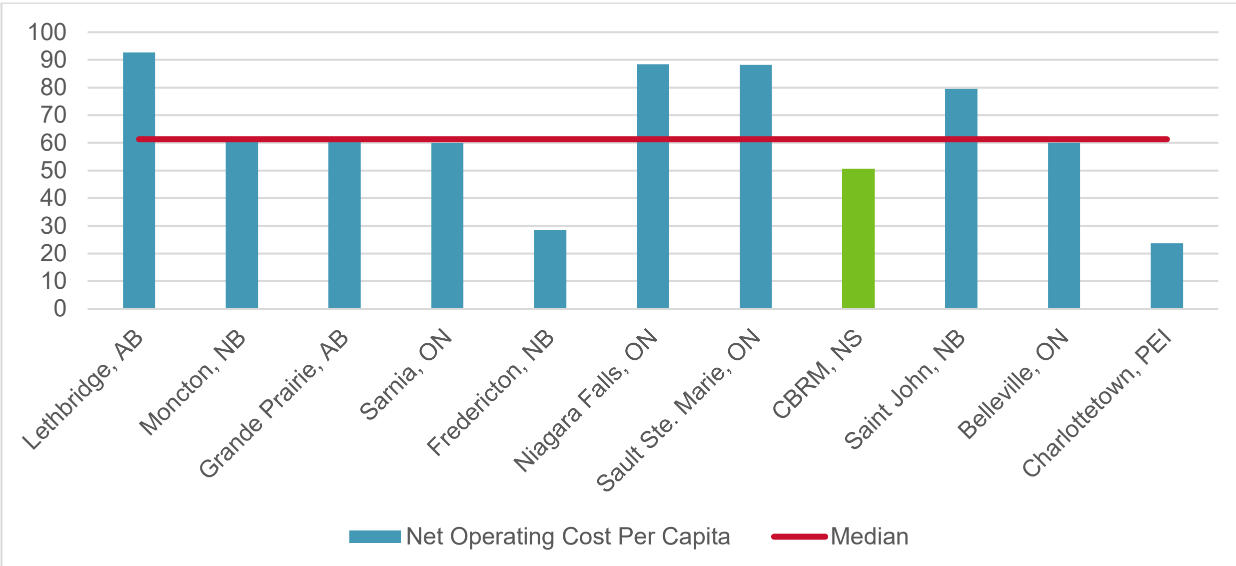

Figure 7: Net Operating Cost per Capita

Average fare (**Figure 8**) is calculated by dividing all revenues received by the number of riders that use the service. Average fares among the peer group range from $1.18 to $4.23 with a median of $1.72. CBRM is below the median at $1.30, which is slightly higher than a one-zone ticket for the system ($1.25). With a second zone fare increase to $2.25, a $1.30 average fare can either indicate a low use of transit service to travel among zones, or that the average fare is kept low by use of concession fare passes such as the $60 30-day bus pass for all Cape Breton University students, costing $60 per month, or an average of $2 per day. With university student passes making up 62% of total revenue, the latter is probably the case.

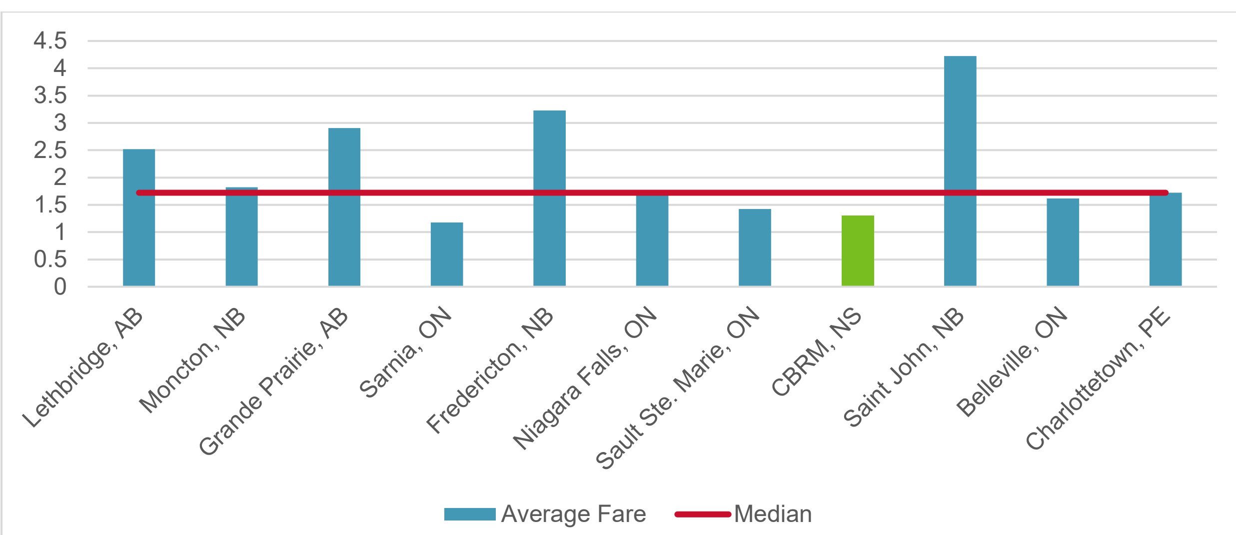

Figure 8: Average Fare

Spare ratio (**Figure 9**) is calculated by dividing the number of vehicles unused at the peak by the vehicles used at peak to show the level of surplus vehicles that are maintained but not needed to meet peak demand. This surplus vehicle count that's not needed to meet peak demand is used to accommodate vehicle repairs (minor and extensive due to accidents, etc.) and scheduled preventative maintenance. CBRM is currently operating a spare ratio below the average at 17% The highest spare ratio is Lethbridge at 71%. A high spare vehicle ratio is an inefficiency that translates to unnecessary costs in storage and maintenance.

While maintaining a low spare vehicle ratio will reduce the capital and operating expenditures of the transit agency, it does create potential operating challenges. Operating a low spare vehicle ratio creates a risk that, in the event of multiple vehicles requiring service, CBRM may not be able to provide their full peak period service. CBRM is currently operating well below the median for peer agencies of 38%, suggesting potential for improvement by increasing investment in spare vehicles when funding is available.

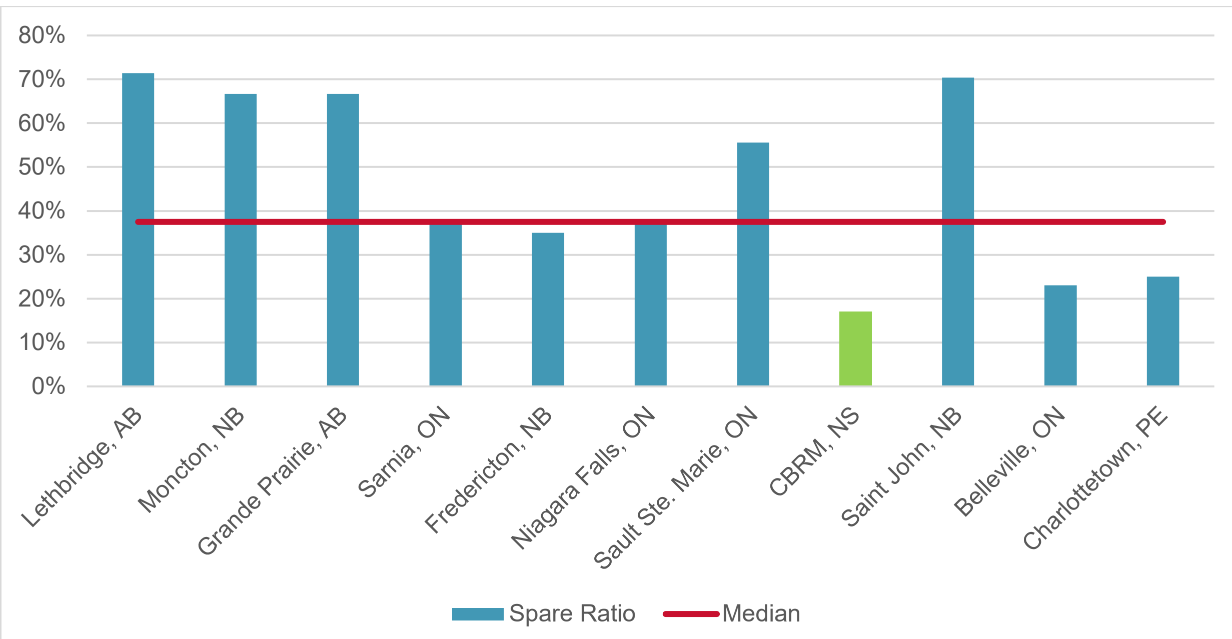

Figure 9: Spare Ratio

2.2 Specialized Transit Peer Review

The Project Team identified six peer transit systems with a similar number of registrants, specifically between a range of 500 to 800 registrants.

Table 2: Comparison of Municipalities

Transit System	Population	Service Area (square km)	Population Density (people per square km)	Registrants	Net Operating Cost	Registrants as % of Population
Cobourg, ON	19,440	13	1495	624	179803	3.21%
North Bay, ON	47,084	53	888	529	704288	1.12%
Sault Ste. Marie, ON	69,900	224	313	535	1227541	0.77%
Fredericton, NB	58,000	132	439	526	230230	0.91%
CBRM, NS	93,694	2420	39	680	700,727	0.73%
Rocky View District, AB	94,828	4631	20	578	815037	0.61%
Renfrew, ON	27,246	2864	10	750	339617	2.75%

Figure 10 through Figure 12 graphically illustrate a number of indicators and conclusions that can be drawn from the comparisons made.

CBRM has 680 registrants, which is a little higher than the 578 median for the peer group. As **Figure 10** shows, this is approximately 0.7% of the population and lower than the median for peer transit systems.

The number of registrants for paratransit service is dictated by eligibility criteria set by the municipality. According to CBRM guidelines, a person qualifies for paratransit use if they have a disability that restricts them from using Transit Cape Breton's regular route service or other modes of transport. People who qualify can use the service for medical appointments and getting to social, personal and recreational activities around CBRM.

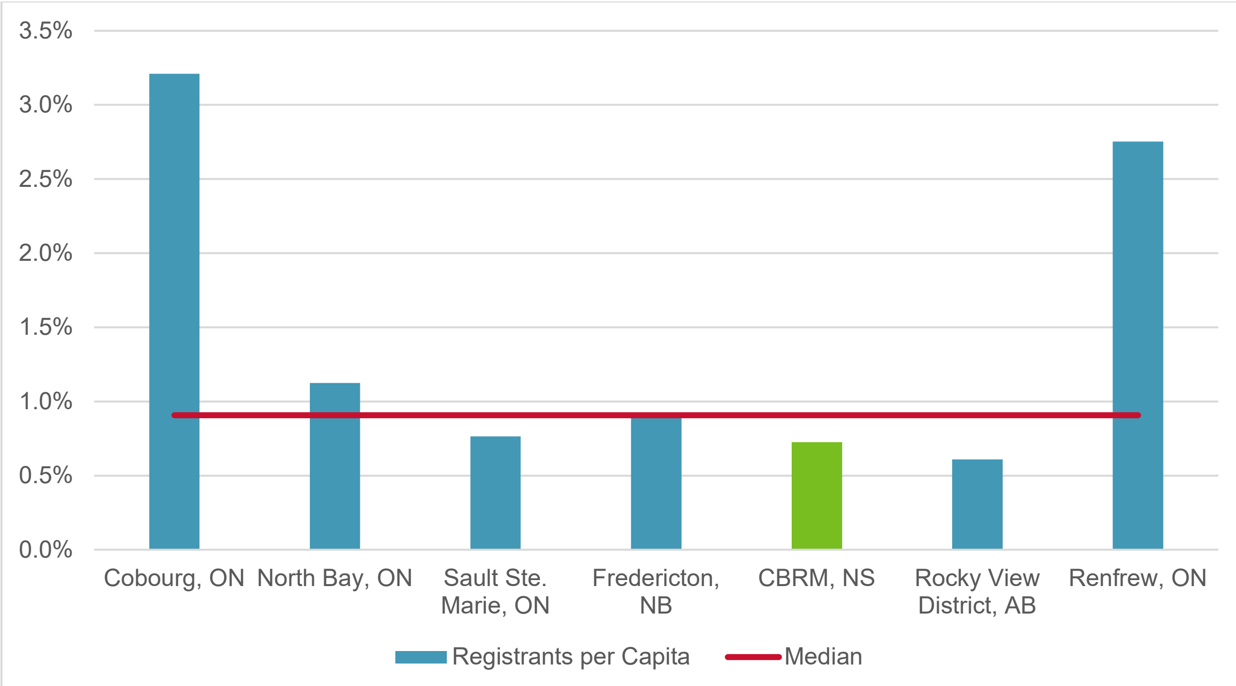

Figure 10: Registrants Per Capita

CBRM is very close to the 37 median total trips requested per registrant at 36 annual total trips by registrant (**Figure 11)**. Sault Ste Marie and Fredericton are not included in the chart because they do not have publicly available information for total trips requested.

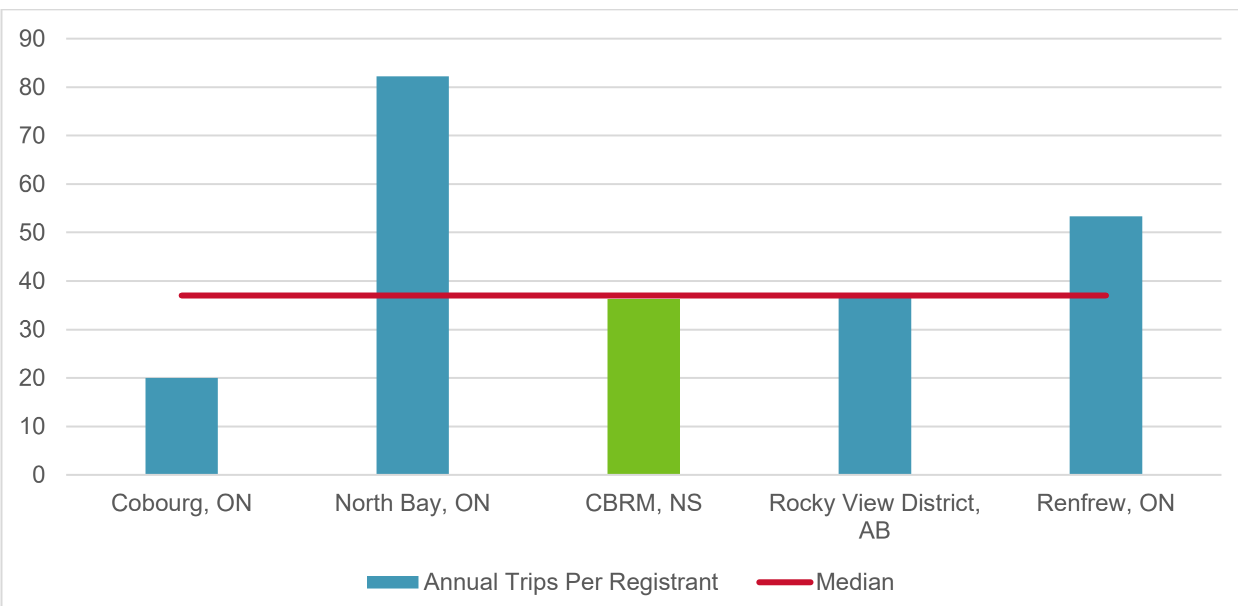

Figure 11: Annual Total Trips Requested Per Registrant

CBRM is below the $9.25 median net operating cost per capita at $7.48 (**Figure 12**). There is a significant amount of variation in net operating costs per capita among CBRM and its peers – the lowest net operating cost per capita is Fredericton at $3.97 while Sault Ste Marie is the highest at $17.56.

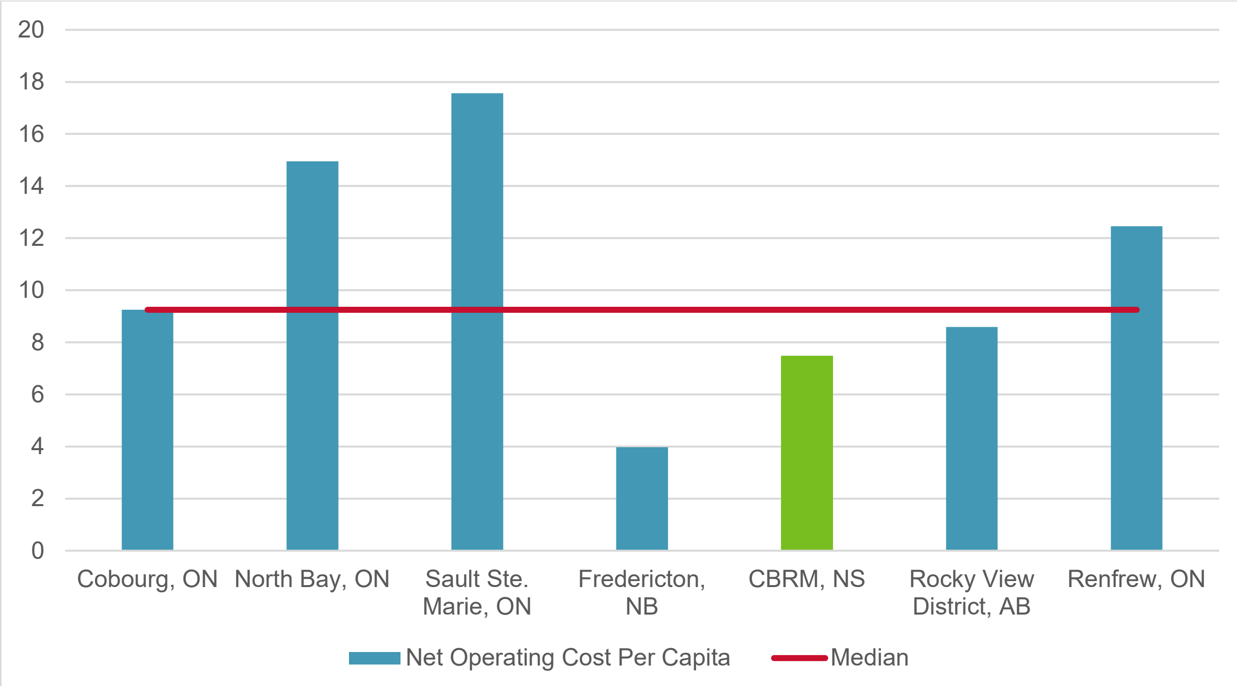

Figure 12: Net Operating Cost per Capita

3 Policy Framework

3.1 Development of Service Strategies

3.1.1 Policy Framework

Transit policy drives the decision-making process by providing transit management and political decision-makers with the tools needed to support service recommendations, as well as to maximize transit growth opportunities while maintaining cost effectiveness. Setting policies early also drives the planning process and clarifies, for example, whether service changes should be designed to expand the system and target new riders, or whether existing funding levels should be reallocated to better serve existing customers. It was important to ensure that the policies reflect input from all stakeholders, including both transit users and non-transit users.

The policy framework consists of:

- **Goals and Objectives** to provide general policy direction for the community.
- **Transit Service Standards** to assist in determining where service will be provided, when service will be provided, and how it will be provided.

3.1.2 Vision and Mission Statements

Through consultation with the public and stakeholders, and the consensus-building process at the staff level, the Project Team developed a number of goals and objectives based on draft vision and mission statements. The preferred future of public transportation in CBRM:

Vision: “CBRM will provide a local public transportation system that is fully accessible and meets the needs of its residents and the business community.”

THE PURPOSE OF TRANSIT CAPE BRETON:

Mission Statement: “To provide a safe, efficient, customer-focused public transportation system that supports the economic vitality, growth, environmental sustainability, and health of the regional community.”

3.1.3 Transit Goals and Objectives

To support the transit vision, a number of goals and objectives were developed.

SERVICE GOALS

To provide a public transportation system as a viable alternative to the automobile in CBRM which:

- Improves the quality of life of residents who do not have access to an automobile.
- Improves pedestrian access to transit service.
- Meets the travel demand generated by various target markets in the employment, academic, commercial, medical, and service industries.
- Recognizes that transit is an integral component of the urban environment.

PERFORMANCE GOALS

Transit performance targets have been established for the next five years:

- **Effectiveness**: To increase transit use by 20% from 1,500,000 passengers in 2022 to 2,275,000 passengers by 2027.
- **Efficiency**: To increase Transit service efficiency by 10% from 31 passengers per hour in 2022 to 35 passengers per hour by 2027.

The performance targets identified can be adjusted, as required, and are designed to be slightly out of reach to ensure continuous improvement is sought and to balance ridership growth initiatives with fiscal responsibility.

SERVICE AREA OBJECTIVE

Transit Cape Breton should provide an adequate level of service within all the urbanized areas of the Region.

SERVICE OBJECTIVE

The minimum frequency of service and service hours to be provided shall be adequate to enable residents to access work, school, shopping, medical, and recreational centres.

3.2 Transit Service Standards

Transit service standards provide goals, objectives and general policy direction for Transit Cape Breton to follow with respect to the provision of transit service. Transit service standards are needed to guide Transit Cape Breton in determining when transit service will be provided, how often it will be provided, and how it will be provided through:

- A framework for making rational decisions on the level and quality of service in the community;
- Increased public awareness of the philosophy of service and growth;
- A strong commitment by Council to maintain service standards within the context of balancing social and environmental objectives with fiscal responsibility; and
- A high degree of acceptance for transit expenditures since the decision-making process will be perceived as fair.

3.2.1 Transit Service Level Policies

Recognizing fiscal restraint and the need for an expanded and sustainable public transportation system, there must be a balance between providing a desirable high level of service and affordability. Service priorities and the service level policies have been designed, within reason, to enable residents that are captive to transit to expect a minimum level of service. Based on demand, the minimum service levels can be exceeded.

SERVICE PRIORITIES

Each year, and on an ongoing basis, Transit staff assesses service requests and attempt to meet performance goals. In doing so, staff must establish service priorities to determine the best return on investment, demonstrating fiscal responsibility. In this regard, routes that do not meet minimum performance criteria become candidates for reductions in the service hours provided or through a restructuring of the routing. Typically, transit agencies target a minimum revenue-cost ratio of 0.3 in order to justify provision of the service or route.

Based on stakeholder input, assessment of existing transit services and best practices, new services shall be introduced based on the following progressive steps:

- Weekday peak: 6am - 9am, 3pm - 6pm
- Weekday off-peak: 9am - 3pm, 6pm – 12:00am
- Saturday: 7am - 6pm
- Saturday evening: 6pm – 12:00am
- Sunday: 8am - 6pm

Where service does not meet minimum requirements, services are reduced in the reverse order. Alternative methods of service delivery can be assessed such as the use of fixed route shared ride taxis and Transit On-Demand. Ultimately, steps will need to be undertaken to work within budgets. Another method to reduce deficits is to increase revenues through low-cost ridership growth strategies and fare increases. It should be cautioned; however, service reductions will result in revenue reductions, so it is more advisable to maintain total revenue hours of service but reallocate the service hours where there is a better return on investment.

Each year, the transit services offered should be evaluated against minimum performance requirements. Service to unserved areas identified by Transit Cape Breton or through service requests from the public should be reviewed by identifying the bottom quartile of lowest performing routes and to assess the estimated costs and projected ridership of new services. For example, existing routes that do not meet minimum performance can be cut back by reducing service hours that have the least impact (e.g., late evening) and replace those hours with peak service to the new areas.

MINIMUM SERVICE HOURS

The minimum hours of service operation to accommodate the various target market groups identified shall be:

- 6:00am – 10:00pm weekdays
- 7:00am – 7:00pm Saturdays
- 10:00am – 7:00pm Sundays

MINIMUM FREQUENCY OF SERVICE

Based on the current and future development of the city, the following minimum service frequencies are recommended.

- Within Sydney and Glace Bay:
    - 30 minutes during weekday peak periods
    - 60 minutes during weekday off-peak and evening periods
    - 60 minutes during Saturdays and Sundays
- All other communities with service to Sydney
    - 60 minutes during all service hours

MINIMUM SERVICE COVERAGE

To ensure there is reasonable access to bus service and that priority is given to higher densities of development (as defined in the *Cape Breton Regional Municipality Land-Use By-Law, July 2023*), the following minimum service coverage is recommended:

- 90% of low-density housing units within the urbanized area of CBRM shall be within a 400 m walk (less than five minutes) of a bus route.
- All medium to high density residential units within the urbanized area of CBRM shall be within a 300 m walk (less than three minutes) of a bus route.
- Conventional bus service shall be provided to new subdivisions with 400 households or 1,000 residents; alternative forms of service delivery shall be considered for new subdivisions that do not meet the criteria.

It should be pointed out that it is generally cost-prohibitive to provide reasonable access to 100% of residents and businesses. It is important that new and existing residents and business should determine their proximity to bus service that is in place or is planned when they decide to purchase property or relocate. Development plans should, therefore, identify potential bus routes, not unlike the identification of schools, parks and roadways in area plans.

ROUTE DESIGN

To ensure efficient and effective bus service is in place:

- All routes shall be provided in both directions to the extent possible. One-way service loops beyond 2 km are considered unacceptable.
- Routes shall be located along major arterial and collector roads and only be provided along local residential roads in order to meet walk distance guidelines.
- Routes shall be designed so that the need to travel to any destination within the urbanized area of CBRM does not require more than one transfer in 90% of all transit trips.

VEHICLE REPLACEMENT

In order to minimize transit fleet costs, fleet managers are required to balance the cost of ongoing operating and maintenance costs for ageing vehicles against cost of those for a new vehicle coupled with the purchase price of the vehicle. While these vary by individual vehicle based on usage and maintenance, the following vehicle lifespans are typically used for fleet replacement planning purposes (**Table 3**):

Table 3: Transit Vehicle Lifespan Guidelines

Vehicle	Diesel Vehicle Replacement Schedule		Electric Vehicle Replacement Schedule	
	Age (years)	Mileage (kms)	Age (years)	Mileage (kms)
12m City Bus	12	805,000	14	1,000,000
7m Community Bus	7	400,000	N/A	N/A

PASSENGER LOADING STANDARDS

Where routes are experiencing passenger loading above the following limits, consideration should be given to introducing additional vehicles and increasing service headways for the subject period.

- The Maximum Load on a vehicle should not exceed 150% of the seated capacity during peak periods
- The Maximum Load on a vehicle should not exceed 100% of the seated capacity during off-peak hours

VEHICLE SPARE RATIO

Transit CB should operate minimum spare vehicle ratio of 25% to minimize disruption to service in the peak period in the event of vehicles being disabled and awaiting repairs.

3.2.2 Land Use Design Guidelines

The efficiency and effectiveness of public transportation (conventional and specialized) is dictated by the degree to which land use design policies support transit operations and sustainable development initiatives. Although development growth is currently minimal, transit supportive land use guidelines should be in-place should development (new and in-fill) take place in the future. CBRM will be able to avoid the costly mistakes of other larger municipalities. In this regard, based on consultations with CBRM planning staff, it is recommended that the Region amend their by-laws for new residential developments within the transit service area ensuring that they are designed to meet the 400 m transit walk distance guidelines.

The Land Use Design Guidelines address:

- Acceptable walk distances from developments to existing and future transit services
- Accessibility infrastructure
- Incorporating transit-supportive guidelines in the development approval process

POLICY HIGHLIGHTS

- **Bus Stop Locations:** That the location of bus stops be co-coordinated with the design of walkways, intersections and development in order to minimize walk distances and provide for reasonable bus stop spacing.
- **Walk Distances:** 90% of all dwelling units should be within a 400 m walking distance of an existing or future bus stop with 70% of the dwelling units within a 300 m walk distance of the bus stop.
    - All multiple dwelling units should be within a 300 m walk distance of an existing or future bus stop.
    - All institutional centres (hospitals, colleges and schools) should be within 100 m of an existing or future bus stop.

- **Walkway Locations:** Walkways shall be provided such that walking distances from the residences of a subdivision to existing or future transit routes are minimized to the extent possible.
- **Acceptable Transit Routes:** Transit routes can be provided on arterial roads and major collectors which have reasonable through access; not on crescents or cul-de-sacs. A 9m pavement width is the minimum acceptable for transit routes.
    - Arterial and major collector 'through' roads should be spaced no more than 900 m apart to allow adequate transit route coverage of future residential developments.
    - Provision should be made to minimize the length of one-way transit loops. One directional loops longer than 2.0 km are generally unacceptable.
    - Provision for temporary transit vehicle turning circles must be provided, where necessary, to allow transit route phasing to coincide with development phasing. A minimum 15.2 m radius is required for the turning circle.
- **Transit Route Length:** Road layouts in residential developments should be designed such that transit routes require a maximum of 1 km of transit route per 1,000 residents served. This would not apply to rural roads.

  It is worth noting that given the biggest destination in CBRM is Sydney, many communities such as Glace Bay, New Waterford, North Sydney, etc. requires bus routes to travel greater distances along rural arterials and highways. This negatively impacts route efficiency in terms of passengers carried per hour of service, which cannot be compared to peer transit systems that operate predominantly in built-up urban areas.
- **Trade-Offs:** That land use / transit co-ordination is a necessary and valuable goal recognizing that, in the implementation of the design objectives, trade-offs may exist in some instances with other planning, engineering and environmental considerations.

3.2.3 Accessibility Policies

Changes in health care services (e.g. consolidation of programs) and the trend to greater outpatient service have increased travel needs for people with disabilities. The rate of mobility disability in the population increases substantially with age. As a greater segment of the population reaches age 65 and beyond and life expectancies continue to rise, there will be a proportionate increase in travel by persons with disabilities.

Strategies have been developed to provide a framework for the future:

- All Conventional Transit vehicles shall be low floor wheelchair accessible.
- Land Use Design Guidelines shall be designed to maximize accessibility to bus stops.

- All bus stops and bus shelters must be fully accessible (per current AODA and local guidelines).
- Site plans must be designed to minimize walk distances and maximize safety from bus stops to buildings.

3.2.4 Bus Stop Area Design Guidelines

A bus stop zone (or simply, a 'bus stop') is the area designated exclusively for the boarding and alighting of Transit Cape Breton customers. The definition of 'bus stop zone' refers not only to the actual point at which people board and alight, but also to the space required for a bus to approach the zone, align parallel to the curb and leave from a stopped position. When buses are absent, other vehicles may treat this area as part of a travel lane, but not as a parking, stopping or loading zone.

Transit accessibility improvements are undertaken to attract new riders, provide universal accessibility to transit, and reduce dependency on the automobile. Full-accessibility improvements include hard-surfaced (preferably concrete) pedestrian links to sidewalks (bus stop pads), benches, shelters and possibly, unique and highly visible bus stop identification markers.

