ELECTRIC SCHOOL BUS FEASIBILITY STUDY

COUNCIL OF ATLANTIC MINISTERS OF EDUCATION AND TRAINING

FINAL REPORT - FEBRUARY 2025

wsp Newfoundland & Labrador CANADA NOVA SCOTIA NOUVELLE-ÉCOSSE New Nouveau Brunswick CANADA

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EXECUTIVE SUMMARY

Three of the Atlantic provinces – Nova Scotia, New Brunswick, and Newfoundland and Labrador (collectively referred to as 'provinces') – through the coordination of CAMET, have taken the initiative to undertake a feasibility study for the electrification of their public school bus fleet.

The primary objective of this study is to evaluate the potential of an electric school bus (ESB) system. The aim is to gain insights into the feasibility, financial benefits and operational constraints associated with transitioning to ESBs. The study provides insight into how the Atlantic provinces can effectively implement electrification across their school bus fleets and prepare for their infrastructure, all while estimating the greenhouse gas (GHG) emissions and costs with electrification. This study may be used to secure funding through available initiatives such as Infrastructure Canada's Zero Emission Transit Fund (ZETF), Infrastructure Canada's Rural Transit Fund (RTSF), and the Canadian Infrastructure Bank's (CIB) Zero Emission Bus program, among others. This strategic approach aligns with the provinces' commitment to sustainable and innovative transportation for the public school education system.

CURRENT OPERATIONS

An investigation of the current operations[1] of the existing school bus fleet was conducted to approximate the total cost of ownership of the buses used by the provinces and their associated GHG emissions.

PROVINCE	TOTAL ACTIVE BUSES	TOTAL ANNUAL KM'S DRIVEN	% OF DISTANCE TRAVELLED	AVERAGE KM'S DRIVEN	AVERAGE ROUTE LENGTH (KM)	ANNUAL GHG EMISSIONS (TCO_2E)
New Brunswick	1,108	24.01 M	50%	21,770	85.8	21,593
Newfoundland & Labrador	262	3.12 M	6%	11,908	70.5	2,626
Nova Scotia	814	21.12 M	44%	27,637	166.2	23,288
Provincial Total	**2,184**	**48.25 M**	**100%**	**22,092**	**119.3**	**47,507**

It is estimated that across all three provinces, the school buses produce 47,507 tonnes of CO_2e annually. While Nova Scotia accounts for 44% of the total travel distance of the provinces, it is still responsible for 49% of the GHG emissions.

Across the provinces, the current annual operational expenses account for approximately $39.7 M, of which, 41% ($16.1 M) is attributed to maintenance, while the remaining 59% ($23.6 M) is for fuel. Newfoundland and Labrador have the highest operating cost per kilometre, which may be linked to the following: 1) higher fuel cost within this province, 2) lower total distance travelled compared to the other provinces, and 3) the routine maintenance work required.

KEY TAKEAWAYS

- Nova Scotia's buses are being driven over longer distances, on average, than the other provinces. These longer route distances impact the feasibility of electrifying routes.
- Nova Scotia accounts for over 49% of the GHG emissions. Nova Scotia's transition towards ESBs would have the greatest impact on emissions reduction across all three provinces.

[1] The current operations are a snapshot in time for the 2024 school year. Each year will change slightly, as routes change due to student needs and drivers assigned to each route.

BUS ELECTRIFICATION AND SITE MODIFICATIONS

This feasibility study is assessed through two distinct scenarios:

Scenario 1 presents the results of electrification considering overnight charging only. For this scenario, it was assumed to follow a 1:1 vehicle-to-charger ratio with a level 2 charger capable of charging at a rate of 19.2 kW. This scenario allows for a minimum of an 8-hour charging window (from the moment the bus completes its daily operations).

Scenario 2 presents the results of electrification considering overnight charging combined with mid-day charging. While DC Fast Charging (‘DCFC’ or ‘level 3’) could be a useful addition to the charging strategy of the provinces, they are not required to fulfill the operations planned with Scenario 2. The long period between the morning and the afternoon runs would still make the operation viable on a level 2 charger.