It is recommended that CBRM establish a standard design guideline for bus stop areas. Bus Stop Area Design Guidelines will enable the CBRM to serve and function in the overall transportation system better. Bus stop zones that are poorly integrated in the street network reduce levels of service for all road users.

3.3 Paratransit Service Standards

A review of the practices and policies of peer paratransit agencies was conducted to inform the recommended service standard improvements for Cape Breton's Handi- Trans service. The peer paratransit agencies reviewed include:

- Halifax, NS
- Halton Hills, ON
- Waterloo Region, ON
- Hamilton, ON
- Fredericton, NB

A summary of the review findings and resulting policy recommendations can be found in **Table 4.**

Table 4: Paratransit Peer Review Summary

	Handi-Trans Existing Conditions	Policies Peer Review
Fares	• $1.75 within one community • $3.25 between communities within the municipality • $6.50 to rural areas • $60.00 monthly passes	• Peer municipalities charge $3.00 - $4.00 per trip, and $80 - $100 for monthly passes. • Generally, paratransit fares on-par with conventionally transit fares
RECOMMENDATION	**Adjust Handi-Trans Fares to be comparable to conventional transit fares**	
Eligibility and Registration	• Doctor's note is required to specify that the customer has a disability that restricts them from using conventional transit. • Nursing home residents automatically qualify. • Applicants only need to apply once. • No online application portal, applicants call in to ask about eligibility	• Most peer municipalities accept completed application via mail or email. • Halifax and Waterloo grant different categories of service (permanent, temporary, seasonal, etc) depending on nature of disability. • Waterloo and York Region have appeals processes with a third-party panel for disputes regarding eligibility.
RECOMMENDATION	**Introduce online application portal option, and consider eligibility renewal requirements (re-application) to deter use by ineligible passengers.**	
Booking and Dispatch	• Bookings are typically made in advance. • Subscription service available • Scheduling and dispatch is done manually on paper	• Waterloo, Halton Hills, and Hamilton have an online booking portal through their paratransit webpage. • Advance booking window ranges between municipalities, from as early as 2 weeks to as late as 48 hours in advance. • Same day booking is subject to availability
RECOMMENDATION	**Implement online booking portal**	
Service Hours	Service hours: • Monday-Friday: 7 am – 10 pm • Sunday 11 am – 7 pm Booking hours: • Monday- Friday: 8:30 am – 4 pm	• Peer municipalities have varying hours, but generally similar to CBRM

	Handi-Trans Existing Conditions	Policies Peer Review
Customer Service Policies	• Currently no pick-up window policy • Drivers sometimes go into clients' homes at the client's request • No established no-show or late cancellation policy	• Pick up window ranges between 20 and 30 minutes, 5-minute wait policy • In most peer municipalities, no-shows are charged the fare of the trip • All peer agencies have Users Guide to outline policies on booking timelines, pick-up windows and locations, no-show and late cancellation, eligibility, and driver conduct. • Most municipalities specify that drivers cannot help riders in and out of their houses, usually a curb-to-curb service, not door-to-door
RECOMMENDATION	**Consider implementing a no-show or late cancellation fee if rate of occurrence is high**	

4 Review of Current and Projected Ridership Growth

Although the Regional Municipality of Cape Breton has seen a population decrease since the previous Transit Operational Review in 2011, Transit Cape Breton use has now increased from a recent low of 360,000 in 2017 to 1,300,000 in 2019, eclipsing the high of 1,250,000 reached in the mid-1990s. The significant enrollment of international students at Cape Breton University (CBU) has had a profound and positive impact on Transit use.

As part of the Project Team's review of Cape Breton Transit operations, a review of route alignments and service levels was conducted, and future service improvements aimed at increasing ridership were identified. This section summarizes the findings of that analysis, including proposed new route alignments and service levels, using a phased approach for implementation. Precise alignments in Downtown Sydney are not included in this proposal but are included along with the proposed downtown hub location assessment.

4.1 Existing Route Reviews

To understand the current performance of the Cape Breton Transit System, the Project Team conducted a comprehensive system performance assessment. This included a review of route structure and coverage area in relation to major origin-destination pairs; ridership of each route; service frequency and span of service; key performance indicators such as schedule adherence and on-time performance. Transit vehicle electrification factors were also considered as part of this assessment to make recommendations on route structure changes for improved service access, performance, and compatibility with electrification plans.

Transit Cape Breton operates a fixed-route transit system, comprised of 13 conventional bus services linking communities within the Region, focusing on Sydney as the most central hub. Services generally branch out radially from Downtown Sydney or Glace Bay to the area communities, including New Aberdeen, Dominion, Reserve Mines, New Waterford, Cape Breton University, Sydney River, North Sydney, and Sydney Mines. The route structure and common origins and destinations are illustrated in **Figure 13.**

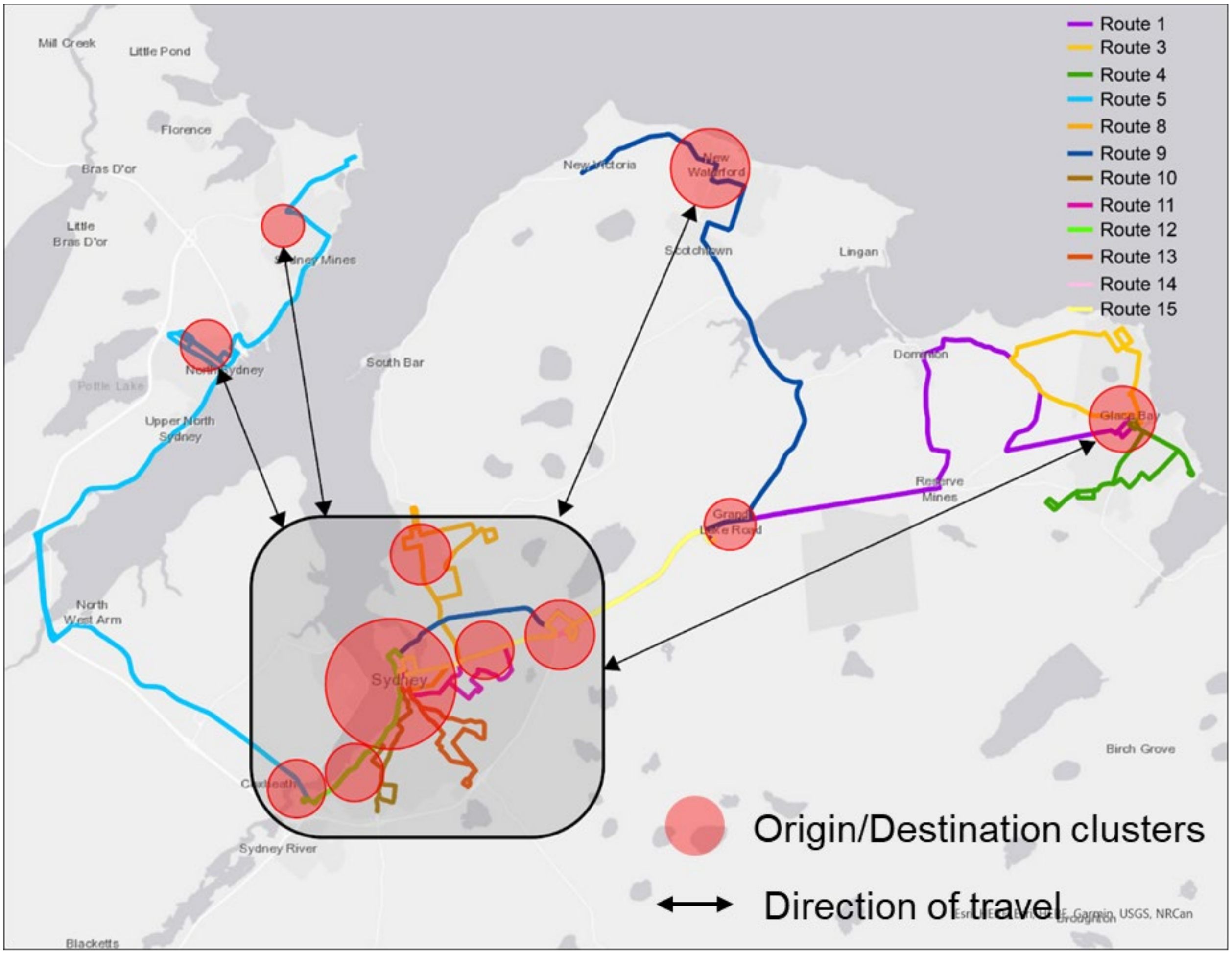

Figure 13: Transit Cape Breton Routes and Common Origins and Destinations

4.2 Phasing

This proposal uses a phased approach to introduce new bus service. The goals of each phase of service changes are outlined in the table below.

Table 5: Proposed Phasing Approach

Phase	Timeframe	Description
Phase 0	Immediate	• Addressing immediate schedule and capacity issues
Phase 1	Short Term	• Reconfiguring one-way loops to provide two-way service
Phase 2	Medium Term	• Expanding service coverage • Improving regional connections between communities
Phase 3	Long Term	• Improving and expanding the network

The fleet and operating cost implications of each phase are summarized in **Table 6.** These service costs assume no change to existing service spans; increasing service spans (including Sunday service) should be considered as an additional improvement to these route and service proposals.

Table 6: Estimated Fleet Requirements and Operating Costs, By Phase

Phase	Peak Fleet Requirement	Annual Revenue Hours	Annual Revenue Service Cost ($105 per Revenue Hour)	% increase from base (before Sep-23)
Before Sep-23	12	50,300	$5.3 million	-
As of Sep-23	15	63,200	$6.7 million	26%
Phase 0	18	74,800	$7.9 million	41%
Phase 1	21	86,600	$9.1 million	72%
Phase 2	24	97,400	$10.3 million	94%
Phase 3	25	101,900	$10.7 million	102%

4.3 Assumptions

There are several assumptions that are made in these route alignment and service level proposals:

- Area taxation limitations to bus service will no longer exist by Phase 2;
- Assumed route cycle times allow for sufficient travel time and recovery time;
- Schedule interlining is permitted.

Interlining: Interlining is when vehicles are assigned to operate on two different routes, typically switching routes upon completion of each run. Interlining between two routes is permitted when the two routes share a terminal point on one end, have the same headway, and where the total terminal time of each route would be more than the headway without interlining, assuming sufficient terminal buffer time remains. Interlined routes have two benefits. Some passengers will not have to alight their original bus to board another bus to get where they want to go (improved destination satisfaction). Inter-lined routes also balance the travel times between both routes, which is helpful if one route has less built-in layover than the other. Each instance of interlining can save one bus. References to ”0.5 bus” requirements in the route modification proposals in **Section 4.4** indicates assumed interlining.

4.4 Route Alignment Proposals

Route alignment proposals are shown in **Table 7** with a description, reasoning and fleet impact for each change. Maps are provided below showing the proposed subregional service networks for each phase separated into four subregions: Sydney, Glace Bay, North Sydney, and New Waterford.

Table 7: Proposed service changes

	Change #	Description	Reasoning	Peak Fleet Impact	Implementation Status
Phase 0	1	Route 2 implemented, travelling the most direct path between Sydney and Glace Bay. 60-minute service.	Most passengers are not travelling to a location along this diversion, and straightening the route would offer faster travel times to these passengers.	2	Sep-23
	2	Route 2 increased to 30-minute service	Increasing service levels to accommodate growth in demand.	2	Not yet implemented
	3	Route 2 adjusted to service Wal-Mart on Kevin Quinlan Ave	With a shorter distance from Sydney to Glace Bay, this route can accommodate a diversion to better service passengers at the Walmart within a 60-minute run time.	0	Sep-23
	4	Routes 7 and 14 are eliminated with service consolidated onto Route 15 with a 20-minute headway.	Improves service levels and consistency of service on the Sydney-CBU corridor and allows for easier adjustment of service levels along this corridor if needed.	0.5	Partially, Sep-23
	5	Route 6 introduced providing service along Kings Road to Westmount. To maintain schedule efficiency, this route's schedule should be blended with Route 12 to provide even headways along Kings Road.	This new route addresses feedback from the public survey that there is a desire for service to this area.	1	Sep-23
	6	Route 12 extended into the Sydney River and Howie Centre neighbourhoods via Kings Road. Service is reduced to 60-minute headways and is blended with new Route 6 to maintain combined 30-minute headways along Kings Road.	This route extension addresses feedback from the public survey that there is a desire for service to this area. The extension is proposed on Route 12 rather than routes 10 or 11 since it provides the fastest connection to Downtown Sydney, offering the most potential to encourage transit use.	0	Sep-23

	Change #	Description	Reasoning	Peak Fleet Impact	Implementation Status
Phase 1	7	Route 9 operates hourly service between New Waterford and CBU throughout the day (removing service to Downtown Sydney).	Improved the connection from New Waterford to Sydney while supplementing service along the Sydney-CBU corridor. Service is removed from Sydney Port Access Road which has few stops and very little ridership.	0	Not yet implemented
	8	Route 8 modified to provide two-way service, according to the map below, and increased to 30-minute service on weekdays until 18:00 to address increased demand	Two-way alignment via Henry Street and Gatacre Street at Victoria Road and E Broadway ensures that there is still coverage in important parts of the Sydney Port neighbourhood. Recent demand has required a second bus operating on the route.	1	Not yet implemented
	9	Route 10 modified to provide two-way service straight along Alexandra Street and Kenwood Drive to Walmart, according to the map below.	This two-way alignment simplifies the network and adds an anchor on the west end of the route while maintaining coverage along Alexandra Street.	0.5	Not yet implemented
	10	Route 11 modified to provide two-way service for most of the route by returning downtown via the same route after reaching Reeves Street and Lorne Street, according to the map below.	This two-way alignment simplifies the network and avoids duplication of service on Reeves Street and prepares the route for further modification in Phase 2.	0	Not yet implemented
	11	Route 13 modified to provide two-way service to neighbourhoods along George Street, according to the map below.	This two-way alignment maintains service along Cottage Road, Rotary Drive, parts of George Street, and the hospital.	0.5	Not yet implemented
	12	Routes 3 and 4 modified to provide two-way service according to the map below. Each route operated with its own bus.	Route 3: This two-way alignment maintains service along Sterling Avenue and Connaught Avenue to Main Street. It removes service from the low-ridership portion of Main Street. Route 4: This two-way alignment maintains service along Douglas Avenue, Dominion Street, and part of Brookside Street. Service is mostly maintained through the higher ridership parts of the neighbourhood while service is removed on a small portion of Brookside Street that has relatively low ridership.	1	Not yet implemented
	13	Route 5 alignment modified near North Sydney Mall according to the map below.	This adjustment simplifies the route by providing the same service in both directions.	0	Not yet implemented

	Change #	Description	Reasoning	Peak Fleet Impact	Implementation Status
Phase 2	14	Route 10 extended into the north end of Downtown Sydney via George Street, turning back via Desbarres Street and Ortona Street.	This route extension addresses feedback from the public survey that there is a desire for service to this area. The extension is proposed on Route 10 since this new service area most resembles the neighbourhood on the rest of its route versus any other of the routes terminating downtown.	0	Not yet implemented
	15	Route 11 overhauled – terminates at Mayflower Mall at the east end and Walmart at the west end, and no longer connects to Downtown Sydney. The alignment travels through various neighbourhoods on the southern end of Sydney, including new service to Membertou.	A route overhaul is proposed for this route as it currently has very little ridership and has potential to provide new connections throughout Sydney. Service is maintained on most streets with existing service from Route 11, but also gives passengers coming from Mayflower Mall or further east (including CBU) a more direct connection to neighbourhoods throughout Sydney without the need to travel into downtown to transfer.	1.5	Not yet implemented
	16	Route 13 is modified to serve George Street between Common Street and Rotary Drive instead of serving Hillside Street and Rotary Drive, as Route 11 now serves this area.	This change avoids service duplication and simplifies the network by working towards service straight along George Street.	0	Not yet implemented
	17	Route 3 is extended into Dominion. An exact turn-back alignment in Dominion will need to be determined.	This route extension provides a better connection between the northern Glace Bay and Dominion communities.	0	Not yet implemented
	18	Route 19 is introduced between Downtown Glace Bay and New Waterford via Main Street and Seaside Drive at a 90-minute headway.	This new route provides a direct connection between the Glace Bay and New Waterford communities, re-introduces bus service to Main Street in Glace Bay, and provides new service to Seaside Drive.	1	Not yet implemented
	19	Route 21 introduced providing service from North Sydney Mall to Florence via King Street, Pierce Street, Memorial Drive, Fraser Avenue, and Pond Road at a 90-minute headway.	This new route addresses feedback from the public survey that there is a desire for service to Florence, and it addresses a gap in service in the industrial area on Memorial Drive where many passengers currently have to walk to.	1	Not yet implemented

	Change #	Description	Reasoning	Peak Fleet Impact	Implementation Status
Phase 3	20	Route 16 is introduced as a new route connecting Downtown Sydney with Cape Breton Regional Hospital via Brookland Street and Cottege Road.	This new route allows Route 13 to be straightened along George Street while maintaining direct service between Cottage Road and Downtown Sydney.	1	Not yet implemented
	21	Route 13 is modified to provide service straight along George Street.	This allows for the shortest travel times possible along George Street, with Route 16 covering the neighbourhoods surrounding George Street.	0	Not yet implemented
	22	Route 22 is introduced, providing service between Downtown Glace Bay and Reserve Mines via Brookside Street, Dominion Street, and Wilson Road, operating with a 60-minute headway.	This new route provides a new connection between southern Glace Bay and Reserve Mines, it re-introduces service to the entirety of Brookside Drive, and it introduces service to the western end of Dominion Street and Wilson Road.	1	Not yet implemented

4.4.1 Phase 0

Phase 0 is intended to be implemented immediately. It requires six additional vehicles during peak service relative to baseline service. Changes are made with the goal of addressing immediate schedule and capacity issues. The proposed Phase 0 bus routes are illustrated in **Figure 14** and **Figure 15.**

The change in service levels that these changes provide along the Sydney-CBU corridor are outlined in the table below.

Table 8: Proposed Service Level Changes - Phase 0

Route	Current Headway (minutes)	Current Frequency (buses/hr)	Proposed Headway (minutes)	Proposed Frequency (buses/hr)
1	60	1	60	1
2	60	1	30	2
7	Occasional trips only		-	-
9	120	0.5	-	-
14	60	1	-	-
15	60	1	20	3
TOTAL	**13.3**	**4.5**	**10**	**6**

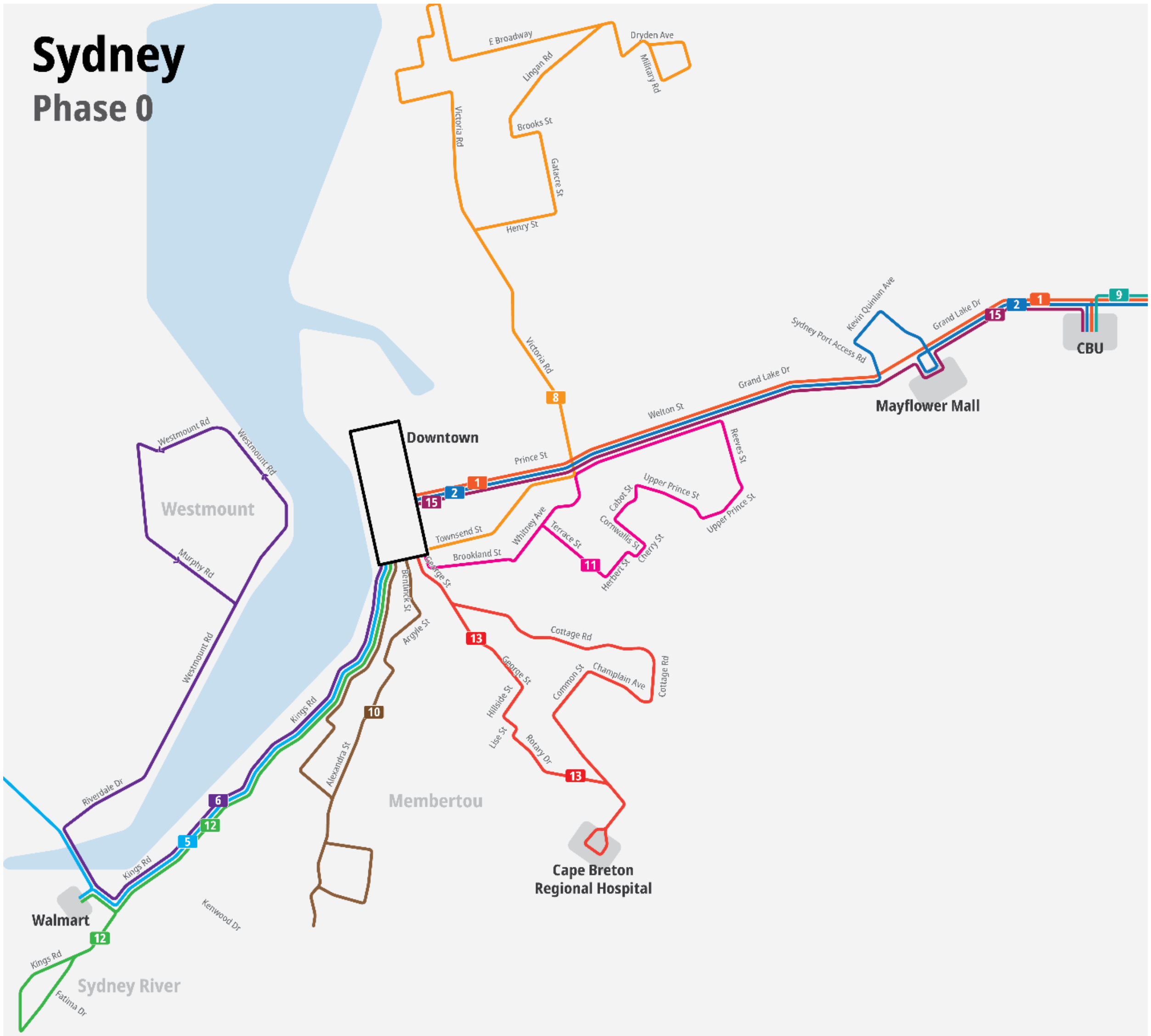

Figure 14: Proposed Route Structure (Sydney) - Phase 0

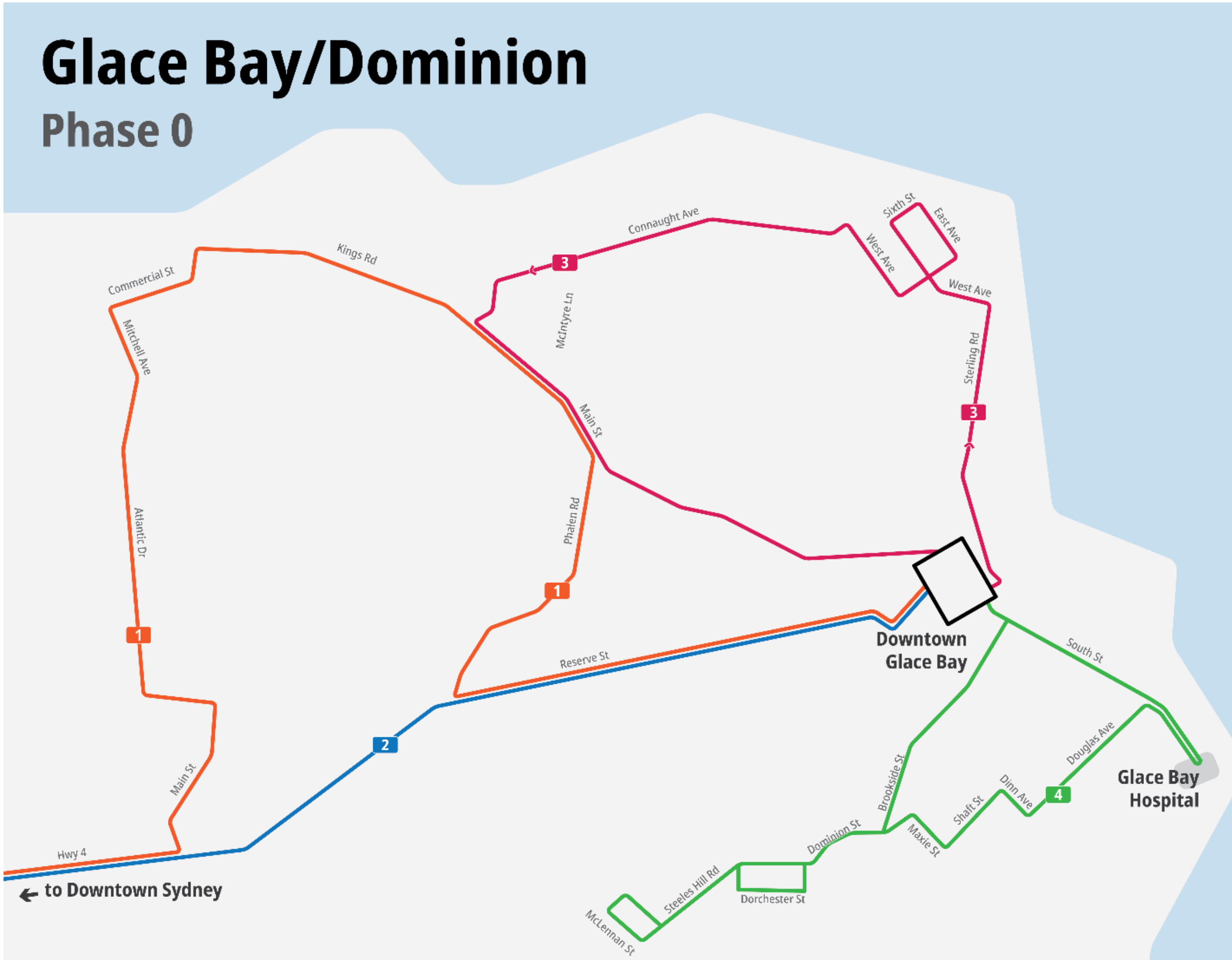

Figure 15: Proposed Route Structure (Glace Bay) - Phase 0

4.4.2 Phase 1

Phase 1 is intended to be implemented in the short term. It requires nine additional vehicles during peak service relative to current service. Changes are made with the goal of reconfiguring one-way loops to provide two-way service. The proposed Phase 1 bus routes are illustrated in **Figure 16** to **Figure 18.**

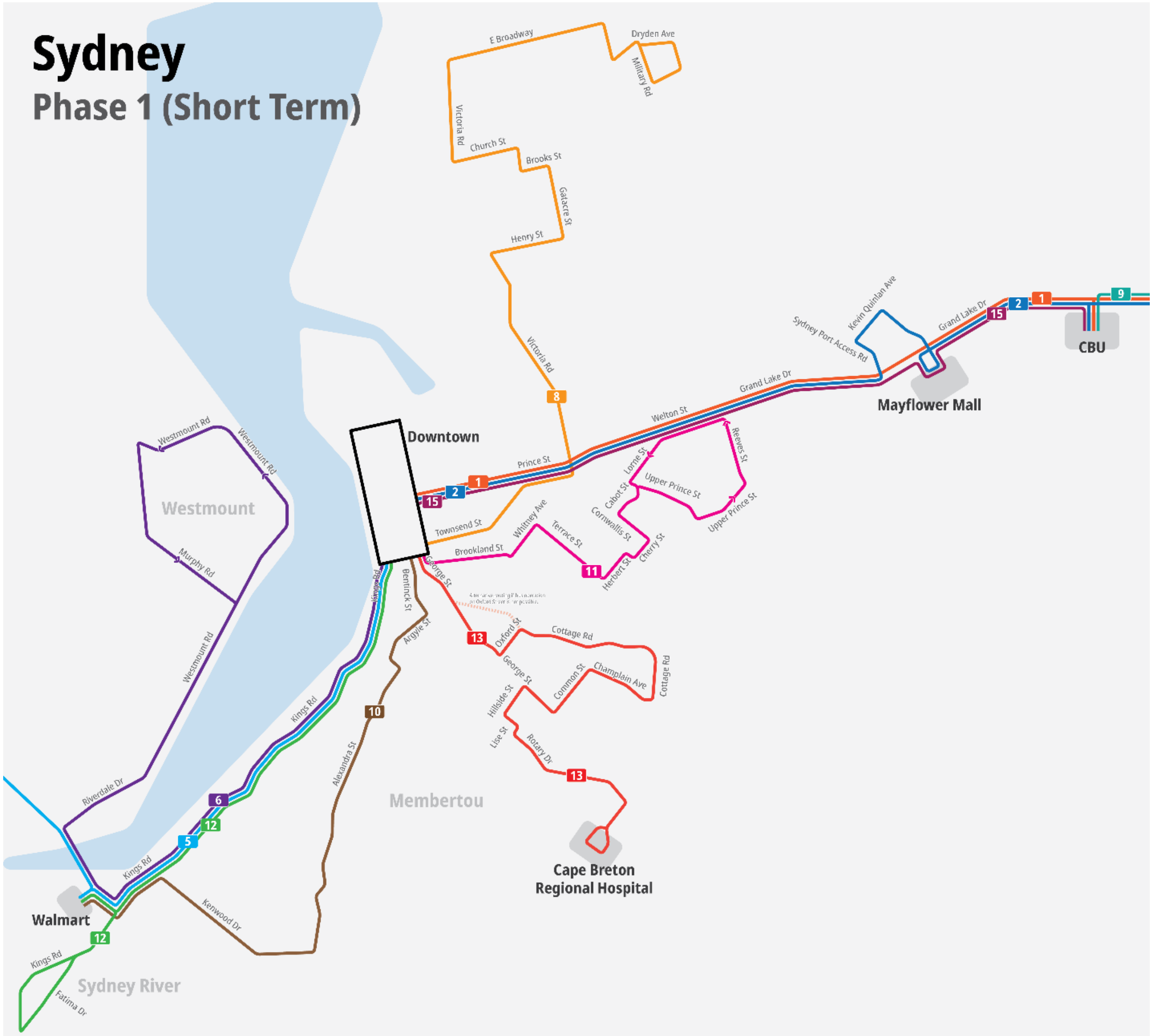

Figure 16: Proposed Route Structure (Sydney) - Phase 1

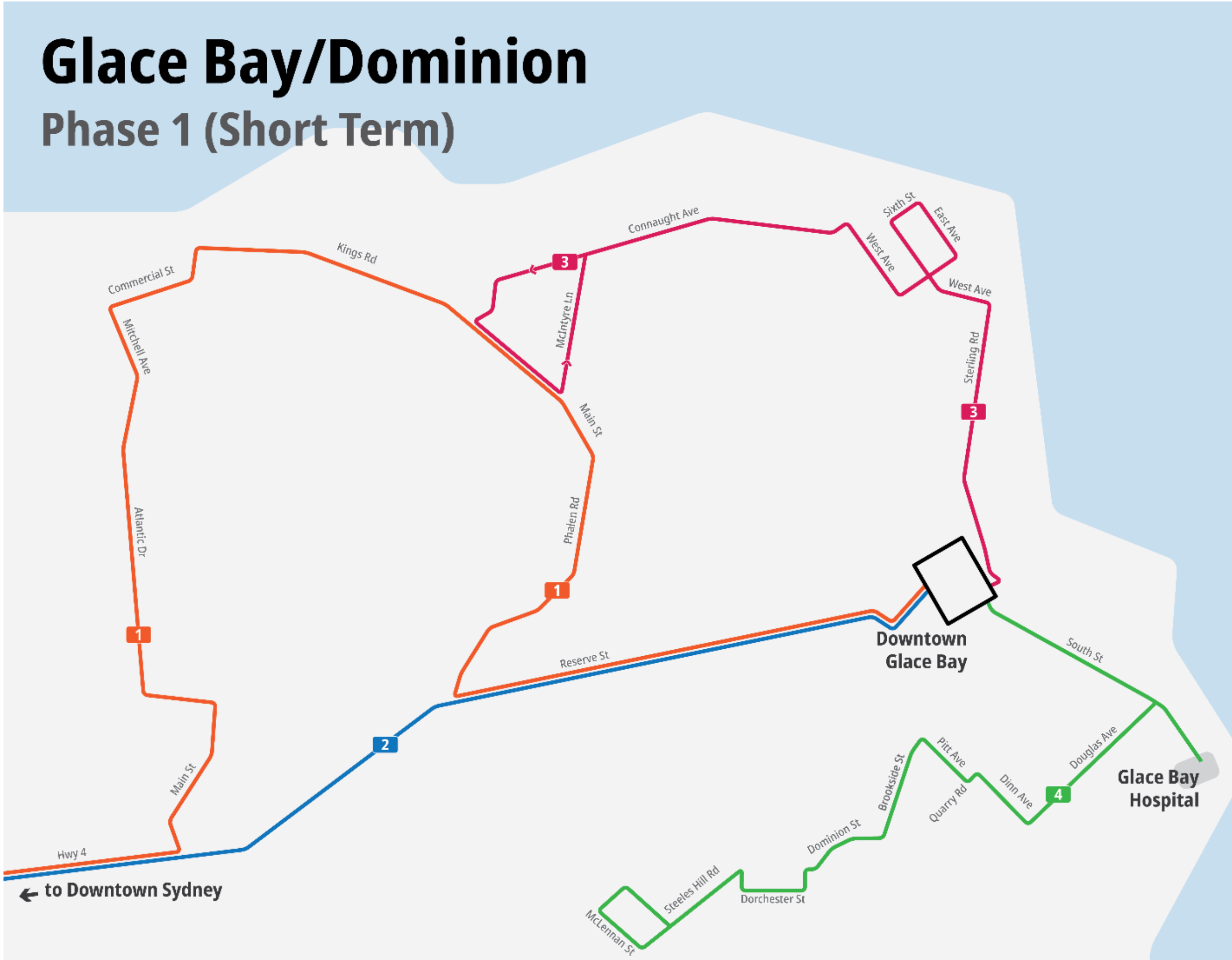

Figure 17: Proposed Route Structure (Glace Bay) - Phase 1

Figure 18: Proposed Route Structure (North Sydney) - Phase 1

4.4.3 Phase 2

Phase 2 is intended to be implemented in the medium term. It requires 12 additional vehicles during peak service relative to current service. Changes are made with the goal of expanding service coverage and improving regional connections between communities. The proposed Phase 2 bus routes are illustrated in **Figure 19** to **Figure 21.**

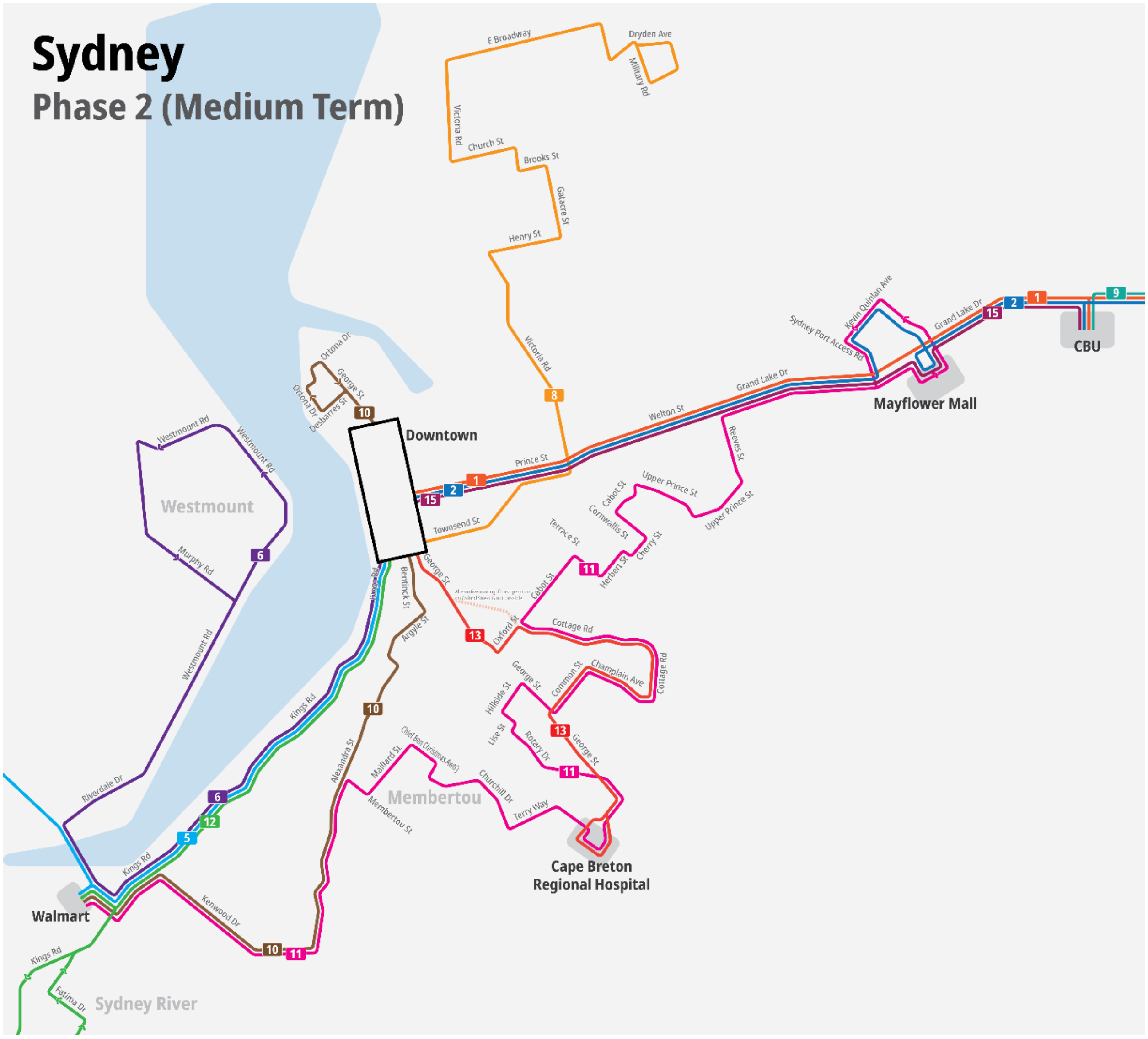

Figure 19: Proposed Route Structure (Sydney) - Phase 2

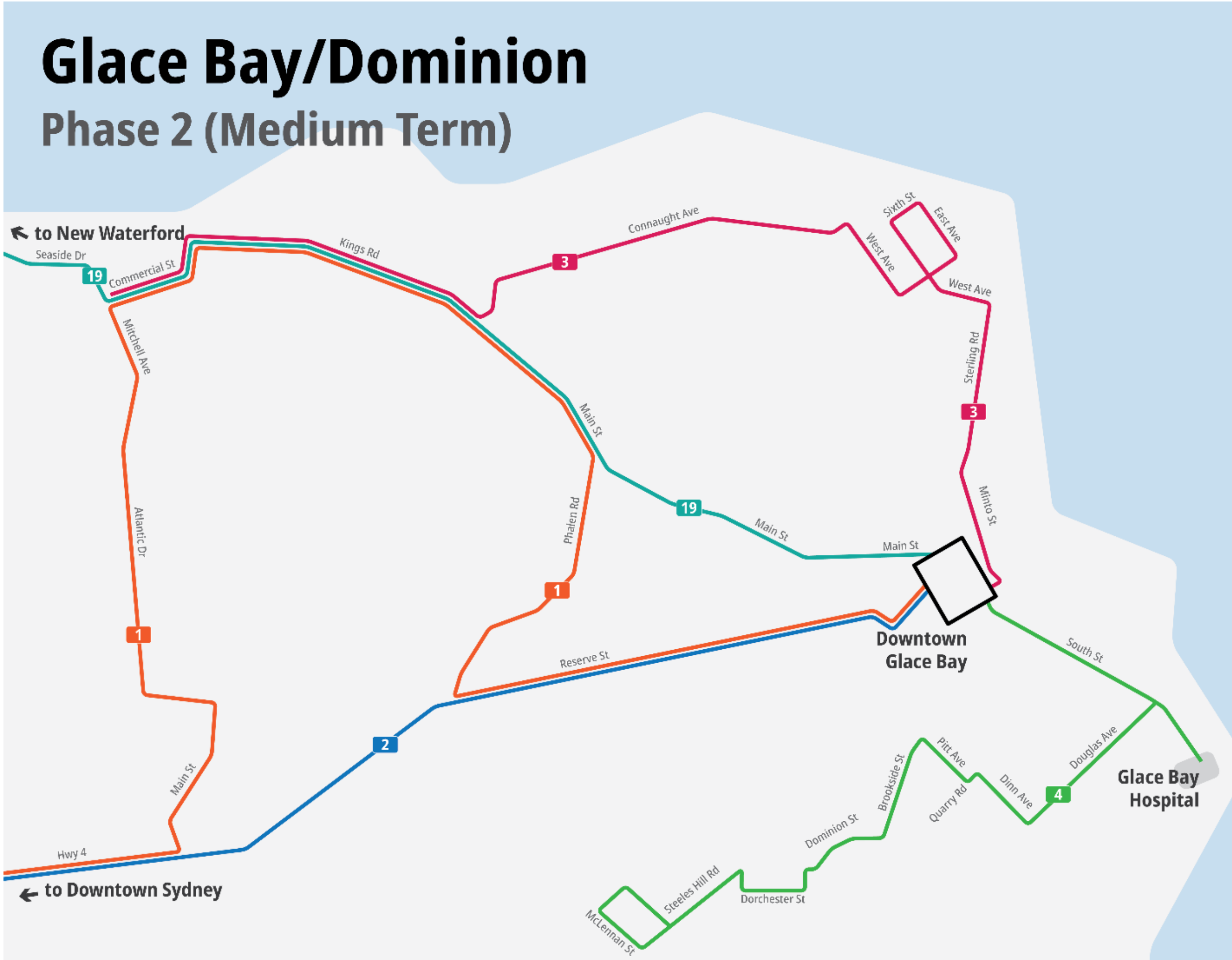

Figure 20: Proposed Route Structure (Glace Bay) - Phase 2

Figure 21: Proposed Route Structure (North Sydney) - Phase 2

4.4.4 Phase 3

Phase 3 is intended to be implemented in the long term. It requires 13 additional vehicles during peak service relative to current service. Changes are made with the goal of improving and expanding the bus network. This phase should be used only as a general guide and may be adjusted in the future based on emerging needs and priorities. The proposed Phase 3 bus routes are illustrated in **Figure 22** and **Figure 23.**

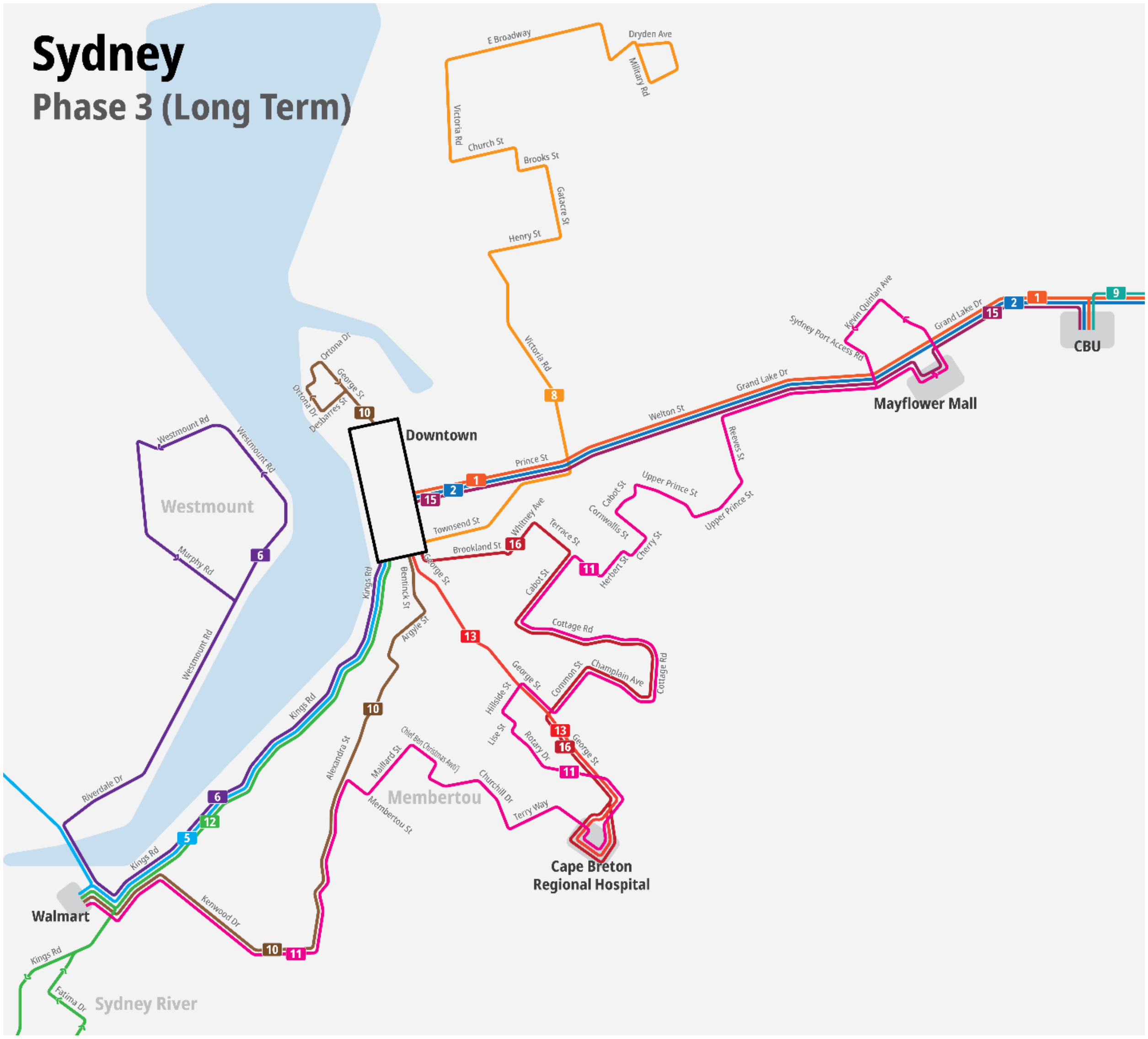

Figure 22: Proposed Route Structure (Sydney) - Phase 3

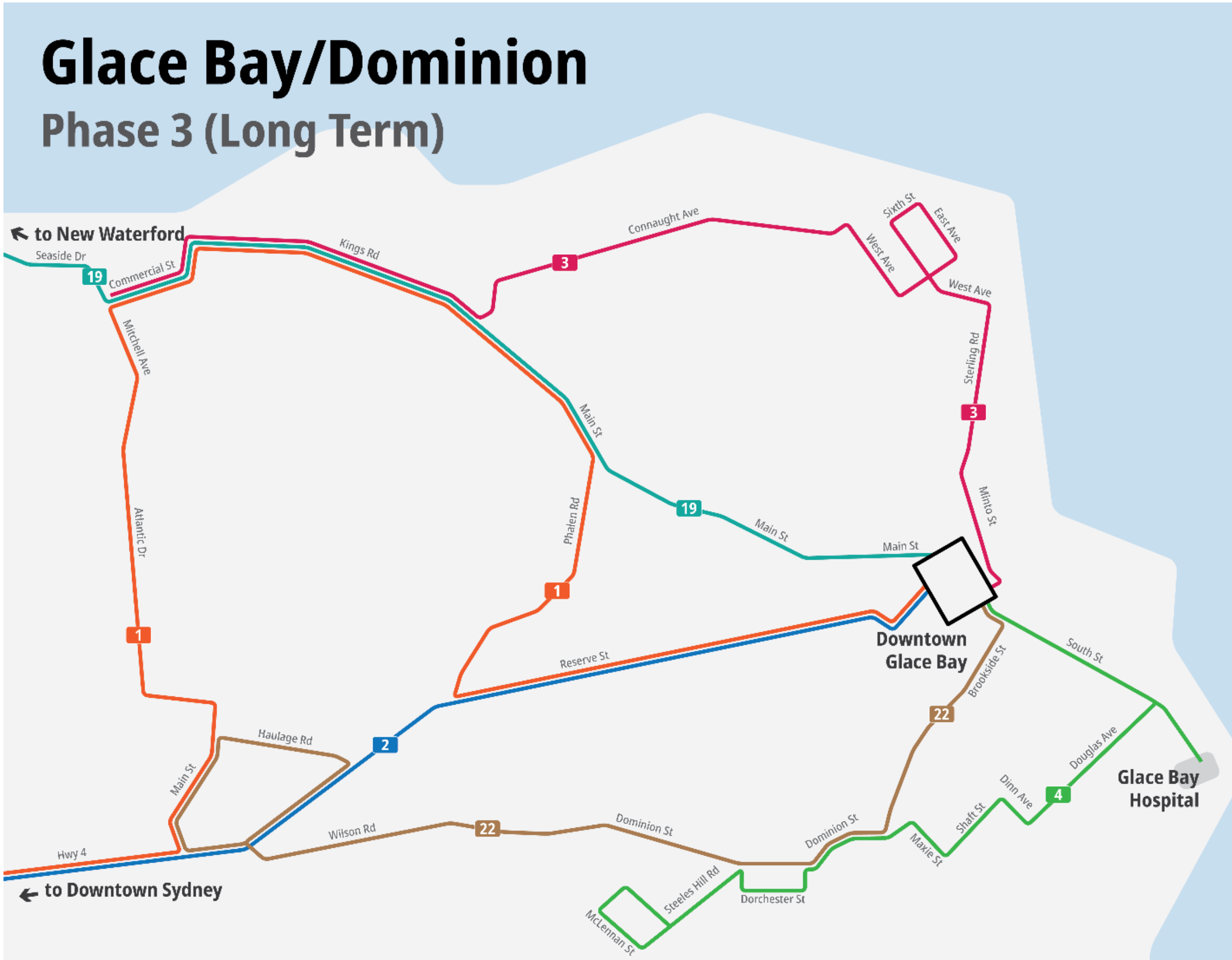

Figure 23: Proposed Route Structure (Glace Bay) - Phase 3

See **Appendix A** for a summary of estimated annual service hours and operating costs for each phase of improvements.

5 Fare Structure Review

5.1 Transit Fare Policies

Transit fare pricing policies are needed to enable Transit Cape Breton to price all fares to meet revenue targets – cash, tickets, passes, and transfers – in efforts to financially maintain or improve upon existing services, and to minimize deficits supported by the taxpayer. This Section summarizes the current state of Transit Cape Breton's fare policies and a proposed strategy that reflects priorities obtained through the community engagement process.

5.1.1 Existing Fare Structure and Fare Collection

Transit Cape Breton's zone fare structure is summarized as follows:

Table 9: Fare Structure

Fare Category	Single Zone	Cost Per Extra Zone
Adults and Students	$1.25	$1.00
Seniors	$1.00	$1.00
Children 5-12	$1.00	$1.00
Children under 5	Free	Free

A book of tickets (valued at $13.75) can be purchased at $12.50, representing a $1.25 or 9% discount. Tickets that do not provide for the full fare can be supplemented by cash. Books of tickets can be purchased at Shoppers Drug Mart, Cape Breton University (CBU), and City Hall. Monthly passes are sold at CBU (Student Union) and City Hall; however, the effort to implement the program is reported to be high.

The concession fares are offered to seniors aged 55 and older, which is below the typical threshold of 65 years of age in Canada. Children under 5 accompanied by an adult are provided with free transit, which is the norm in many cities across Canada because it allows parents to travel without paying an additional fare.

Tickets and cash fares are deposited in 'drop boxes' that are scrutinized by the bus operator to ensure full payment is made and transfers are valid for one-way travel on the next bus. The fare boxes are delivered at the end of the day to the secure coin room where tickets are manually separated and counted the next day. An empty drop box is then installed on the bus for the next day.

In 2022, Transit Cape Breton carried approximately 1,500,000 revenue passengers and collected an estimated $2,100,000 of total fare revenues with over half received from Cape Breton University students.

5.1.2 Public Input on Existing Fare System

To solicit feedback from the public and key stakeholder groups on (among many subjects) Cape Breton Transit Fares, the Project Team held a series of Transit Focus Groups (TFG) during the week of January 9, 2022 as well as in-service observations by the consultant, and by an on-line community survey. Participants had identified issues associated with the existing fare system, from both the customer perspective and from that of bus operators and management.

Transit customers, particularly existing residents new to Transit and university students moving to the area, are in many cases confused about the zone-based fare system and transfer policies. This creates significant delays as they board transit vehicles which, in turn, causes bus delays; this negatively impacts schedule reliability, resulting in missed connections. At a time when demand is at its highest level ever, this is a significant issue if customers miss their transfer connection and are left to wait up to an hour for the next bus, especially during inclement weather.

From a Transit operations perspective, bus operators confirmed that the time needed to explain the fare system to passengers, validating tickets, passes and transfers does take several seconds. In some cases, bus operators have to deal with fare evasion when cash fares are deposited – operators do not have the time to verify the amount of cash deposited – while transfers can be invalid, and there are reports that tickets are either counterfeit or are peeled in two. Confrontations are inevitable between bus operators and customers.

In summary, the existing fare structure and fare payment options are complex, not customer-friendly, impacts Transit schedules negatively, results in lost revenue through fare evasion, counterfeiting, and time-consuming confrontations between bus operators and Transit customers. To address the fare challenges, fare pricing strategies and fare collection alternatives do exist; however, these challenges can best be met with the use of smart card technology, which is becoming the norm in the Transit industry.

To develop a Transit Cape Breton fare strategy, the following have been addressed:

- A description of the Transit smart card technologies available;
- The benefits and business case for a smart card technology fare payment system; and
- A proposed fare pricing strategy that is customer-friendly and builds on the availability of smart card technology.

5.2 Overview of Smart Card Technology

Transit smart card systems have significantly grown in popularity since the 2010 CBRM Transit System Review to replace the need for transit customers to carry exact cash fares, tickets or passes and the need, in many transit agencies, to purchase far more expensive electronic registering fareboxes that are equipped to count coins and paper currency. Smart card systems enable transit customers to load value on a microchip-based card that acts like an electronic purse (e-purse), also referred to as a farecard.

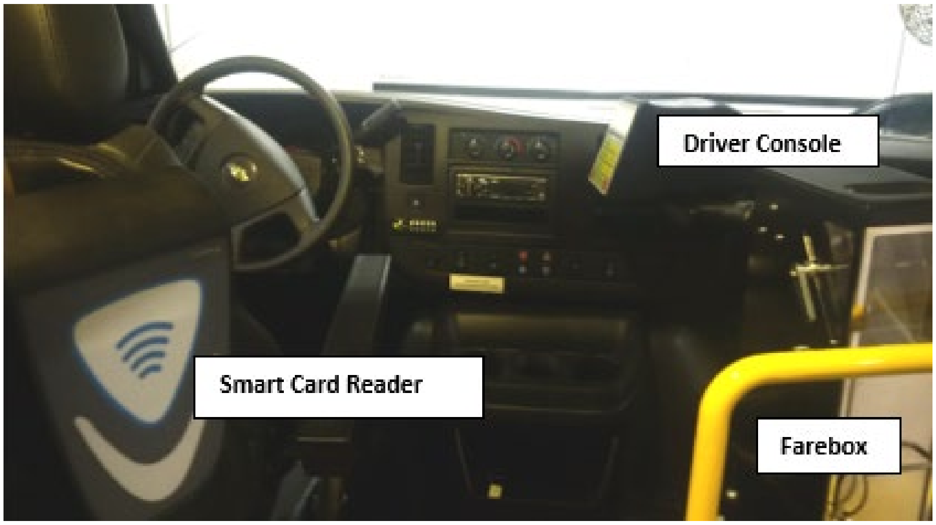

Figure 24: Overview of Smart Card System

The transit smart card has monetary value similar to those typical of retail sector loyalty cards; however, that's where the similarity ends. What differentiates the transit smart card from a retail card is the back-end software that consists of 'business rules' such as a complex fare pricing system built into the card, including the option for mobile apps to pay fares when boarding. Value can also be reloaded onto the (re-usable) smart card, as required, in-person or on-line.

Transit smart cards also reduce the cost of the revenue management system (RMS) – fare collection and verification, coin counting, printing, and distribution of paper media (e.g., tickets and passes), commissions paid to sell fare media, and farebox maintenance in the case of registering fareboxes (Transit Cape Breton uses gravity-based 'drop boxes'). Transit smart cards also significantly reduce or eliminate revenues lost to fare evasion and counterfeit.

Another critical benefit of an integrated smart card-GPS system (see **Figure 24**) is that CBRM would not only be able to monitor bus stop activities, but also acquire schedule adherence performance data. This would provide the information needed to adjust schedules, as required, and provide the CBRM with the ability to monitor the performance of all services. Monthly and annual transit ridership and performance reports can be produced instantly; this would greatly benefit CBRM given the very lean management and administrative staff structure.

Other benefits of the smart cards include:

- Reduced boarding times
- Tracking of smart card use through embedded serial numbers
- Flexibility in fare pricing (i.e., to the one cent level, if required)
- Ease of implementing fare changes
- Built-in times for transfers, which do not have to be viewed by the bus operator
- Ridership boarding data for 100% of all trips

- Enables mobility payment from a smart phone
- Built-in GPS will enable Transit Cape Breton and Handi-Trans to add real time schedule information
- Lost or stolen smart cards can be replaced with the remaining value credited to the Transit customer

Knowing bus stop boarding activities by passenger classification (child, student, senior, and adult,) will also help identify priorities for bus stop infrastructure enhancements such as concrete bus pads, benches and shelters. There is no ongoing requirement for a server or support required from CBRM IT staff since the supplier would host and manage the secure data, which can be accessed by Transit staff.

A significant breakthrough of smart card technology since the development of the 2010 Transit Cape Breton Transit Master Plan is that the technology is far more affordable and not the purview of only larger transit systems with significant financial resources. Transit systems across Canada with as few as a single bus have now successfully embraced the technology. While the use of smart card and related technologies provide unprecedented benefits to Transit customers, from a business case perspective, there are financial savings that would be incurred by CBRM to support a smart card system investment.

A growing number of small transit systems across Canada now utilize low-cost fare collection technology that is integrated with GPS. The technology is considered a transit ridership growth strategy given its ease of use and eliminating the need for exact cash fare. By integrating with GPS, the Transit Cape Breton and Handi-Trans would be able to track transit use by bus stop, direction and time period (by trip, by hour, time of day, week, month, and annually).

Benefits of using smart cards are summarized as follows:

- Reduced Revenue Management System (RMS) costs by eliminating the need to print and distribute tickets, passes and transfers, and reducing the time and effort to count and report daily fares deposited in the coin counting operations
- Elimination of commissions paid to sell various fare media
- Eliminates fare evasion and counterfeiting (i.e., added revenue)
- Reduced boarding times
- Tracking of smart card use through embedded serial numbers
- Flexibility in fare pricing
- Ease of implementing fare changes
- Availability of tracking bus stop use by any time period

5.3 Smart Card Business Case Assessment

5.3.1 Lost Revenue Savings

In 2022, Transit Cape Breton carried a historical record of 1,500,000 revenue passengers and collected $2,100,000 in passenger fares. This represents an average fare paid of $1.40. With a steady increase of the CBU student body in 2023, the ridership and revenue experience in 2023 is expected to be even higher; however, for conservative estimate purposes, 2022 figures will be used.

Tracking of revenues lost due to fare evasion (e.g., coin shortage, lack of zone fare knowledge by new transit customers/ students and counterfeited tickets), Transit staff, including bus operators, estimate that in excess of 10% revenue loss is experienced. For conservative estimating purposes, a figure of 7% revenue loss was recommended. The 2022 average fare paid was $1.40. If a smart card system was in place to virtually eliminate fare evasion, the average fare would have been 7% higher at $1.53 per passenger. This translates to a revenue loss of approximately $140,000 in 2022.

5.3.2 Transit Operating Budget Impact

For the purpose of developing a conservative business case to support the purchase of a smart card system, those savings that will impact the Transit operating budget were estimated. These cost benefits include recovering lost revenues due to fare evasion and counterfeiting, eliminating commissions paid to sell tickets and passes, and the cost to produce tickets and passes.

Cost savings that are not realized in a Transit operating budget include reductions in staff effort (i.e., coin room sorting and counting) where staff hour savings realized can be allocated to other more important administrative functions; fare distribution effort, data collection/ analysis and reporting. A critical operational benefit is that more efficient Transit operations would be realized through improved schedule adherence and transfer reliability (e.g., missed transfer connections), while transit ridership growth could be expected due to ease of use, especially compared to existing transfer rules and the zone fare structure that could be eliminated.

With the installation of a comprehensive smart card system, the Transit operating budget can be reduced by:

- $15,000 elimination in the cost to produce tickets, passes and transfers
- $155,000 in commissions paid to sell fare media to CBU (based on 2023 data)
- Up to $140,000 in additional revenue through the elimination of fare evasion
- $360,000 total per year in potential budget savings

With the implementation of a smart card system, costs reductions, coupled with anticipated revenue savings, equates to a net positive impact on the transit budget of $310,000 annually.