Complete electrification presents the scenario where the whole fleet could be electrified, without the technology barriers (range, available power, charging windows, operational constraints, etc.). While not the most realistic scenario, the conclusion from the complete electrification scenario can be used for strategic planning before moving forward with infrastructure modifications.

Table ES-1 presents the number of charging pistols that would be required to accommodate the ESBs, based on the different scenarios. For locations where there are two (2) ESBs at one location, one (1) dual-port charger may be used to reduce costs associated with infrastructure and electrical demand.

Table ES-1 Number of charging ports based on the three scenarios

	New Brunswick							Newfoundland and Labrador	Nova Scotia						
	AN	AW	AS	AE	FNE	FS	FNO		AVRCE	CBVRCE	CCRCE	CSAP	SRCE	SSRCE	TCRCE
Scenario 1	51	148	89	69	39	53	27	193	29	31	70	8	46	26	42
Scenario 2	82	225	174	108	89	125	55	235	71	56	137	30	75	55	72
Complete electrification	128	267	231	127	107	187	61	262	100	83	185	43	110	87	89

The number of ESBs at each parking location will have a significant impact on the site modification that will be required to accommodate the transition. Understanding the number of buses at each location will help determine the power requirements at each parking facility. As there are hundreds of parking locations across the provinces, parking archetypes were developed to indicate residential versus depot charging and their associated costs. The following table shows the count of parking locations concerning the number of buses it accommodates.

Table ES-2 Number of Different Parking Locations

	New Brunswick							Newfoundland and Labrador	Nova Scotia						
	AN	AW	AS	AE	FNE	FS	FNO		AVRCE	CBVRC	CCRCE	CSAP	SRCE	SSRCE	TCRCE
1 Bus	106	189	156	52	100	28	65	48	89	-	27	53	109	84	54
2 Buses	5	9	2	-	2	-	-	15	9	-	-	-	-	2	3
3 to 9 Buses	-	5	7	6	-	8	-	25	2	2	1	-	3	-	6
10 to 20 Buses	-	2	3	1	-	1	-	5	-	1	2	-	-	-	1
20+ Buses	-	1	-	-	-	2	-	-	-	2	3	-	-	-	-

For ESBs parked at drivers' residences, it is advisable to set up a distinct service and electrical feeder exclusively for vehicle charging. This approach is preferred due to multiple factors, such as simplified billing, specific power needs and improved accessibility. However, it is essential to note that not all utility providers permit a second service at a single location.

KEY TAKEAWAYS

- While Level 3 chargers could be beneficial if they are centralized and easily accessible to a high number of ESBs, they are not required to fulfill the operations planned with the proposed scenarios. However, to ensure operation viability and access to chargers between the morning and afternoon runs, operations across school districts may need to change to ensure the buses are returning to their designated charge location.
- Energy and power needs will have an impact on the electricity pricing. These factors will be impacted by the number of ESBs parked at different locations. To reduce the operational expenses for electricity, it may be beneficial to increase the power demand at certain times of day and reduce it at others, based on the specific location energy requirements.
- Engagement with the utility companies must occur early in the facility design process. Depending on the location of the depots, the levels of power required may not be readily available and may require a distribution infrastructure upgrade on the side of the utilities. Depending on the location and power level required, this process can potentially take up to a few years in the worst-case scenario. Typically, sites with a multiplicity of chargers will require the largest power upgrades and have the longest lead time for upgrades.

ENVIRONMENTAL BENEFITS

ESBs are recognized for producing zero tailpipe GHG emissions. By adopting ESBs, students, drivers, and community members are exposed to significantly fewer harmful criteria air contaminants and leads to a reduction in GHG emissions. Beyond addressing air pollution, ESBs also play a role in reducing noise pollution, which benefits students, drivers, and the local neighbourhood. Following discussions with the provinces and similar jurisdictions that are transitioning their electric school buses, it was concluded an auxiliary diesel heating system would be an important addition in order to reduce the effects of the outside temperature on the operations. While the auxiliary heated ESBs will still produce some emissions, the transition towards ESBs would have a substantial impact on greenhouse gas emissions compared to business-as-usual.

Table ES-3 below presents the average annual emissions savings that would occur from the transition to a single ESB, as well as the total annual GHG reduction that would result from a complete fleet transition.

Table ES-3 Average Annual Emissions Savings

	NEW BRUNSWICK	NEWFOUNDLAND & LABRADOR	NOVA SCOTIA
Average Annual GHG Emissions Savings for a single bus (tCO_2e)	13.89	9.39	11.31
Average Annual GHG Emissions Savings for complete fleet electrifications (tCO_2e)	15,317	2,431	9,427

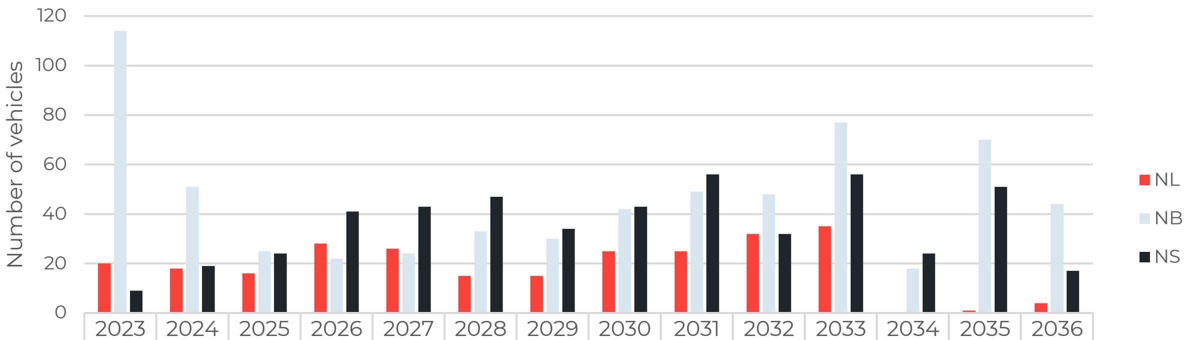
KEY TAKEAWAYS

- GHG emissions savings will vary between provinces due to the various utilization rates from ICE (internal combustion engine) buses.
- The ZETF application requires that emissions from both the production of the fuel and the operations of the school buses are accounted for. This consideration means that the savings resulting from the transition towards ESB are highly dependent on the emissions produced by the electricity used.

TOTAL PROJECT COSTS

An annual transition plan was produced which considers the end-of-life replacement with the feasibility of route electrification. Financial modelling conducted to assess the project costs covered over 20 years, and captured ESB initial procurement, mid-life overhaul and end-of-life replacement. This transition plan assumes that each ICE bus will be replaced with an ESB when it reaches the end of its useful life (12 years).

After 10 years of replacement, following Scenario 2, it is expected that Newfoundland and Labrador's fleet would be composed of 222 electric school buses (85% of the total active fleet), while New Brunswick's fleet would be composed of 712 electric school buses (67% of the active fleet) and Nova Scotia's fleet would be composed of 577 electric school buses (71% of the fleet). The figure below illustrates the 14 year-procurement plan for ESBs and associated chargers.



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
NL	20	18	16	28	26	15	15	25	25	32	35	0	1	4
NB	114	51	25	22	24	33	30	42	49	48	77	18	70	44
NS	9	19	24	41	43	47	34	43	56	32	56	24	51	17

Figure ES-1 ESB Procurement Schedule

Table ES-4 presents the summary of the project costs, for the capital (CAPEX) and operation expenses (OPEX). Results from the financial modelling indicates that over the long term, the operational cost of an electrified fleet may reduce fuel and maintenance costs, when compared to business-as-usual.