5.3.3 Smart Card System Cost

The cost to equip Transit Cape Breton and Handi-Transit with a smart card system can vary, depending on the number of vehicles equipped, options selected and the vehicle types. The number of vehicles scheduled during the peak hour are 17 Transit and 7 Handi-Trans vehicles, while there are also 8 Transit bus/ minibus spares and 2 Handi-Trans spares. While in-service vehicles would be fully equipped with the smart card technology, unallocated spare vehicles can be equipped with brackets to quickly mount the smart card equipment from vehicles that are out of service due to long-term periods of maintenance.

When budgeting for a smart card system, it is imperative to seek bids on the equipment to be installed as well as the software required and ongoing support costs by the supplier.

Based on relatively recent smart card system procurements, a turnkey smart card system cost based on the in-service and spare Transit and Handi-Trans fleet is estimated at $225,000. Maintenance costs after the first year would approximate $25,000 per year. To obtain real time passenger information for Transit, an additional cost of $50,000 has been estimated. To be conservative, it is suggested that $250,000 be set aside for a smart card system for the first year, while setting aside $75,000 for the second year for real time passenger information. This could help offset recent inflationary budget challenges.

Regarding staffing impacts of the Smart Card system, once installed, there is no need for staffing other than to liaise with the supplier, and therefore no additional administrative staff would be required. Point of purchase units can be placed anywhere (municipal buildings, etc.) and card value can be loaded on-line. All reports etc. are developed prior to implementation. All equipment is modular and can be replaced, if required, in a few minutes by existing maintenance staff.

Regarding data collection, all Smart Card data is reported in real time and accessed through the 'cloud' so there is no need for servers or additional technical support staff. Driver and maintenance staff would be trained in advance; an exercise requiring an estimated 1/2 day of each staff member's effort. Coin counting efforts would be negligible.

Ongoing support would be provided by the supplier, so the associated costs can vary. It is recommended that CBRM request ongoing support costs in their request for quotes for the Smart Card system. This is not included in the above-noted estimate.

5.3.4 Summary of Business Case to Support Smart Card Investment

With the installation of the smart card technology, commissions paid to sell fare media could be virtually eliminated since smart card value can be replenished on-line while the printing of tickets and passes would be eliminated. This cost savings of $155,000 per year combined with the potential fare revenue increase of $140,000 per year provides an estimated net positive impact of $310,000 per year in the annual Transit budget. Given the estimated $225,000 cost of a comprehensive smart card system, there will still be an eventual net surplus of $85,000 per year – a positive impact on the existing budget. It is worth noting that this excludes any fare increase in the existing fare structure.

To put the savings into perspective, $85,000 in annual savings equates to adding 1,200 hours (approx.) of bus service annually. This would equate to 2 additional buses between CBU and the downtown being added during the weekday peak hours (4 hours total per day per bus).

The business case to introduce smart card technology based, coupled with the very positive feedback from Transit stakeholders, including Council members, a smart card system should be secured as soon as possible. Once the system is in place and benefits are confirmed, the real time passenger information option could be added.

It is recommended that CBRM include a minimum $250,000 in the 2024 Transit operating budget for the purchase and installation of a smart card system.

While the business case supports the procurement of a smart card system, there are also other longer-term benefits, namely, more efficient use of staff and more efficient Transit operations as a result of improved schedule adherence described below.

5.3.5 Increased Bus Efficiency

Transit boarding time savings are significant. For example, the time taken to deposit and verify cash fares deposited, tickets, passes, and transfers can take an estimated 5 seconds average per boarding. In comparison, boarding with a transit smart card will take an estimated 1.5 seconds. If, for example, 50 passengers boarded a bus during a 30-minute peak trip, the current payment process will take an estimated 4.2 minutes. If all 50 passengers boarded with a farecard, the total time attributed to boardings would approximate 1.25 minutes; this would save an approximately 3 minutes per roundtrip, sufficient to address many schedule adherence problems experienced today.

In the case of Transit Cape Breton, the delays are likely much higher since newer Transit customers, such as new residents and foreign university students, currently require bus operators to answer complex fare system questions prior to paying fares. A Transit customer boarding a bus with a smart card does not have to know the fare amount, so no questions need to be asked.

5.3.6 More Efficient Use of Staff

The cost of the administrative support staff that is allocated to manually counting fares is approximately $57,000 per year, of which approximately 70% ($40,000) is dedicated to the RMS process. Given the lack of administrative support in Transit Cape Breton, the time savings can be better allocated elsewhere.

5.3.7 Other Municipal Applications for Smart Card Technology

The rollout of a smart card system for Transit Cape Breton and Handi-Trans, card reader equipment can also be placed at all municipal facilities that collect revenue such as at sports venues, library, parking, etc. With modifications to the back-end software, the same transit smart card can be used for payment of other municipal services. If lost or stolen, registered smart cards can be replaced for a nominal fee and the value remaining would be loaded on the replacement card.

5.4 Fare Pricing Principles

To guide fare structure decisions, a number of fare pricing principles are recommended for consideration:

- The fare structure should be easy to understand and enforce
- Elimination of the zone-based fare structure
- To encourage smart card use, cash shall be the highest fare paid and be the same for all Transit customers. Discount fares should only be available on the smart card
- Smart card fares should be priced at a 10-20% discount to the cash fare to provide a financial incentive to use smart cards
- Concession (discount) fares, if desired, should target various markets to grow ridership
- Transfers should be valid on all routes and in any direction, acting as a ‘period’ pass.

5.5 Smart Card Fare Pricing Strategies

There are a number of fare strategies that have been successful in growing ridership that can be applied to Transit Cape Breton.

5.5.1 Allow for Single Cash Fare Only

Transit fares have not been increased in over 40 years, resulting in an average fare of only $1.30 in 2022. Adult cash fares currently range from $1.25 for travel within a single zone (Sydney urban area), $2.25 when travelling to Zone 1 from Zones 2,3 and 4 and up to $3.50 from Zone 5 when travelling to Zone 1, crossing two zones.

Recommendation: The base transit cash fare should be set at $2.25 and apply to all Transit customers for travel within all zones.

5.5.2 Seniors Fares

Transit systems across Canada classify seniors as being aged 65 and older, while at Transit Cape Breton the threshold is 55 years and older. Given that fares have not increased in over 40 years, a significant increase can be justified. It is suggested that the definition for seniors be established at 65 years of age.

5.5.3 Two-hour Time-based Transfer

Transit Cape Breton customers can transfer on any route in one direction and are issued a transfer upon boarding. The transfer is valid for a period that enables them to transfer to the next bus but not for a stop-over or the return trip. A growing practice among transit systems is the issuance of a time-based transfer that allows customers to transfer to any bus and in any direction within a specified period of time. This policy is in place in many transit systems across Canada and is considered revenue neutral.

The policy will allow, for example, a parent to take their pre-school child to a day care centre by bus, then board the bus in the same direction to continue their journey to work without paying an additional fare. A transit customer will also be able to go for short-term shopping and return on the same fare. Another benefit is that all transfers are the same for all routes, which eliminate fare disputes.

It is recommended that Transit Cape Breton provide a time-based transfer, which is valid within all zones served by Transit for a period of 2 hours from time of the initial boarding.

Note: While the single cash fare would significantly increase from $1.25 to $2.25, the fact that a transfer would be valid for two hours, would enable some return trips to be completed on a single $2.25 fare, which is a $0.25 savings compared to the existing return trip cost of $2.50.

5.5.4 University Pass (U-Pass)

Sustainable revenue sources provide transit systems with the ability to plan based on sustained predictable revenue sources. University fare policies such as the 'U-Pass' have proven to be a boon for many transit systems while being well received by students, with several experiencing major student ridership increases. The U-Pass is a transit pass provided to all students for free transit travel and is added to student activity fees similar to other programs funded by students. The cost would be based on a deep discount. With the expansion of service proposed and growing student populations, the U-Pass will be more attractive to Cape Breton University students. To implement the U-Pass, ongoing conversations with CBU staff and student representatives are needed, and ultimately, a decision can be achieved through a student referendum.

As of the 2022 school year, CBU offers the following bus pass-purchasing options to their students:

- CBU offers all students a 30-day bus pass at the rate of $60/month, which is consistent with the regular student bus pass rate offered by CB Transit
- Students who study at the downtown Cineplex location in the Spring/Summer semester are eligible for a $50 credit towards their next bus pass, this offer expires in September
- Students who study at the downtown Cineplex location in the Fall semester are eligible for a discounted bus pass at the rate of:
    - 3-month pass for $150 ($30 discount)
    - 4-month pass for $180 ($60 discount)

Given the significant rise in the student population, it is recommended that Transit Cape Breton continue negotiations with CBU on the introduction of a University Semester Pass to the whole student body through a student referendum.

5.5.5 High School Student Activity Pass

Organizations recognize that marketing to teenagers creates customer loyalty at an early age. With respect to transit, marketing to high school students is the equivalent, as they become the customer base for the future. There is also a more recent phenomenon that students today are more unlikely to purchase vehicles in the future; many will also defer obtaining a driver's licence. Since the pass would only be valid after school hours, evenings, and weekends, there would not be any vehicle capacity issues to accommodate the expected increase in ridership.

It is recommended that Transit Cape Breton provide a monthly After School Activity Pass (smart card) based on the cost of 14 trips per month at the single cash fare and would be valid weekdays after high school ends and all day on weekends. This should be assessed after one year.

5.6 Proposed Fare Pricing Policies

The cost of doing business increases with inflation and is increasingly vulnerable to spikes that occur in fuel prices and labour costs.

To guide staff, it is recommended that following fare pricing policy be in place:

- Transit fares should keep pace with inflation to the extent possible, balancing affordability with fiscal responsibility. Although fare increases are never popular, they can be more justified when supporting Transit service improvements.
- Cash fares should be the same for all passengers to encourage discount forms of fare payment that, in turn, encourages transit use.
- Smart cards used to board Transit should be discounted by up to 20% to encourage smart card use
- Student Activity Passes should be priced at 14 trips per month and re-evaluated after one year.

While fare increases are not popular, they are necessary. As evidenced in the over 40 years since the last fare increase, Transit budgets have been challenged due to normal inflationary pressures such as in the cost of fuel and equipment. A significant immediate increase in the fares is justified but fares would still remain well below the industry norms. Rather than catching up overnight, it is recommended that fares increase each year to better enable Transit to improve service and have the appropriate technology, vehicles, and infrastructure in place to meet both existing and future demand.

When setting future fares, consideration can be given to increasing the single cash fare at a higher rate than discount fares offered in a smart card. The rationale is that those that pay cash fares are likely infrequent users of Transit and are less price sensitive, especially since the cost of alternatives such as taxis are significantly higher.

As Transit revenues increase through fare increases and ridership growth, so does the ability of the Regional Municipality of Cape Breton to support future service improvements. This will benefit both residents and businesses.

5.7 Review of Transit Taxes

A review of how taxes are collected for transit service is undertaken for several peer municipalities. The findings of the peer review are summarized in **Table 10.**

Table 10: Transit Tax Peer Review Summary

CBRM. NS	Halifax, NS	Moncton, NB	Saint John, NB	Niagara Falls, ON
Transit tax rate in Sydney (residential): $0.1042 per $100 of assessment. Transit tax rate in all other areas: $0.1250 per $100 of assessment	Pay a “local transit rate” if living within one km walking distance of any conventional or community transit stop. Residential transit tax rate: $0.091 Commercial rate: N/A	Transit is included in the base rate of $1.4231 per $100 of assessment	Transit is included in the base rate of $1.58 per $100 of assessment	All properties pay a transit tax rate, ranging from 0.024% for farmland to 0.19% for multi-unit residential

Due to the area taxation policy in CBRM, the areas currently not paying transit tax (consequently unable to receive transit service) include:

- Oland Heights
- Tower Road
- Donkin
- Florence
- Alder Pt
- Mill Creek
- Birch Grove
- Carmichael
- Other unserved areas (where other services are also not provided)

Recommendation: Consider implementing a blanket transit tax across the Region to support the implementation of transit services to all areas, supporting housing needs and contributing to the local economy.

6 E-Bus Technology Review

This review involved an industry scan of zero emissions propulsion technology vehicles that are commercially available and their requirements in North America. This scan developed a clear picture of the zero-emissions landscape in North America and Canada. The following are examined to help guide recommendations and the decision-making process in CBRM:

- List of North American vehicle manufacturers, vehicle models, and specifications;
- Buses in service at other North American transit agencies;
- Canadian fuel source availability and suppliers;
- Emissions data for each propulsion option, including Scope 1 and Scope 2 emissions; and
- Infrastructure requirements, such as facility requirements, fueling equipment, supporting infrastructure, commercial availability and any codes and standards.

The review compared Battery Electric Bus (BEB) technology to Fuel Cell Electric Bus (FCEB) technology. Given the prevalence of BEB technology in use in the industry over FCEB, the availability of fuel, relative ease of implementation and maintenance of equipment, and capital costs, CBRM will employ a BEB system.

The full E-Bus Technology Review is documented in **Appendix B**. The following sections present a summary of the key findings as they pertain to BEB infrastructure.

6.1 Bus and Fuel Availability

Zero-emissions vehicles (ZEVs) are vehicles with the potential to produce no tailpipe emissions, such as battery-electric (BEV), plug-in hybrid electric (PHEV), and hydrogen fuel cell electric (HFCEV) vehicles.[1] They counter the traditional internal combustion engine vehicles (ICEV) that emit a higher amount of greenhouse gas (GHG) emissions. This section contains a list of vehicle manufacturers producing light, medium and heavy duty zero emission vehicles and a more detailed table with manufacturers of zero emissions buses and vehicle models. The information in this section is from the US Department of Energy's Alternative Fuels Data Center and is up to date as of January 5, 2023.[2]

CBRM's current transit fleet consists of a mix of medium- and heavy-duty vehicles. The zero emissions propulsion options for medium- and heavy-duty vehicles are battery electric, plug-in hybrid, and fuel cell electric. The definitions for the vehicles are:

- **Battery Electric Vehicles (BEVs):** Includes a battery pack and an electric motor instead of a fuel tank and an internal combustion engine. The battery must be recharged by the electric grid.

- **Plug-in Hybrid Electric Vehicles (PHEVs):** A combination of gasoline or diesel and electric vehicles with battery, an electric motor, a gasoline tank, and an internal combustion engine. They are considered zero emissions when gasoline/diesel is not being used as a fuel source. Hybrid electric vehicle have series or parallel configurations depending on how mechanical power is created by the battery and engine. Some PHEV models operate on electricity until the battery is almost empty, which is when gasoline/diesel takes over. Other PHEVs use both electricity and gasoline at the same time.

- **Fuel Cell Electric Vehicles (FCEV):** Uses a motor only and use a fuel cell to create on-board electricity by using compressed hydrogen and oxygen from the air.

- **Medium- and heavy-duty vehicles** options aligning with CBRM's fleet range from pickup trucks and passenger/shuttle buses to transit buses are shown in **Table 11.**

Table 11: List of Medium and Heavy-Duty Vehicle in North America

Vehicle Type	Manufacturer	Category	Engine size/ cylinders (L)	Battery (kWh)	Stated all-electric range (km)	Number of Passengers
BEV	Battle Motors, Blue Bird, BYD, COBUS Industries, Collins Bus Corp., ENC, Ford, Freightliner Custom Chassis	Passenger Van / Shuttle Bus, School Bus, Step Van, Transit Bus, Van, Vocational / Cab Chassis	-	68-676	100-529	16-110
PHEV	US Hybrid, Ford	Step Van, Passenger Van/Shuttle Bus, Pickup	7.3	-	201-451	25-29
FCEV	ENC, New Flyer	Transit Bus	-	-	-	43-52

There are two main **zero-emission bus** types – battery electric buses (BEB) and fuel cell electric vehicle buses (FCEB).

Battery electric buses (BEBs): BEBs are electric buses that are driven by one or more electric motor(s). Their energy comes from the on-board high voltage batteries, which means any voltage above 50V for BEVs, but BEB batteries are anywhere between 400V and 800V. The batteries power an electric motor and must be charged for a period of time to continue to operate. They can either be charged at a facility or along the route. The bus design is similar to a diesel bus but it operates quietly and provides savings for fuel and GHGs. Unlike diesel buses, BEBs have a range of 40 to 400km between charges, whereas diesel buses have 500 to 600km range before refueling. **Figure 25** provides an example of a Battery Electric bus and the components within it.

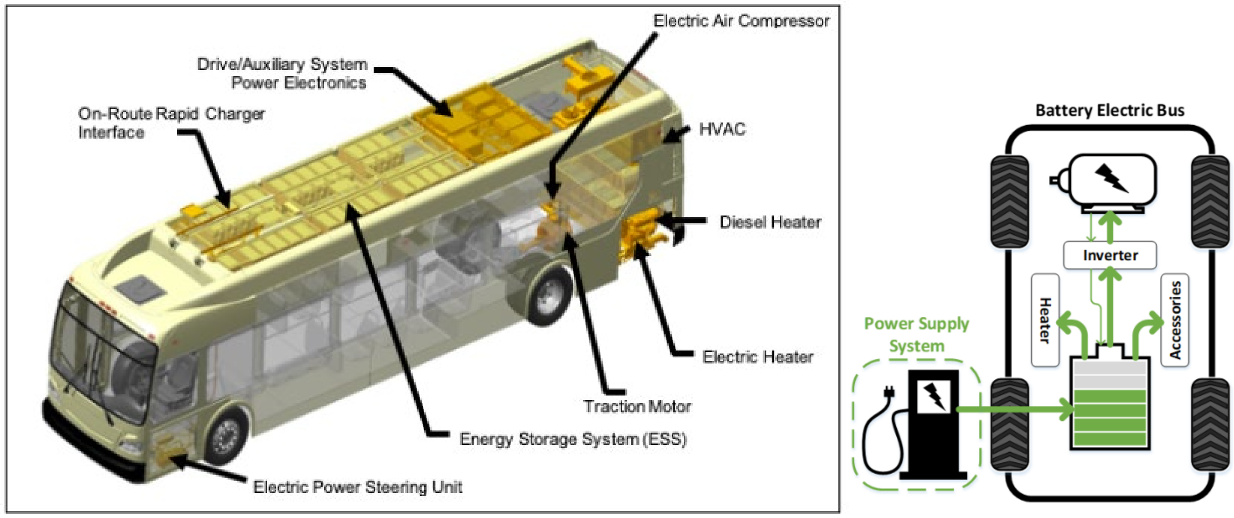

Figure 25: New Flyer Model XE40 BEB configuration system (Left) (Source: New Flyer Industries Canada ULC) and High Level BEB Schematic (Right)

Fuel Cell Electric Bus (FCEB) FCEBs use hydrogen and oxygen to produce electricity, which powers the propulsion system with only water as a byproduct. The fuel cell is often used alongside a battery that supplements the fuel cell's power during peak loads and stores electricity that is recaptured through regenerative braking. This process improves the fuel economy. **Figure 26** shows the main components of an FCEB.

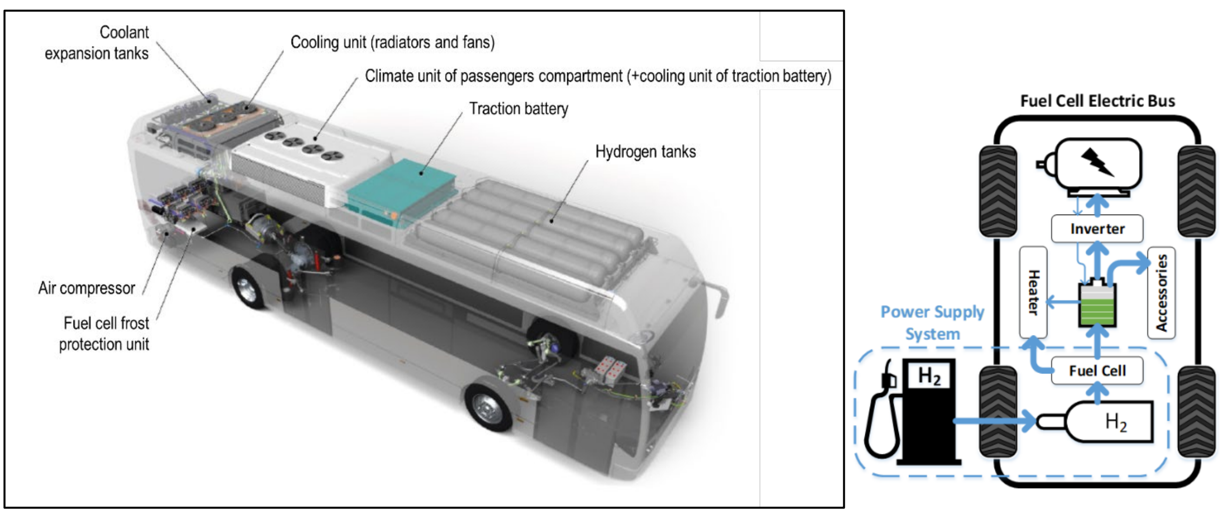

Figure 26: Example of an FCEB and its main components (Source: Van Hool NV) (Left) and High Level FCEB Schematic (Right)

Commercial availability, including supply chain network: BEBs are the more popular option because the technology is efficient in converting energy to power, more developed, readily available, and cost effective. BEBs also contain fewer mechanical parts, which typically results in lower long-term maintenance costs than diesel.

In terms of commercial availability, a rule of thumb based on experience in the US is that buses have a lead time of about 12-18 months while chargers have a lead time of 6-8 months from Notice to Proceed.

Turning to supply chain, BEBs from the manufacturers listed in the previous section are Buy America compliant for the US Market – meaning most parts will be from the US (approximately 70%). There are some larger components such as batteries and motors that can come from Canada, China, or Europe.

Currently, operation costs are unknown and there is a limited supply chain for FCEBs; however, hydrogen fuel cell technology is rapidly evolving and so should continue to be considered.

6.2 Review of Fuel Source and Supplier availability in Canada

Electricity is used to charge batteries in BEBs and comes mostly from the grid and other off-board electrical power sources, which in Nova Scotia can come from coal, petroleum coke, oil, natural gas, biomass, wind, tidal and hydro power plants. Recently, TTC formed a three-way partnership with Toronto Hydro and Ontario Power Generation (OPG) to scale charging infrastructure at the same time it procures buses for the fleet's expansion. Toronto Hydro will upgrade the electrical supply to TTC properties while OPG co-invests, designs, builds, owns, and operates electrification infrastructure on TTC property.

6.3 Facility Requirements

Bus yards or maintenance facilities are ideal locations for depot chargers because they are:

- Transit agency-owned and maintained
- Almost always at the end of the line for route
- Closed to other vehicular traffic

Some of the primary considerations for in-depot BEB charging for heavy duty vehicles are:

- Sufficient depot space for buses and charging posts.
- Ceiling space to handle chargers.
- Number of buses stored.
- Electrical Infrastructure (Charger needs to be installed where power utilities can provide a supply line).
    - As more electric buses are added, more chargers are required, and power requirements will increase. This will require upgrades to the utility service, including the addition of substations with large transformers (potentially 2 MVA and greater) and switchgears. Chargers and transformers will take up depot space, potentially reducing space for bus storage.

  - Need consider utility integration and optimal placement of transformers considering more will likely need to be added over time.

- Might need one charger per bus or multiple buses per charger (with multiple dispensers).
- Spare chargers are also needed in case a charger needs maintenance or has a malfunction.
- For initial deployments, it is a best practice to have one charger per depot-charged bus with a redundant charger to limit service interruptions.
- The design of the station and options for charger locations will dictate the number of chargers and the number of buses that can be stored.
- Overhead pantographs or reel dispensers attached to gantries are options for limited space.
- Facility upgrades likely necessary to improve structural (for installing overhead chargers), HVAC (to deal with added heat from charging) and safety (high powered equipment).
- New maintenance procedures will be needed to accommodate the charging infrastructure.
  - Fall arrest for working on top of buses where batteries are typically stored
  - Maintenance on gantry systems if overhead charging solution is chosen
  - Electrical protection on charging equipment

Medium duty vehicles (30’, 35’ buses) can likely use the same charging infrastructure as heavy-duty vehicles – however potentially at a lower charging rate. Light-duty vehicles will likely require separate charging infrastructure as they typically charge at a lower rate – ranging from as low as 40 kW to as high as 150 kW in some limited cases.

6.4 Fueling Equipment and Components

6.4.1 BEB Charging Station Components

BEB charging station components are:

- Transformer
- Switchgear
- Charger
- Dispenser(s)+

This is the main equipment, but more might be needed based on size of deployment, requirements from electric utility, and charging method. For example, at times more than one dispenser might be needed for one charger or one transformer and switchgear can support more than one charger (**Figure 27**).

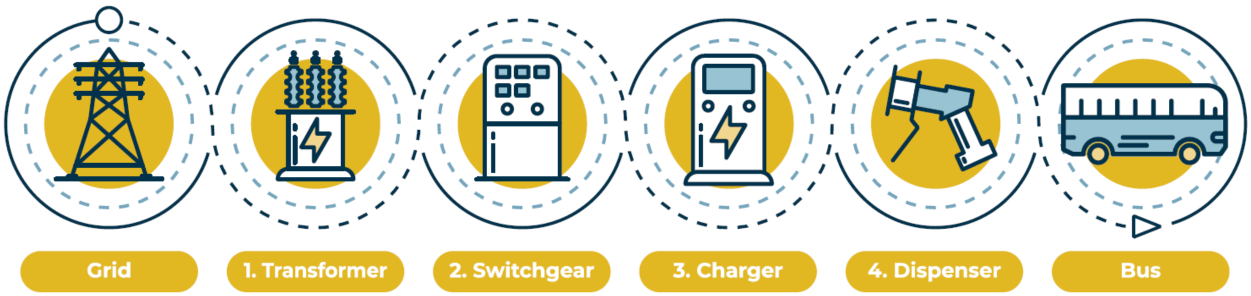

Figure 27: Generalized battery charging station schematic

The charger type that is chosen influences what types of other components are chosen so this section goes into more detail about charger types. This information is provided from Transit Cooperative Research Program (TCRP)'s Guidebook for Deploying Zero-Emission Transit Buses.

6.4.2 BEB Charger Types

EV charging continues to advance rapidly. More transit agencies are electrifying their fleets and more vehicles and chargers are entering the market or advancing technology within the market. A brief summary of current and emerging charging technologies is given below.

LOW-POWERED IN-DEPOT CHARGING

This charging is typically used in storage or garage facilities to charge slowly during the day or night at a lower power level. The charging operates at 150 kW power range or lower.

There are 3 levels of plug-in chargers for in-depot charging– levels 1, 2 and direct current fast chargers (DCFC). In most cases, charging with Level 1 and Level 2 is not feasible for larger vehicles due to the larger battery sizes, shorter charging windows, and the utmost need for reliable service. **Figure 28** describes the differences further and includes the power ranges and types of vehicles the charging is applicable for.

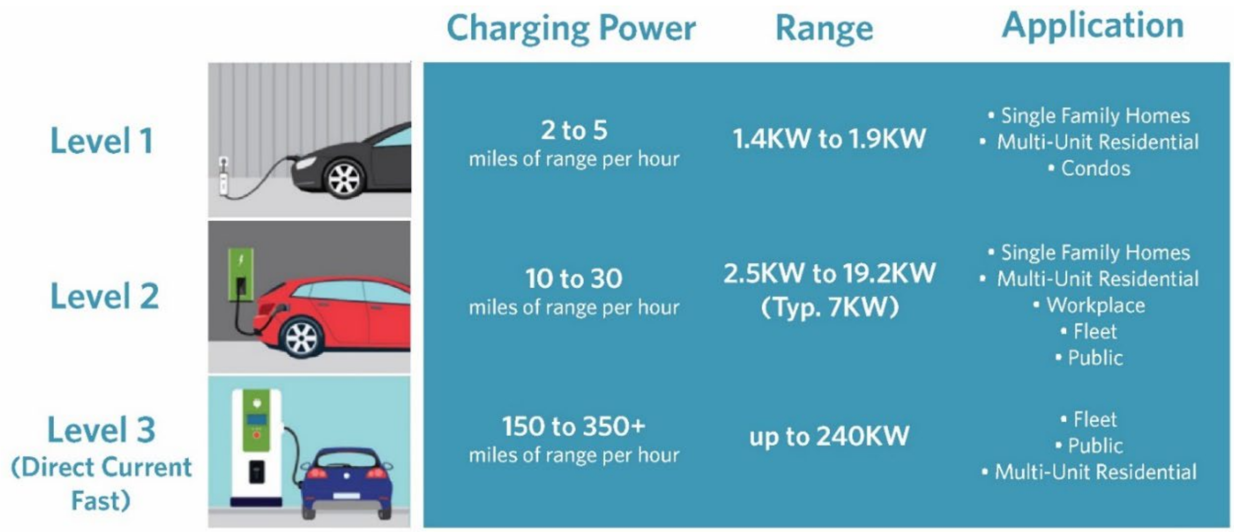

Figure 28:Types of EV Charging

MID-POWERED INDUCTIVE CHARGING

This charging utilizes a stationary charger buried under the pavement to wirelessly charge a vehicle stationed over the charger. Several different manufacturers are currently working on this technology for buses and heavy-duty vehicles as well as light-duty vehicles. They can have low-power levels of sub-100kW up to mid-levels of 300kW and can either be in the form of on-route charging or charging in a garage. One potential use for this technology in the future would be for induction chargers to be located within a roadway travel lane and charge EVs while driving so there is no lost drive time for charging.

HIGH-POWERED OVERHEAD/OPPORTUNITY CHARGING

Opportunity charging extends the distance and use of heavy-duty electric vehicles, particularly buses. These chargers often operate at a higher wattage (i.e., 450 kW) to deliver a quicker charge and are effective at extending the bus range by charging while the bus is stopped to load or unload passengers, such as at a transit center. It can also be installed at garages in the form of an overhead pantograph system. Typically, an overhead charging station with a range of 150 to 600kW will take 5 to 10 minutes to charge a BEB and will add 20 to 50km depending on geographical conditions.

HIGH-POWERED MEGAWATT CHARGING

The goal of this charger is to develop a universal (non-proprietary) method for charging electric heavy-duty vehicles within a reasonable time. The self-imposed requirements are that the charger utilizes a single conductive plug that is touch safe and bi-directional to charge a commercial vehicle (and possibly other forms of transportation) at 1 MW or greater of DC load. CharIN has tested several plugs and is working to develop the standard by the end of 2021.