Table ES-4 Summary of the project cost

		BUSINESS-AS-USUAL ($)	ESB ($)	INCREMENTAL COST
New Brunswick	CAPEX	197.6 M	569.1 M	371.4 M
	OPEX	209.2 M	162.7 M	(46.5 M)
	Total	**406.8 M**	**731.8 M**	**325.0 M**
Newfoundl and and Labrador	CAPEX	93.8 M	269.7 M	175.9 M
	OPEX	101.5	78.6	(22.9 M)
	Total	**195.3 M**	**348.3**	**153.0 M**
Nova Scotia	CAPEX	155.7 M	445.7 M	290.1 M
	OPEX	153.1 M	99.9 M	(53.1 M)
	Total	**308.8**	**545.6**	**236.8**

KEY TAKEAWAYS

- Procurement options to mitigate the upfront cost barriers should be considered. Those procurement options include but are not limited to:
  - **Charging as a service (CaaS),** where a user contracts with a service provider that will manage the installation, operation, and maintenance of the EV charging infrastructure.
  - **Capital lease**, where an agreement is structured in a way that effectively transfers the use of an asset without owning the vehicle.
  - **Dual Port Chargers** where operationally feasible over single port chargers to reduce the infrastructure needed.

ROUTE ELECTRIFICATION AND PRIORITIZATION

The route profile assessment consisted of an evaluation of the feasibility of the electrifying routes, based on the total distance for each route and the energy efficiency of the electric school buses for each scenario.

Table ES-5 below provides the results from the route modelling for each scenario.

Nova Scotia currently operates a total of 699 routes daily. Within its fleet, 252 routes (36% of the routes) could be completed by ESBs based on the overnight charging (scenario 1), with the potential to increase this number to 496 (71% of the routes) by incorporating mid-day charging sessions (scenario 2).

New Brunswick operates a larger number of routes than Nova Scotia and Newfoundland & Labrador, with over 1,108 routes. Among these, it is anticipated that 490 routes (43%) could be completed with an ESB with solely overnight charging (scenario 1). This number could rise to 872 (79%) with a combined overnight and mid-day charging strategy.

Newfoundland and Labrador province operates 262 routes. Under scenario 1, approximately 229 of those routes (87%) are suitable for electrification, while under scenario 2, a total of 260 routes (99%) could make the transition.

Table ES-5 Summary of Electrification Analysis for School Districts in Nova Scotia, New Brunswick, and Newfoundland & Labrador

PROVINCE	OPERATOR	ROUTE COUNT	TOTAL CONSUMPTION (MWH)	AVERAGE ROUTE DISTANCE (KM)	SCENARIO 1			SCENARIO 2			
					Electrifiable Route Count	Non-electrifiable Route Count	Completion (%)	Electrifiable Route Count	Non-electrifiable Route Count	Completion (%)	Improvement between Scenario 1 and Scenario 2
New Brunswick	AN	128	20.14	157.37	51	77	40%	82	46	64%	24%
	AW	267	32.20	121.50	158	107	60%	235	30	89%	29%
	AS	231	34.28	150.24	66	113	37%	135	44	75%	39%
	AE	127	16.20	119.70	60	43	58%	92	11	89%	31%
	FNO	61	7.97	124.28	13	11	54%	21	3	88%	33%
	FS	187	30.54	155.26	21	43	33%	45	19	70%	38%
	FNE	107	15.26	149.51	16	30	35%	37	9	80%	46%
	Total	1,108	156.6	141.49	490	618	43%	872	236	79%	36%
Newfoundland & Labrador	N&L	262	18.46	70.46	229	33	87%	260	2	99%	12%
Nova Scotia	AVRCE	100	15.95	159.49	29	71	29%	71	29	71%	42%
	CBVRCE	84	14.92	177.57	31	53	37%	56	28	67%	30%
	SSRCE	88	14.18	161.19	26	62	30%	55	33	63%	33%
	CCRCE	185	28.01	151.42	70	115	38%	137	48	74%	36%
	TCRCE	89	11.85	133.19	42	47	47%	72	17	81%	34%
	SRCE	110	17.10	155.43	46	64	42%	75	35	68%	26%
	CSAP	43	9.61	174.59	8	35	19%	30	13	70%	51%
	Total	699	111.62	158.98	252	447	34%	496	203	70%	36%
Provincial Total		**2,069**	**286.67**	**144.92**	**971**	**1,098**	**47%**	**1,628**	**441**	**79%**	**32%**