6.5 Commercial Availability

6.5.1 BEB Charging

LOW-POWERED IN-DEPOT CHARGING

This charging is commercially available and used by many transit agencies.

PLUG-IN CHARGERS FOR IN-DEPOT CHARGING

There are six major Direct Current Fast Chargers (DCFC) manufacturers available in the North America market that have wide use with the bus manufactures. **Table 12** provides six charger manufacturers currently utilized by bus OEMs. The table provides typical plug-in charging sizes utilized by bus manufacturers. These charger manufacturers may also offer larger plug-in chargers, but they are not typical to the transit bus industry and not included within this report. En-route, opportunity charging through overhead or inductive chargers are often available through these manufacturers as well.

Table 12: Typical Charger Manufacturers

Charger Manufacturer	Charging Capacity (kW)	Number of Dispensers per Charger	Type of Charging
ABB[1]	50	1	Single
	100	3	Sequential
	150	3	Sequential
ChargePoint[2]	62.5 kW (single) 125 kW (paired)	Up to 2	Sequential or Simultaneous
	Varies	Multiple	
Efacec[3]	90	1	Single
	150	1	Single
	160	1	Single
Heliox[4]	180	3	Sequential or Simultaneous
Proterra[5]	75	4	Sequential
	150	4	Sequential or Simultaneous
	250	3(6)	Simultaneous (Sequential)

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[1] https://new.abb.com/ev-charging/products/depot-connector-charging, April 1, 2021

[2] https://www.chargepoint.com/products/commercial/, April 1, 2021

[3] New Flyer Infrastructure Solutions Charger Catalog, January 2021

[4] https://www.heliox-energy.com/products-and-services/our-products, April 6, 2021

[5] https://www.proterra.com/energy-services/charging-infrastructure/, April 1, 2021

Charger Manufacturer	Charging Capacity (kW)	Number of Dispensers per Charger	Type of Charging
	500	6(12)	Simultaneous (Sequential)
	1500	20 (40)	Simultaneous (Sequential)
Siemens[6]	100	5	Sequential
	150	5	Sequential

CENTRALIZED CHARGING STATIONS

Recognizing some of the scaling issues that many chargers at a single location such as a bus depot (space, disconnects, number of conduits, etc.), several manufacturers, summarized in **Table 13** have begun to develop charging stations that service a much larger numbers of dispensers.

The benefit of centralizing the charging equipment is that there are significant space savings. Beyond combining the power modules into a more compact singular unit, some manufacturers are also advertising the ability to incorporate a medium voltage transformer which may allow the charging unit to be directly connected to the grid power without the need for a separate transformer and substation.

A trade-off with a centralized charging station is that the purchaser may have to commit to purchasing more charging capacity than is immediately needed if the initial deployment is small. Some manufacturers have indicated that a full-size cabinet could be purchased with only a portion of the power modules needed installed and have the remaining installed at a later date. While in theory this could be true, with a fast-moving industry, there is a risk of obsolescence as to whether those modules would be available when needed. The centralized charging stations are capable of both using plug-in and/or overhead pantographs as dispensers.

Table 13: Centralized Charger Manufacturer

Charger Manufacturer	Charging Capacity (kW)	Number of Dispensers per Charger	Type of Charging
Hitachi[7]	1000	10/20	Simultaneous/ Sequential
	1000	15/30	Simultaneous/ Sequential
	1000	20/40	Simultaneous/ Sequential
Proterra[8]	1440	24/48	Simultaneous/ Sequential
Kempower[9]	600	4/8	Simultaneous/ Sequential

[6] https://new.siemens.com/global/en/products/energy/medium-voltage/solutions/emobility/ebus-depot.html, April 1, 2021

[7] https://go.hitachienergy.com/Transportation_eBus

[8] https://www.proterra.com/products/charging-infrastructure/

[9] https://kempower.com/product/kempower-satellite/

MID-POWERED INDUCTIVE CHARGING

Inductive charging is currently under development, with limited commercial use.

HIGH-POWERED OVERHEAD/OPPORTUNITY CHARGING

Overhead charging is widely utilized in Europe and Asia, with increasing use in North America. Opportunity charging extends the distance and use of heavy-duty electric vehicles, particularly buses.

Several tests are currently ongoing within North America to obtain additional information regarding these chargers and the bus compatibility. One such test is currently being conducted by CUTRIC, while a second will be conducted using multiple charger and bus manufacturers within King County Metro in Seattle, WA.

HIGH-POWERED MEGAWATT CHARGING

A megawatt charger system (MCS) is currently being developed by CharIN, however limited information is publicly available.

SUPPLY CHAIN

The fueling supply chain for BEBs is fairly new and the components of the electricity provider, high- and low- powered chargers, and energy storage systems (ESSs) need to be carefully reviewed. Unlike diesel and CNG buses, there will need to be discussion with utilities and energy providers and installation of network equipment to ensure there is enough energy for the fleet.

When planning the installation of charging equipment, it’s recommended that the schedule should allow for a significant amount of time for materials to arrive and be installed prior to vehicles arriving (3-6 months). The schedule should be based on manufacturer projections.

Additionally, critical spare parts should be considered when ordering equipment to have on hand. With the high demand for parts and the limited number of installations of this type of equipment it can often take months for components to be sourced and shipped from overseas.

6.6 Codes and Standards

Plug-in charging in North America is currently standardized on the Society of Automotive Engineers (SAE) J1772. This standard covers Level 1 (120V), Level 2 (240/208V), and direct current fast chargers (DCFC). This standard defines how a charging station connects with, communicates with, and charges the vehicle. All major BEBs, as well as most other light- and heavy-duty vehicles, utilize this SAE standard. Two versions of the J1772 Combined Charging System (CCS) exist, but the CCS Type 1 connector is almost exclusively adopted throughout North America. The CCS Type 2 connector is used in European and other markets and is generally not found in North America. One additional charger plug, CHAdeMO, was available for light-duty vehicles in North America but has never been utilized for larger vehicles within this market.

Overhead chargers utilize a pantograph to charge and those charging systems utilize SAE standard J3105. In addition, trucking manufacturers are currently working on a larger plug-in charger that is capable of charging at 1 MW, called the Megawatt Charging System (MCS). The MCS standard is still in testing and development but will one day be available for charging heavy-duty trucks and may also be available for buses in the future. The larger, faster charging is usually seen as great for the operators since it reduces charging time; however, the faster charging also has potential adverse impacts on the battery life.

Another protocol that is complimentary to SAE J1772 and that is critical to networked charging is the Open Charge Point Protocol (OCPP). This protocol promotes open and accessible networking between the chargers and dissuades proprietary networks. Therefore, secure third-party software packages can access the network and allow connection of multiple charger and bus manufactures within the system to communicate through a single interface. Beyond opening the possibilities for smart charging, this protocol creates a piece of mind for fleets and operators that old technology can work with newer technology and that different manufactures can also be accessed through a single portal. OCPP version 1.6 is mostly commonly used at this time, but much of the equipment and networks are also moving toward the most recent OCPP 2.0.1 version.

SAE J1772 is the backbone and OCPP is the brains for plug-in BEB charging. However, each equipment manufacture, both bus and charger, utilize slightly different processes to meet the standards and protocols and implement their technology differently. Sometimes, this implementation leads to disconnects between the bus and the charger, mostly due to software issues that can be resolved through updates.

To provide the best user/fleet experience, bus OEMs often test the charger technology to work through the bugs and avoid most issues experienced in the field. These bus OEMs often approve a charger manufacture and many even approve the charger models and sizes for their bus.

Chargers should comply with existing standards such as the Canadian Electrical Code (CSA C22.1). With the introduction of new equipment – it should be ensured that facilities are still in compliance with building codes such as the Ontario Fire Code (O. Reg. 213/07). While Canadian codes and standards will always take precedence, NFPA has several fire safety codes that can be used as design reference points.

6.7 Technical and Economic Feasibility

6.7.1 Opportunities and Challenges

BEB OPPORTUNITIES

Transitioning to battery electric buses presents many opportunities, including:

- Significantly reducing GHGs and local air pollution
- Emissions related to vehicles will continue to become greener (as the electricity grid adds more renewable sources)
- Lower refueling costs than diesel and CNG
- Potentially lower maintenance costs than diesel and CNG

- Battery electric has higher energy efficiency than diesel and CNG
- Less infrastructure investment required than FCEBs
- Quieter operations and overall rider experience (noise, vibration, etc.), which could lead to an improved experience for riders and increased ridership
- Smoother acceleration for drivers
- Many Canadian manufacturers for BEBs
- Digitally connected today and data-sharing can occur
- Hybrid buses can help with transition to fully electric fleet, especially for getting mechanics used to newer technology
- Real-time data-sharing opportunities since most BEBs and charging systems are cloud-networked
- Implementing emerging and green technologies can improve public perception of transit service

BEB CHALLENGES

The shift to BEBs also has the following challenges:

- Higher vehicle cost than diesel
- Limited range for longer routes, rough terrains, and colder climates
- Higher infrastructure investment and upfront capital costs than diesel as new infrastructure is required
- Costly charging infrastructure that necessitates systems design thinking
- Recharging can take approximately 4-6 hours for in-depot charging, depending on charger and battery size
- Some BEBs procured for cold climate conditions have diesel-fueled heaters on board as an auxiliary system, which are a source for air pollution . Diesel heaters are not subject to the same controls as diesel engines and can have very high emission rates.
- Limited ranges compared to fully fueled diesel – diesel and CNG-fueled buses have a range of 500-600km while BEBs have 40-400kms before charging, though the technology is constantly evolving
- BEBs require more depot space due to chargers
- Unknowns about BEB degradation and performance overtime (some of this risk is mitigated by warranties) – uncertain when major mid-life work may be needed

- High-powered charging can potentially degrade vehicles and batteries sooner than expected
- Running batteries down to 0% charge can reduce battery lifetime – OEMs are often limiting the usable battery energy to 80% to avoid this issue
- Lack of knowledge by local utilities about transit industry
- Currently not much collaboration between utilities and transit agencies
- Capital costs related to associated charging infrastructure has to be considered (e.g., money to rearrange a garage to add in-depot chargers. Upfront capital costs are typically more than diesel buses ($1 million – 1.2 million compared to $500,000-600,000), however operational costs over time may be lower as a result of lower fueling costs
- Limited data available on maintenance procedures and costs for charging infrastructure. Likely that depot charging stations will require minimal maintenance – design is often modular so that malfunctioning components can be replaced.
    - OEMs should provide maintenance manuals including preventative maintenance requirements, required skill and time to complete tasks. Should also include spare parts list
    - Licensed electrician or OEM technician may be required due to risks with high-voltage systems
- Fast-charging stations likely to require ongoing maintenance as they have cooling systems, filters and other components that require preventative maintenance
- Light-duty vehicles (such as those used for Handi-Trans services) may require different infrastructure if the vehicle cannot use high-powered chargers commonly used for heavy-duty transit buses

CUTRIC's Pan-Canadian Electric Bus Demonstration and Integration Trial identified and evaluated any interoperability issues that would arise from using different buses and chargers on the same route. No data can be shared at this time due to an NDA, but CUTRIC was able to share challenges they have encountered such as:

- Issues with Wi-Fi Connections between charger and bus
- Effectiveness of different communication protocols between buses and chargers
- SAE standard J3105 Electric Vehicle Power Transfer System Using Conductive Automated Connection Devices needs further refinement

TTC put 60 e-buses into service in June 2019 from BYD, New Flyer and Proterra. They used a series of metrics separated into domains to evaluate the buses against each other as well as to the existing Nova hybrid vehicles already in service. These metrics are summarized for reference in **Table 14**.

Table 14: Evaluation Domains and Metrics used for TTC's Green Bus Program

Domain	Metrics
System Compatibility	Physical Compatibility, Charging Technology Interoperability, Corrosion Resistant Frame Structure
Vehicle Performance	Vehicle Reliability MDBF, Distance between Repairs, Fleet Availability, Energy Consumption, Fall Regen Rate, Winter Regen Rate, Battery Capacity and Range
Operator and Maintainer Experience	Surveyed operators and maintainers on ride quality, visibility, ergonomics, acceleration, steering, braking, night driving, maintainability
Charging System Performance	Charging System Performance
Vendor Performance	Compliance to Vehicle Delivery Schedule, Quality Review, Quality Defects, Duration to Final Acceptance, 30-Day Reliability, Contract Deliverables, Canadian Content, Training
Maintainability	Average days to repair
Customer Experience	Survey including ride comfort, seat comfort, seating layout, interior noise levels, lighting levels
Accessibility	Compliance with AODA and CSA D435
Total Life Cycle Cost	Operating cost, energy costs, capital costs

6.7.2 Vehicle Operations

Considerations for vehicle operations include:

- Should keep in mind that batteries will degrade overtime, which will especially impact BEBs.
- Must plan for battery capacities and usable vs. nominal (nameplate) ranges of BEBs and FCEBs. Current longer blocks likely have to be split apart to accommodate a shorter range and midday charging.
- Measure battery capacity regularly. This can either be done by a contractor who conducts a battery capacity test or OEM-provided test procedures to measure battery capacity. Telematics may also be a source for validation.
- Battery capacity should be measured when buses are first delivered to know the baseline for battery capacity.
- Schedulers need to be aware of vehicle limitations – cannot cut vehicle blocks in the same way
    - Any vehicle "swap" on existing blocks will likely require an increase to peak vehicle requirement. Splitting long blocks also includes additional operator requirements since buses return to the depot, and another bus and operator would drive from the depot to take its place.

  - Time spent on charging vehicles during schedule must also now be planned
  - May consider seasonal schedules due to the reduction in range during the winter unless an auxiliary diesel heater is used
  - The optimization of layover times with interlining might pose a challenge since BEBs would need to take advantage of layover times to top off a battery with opportunity charging
- Operational differences and timing between fueling a vehicle and charging (time differences, positioning)
- Need for a managed charging software that "sees" the state of charge of each vehicle and assigns vehicles to blocks based on available charge.

6.7.3 Maintenance & Servicing

Considerations for maintenance and servicing include:

- Maintenance involves spare parts inventory, preventative maintenance, bus maintenance, and fueling infrastructure maintenance.
- Spare parts inventory: It might be difficult to get parts through the years if they need to be replaced.
  - The bus and fueling infrastructure OEMs should send a list of critical and recommended spare parts for on-site inventory.
  - Knowledge of pricing and the time it takes to receive other spare parts would also be helpful.
- Bus and preventative maintenance:
  - **Figure 29** shows the cost per mile by bus system for maintenance needs
  - Onboard communication systems will report issues and error messages
  - Bus and infrastructure OEMs should provide list of maintenance needs and how long they will take, skills required, and parts needed to address the problem
  - OEMs should provide maintenance manuals with a list of preventative maintenance activities

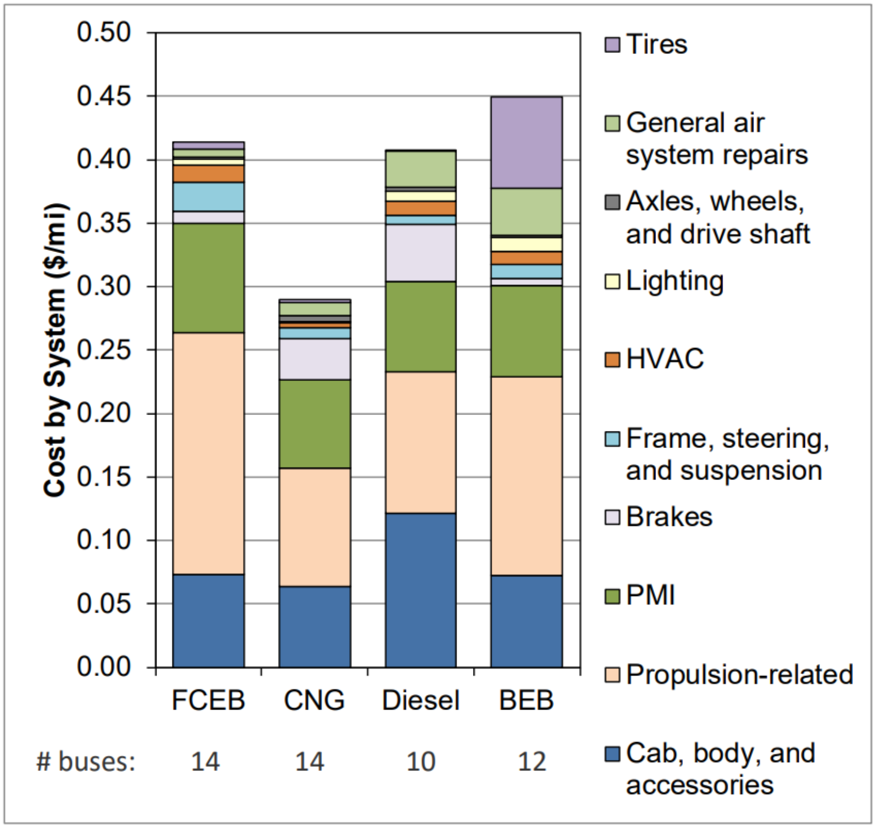

Figure 29: Cost per mile of maintenance needs by bus system (May 2020)

- Fueling infrastructure maintenance
  - The type of infrastructure will have different maintenance needs
  - Depot charging will have minimal maintenance
  - Fast-charging stations require ongoing preventative maintenance because they have cooling systems, filters, and other components that make them more complex
  - Hydrogen fuel stations: Should have minimal maintenance, however procedures must be followed on a strict timeline as sensors and monitoring must be checked to ensure quick and reliable detection of any hydrogen leaks
- Maintenance schedule will be needed
- Difficult to find mechanics who already have experience with electric vehicles.
- New Tools and Personal Protective Equipment (PPE) will likely be required for maintaining charging infrastructure

6.7.4 Training

Considerations for training include:

- CBRM should make sure the procurement documents for buses and fueling/charging technology include all regulations, codes, and training requirements.
  - Training requirements include training hours, aids, materials, tools, and diagnostic equipment.
- Plan which staff will be trained – limit buses to a number of operators depending on the number of ZEBs in the whole fleet.
- Employees should have knowledge of electrical safety requirements that are in the Canadian standard CSA Z462-18
- Provide sufficient training to staff, including drivers and people charging/fueling the vehicles. May require more than standard hours for diesel buses but difficult to estimate at this point in time.
- Coordinate operations and maintenance training before or at the same time as bus delivery
- High-voltage hazards and safety training and/or hydrogen fuel safety training also must be provided
- Train drivers on differences between ZEBs and conventional buses to show how to efficiently operate the ZEBs
- Maintenance staff must be trained to service and troubleshoot electric propulsion and auxiliary systems
- They must also be trained to work with the onboard diagnostic systems
- The limitations present in ZEBs (such as range limitations for BEBs) must be known and prepared for by staff
- Train divers on optimal driving habits for the bus
- Fueling processes training is needed, potential for change in process where operators need to charge vehicles
- Safety training and an overview of emergency procedures should occur during the staff training.
- Mechanic training program will need to be robust, existing mechanics will not have the experience

    - Good to get a hybrid bus so mechanics can get trained on this (due to similar powertrain)

- First responder training required for cutting into buses with batteries and managing lithium battery thermal runaway incidents

- Tow truck driver training will be required for battery electric buses (specific requirements with tow truck driver operator)

6.8 Geographic & Climate Impacts

The kilometers a BEB can travel depends not only on the size of the battery pack or capacity but local geographic conditions. These conditions are route ruggedness, average speeds, ridership, topography, and number of stops and starts the bus needs to make while in service depending on stop signs, yield signs, and pedestrian crossings. BEB batteries have a lower energy density than fossil fuels, which means that these conditions have a greater impact on the energy levels of a BEB. This means that some BEBs might only stay on one route based on its conditions and cannot move around to different routes as needed. At times, on-route charging may also be more advantageous rather than charging systems in garages based on geographic constraints. Kilometers driven during dead-head time should also be reassessed to make sure they do not consume too much energy when/if buses are repositioned.

With some BEB models, an auxiliary diesel heating system is needed that can create air pollution and utilize a large amount of energy in cold conditions. This can be mitigated with currently available technology and sensors to manage when the heater is activated.

When considering transitioning all system routes and blocks – it can be helpful to separate them by feasibility. By identifying what routes or blocks can be replaced 1 to 1 with today’s technology, you can prioritize those routes first. Blocks that are challenging with today’s technology and require extensive block splitting may become feasible as battery sizes increase and become cheaper in the future.

6.9 Life Cycle Costs

Vehicle life cycle costs can be broken down into multiple components – purchase, operating and maintenance costs, overhaul costs and disposal.

Purchase cost for various battery electric bus models have been summarized in **Table 15**. These cost estimates are based on the US context, so in the Canadian context this will likely differ. The cost of the bus largely depends on the battery size; for 40’ buses the price is likely to be between $800,000 and $1.1 million CAD.

Operating and maintenance cost differentials can be difficult to determine as zero emission buses have not been in operation as long as diesel counterparts. Based on conversation with US transit agencies, such as LA Metro and Indigo Transit, with mixed BEB and Diesel fleets, on a cost per mile basis battery electric buses are approximately $0.03 (USD) cheaper than diesel vehicles.

Overhaul costs are generally not currently available for battery electric buses or hydrogen fuel cell buses. Battery electric bus manufacturers are currently offering warranties as part of the bus purchase price that will cover the replacement of a battery if needed during the 12-year life span of the vehicle.

Disposal costs are also currently unknown for battery electric buses. Battery disposal will have to be considered due to the elements used in the production of batteries.

Table 15: Estimated Purchase Cost of Various BEB Models

OEM	Model	Length (ft)	Seats	Battery Capacity (kWh)	Battery Warranty (yr)	Charging Rate (kW)	Estimated Cost USD ($)	Estimated cost CAD ($)*
BYD	K7M	30.7	22+1	215	12	80 (Plug)	498,000	667,320
BYD	K9S	35.8	32+1	352	12	80 (Plug)	686,000	919,240
BYD	K9	40.2	37+1	324	12	80 (Plug)	741,000	992,940
Proterra	ZX5 35'	36.9	29	225	12	73 (Plug) 165 (Overhead)	613,885	822,606
Proterra	ZX5+ 35'	36.9	29	450	12	132 (Plug) 330 (Overhead)	689,000	923,260
Proterra	ZX5 40'	42.5	40	225	12	73 (Plug) 165 (Overhead)	653,885	876,206
Proterra	ZX5+ 40'	42.5	40	450	12	132 (Plug) 330 (Overhead)	699,000	936,660
Proterra	ZX5 MAX 40'	42.5	40	675	12	132 (Plug) 330 (Overhead)	749,000	1,003,660
New Flyer	Xcelsior CHARGE NG 35'	36.3	32	350	12	350 (Plug) 600 (Overhead)	700,725	938,972
New Flyer	Xcelsior CHARGE NG 35'	36.3	32	440	12	350 (Plug) 600 (Overhead)	745,325	998,736
New Flyer	Xcelsior CHARGE NG 40'	41	40	350	12	350 (Plug) 600 (Overhead)	705,725	945,672
New Flyer	Xcelsior CHARGE NG 40'	41	40	440	12	350 (Plug) 600 (Overhead)	750,325	1,005,436
New Flyer	Xcelsior CHARGE NG 40'	41	40	525	12	350 (Plug) 600 (Overhead)	795,925	1,066,540

Green Power	EV STAR +	Cutaway	24	118	–	61 (Plug)	499,900	669,866
Green Power	EV250	30.2	21+2	260	–	300 (Plug)	548,888	735,510
Green Power	EV300	40.9	40	400	–	300 (Plug)	788,688	1,056,842
Nova Bus	LFSe+	40	41	564	–	150 (Plug) 450 (Overhead)	774,599	1,037,963
Optimal EV	S1LF	Cutaway	–	113	–	60 (Plug)	–	–
Gillig	Low Floor Electric	35	32	444	–	–	810,780	1,086,445
Lion	LionM	26	31	160	–	60 (Plug)	290,000	388,600
Lightning Electric	FE4-86	Cutaway	–	86	5	80 (Plug)	330,000	442,200
Lightning Electric	FE4-129	Cutaway	–	129	5	80 (Plug)	350,000	469,000
Lightning Electric	FF5-128	Cutaway	–	128	5	80 (Plug)	–	–
Lightning Electric	FF5-160	Cutaway	–	160	5	80 (Plug)	–	–
Motiv / TurtleTop	EPIC 4	Cutaway	–	106 / 127	–	50 (Plug)	350,000	469,000
Phoenix Motorcars	ZEUS 400	Cutaway	23	63 / 94 / 125 / 156	5	50 (Plug)	225,000	301,500

7 E-Bus Transition Strategy

CBRM is undergoing a Transit Operations and Facility Design Study, a major component of which is developing a plan to transition from the existing diesel transit fleet to an electric fleet by 2040. The fleet electrification will support the reduction of GHG emissions, aligning with the objectives and requirements of various plans and policies across all levels of government. Namely, the Canadian Net-Zero Emissions Accountability Act (2021), the Nova Scotia Environmental Goals and Climate Change Reduction Act (2021), and the Municipal Climate Change Action Plan (2014).

Electrifying the transit fleet may significantly impact daily operations; Cape Breton has begun planning the transition to zero emissions by developing a Fleet Transition Plan that will act as a roadmap to guide the process. The Fleet Transition Plan will identify the feasible transition pathway(s), associated capital and operating costs, service impacts, and, ultimately, the preferred transition pathway. This Energy Modelling Results Memo will feed the larger fleet transition plan to provide a strategy for electrification of the transit fleet.

When planning for a transition to battery electric buses (BEBs), it is important for agencies to not only look at the vehicle requirements, but also the infrastructure changes and other operational impacts that will be required to operate and maintain those vehicles. For many Canadian transit agencies, current battery electric bus technology cannot replace diesel buses at a one-to-one replacement ratio while maintaining the same service level, primarily due to vehicle range limitations. To mitigate range limitations, agencies may require additional vehicles, en-route charging infrastructure, or a combination of both. Converting a transit fleet to zero emission vehicles may impact schedules for operations, peak vehicle requirements, infrastructure, capital and operating costs, training requirements for maintenance staff and vehicle operators, as well as customers. Understanding how the system will need to operate with battery electric buses and how those decisions will impact these variables are important in determining an optimum fleet transition pathway. This memo documents the process and analysis involved in the development, assessment, and recommendations for a transition pathway for Cape Breton's fleet from diesel internal combustion engine buses to battery electric buses. The processes and analyses include:

- Review of current fleet composition, the existing capital replacement plan, and service operations for transit and paratransit services
- Estimation of energy consumption of the transit fleet using the Zero+ tool and the consolidation of the model results to identify feasible transition pathway(s)
- Recommendation of the optimal vehicle battery size required for the BEB deployments based on the energy consumption modelling results
- Recommendation of a preferred transition pathway which shall guide future analysis of Cape Breton's transition from diesel buses to BEBs
- Determination of charging infrastructure required to operate the vehicles based on the fleet's daily energy consumption profile

7.1 Existing Conditions

The first step in exploring battery electric vehicles is to document existing conditions and evaluate the current routes and fleet vehicles used to provide service. Key data includes:

- Operator blocks for weekdays and weekends
- Block and bus-type assignments
- General Transit Feed Specifications (GTFS) data built in accordance to *CBRM Transit Routing Review Memo* Fleet Replacement Plan

Adding this data to the Zero+ model creates an accurate energy consumption profile unique to Cape Breton's existing service. Below is a summary of the fleet composition, fleet replacement plan, and fixed route and paratransit service operations information that feeds into the modelling effort and analysis that follows.

7.2 Fleet Composition and Replacement Plan

7.2.1 Current Transit Fleet Composition

The current transit fleet includes a mix of full-size fixed route diesel buses and paratransit gasoline transit shuttles as shown in **Table 16**. Currently, there are a total of 28 fixed route transit buses in service. There are 13 paratransit buses.

Table 16: Current Fixed Route and Paratransit Fleet Composition

Fleet Count	Vehicle Type	Vehicle Make	Model Year(s)	Fuel Type	Facility Assignment
Fixed Route Transit Fleet					
10	LFS	Nova	2004-2022	Diesel	227 Welton St
4	DF40	New Flyer	2004-2009	Diesel	227 Welton St
6	D5D	New Flyer	2009-2010	Diesel	227 Welton St
5	Unspecified	New Flyer	2005-2009	Diesel	227 Welton St
3	Unspecified	Unspecified	Unspecified	Diesel	227 Welton St
Paratransit Fleet					
3	Cutaway	GMC	2015-2020	Gasoline	227 Welton St
2	G4500	Chevrolet	2015-2016	Gasoline	227 Welton St
2	Econoline	Ford	2017	Gasoline	227 Welton St
6	Unspecified	Unspecified	Unspecified	Gasoline	227 Welton St

EXISTING FLEET REPLACEMENT PLAN: 2026 - 2040

Cape Breton's preliminary fleet replacement plan outlines in which year(s) the current fleet will be replaced. The full size and mini transit buses are projected to be replaced between 2026 and 2040. **Figure 30** and **Figure 31** show the replacement schedules. As a result of the COVID-19 pandemic-related decline in service level and ridership, no service expansion was included in the analysis between 2022 and 2040. For Cape Breton to achieve the Net Zero Strategy (NZS)'s goal to transition to 100% zero emissions by the 2035 target, the agency will need to consider an accelerated replacement schedule for the fixed route transit fleet.

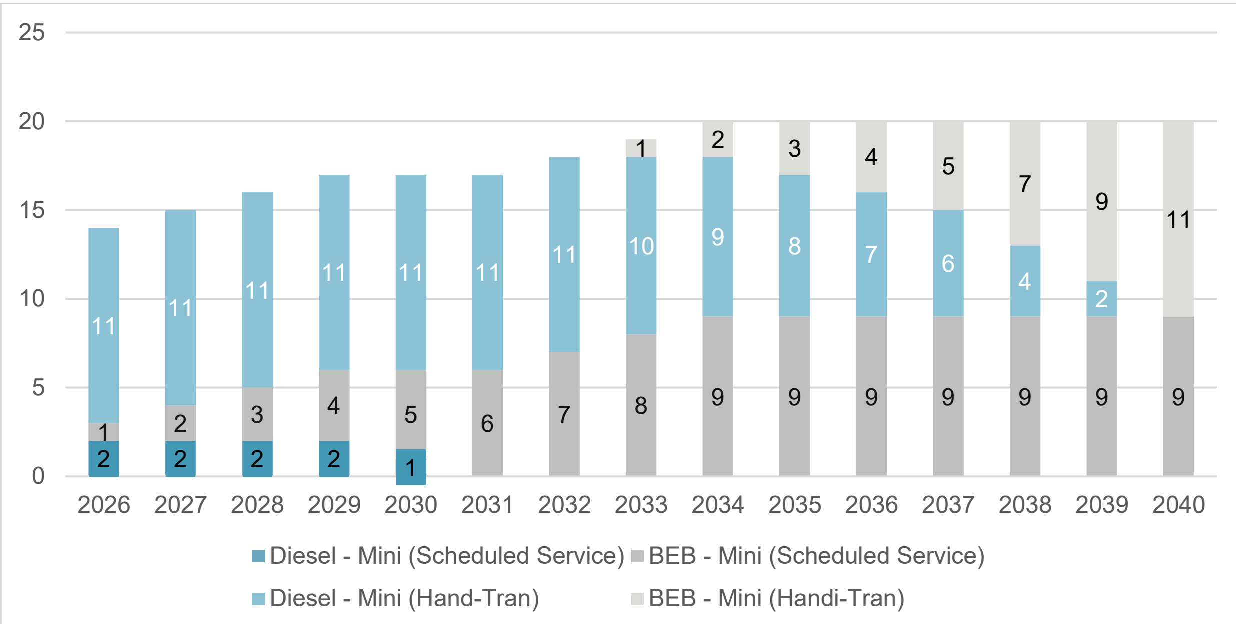

Figure 30: Mini Fleet Replacement Schedule

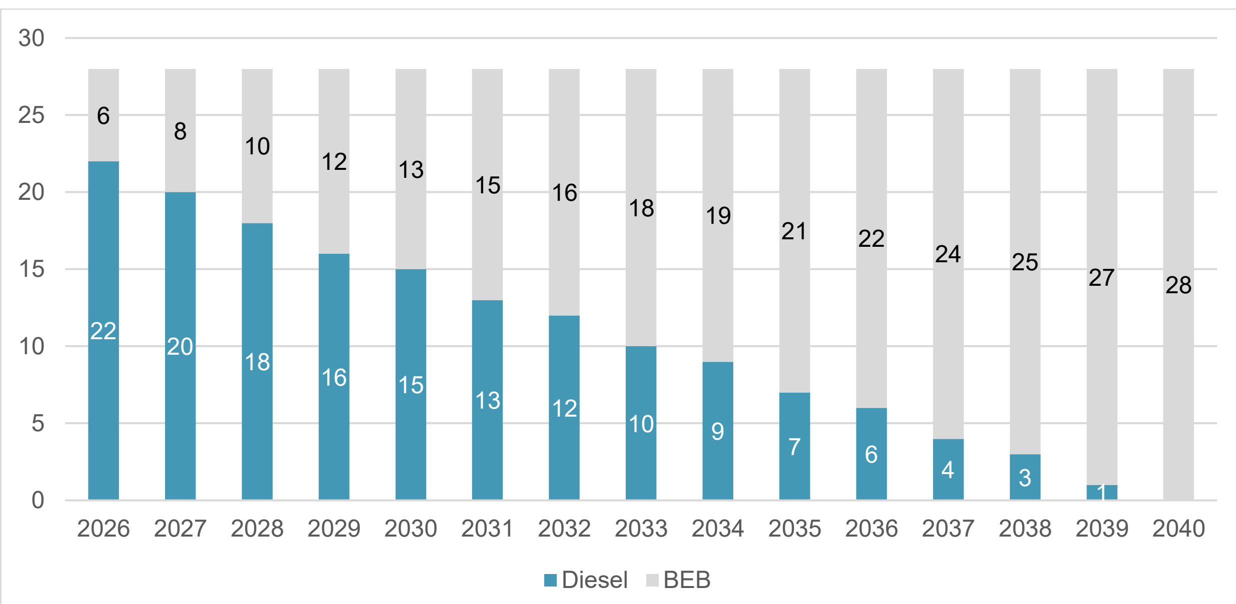

Figure 31: Full Size Transit Fleet Replacement Schedule

7.3 Fixed Route Operations

7.3.1 Operating Schedules

7.3.1.1 CAPE BRETON FIXED ROUTE TRANSIT

Currently, Cape Breton Transit has 13 operating routes. The route-planning analysis conducted as part of the Transit Operations and Facility Design Study recommended 17 routes to be gradually implemented in the long-term in CBRM **(Figure 32**).

For the purposes of the fleet transition modelling, the 17 routes were determined to operate on 26 blocks. A piece of work for a transit bus is typically called a block which has information on the start/end time, routes on which it will operate and timetable of when it will be at various stops on the route. Cape Breton, like many other transit services, operates longer blocks where a bus may be used by multiple operators in a single block.

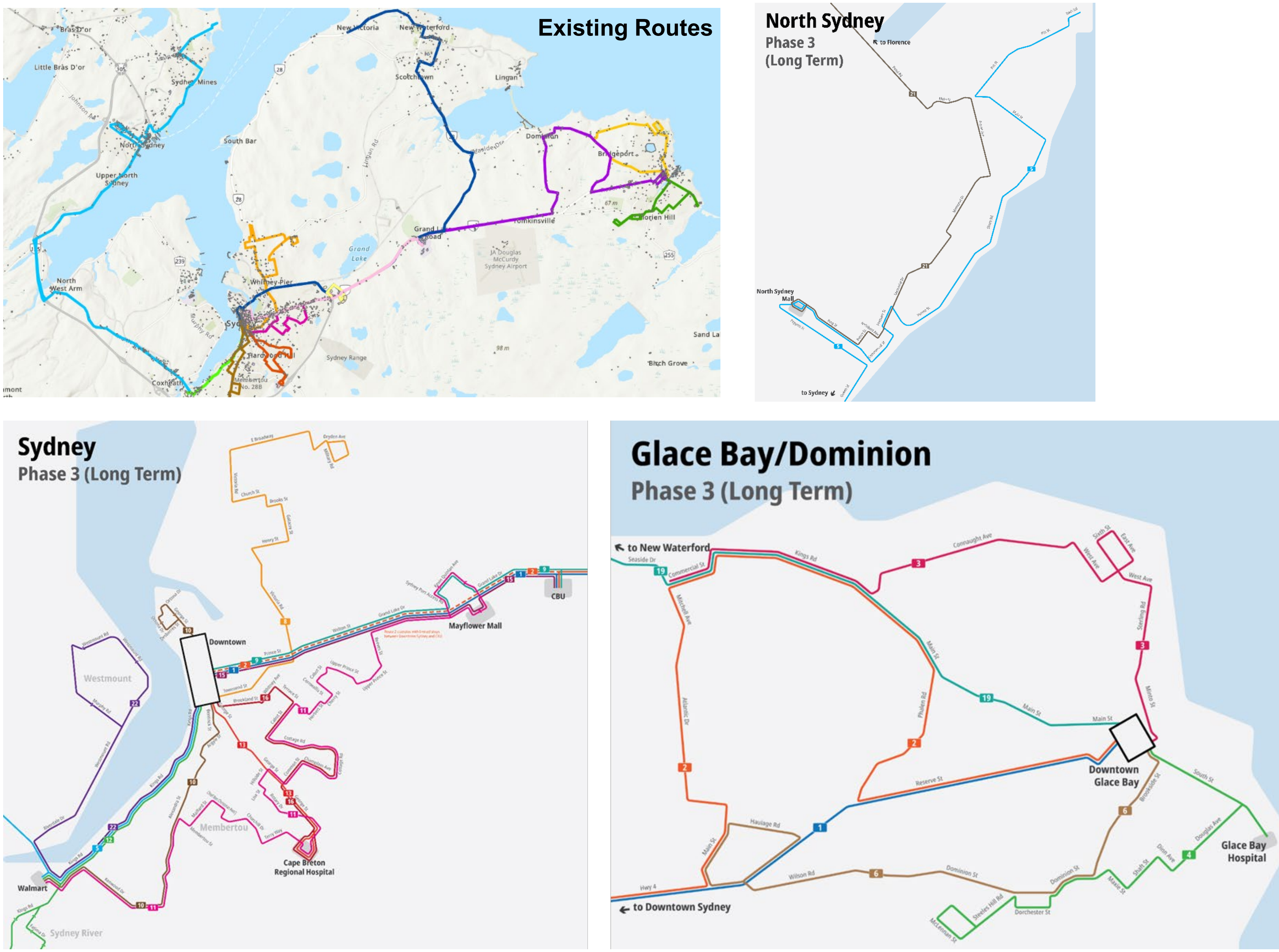

Figure 32: Existing and Future Cape Breton Transit System

The operation of longer blocks makes it challenging to accommodate with today's battery electric vehicles. Based on GTFS data for long-term transit service, **Figure 33** and **Figure 34** show the distribution of blocks for a typical weekday by block duration and distance, respectively. The feasibility of battery electric buses running on routes is confirmed with detailed route modelling, but a guideline of feasibility is that blocks at or below 200km are in range of what BEBs (with 525 kWh battery size or larger) should be able to do in a single charge. Shorter blocks such as those under 200km should be feasible with electric vehicles on a single overnight charge. However, most blocks are greater than 200km, so most blocks cannot be completed with a single charge overnight. Currently the longest blocks are about 19 hours.

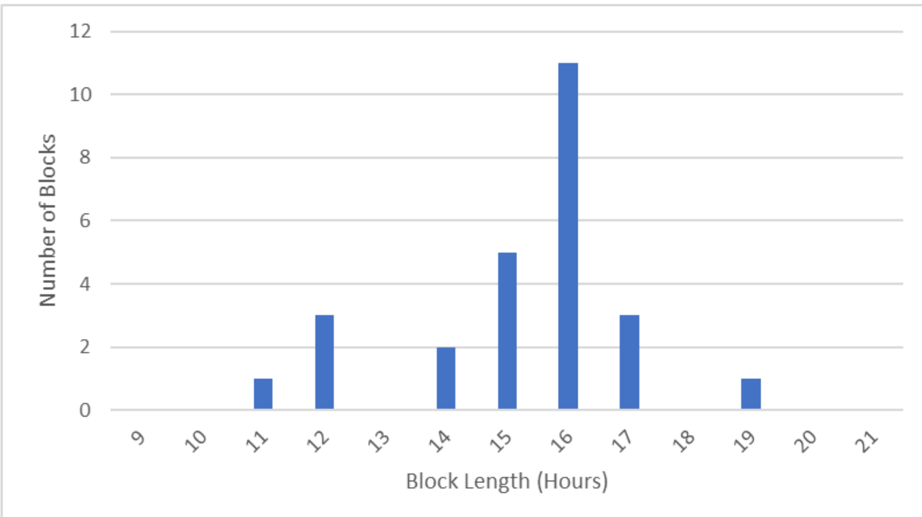

Figure 33: Distribution of Blocks by Duration

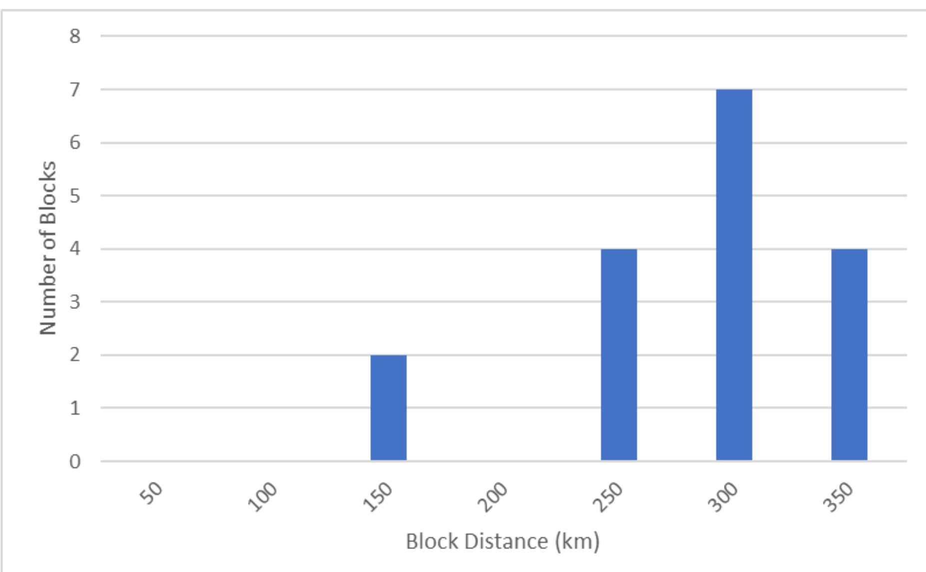

Figure 34: Distribution of Blocks by Distance

7.3.2 Vehicle Mileage and Fuel Consumption

A summary of 2022 and 2023 fuel usage and distance travelled for the Cape Breton fleet is shown in **Table 17**. The vehicles used for fixed route transit comprise over 80% of the kilometres and litres of fuel used in 2022.

Table 17: Fleet Fuel Usage and Distance Travelled

Year	Fuel Type	Vehicle Type	Total Distance (Km)	Total Fuel Consumption (Litres)	Average Fuel Economy (Litres per 100km)
2022	Diesel	Full size buses and one Handi-Trans mini-bus	1,257,434	568,558	45.22
	Gas	Handi-trans mini-buses	325,994	113,852	34.92
2023	Diesel	Full size buses and one Handi-Trans mini-bus	1,653,927	733,242	44.33
	Gas	Handi-trans mini-buses	392,623	125,519	31.97

7.4 Energy Consumption Analysis

The energy consumption analysis for Cape Breton's fixed route fleet was done using Zero+, HDR's proprietary energy consumption modelling tool, to provide a comprehensive understanding of the potential impacts BEB technology may have on Cape Breton's existing service. Energy consumption is impacted by several factors including slope and grade of the bus routes, number of vehicle stops, anticipated roadway traffic, and ambient temperature. Zero+ also analyzes variables known to impact lifetime vehicle performance like energy density, battery degradation, operating environment, auxiliary loads like heating and air conditioning, and lifecycle of bus batteries.

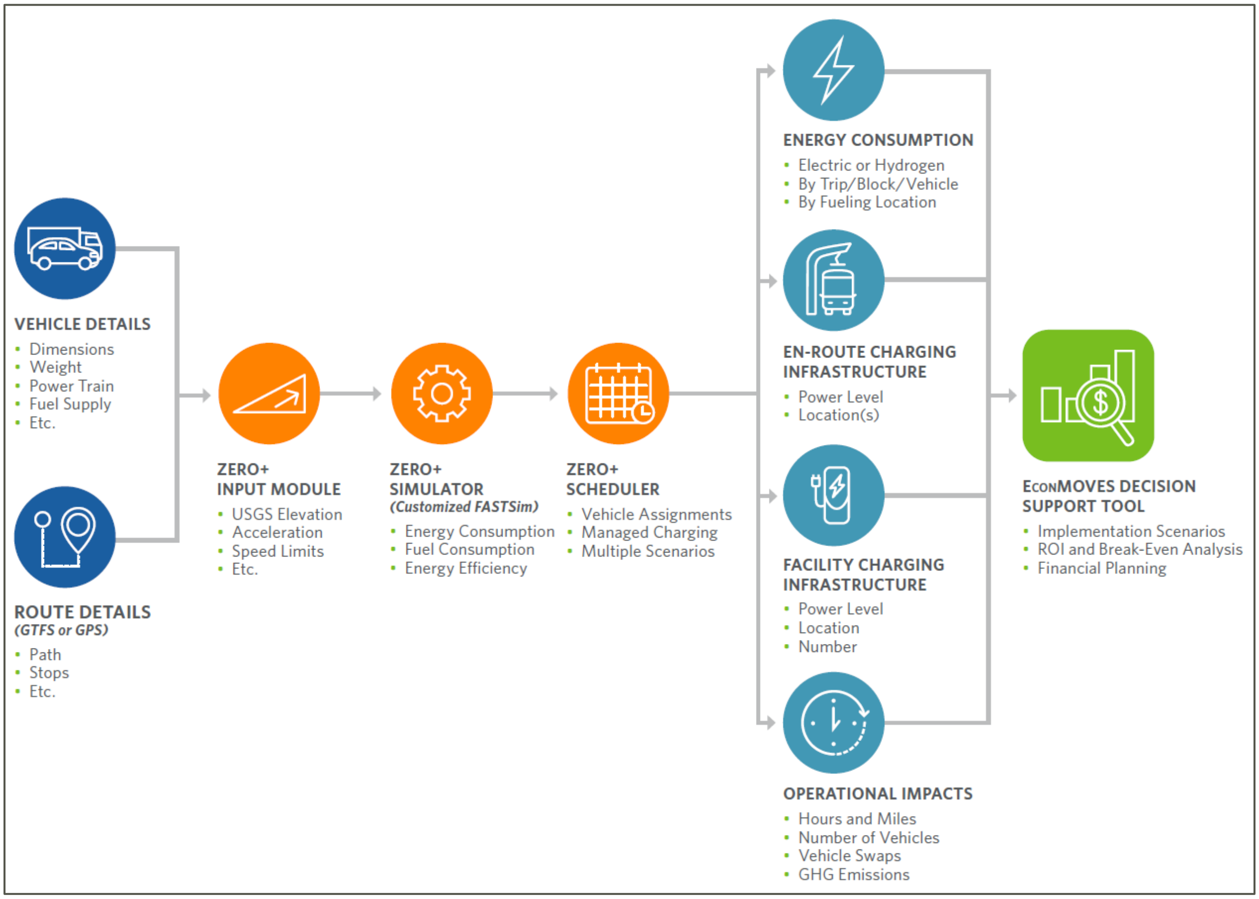

Figure 35: Zero+ Fleet Optimization Tool

The service data used was based on GTFS data for long-term weekday transit service. All baseline scenarios are based on Phase 3 long-term transit service route structure and data. Transit service routes in Phase 3 are the final iteration of routes to be implemented in the long-term (no current date set). Upon implementation of Phase 3, Cape Breton's transit service would consist of the following high-level improvements:

- Addresses existing schedule and capacity issues
- Reconfiguration of one-way loops to provide two-way service

- Expanding service coverage and regional connectivity
- Improving and expanding whole transit network.

Future changes are likely imminent prior to full electrification being realized and may affect the actual vs anticipated outcomes of the modelling. Three BEB scenarios were modelled: baseline, block split, and en-route charging. The scenarios are detailed below following discussion of key assumptions.

7.5 Key Assumptions

To develop a model relevant for Cape Breton Phase 3 transit fleet and operations, a set of assumptions and variables were identified (**Table 18**). It is noted that the assumptions regarding vehicle Original Equipment Manufacturer (OEM) attributes represent a typical, commercially available battery electric bus model. Subsequent procurement following this analysis may result in vehicle OEM specifications which differ from these assumptions, which may impact the results of this analysis. Additional energy consumption modelling based on the selected OEM should be conducted to confirm energy and infrastructure requirements.

Table 18: BEB Simulation Assumptions

Variable	Input
Service Data	Phase 3 (Long term)
Battery Capacity	525 kWh & 675 kWh
End-of-Life Battery State of Health	80% (max battery degradation)
Energy Reserve	20% state of charge (SOC)
Heating	Diesel Hybrid Heat
Ambient Temperature	+28C (Hot weather, 90^{th} percentile)
Passenger Capacity	100%
Depot Charger Power	150 kW @ 95% Efficiency
En-route Charger Power	450 kW (Peak 215 kW & 370 kW) @ 95% Efficiency

As shown in the table above, this model assumes buses with a 525 kWh and 675 kWh nameplate battery capacity, which is typical for a longer range BEB available on the market today. While some bus manufacturers offer BEBs with greater battery capacities, modelling service with a standard vehicle provides flexibility when selecting a vehicle manufacturer.

The depot charging scenario is modelled with 150 kW chargers with a 95% efficiency and the en-route charging scenario is modelled with 450 kW chargers with a 95% efficiency. The main vehicles modelled in the Zero+ modelling tool are the 40' New Flyer Xcelsior Charge with a 525-kWh battery and 40' Proterra ZX5MAX w/PRODRIVE with a 675-kWh battery.

A 20% reduction of battery capacity was applied to reflect end of life conditions. This is consistent with bus original equipment manufacturer (OEM) warranties which typically guarantee 80% of battery capacity for 12-years.

In addition to battery degradation, the model swaps out any vehicle that goes below the 20% state of charge (SOC) energy reserve. This is to account for both the fact that vehicles typically cannot use the last 10% SOC of a battery pack without performance reductions as well as acting as a factor of safety most agencies use to reduce range anxiety for operators.

Energy consumption was modelled for the 90th percentile highest temperature in Cape Breton in August, which is about 28 °C[10]. The initial modelling scenario assumed the use of a diesel hybrid heater. Modelling BEBs with diesel heating under hottest possible temperature is the worst-case energy consumption scenario since air conditioning will be used. The use of air conditioning reduces battery capacity and thus reduces range of BEBs. Furthermore, a diesel auxiliary heater would be used to reduce the power requirement and increase the range of vehicles during cold weather.

It should be noted that while en-route chargers used in the analysis are capable of outputting 450 kW of power, the vehicle must be able to accept that level of power. As-is the case with most transit buses today that can accept fast charging, the actual charge rate of a bus using a 450 kW charger is typically lower. The rate of output of the charger is determined by the vehicle based on a variety of factors and will change based on the state of charge (SOC). The modelling factors in the charge curves (rate of charge vs SOC) are provided by manufacturers for each vehicle type. The achieved charging power in the Zero+ model is limited by both the charging curve for the vehicle and the maximum power of the charger.

7.6 Depot Charging Only Scenario

To develop a feasible alternative for Cape Breton, this scenario assumes that buses will be swapped out part way through the block with a fully charged vehicle when the first vehicle reaches 20% SOC. From a scheduling perspective, this would be done by splitting the buses, so they run in shorter blocks that are able to be completed by the BEB.

The model assumes that when swaps occur, the bus that would normally stay in service would return to the depot, and another bus and operator would drive from the depot to take its place. This has impacts both on fleet size required (peak vehicle requirement) as well as operational costs due to the increased amount of deadhead (non-revenue hours and kilometres between the depot and the first/last stop).

The scheduled blocks have had swaps inserted once a vehicle falls below the parameters set in the model assumptions. This gives an idea of what a schedule would look like that is able to be completed by a full fleet of BEBs and how it impacts fleet size and operational costs.

The schedule developed in this section is only meant to be a minimum viable schedule. In reality, schedulers will use their judgment when cutting blocks where it makes the most sense to do so. The 20% reserve is meant only as a guideline, but gives schedulers operational flexibility (unforeseen events, traffic, detours), improves battery life, and reduces driver range anxiety.

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[10] https://weatherspark.com/y/28838/Average-Weather-in-Sydney-Canada-Year-Round

7.6.1 Depot Charging Only (525 kWh)

MODEL RESULTS

Below is a review of the main components of the transit service and operations that are likely to change and should be considered when transitioning to a BEB fleet. **Figure 36** shows an estimate of the increase in non-revenue hours and kilometres as well as the estimated number of vehicles required to continue the current transit service.

- Revenue Hours & Kilometres remain the same
- Non-Revenue Hours: **82% increase**
- Non-Revenue Kilometres: **87% increase**
- Peak Vehicle Requirement: **35% increase**

  Increase Fleet from 26 to 35 buses
  - 9 more vehicles required
- At least **7 Depot Chargers** will be required
- Cape Breton transit can deploy **6 BEBs** (electrifying 6 blocks) before fleet increases will be required

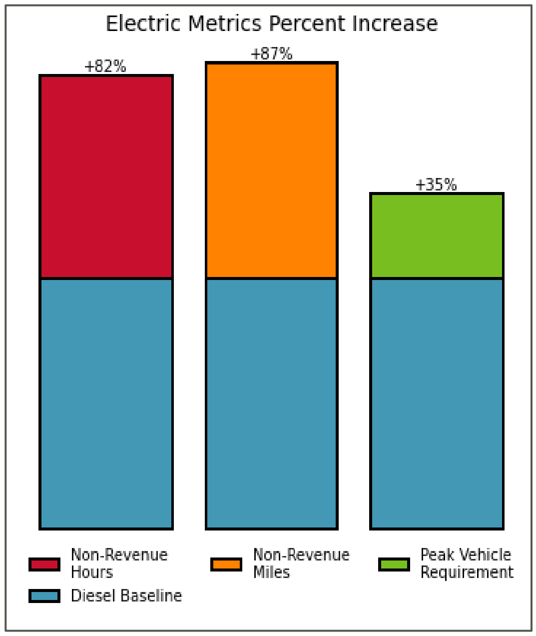

Figure 36: Outputs for Depot-Only Charging plus Bus Swaps (525 kWh)

The vehicle battery state of charge on each block during weekday service are shown in **Figure 37** for Cape Breton operated service. Weekend service was also modeled, but fleet and charging requirements are driven by weekday service which illustrates the most demanding operations for Cape Breton.

Each block is represented by a line on the chart with the color of the line corresponding to the state of charge of the vehicle. The color changes from green to yellow to red to black as the state of charge drops from 100 to 0 percent. Bus swaps (shown in blue) are introduced only between trips to minimize service impacts.

About 23% of blocks can be completed with no splitting when we assume the buses are using diesel heaters, 69% can be done with only one split, and the remaining require two splits, which will be operationally challenging. Operating this service as defined would require a sizable increase in non-revenue hours, kilometers, and peak vehicles required.

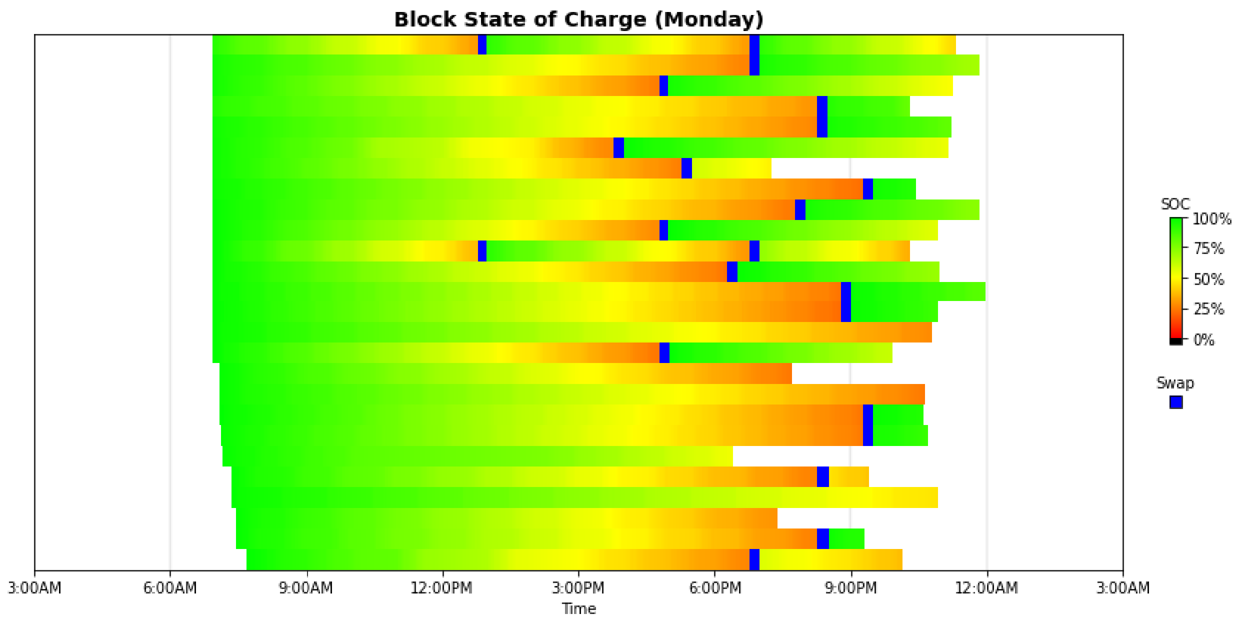

Figure 37: State of Charge for Depot-only Charging plus Bus Swaps (525 kWh)

POWER REQUIREMENTS

The modelling results provide estimates for both power demand and energy consumption at the future transit depot. Using these results, a preliminary assessment of the required infrastructure can be made. Note that the baseline scenarios are not shown here as they were not determined to be viable options.

Knowing the expected the peak power demand is essential for beginning the conversation with the electric utility. Depending on the utility, the cost of energy depends not only on the peak power demand but also on the time of day when that peak demand occurs.

Electricity cost is typically billed based on two factors, peak power demand (kW) and amount of energy consumed (kWh). While consumption is based on the actual amount of energy consumed over the billing period, peak power demand is typically the maximum level seen over the billing period. Both of these factors can be impacted by the Time-of-Use (TOU) rates where costs fluctuate throughout the day.

The simulation results provide a power profile that can be used to understand when in the day the peak load occurs. **Figure 38** shows the managed load profile, meaning the model attempts to use the fewest chargers to have vehicles ready for service the next day. The peak power demand for the future transit depot for a BEB fleet with diesel heating and block splitting is around 1.1 MW assuming seven (7) 150 kW chargers would be required.

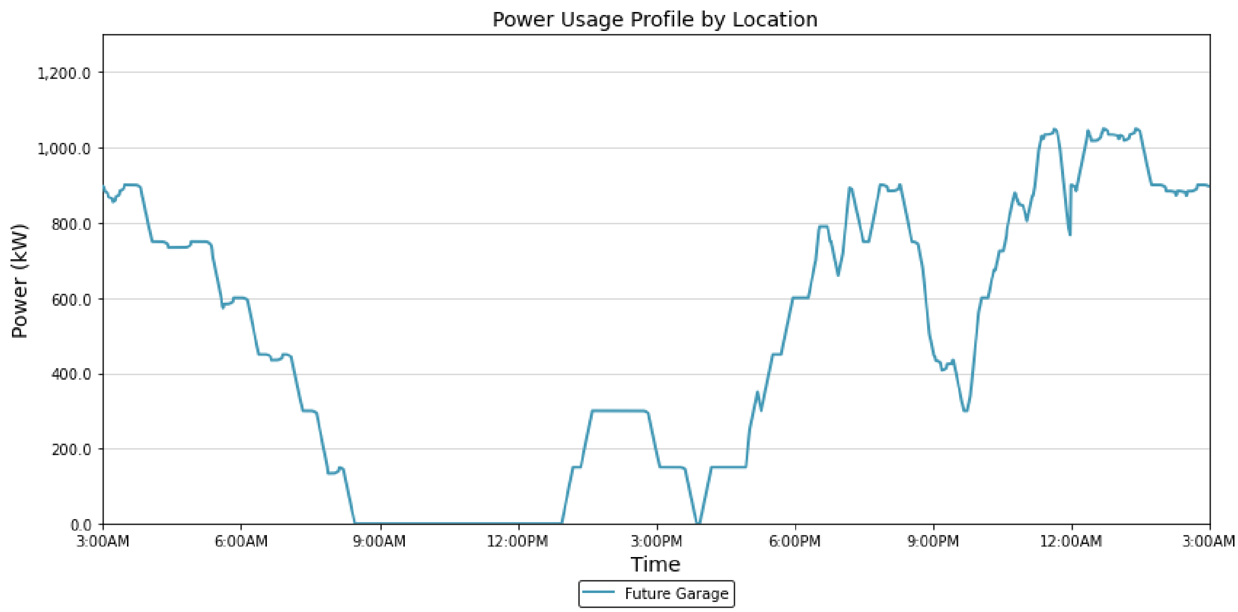

Figure 38: Charging Profile for Depot-only Charging plus Bus Swaps (525 kWh)

VEHICLE BATTERY SIZES

With technological advances expected in the coming years, it may be possible to improve the feasibility of some scenarios by purchasing buses with larger battery sizes. There are vehicles with a battery size of 738 kWh that may offer more range than the 525-kWh battery that was modelled. For the diesel heating with bus swaps and depot charging only scenario, **Figure 39** illustrates that there is approximately 50% gain in block feasibility when comparing a 525-kWh battery with a 738-kWh battery.

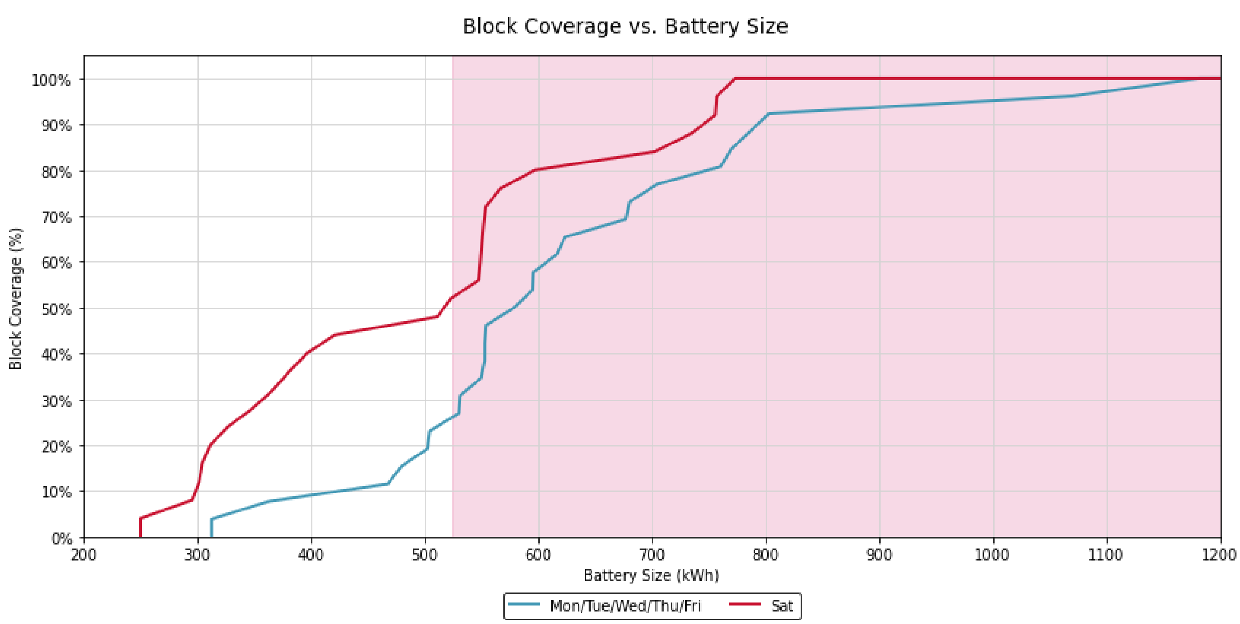

Figure 39: Battery Size Requirement for Depot-only Charging plus Bus Swaps (525 kWh)

7.6.2 Depot Charging Only with Diesel Heaters (675 kWh)

MODEL RESULTS

Below is a review of the main components of the transit service and operations that are likely to change and should be considered when transitioning to a BEB fleet. **Figure 40** shows an estimate of the increase in non-revenue hours and kilometres as well as the estimated number of vehicles required to continue the current transit service.

- Revenue Hours & Kilometres remain the same
- Non-Revenue Hours: **27% increase**
- Non-Revenue Kilometres: **28% increase**
- Peak Vehicle Requirement: **12% increase**

  Increase Fleet from 26 to 29 buses

  - 3 more vehicles required
- At least **10 Depot Chargers** will be required
- Cape Breton transit can deploy **17 BEBs** (electrifying 17 blocks) before fleet increases will be required

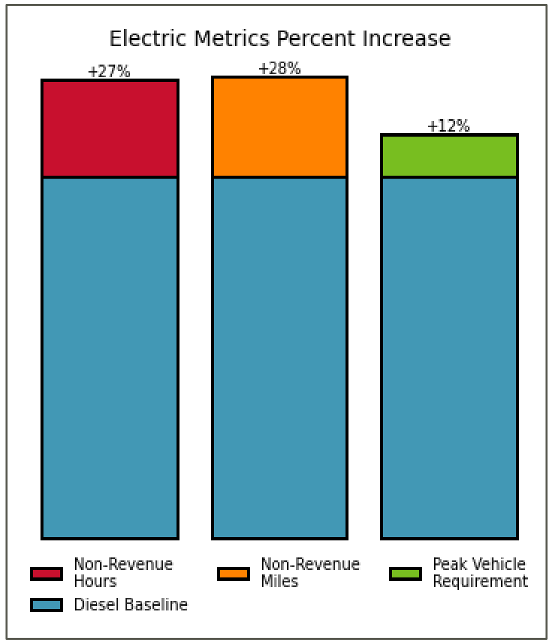

Figure 40: Outputs for Depot-only Charging plus Bus Swaps, (675 kWh)

A larger battery capacity does offer significant operational improvements for Cape Breton service. 65% of blocks are now feasible without swapping buses, and 31% are feasible with only one swap and the remaining blocks require two swaps. The state of charge is shown in **Figure 41**. The increase in non-revenue hours, kilometres, and peak vehicle requirement is still high, though not as substantial as BEBs with 525 kWh battery capacity.

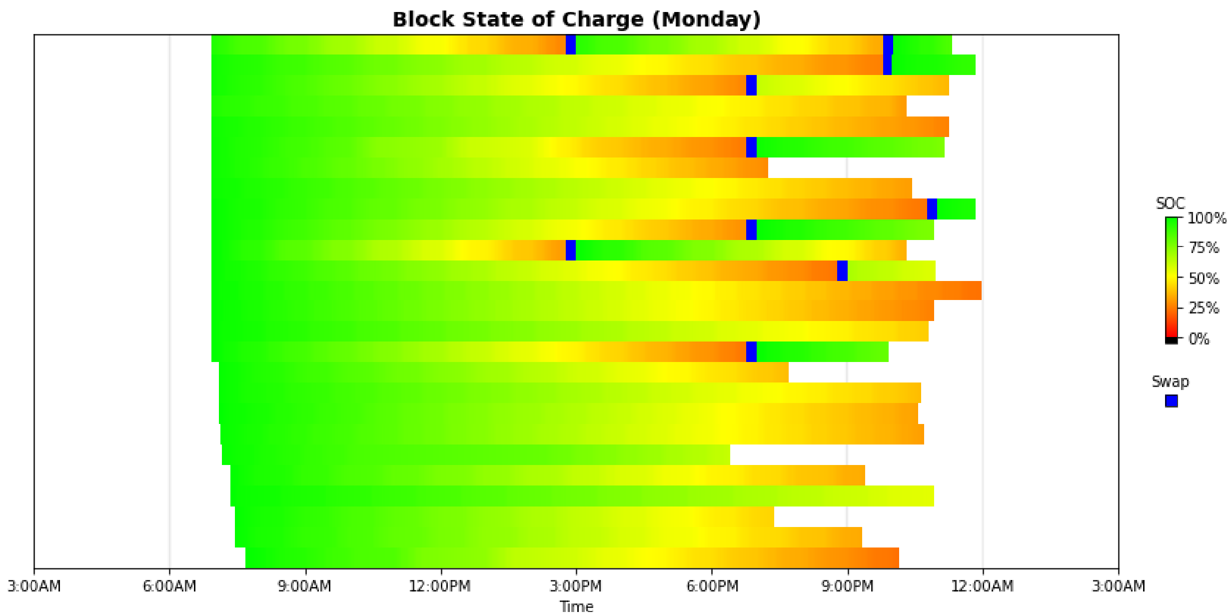

Figure 41: State of Charge Depot-only Charging plus Bus Swaps (675 kWh)

POWER REQUIREMENTS

The power profile for the future transit depot is shown in **Figure 42** for buses with diesel heaters. With larger battery sizes, the power requirement increases slightly to about 1.2 MW at the depot. A minimum of ten (10) 150 kW chargers would be required.

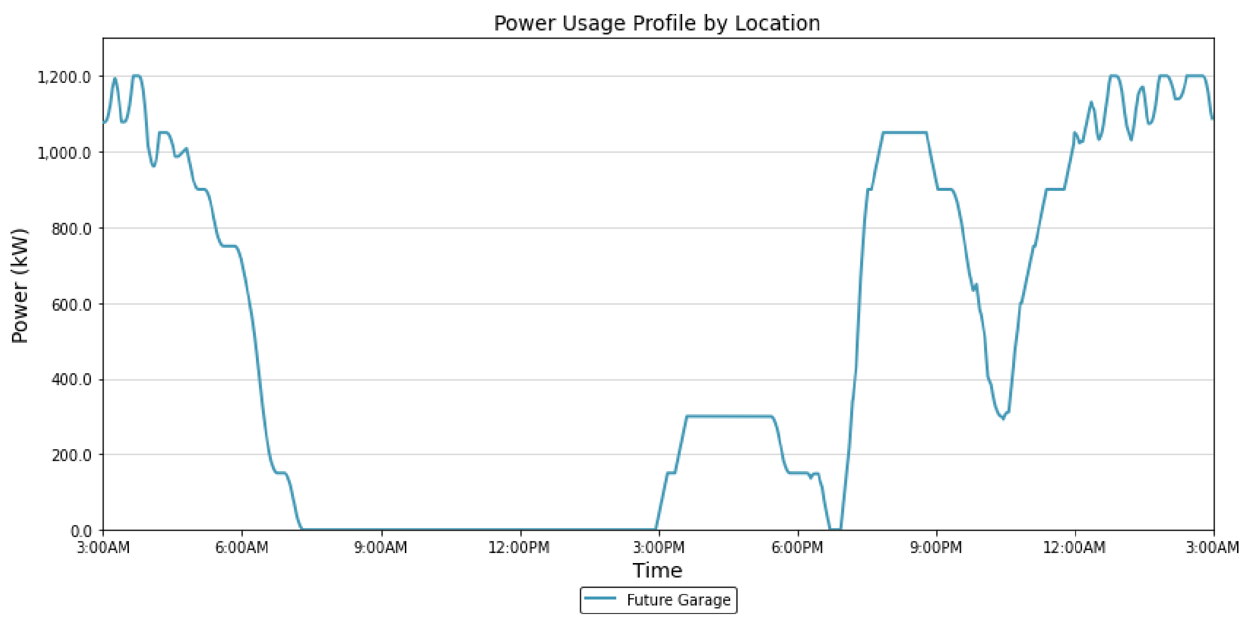

Figure 42: Charging Profile for Depot-only Charging plus Bus Swaps (675 kWh)

VEHICLE BATTERY SIZES

There is significant improvement in block feasibility for the diesel heating depot charging scenario when purchasing buses with larger battery sizes. **Figure 43** shows that approximately 67% of blocks can be covered with a 675 kWh battery compared to approximately 27% block coverage with 525kWh battery.

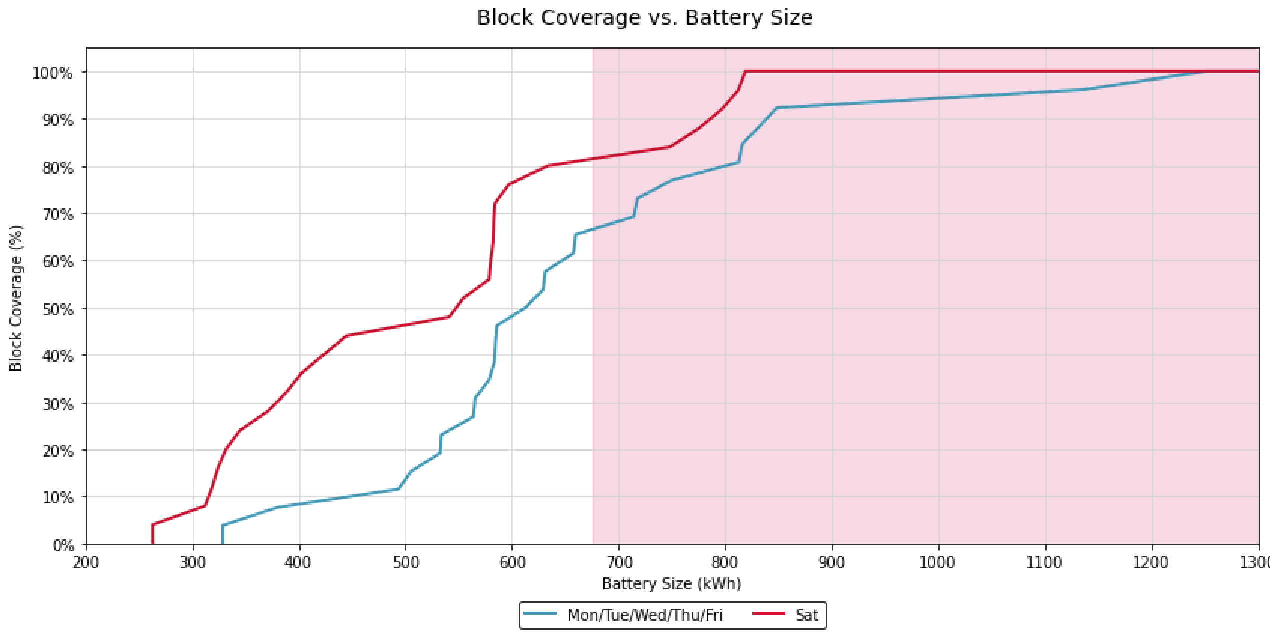

Figure 43: Battery Size Requirement for Depot-only Charging plus Bus Swaps (675 kWh)

7.7 Depot and En-route Charging Scenario

En-route (opportunity) charging is an enhancement that can greatly improve the feasibility of BEBs in many situations. This is particularly helpful with circulatory routes where the same en-route charger can be used by a vehicle multiple times throughout the day. En-route charging involves allowing a bus to charge for a short period of time (minimum 90 seconds) using a high-powered charger (450 kW or greater) while stopped along its route picking up passengers or otherwise laying over. The mixture of en-route charging and charging in the bus depot greatly extends the range of a BEB and facilitates one-to-one replacement of a larger number of diesel vehicles when the routes are conducive to this charging strategy.

Results for en-route charging was done only for BEBs with 675 kWh battery size. This is because a larger battery provides more value in terms of block coverage for Cape Breton's long term transit operations. En-route charging was considered with 525 kWh batteries but have been discounted for reasons discussed later. Electric buses with 675 kWh battery size provide 40% more block coverage than a BEB with 525 kWh in the depot-only charging scenario as shown previously in Figure 36. Furthermore, with en-route charging, the 675 kWh battery sizes also provide 40% more block coverage than BEBs with 525 kWh batteries as shown later in **Figure 51**

7.7.1 En-Route Charger Locations

En-route charging infrastructure is ideally located at places such as transit centers where buses operating on multiple routes all have scheduled layover time. When identifying potential en-route charging locations, property ownership and available grid capacity determine feasibility while average layover times and number of buses and riders passing through each site influence preference over other potential location. Based on discussions with CBRM staff on site feasibility and reviews of the current schedule for sites that have existing layover time, the location below was selected for testing of opportunity chargers.

Some of the sites are on private property and the sites were selected based on current route operations. No discussions have taken place with private property owners regarding their willingness to have en-route chargers installed at these locations.

FUTURE DOWNTOWN SYDNEY TRANSIT TERMINAL

The future downtown Sydney transit terminal is planned to be located on the southwest corner of Dorchester Street and George Street as shown in **Figure 44.** This terminal would operate with buses circulating in a clockwise fashion around an island platform. Within the site itself, three bays would be achievable on the west and south sides of the island. On-street platforms on George Street (to southbound and two northbound), and a single stop on Dorchester Street at the bus terminal, would supplement the on-site capacity. Bus layover capacity would be provided along the western periphery of the bus loop, with space adjacent protected to accommodate future electric bus charging infrastructure. The site would use the existing parking lot access but require a new egress directly on to Dorchester Street west of the George Street intersection. The future long-term routes that are planned to service this terminal are 1, 2, 5, 8, 9, 10, 12, 13,15, 16, and 22.

Figure 44: Proposed Future Downtown Sydney Transit Terminal

7.7.2 Depot and En-Route Charging (675 kWh)

MODEL RESULTS

Below is a review of the main components of the transit service and operations that are likely to change and should be considered when transitioning to a BEB fleet. **Figure 45** shows an estimate of the increase in non-revenue hours and kilometres as well as the estimated number of vehicles required to continue the current transit service.

- Revenue Hours & Kilometres remain the same
- Non-Revenue Hours: **1% increase**
- Non-Revenue Kilometres: **1% increase**
- Peak Vehicle Requirement: **0% increase**
- At least **5 Depot Chargers** will be required
- **2 En-route Chargers** @ Downtown Sydney Transit Hub

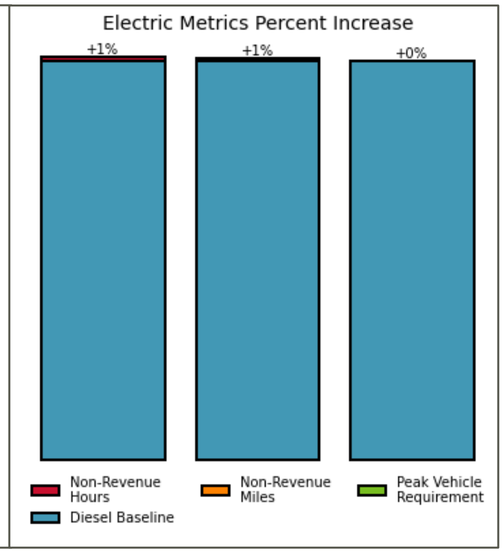

Figure 45: Outputs for En-route and Depot Charging (675 kWh)

Deploying opportunity charging to support BEBs would make a significant number of blocks more feasible and reduce the size of fleet required. As a result, most diesel buses could be replaced on a one-to-one with a battery electric bus (with 675 kWh battery size). As shown in **Figure 46**, all but one block would be feasible without any schedule modifications and that one block would be feasible with one bus swap.

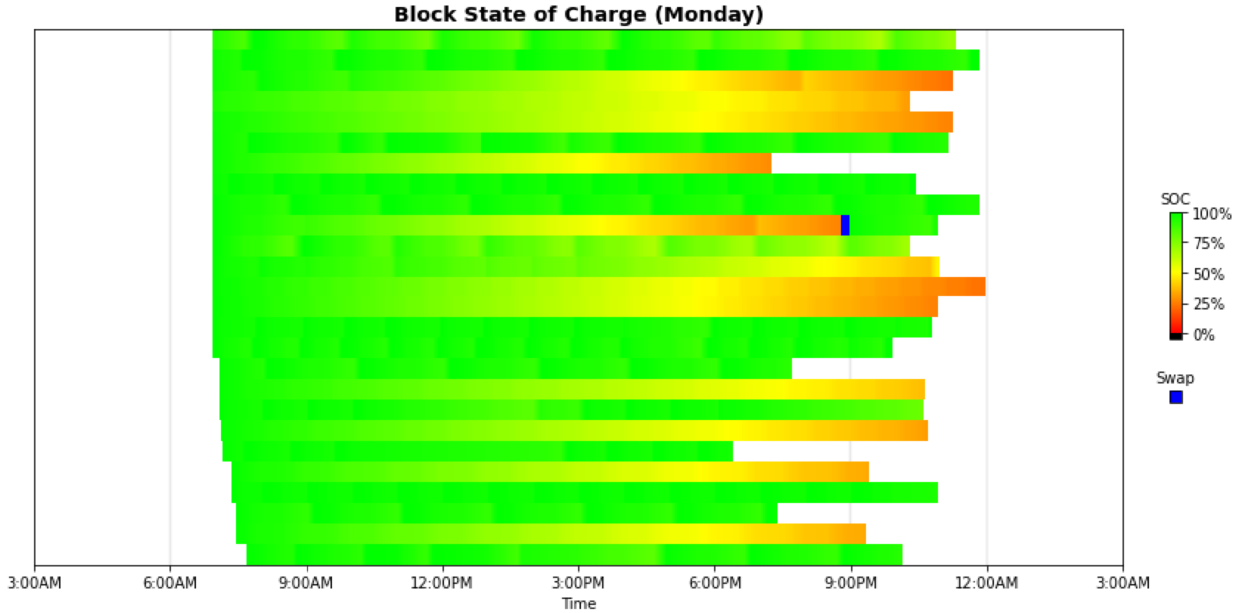

Figure 46: State of Charge for En-route and Depot Charging plus Bus Swaps (675 kWh)

EN-ROUTE CHARGER UTILIZATION

The energy profile by site is shown in **Figure 47**, 52% of total energy could be provided by en-route chargers, with the rest being supplied in depot.

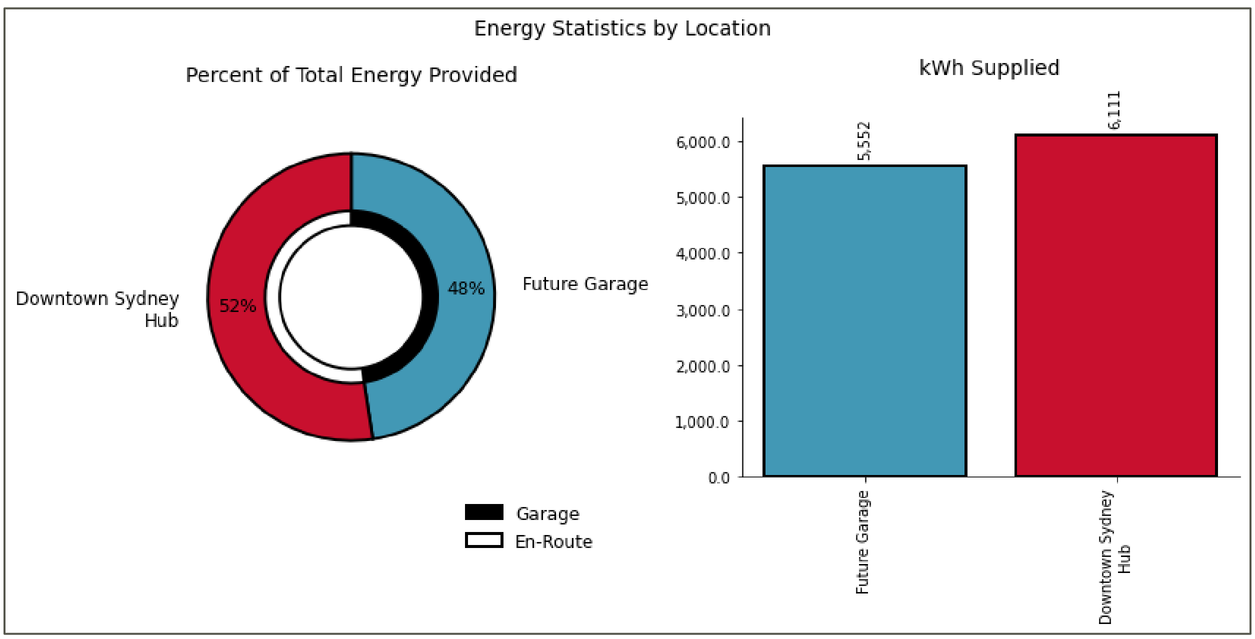

Figure 47: Energy Profile by Site for En-Route and Depot Charging plus Bus Swaps (675 kWh)

The en-route charger utilization is shown in **Figure 48.** The first and second charger are estimated to provided about 3,600, and 2,200 kWh, respectively. Furthermore, one en-route charger is estimated to be used for approximately 4 hours in total. The estimated number of hours where both en-route chargers are used at the same time is approximately 8 hours.

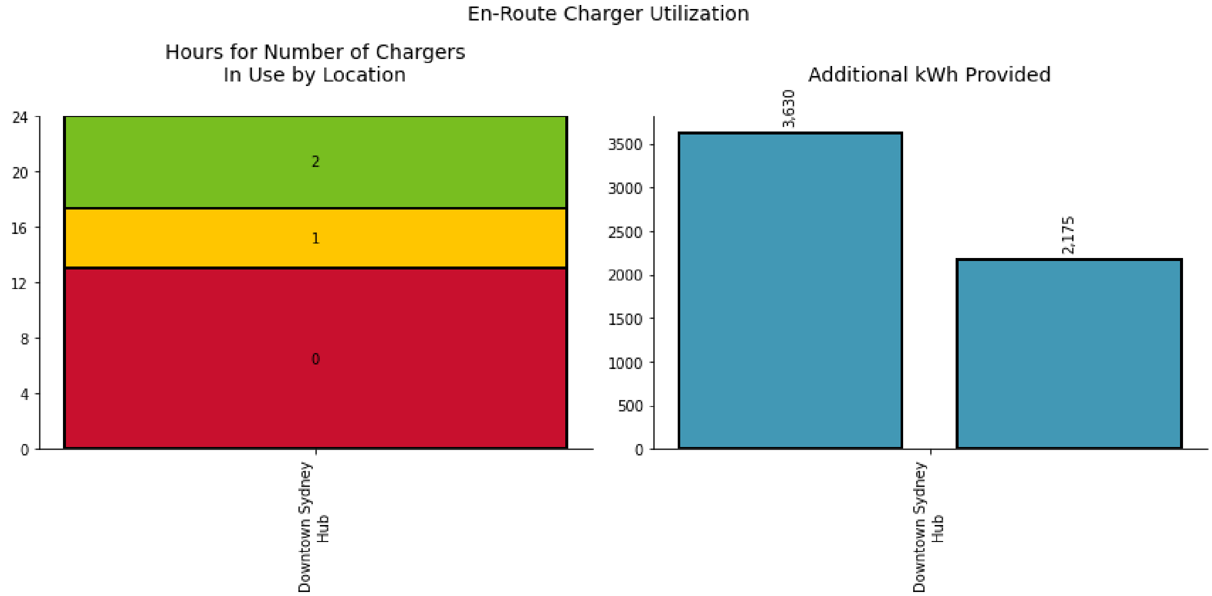

Figure 48: En-Route Charger Utilization for En-Route and Depot Charging plus Bus Swaps (675 kWh)

POWER REQUIREMENTS

With en-route charging, the peak power requirement is reduced significantly at the depot. The peak power demand would be around 0.75 MW and five (5) 150 kW chargers would be required. The power usage profile for the en-route charger scenario is shown in **Figure 49** and **Figure 50.**

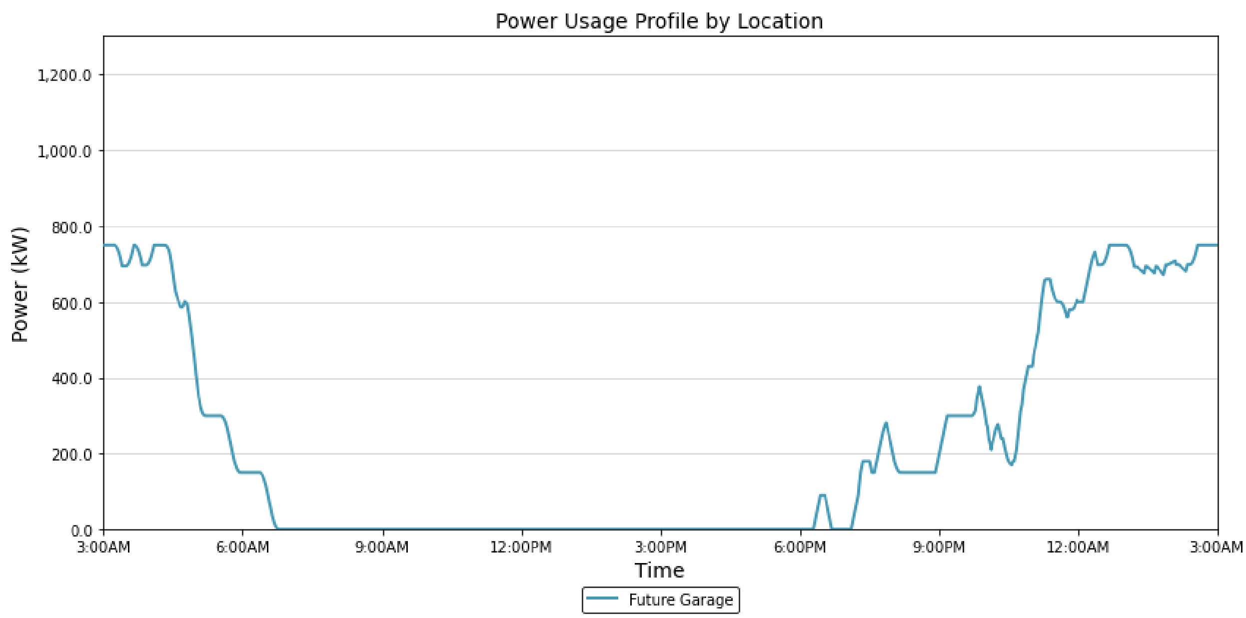

Figure 49: Charging Profile for Depot Chargers for En-Route Charging Scenario with 675 kWh BEBs

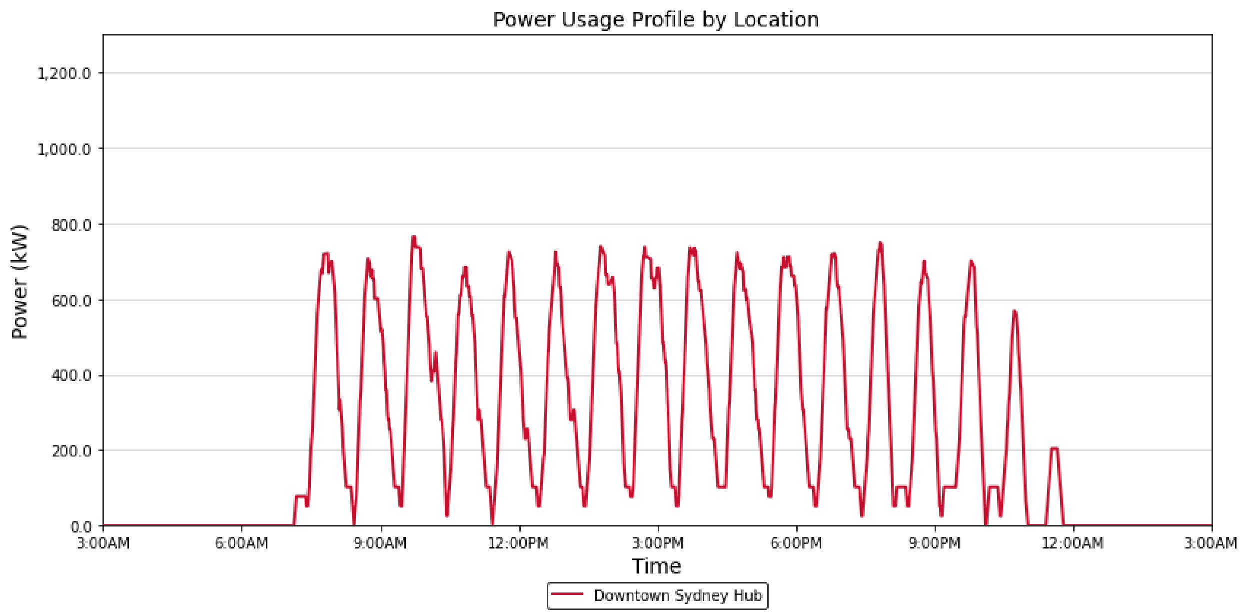

Figure 50: Charging Profile for En-Route Chargers for En-Route Charging Scenario with 675 kWh BEBs

VEHICLE BATTERY SIZE

There is even more improvement block feasibility in the diesel heating, en-route charging scenario than the depot only scenarios when purchasing buses with larger battery sizes. **Figure 51** shows block coverage with a 675 kWh battery is nearly 100% of blocks. Under the same parameters, a 525 kWh BEB would achieve 60% block coverage, which suggests that the larger 675 kWh BEB provides more value than 525 kWh BEB.

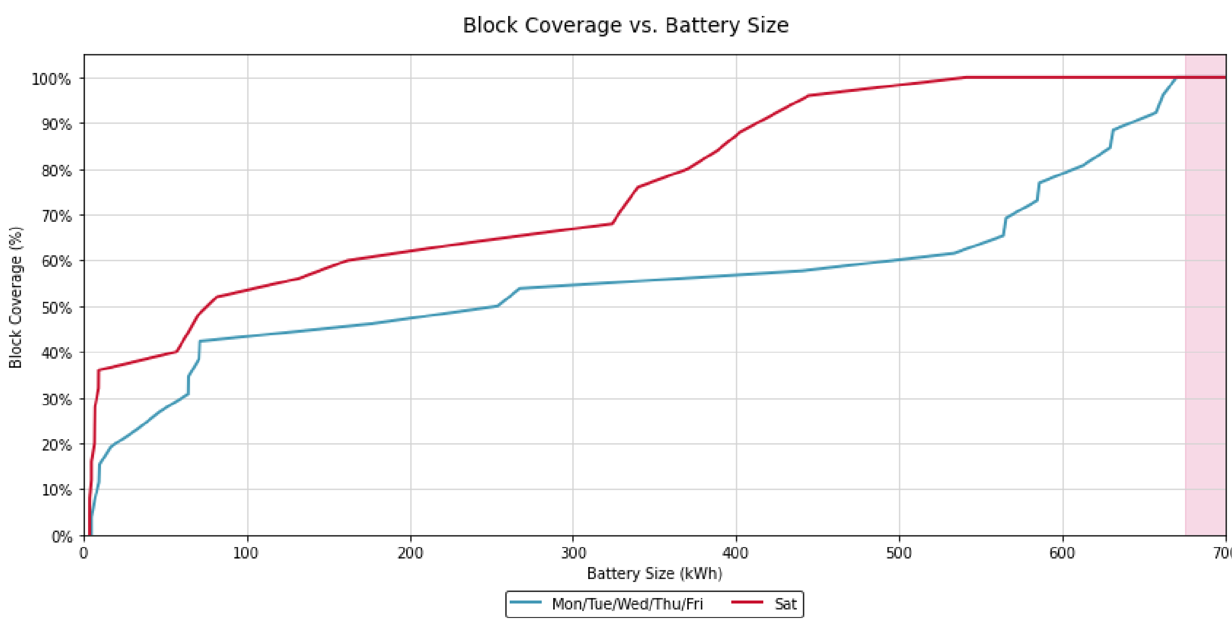

Figure 51: Battery Size Requirement for Depot-only and En-Route Charging plus Bus Swaps (675 kWh)

7.8 Fixed-Route Transit Modelling Summary

The modelled fleet requirement column in **Table 19** shows the peak number of buses without spares and the chargers columns show the minimum number of 150 kw chargers required. The block feasibility column notes the percentage of how feasible the blocks will be based on how Cape Breton currently operates.

En-route charging was able to bring peak vehicle requirements down by three BEBs in the scenario with 675 kWh BEBs.

Table 19: Fixed Route Modelling Summary

Scenario		Block Feasibility	Peak Vehicle Requirement	Depot Charger Quantity	En-Route Charger Quantity
Diesel Heating (525 kWh)	Baseline	23%	6	4	0
	Depot Only	100%	35	7	0
Diesel Heating (675 kWh)	Baseline	65%	17	8	0
	Depot Only	100%	29	10	0
	Depot and En-Route	100%	26	5	2
Diesel		100%	26	-	-

7.9 Pathway Options

To arrive at a final transition pathway, Cape Breton will select one or two scenarios that were discussed in the previous section. The number of BEBs required, costs, and GHG savings are detailed in this section based on the model outputs.

7.10 Fixed Route Transit

High level projections of fleet size requirements, charging equipment requirements, cost estimates, and emission reductions were produced for each option and compared to the baseline diesel "business as usual" (BAU) scenario.

The capital cost estimates include the purchase and installation cost for buses and fueling/charging infrastructure. The capital cost estimates are based on averages of best available quotes from the manufacturers or best available information from industry studies.

Operating costs includes energy and fuel cost, operating costs, and maintenance costs. These cost estimates are based on best available information from industry studies.

Emissions reductions were estimated based on emission intensity data produced by Environmental and Climate Change Canada and the Pembina Institute. **Table 19** summarizes these high-level projections.

In addition to the high-level quantitative estimates, each technology option was evaluated across a number of qualitative criteria:

- Route Flexibility – The routing and operational flexibility given the proposed fleet composition of each pathway
- Facility Constraints – The physical space requirements of supporting infrastructure and vehicle parking/storage
- Maintenance Complexity – The maintenance complexity of both the buses and the supporting equipment including chargers or hydrogen storage equipment
- Future Maintainability Risk – The expected availability of parts for maintenance in the future
- Technology Maturity – The maturity of both the technology and the supporting fuel and parts supply chain

Each pathway was graded on a scale of with the lowest number (1) being the best and highest number (3-5, depending on the category) being the worst. Some option rankings are combined, which means that they are tied. The grading of each pathway is presented in the following **Table 20** along with the quantitative estimate.

Table 20: Pathway Options for Fixed Route Transit – High Level Summaries

Measure		BAU	DH		
		Diesel	BEB (525 kWh)	BEB (675 kWh)	BEB (675 kWh)
		N/A	Depot Only		Depot + Enroute
Peak Vehicle Requirement	BEB		35	29	26
	Alternative	26	0	0	0
Garage Chargers			7	10	5
En-Route Chargers			0	0	2
Transformers			1	1	2
Capital Cost (Cumulative)[11]		$16,900,000	$45,200,000	$39,200,000	$35,600,000
Annual Operating Cost [12]		$5,101,413	$3,648,596	$3,676,336	$3,609,718
Annual GHGs Emissions (tCO2eq)		3789	339	345	339
Annual GHGs Savings (%)[13]		0%	91%	91%	91%
Route Flexibility		1	2		4
Facility Constraint		1	4	3	1
Maintenance Complexity		1	2		3
Future Maintainability Risk		1	2		3
Technology Maturity		1	2	2	3

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[11] Total raw conversion costs. Capital Costs: Fleet, Depot Charger, En-route Charger, Transformer

[12] Operating Cost (based on current costs): Electricity Demand & Regulatory Cost, Electricity Consumption Cost, Fuel Cost, Maintenance Cost

[13] Relative to service level under diesel baseline. Includes upstream emissions and emissions from auxiliary heater.

When considering options, it is important to consider both the initial capital costs of purchasing the vehicles as well as the operating costs. Typically, when transit fleets transition to battery electric buses, there is a significant shift from operating costs to capital costs. While the vehicles are more expensive to purchase, they are typically more cost effective to operate and maintain. One reason for this efficiency is due to electricity being typically a cheaper way to power vehicles and the price is more stable. The vehicles can have a long lifespan of 12-18 years over which to recover those operating cost savings.

As can be seen in **Table 20**, all options require significant capital investment compared to the BAU scenario. The capital costs are significantly higher for all the battery electric bus scenarios. However, there are significant savings in annual operating costs for the BEB scenarios compared to the BAU scenario. Capital and operating costs are comparable across each of the BEB options with the en-route and diesel heating scenario holding a slight advantage in both capital investment and operational cost. Although there are advantages for the en-route and diesel heating scenario, the en-route charging technology is not as mature as depot charging so there is more operational complexities and larger maintainability risk in the future.

It should be noted that the costs shown in **Table 20** assume that the entire fleet and facilities were converted in 2023 dollars with 2023 costs for vehicles and infrastructure. Recognizing the actual transition will occur over 10+ years, actual costs will be impacted by inflation and other factors. It is also not necessary to commit to a single strategy now and it is recommended that a flexible plan that is able adapt to technology improvements be considered.

There are several existing deployments of plug-in, depot charged buses in operation today and the technology is relatively mature. More en-route charging is being deployed by transit agencies in North America and the industry has become more aligned on an overhead fast-charging standard. It’s expected the technology risk of en-route charging will likely go down over the coming years as this becomes more common.

Based on the above evaluation and recognizing the uncertainty in future technological development for BEB technology, it is proposed that a phased approach be taken. This strategy is intended to implement mature technology now while leaving the door open for some of the less mature technology to develop prior to implementation.

RECOMMENDATION:

- Implement BEBs with hybrid-diesel fired auxiliary heaters that are capable of both plug-in & en-route charging and operate them as depot charged buses. The vehicles procured should be longer range (~675 kWh+) BEBs that can replace the current fleet 1:1 using depot charging in the near-term.

- Investigate adding en-route charging at the future proposed Downtown Sydney Transit Hub over the next 5 years. Become familiar with en-route charging technology risk by learning from other transit agencies and/or testing the technology. Installing at least one pantograph charger at the depot that can validate the vehicle charging capability and allow Cape Breton to become familiar with its operation and maintenance prior to implementing it in revenue service.

- Conduct a follow-up evaluation in 3-5 years after first BEB purchase to confirm the number of buses and chargers required at each location based on actual performance in-service of the fleet selected. Increases in battery capacity or vehicle charging capabilities may reduce the number of vehicles or infrastructure required.

See **Appendix C** for the BEB Feasibility Study & Transition Plan.

8 Organizational Review

As Cape Breton Transit grows, in alignment with the general plans set forth in this report, there will be a need to bring additional operations and support staff to manage and deliver the operation. The following is a summary of the preliminary additional staffing needs identified as part of this study for the 2040 horizon year. It is recommended that these be used for planning purposes, but CBRM review their needs as the service grows in order to confirm or adjust the forecast staffing requirements presented herein.

8.1 Introduction

This study includes the development of an organization plan for Cape Breton Transit to effectively manage and deliver the recommended level of transit service to the public. This organization plan includes the responsibilities for all the transit staff positions necessary to support the current and future system based on findings for ridership growth potential. These positions include an organizational structure and staffing plan for the new transit facilities, including maintenance and operations staffing for an electrified fleet.

CBRM management staff currently consists of the following individuals:

- Management:
  - Manager (1)
  - Supervisor (2)
- Administrative positions (union - non confidential)
  - Information Technologist/Computer Tech (1)
  - Regular Transit Dispatch (2)
  - Working Foreman (2)

The following organizational charts (**Figure 52** and **Figure 53**) show the roles currently employed by CB Transit and Fleet departments, and the reporting structure under which they are arranged.

By sharing office space, there are economies of scale attained since the staff share administrative and customer service functions. This arrangement is ideal for a small system and is encouraged to be continued. Bus operators are trained in both conventional and Handi-trans services, providing flexibility and adaptability for CB transit to respond quickly and effectively to changes in needs, reduces the need for additional staff to cover absenteeism, and provides transit operators with an understanding of and appreciation for the challenges that Handi-trans customers face (and will continue to face as the system grows and more conventional transit service options become available for them). See **Table 21** for a summary of proposed future staffing.

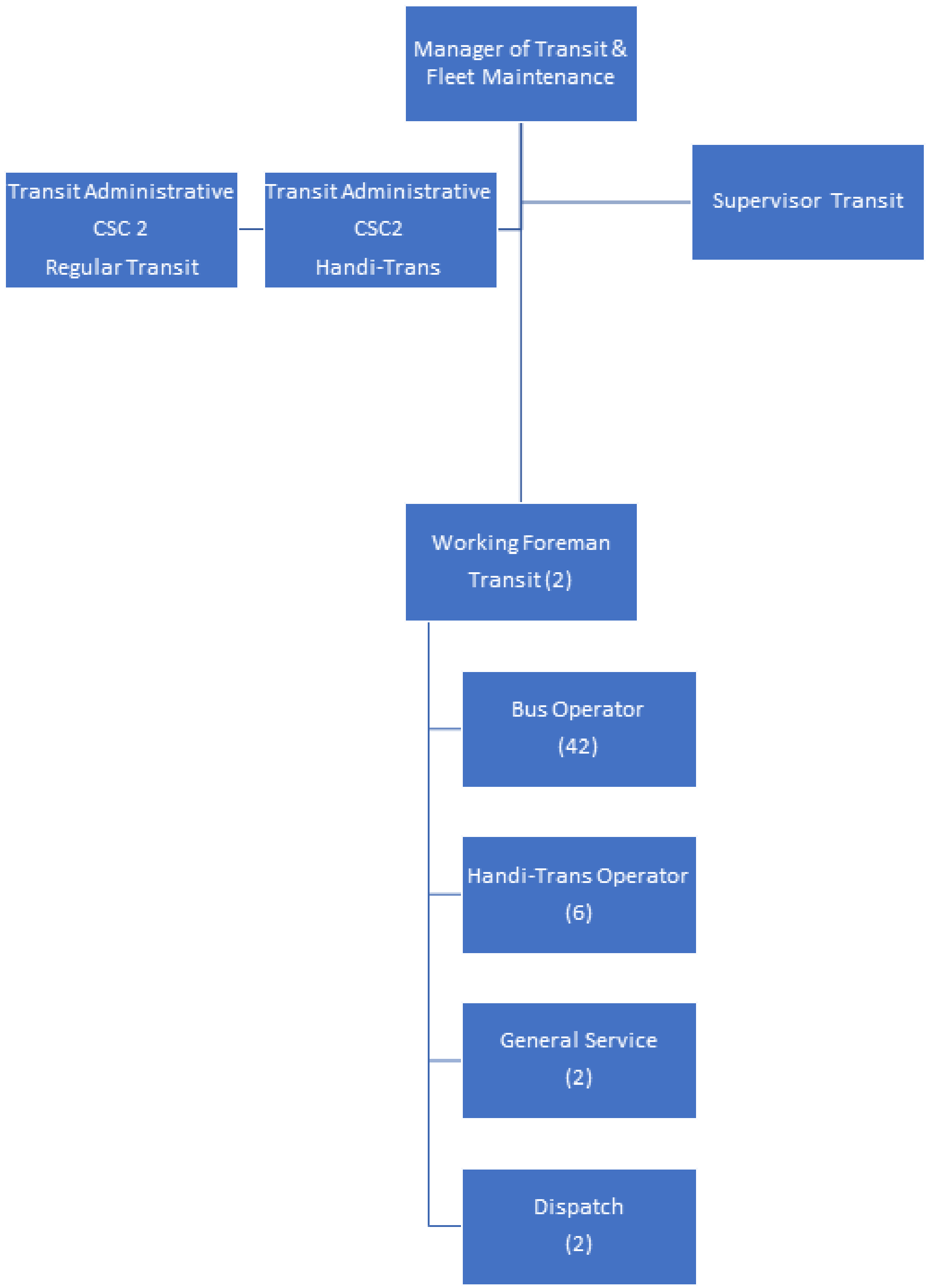

Figure 52: Existing CB Transit Department Organizatonal Chart

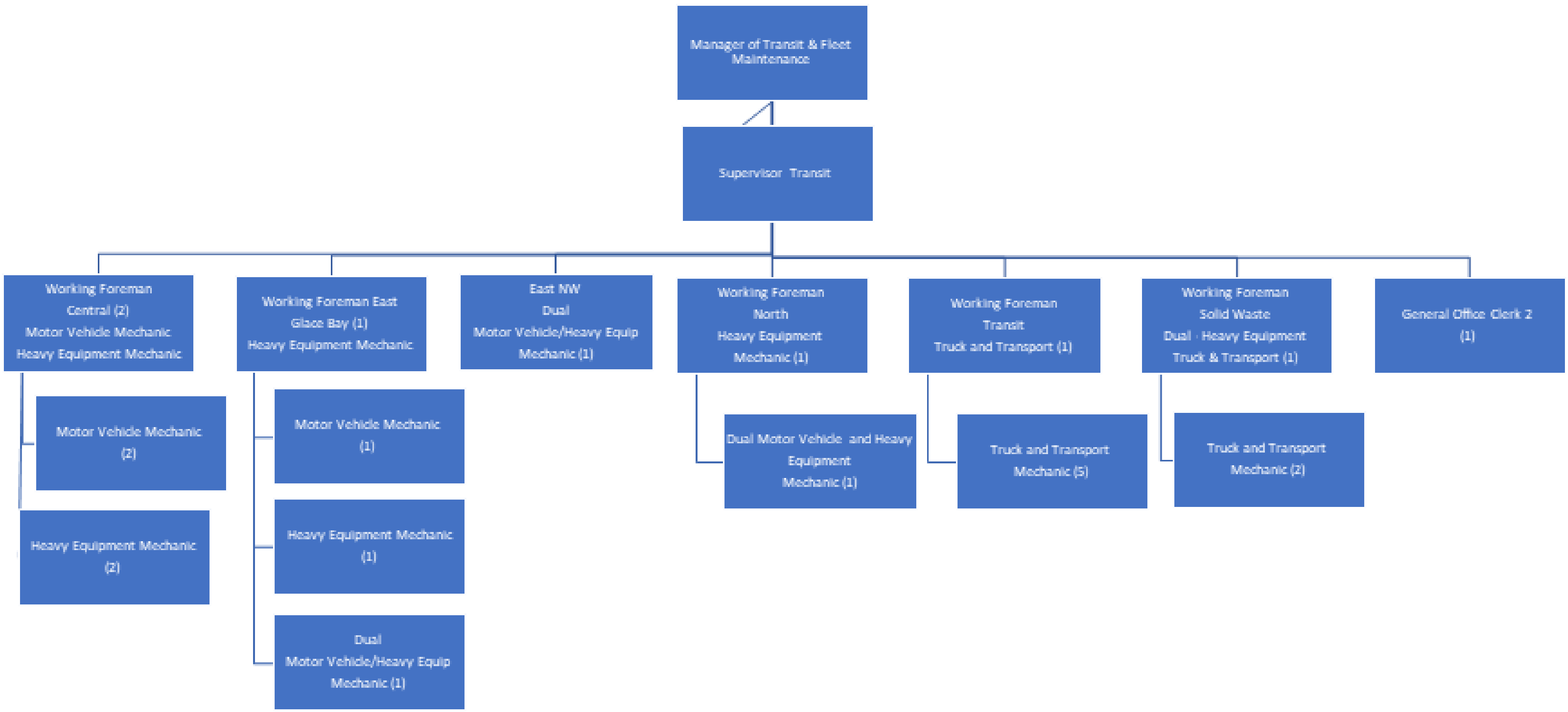

Figure 53: CBRM Fleet Department Organizational Chart

Table 21: Staffing Requirements

GENERAL ADMIN	Existing (2023) Total Staff Count	Future (Phase 1 - Opening Day) Total Staff Count	Ultimate Condition Total Staff Count	Source:
MANAGEMENT				
Manager Of Transit And Fleet Maintenance	1	1	1	
Accounting Clerk		1	1	
Marketing & Communications Manager		1	1	
Customer Service Representative (Conventional Transit)	2	2	2	
Customer Service Representative (Handi-Trans)	1	1	1	
Transit Planner		1	2	
Associate Transit Planner		1	2	
FLEET OPERATIONS				
Supervisor Transit (City)	1	1	1	from CBRM org chart
Transit Operations Manager		1	1	
Handi-Trans Admin / Dispatch		1	1	from Questionnaire
Transit Administrative CSC 2 - Regular Transit	1	1	1	from CBRM org chart
Transit Administrative CSC 2 - Handi-Trans	1	1	1	from CBRM org chart
Working Foreman - Transit		2	2	from CBRM org chart
Dispatcher	2	2	2	from CBRM org chart
Route Supervisor		1	1	Workshop 1
Transit Operator (Bus Operator)	42	47	55	from CBRM org chart
Handi-Trans Operator	6	10	12	from CBRM org chart
Casual Operator		10	15	from Questionnaire
General Service	2	2	3	from CBRM org chart
FLEET MANTENANCE				
Fleet Maintenance Manager		1	1	
Fleet Admin CSC 2 – Regular Transit		1	1	from CBRM org chart

GENERAL ADMIN	Existing (2023) Total Staff Count	Future (Phase 1 - Opening Day) Total Staff Count	Ultimate Condition Total Staff Count	Source:
Working Foreman - Transit Truck And Transport	1	1	1	from CBRM org chart
Mechanic - Truck And Transport	5	10	12	from CBRM org chart
Parts Handler		2	2	
Service Person (Bus & Shelter Advertizing)		1	1	
Bus Detailer		2	3	
FACILITY MAINTENANCE				
Information Technology Technician		2	2	
Facilities Coordinator (Stops, Shelters, Etc.)		3	3	
Janitor		2	2	
TOTAL	**65**	**112**	**133**	

8.2 Management

In order to effectively deliver the recommended transit service, the following new or modified transit management roles are anticipated to be required, in addition to existing roles:

- **Marketing & Communications Manager:** The Marketing and Communications Manager would generally be responsible for the development and implementation of public-facing information, leading the preparation of material (including written, printed, social-media, and multi-media) posts, preparing and delivering presentations to the public, stakeholder groups, and community groups, all aimed at informing the audience on transit services and changes in order to grow ridership.

- **Customer Service Representative:** The Customer Service Representative would be responsible for answering customer inquiries on a day-to-day basis and would support the Marketing & Communications Manager in hosting information sessions and updating the public on improvements/changes to transit services.

- **Transit Planner and Associate Transit Planner:** The Transit Planner and Associate Transit Planner would work together to facilitate route and schedule planning for both regular transit and Handi-Trans services.

8.3 Fleet Operations

In order to effectively deliver the recommended transit service, the following new or modified transit fleet operations roles are anticipated to be required, in addition to existing roles:

- **Transit Operators:** Both conventional and Handi-Trans bus operators will no longer be responsible for fare enforcement upon implementation of a smart-card system. This will likely reduce the operator workload in that regard. However, it is anticipated that (at least in the period of transition to the smart card system), operators will be required to assist passengers with instructions on the use and troubleshooting of the new system.

  Given the anticipated increases in service hours associated with transit network growth, as discussed in Section 4, there will be a need to increase the number of vehicle operators required to deliver the proposed transit service under Phases 0-3. **Appendix D** provides a detailed breakdown of the estimate of new bus operators required.

- **Dedicated Transit Operations Manager** (*currently shared with Manager of Fleet*): A Transit Operations Manager would be responsible for the planning, organization, and implementing of day-to-day services for both the conventional and Handi-Trans services. The Operations Manager would generally assist in setting the goals of the service, coordinating route and schedule updates with the Transit Planners, coordinating staff and equipment requirements, assisting in management of the budget and identification of funding needs, and contributing to the overall oversight of the transit service.

- **Route Supervisor:** A Route Supervisor would be responsible for supervising the day-to-day operations monitoring bus routes, monitoring bus routes to ensure that the service being delivered is consistent with the plans, directions, and regulations in place, as well as identifying and addressing customer complaints regarding transit operations (including disciplinary action where required). It should be noted that with the GPS-based Smart Card system, schedule adherence and boading data and reports will be available on-line to help identify and track issues. This is extremely important given the vast geographic area covered.

8.4 Fleet Maintenance

As the fleet transitions from a diesel to electric bus fleet, additional training and expertise will be required for fleet maintenance staff, including maintenance managers, mechanics, and parts handlers, to respond to the changes in vehicle technology, including repair and replacement of parts on bus and associated charging infrastructure.

It should be noted that, with CBRM taking on the fleet maintenance themselves, the need for additional and dedicated transit maintenance and repair staff, as well as facility maintenance staff. These include the following roles:

- **Fleet Maintenance Manager:** A dedicated Fleet Maintenance Manager would be responsible for daily transit fleet maintenance, preventative maintenance programs, asset management, and maintenance systems. They would be required to provide input to specifications for acquisition of new vehicles, policies and procedures for vehicle maintenance, and maintenance information systems. The Fleet Maintenance Manager would also be responsible for staff recruiting, training, coaching, and performance monitoring.
- **Fleet Admin CSC 2 – Regular Transit:** The Transit Fleet Administrator would be responsible for monitoring maintenance operations of the transit fleet, inspection of the transit fleet, maintenance facility and equipment, field inspections, maintenance reports, safety inspections, and maintenance of documentation on fleet vehicles maintenance status.
- **Parts Handler:** The Transit Parts Handler would be responsible for the coordination and distribution of maintenance materials for transit fleet maintenance staff. The Parts Handler would be responsible for tracking and documenting part usage, preparing requisitions and purchase orders for stock, and checking parts received for accuracy.
- **Service Person (Bus & Shelter Advertising):** The Service Person role would be responsible for the coordination, installation, and maintenance of bus and shelter advertising, supporting the Transit Manager.
- **Bus Detailer:** A Bus Detailer would be responsible for ensuring vehicle cleanliness, including cleaning of all vehicle exteriors and interiors.
- **Information Technology Technician:** A transit Information Technology Technician would be responsible for the installation, configuration, and troubleshooting of all ITS hardware and software for the transit maintenance facility. The Technician would be responsible for

maintaining ITS equipment inventory, documentation, and training materials, providing input to new equipment evaluation, procurement, and confirmation of equipment received.

- **Facilities Coordinator** (Stops, Shelters, Etc.): A Facilities Coordinator would generally be responsible for facility support for management of all activities supporting the regular maintenance and repair of Agency facilities, including supporting the development, monitoring and review of vendor contracts, purchase orders, and work order systems to support routine work of maintaining facilities.

- **Janitor:** The transit facility Janitor would be responsible for the cleaning of facility restrooms, kitchens, storage areas, and floors, emptying trash and recycling bins, vacuuming carpets, mopping floors, setting up furniture for meetings and training sessions, and other cleaning duties as required.

9 Conclusions and Recommendations

Transit Cape Breton has achieved significant ridership growth over the past few years, and this has placed a notable strain on existing resources. Many routes are over-capacity in the peaks, driving a need to increase service frequency to accommodate the demand. In addition, the limited resources available are preventing the Region from expanding service into new areas. The current funding structure prevents service expansion into the Membertou First Nation. The lack of service leaves many residents with no option but to purchase automobiles in order to commute to their jobs. For those without the means to cover the costs of car ownership, the lack of transit service places them at a further economic disadvantage, limiting their employment opportunities and freedom of movement around the Region.

The service plan presented herein addresses that need, in a phased approach, by gradually expanding services into these currently-underserved areas. It does, however, require a significant investment. There are, however, tools that the CBRM could explore as a next step to mitigate the cost of the service improvements, including:

- Full area taxation to recognize public transportation provides region-wide benefits. The current (2022/23) average area rated tax, based on an assessed value (Sydney residential) of $100 is $0.0862, while a projected general rate taxation for a property (all other areas) with an assessed value of $100 is $0.1070. This action would create a basic tax reduction for properties charged under the current system and a tax increase on all newly-charged properties.

- An increase in transit fares could have a substantial impact on funding. Current transit fares have not been increased in over 10 years, and are significantly lower than that of peer agencies. The base transit cash fare should be set at $2.25 and apply to all Transit customers for travel within all zones. Fare could be increased incrementally over the span of 3 years to avoid ridership loss (e.g., 50 cents in year 1, another 25 cents in year 2, and another 25 cents in year 3).

- Implementation of a Smart-Card system brings about many benefits, including increased revenues, reduced revenue management system costs, reduction in fare evasion and counterfeiting, reduced bus operator-customer confrontations, reduced boarding times, and improved passenger data collection to inform system changes. Implementation of a Smart-Card system is expected to result in a net gain of up to $60,000 in the year of implementation (considering an annual savings of operating budget of $310,000 and a smart-card system cost of $250,000).

In an effort to combat climate change and operate their transit system in a more sustainable manner, Cape Breton is developing a plan to transition from the existing diesel transit fleet to an electric fleet by 2040. The fleet electrification will support the reduction of GHG emissions, aligning with the objectives and requirements of various plans and policies across all levels of government. Namely, the Canadian Net-Zero Emissions Accountability Act (2021), the Nova Scotia Environmental Goals and Climate Change Reduction Act (2021), and the Municipal Climate Change Action Plan (2014).

Electrifying the transit fleet may significantly impact daily operations. Cape Breton has planned their transition to zero emissions, in coordination with the proposed ridership growth strategy and phased route modification updates, by developing an E-Bus Transition Plan that will act as a roadmap to guide the process. The E-Bus Transition Plan identifies the feasible transition pathway(s), associated capital and operating costs, service impacts, and, ultimately, the preferred transition pathway.

Based on stakeholder consultations, best practices, and study findings, it is recommended that CBRM adopt this report in principle, and use it as a guide to effect the change needed to better meet the public transit needs of the Region.