1 INTRODUCTION

1.1 CONTEXT

Momentum around Electric School Buses (ESBs) is growing as Canadian governments make significant strides to reduce greenhouse gas (GHG) emissions related to transportation. While the transition towards ESBs will require coordinated efforts amongst several entities (school districts, governments, school bus operators, etc.) the results from this transition would have a myriad of benefits. It would not only help significantly reduce GHG emissions produced by student transportation as well as operational costs, but it would also reduce air and noise pollution, creating a healthier environment for the students and drivers. As of 2023, over 98% of school buses are powered by fossil fuel.[2]

The Atlantic provinces, through the coordination of the Council of Atlantic Ministers of Education and Training (CAMET), have a long-standing history of purchasing school buses jointly, resulting in significant savings for the provincial governments. The Atlantic provinces have primarily purchased diesel, gasoline, and propane school buses, and are now considering the feasibility of adopting clean vehicles with the purchase of electric school buses.

In this initiative's context, three of the Atlantic provinces—Nova Scotia, New Brunswick, and Newfoundland and Labrador (called "provinces")—through the coordination of CAMET, have taken the initiative to undertake a feasibility study for the electrification of the public-school bus fleet.

The primary objective of this study is to evaluate the potential of an ESB system. The aim is to gain insights into the feasibility, and the financial benefits and operational constraints associated with transitioning to ESBs. The study will allow the Atlantic provinces to understand how they can effectively implement electrification across their school bus fleets and prepare for their associated infrastructure while estimating the potential reduction in greenhouse gas emissions and evaluating the financial implications of such a transition. This study may be used to secure funding through available initiatives such as Infrastructure Canada's Zero Emission Transit Fund (ZETF), Infrastructure Canada's Rural Transit Fund (RTSF) and the Canadian Infrastructure Bank's (CIB) Zero Emission Bus program, among others. This strategic approach aligns with the provinces' commitment to sustainable and innovative solutions for their education and transportation systems.

The Atlantic provinces present unique challenges when it comes to electrifying their school bus fleet. The diverse weather conditions such as harsh winters which can affect the performance of electric vehicles, combined with the rural and remote nature of bus routes requiring longer distances, pose unique challenges for school bus school districts that want to transition towards sustainable technologies.

This study required efforts from several stakeholders to create the most insightful portraits of current operations for each operator across all provinces.

Nova Scotia operates on a model in which the province purchases buses, and they are maintained and operated by seven (7) different school districts (Figure 1-1). The school districts are responsible for planning the bus routes, hiring the bus drivers, and conducting the maintenance and daily operations required on the buses. Each school district also has garages.

Similarly, **Newfoundland & Labrador** operates on a model where the fleet is Government-operated. The Department of Transportation and Infrastructure is responsible for the delivery of Student Transportation services in accordance with The Department of Education School Transportation Policies. Provincial policy changes will require Newfoundland & Labrador to add 45 additional school buses to accommodate these changes for September 2024. Newfoundland and Labrador have ten (10) school bus depots, two (2) of which are in Labrador.

New Brunswick's Vehicle Management Agency (VMA) is a Special Operating Agency directed by the Department of Transportation and Infrastructure, responsible for the purchase of the fleet as well as the repair and maintenance

[2] Data adapted from Équiterre, "Accelerating Electric School Bus Adoption in Canada: Watt's next?", November 2023. Online: https://cms.equiterre.org/uploads/313-_Recommendations-Report-EN.pdf

requirements, while also setting the policy and procedures related to the asset. The Government of New Brunswick's Education and Early Childhood Development (EECD) receives the buses from the VMA and sets all the policies on pupil transportation. The fleet is composed of different technologies, including two electric buses (note that New Brunswick recently purchased 20 new ESBs, which will bring the total number of ESBs in the province to 22). There are seven (7) school districts, four (4) English school districts, and three (3) French school districts (Figure 1-1). Routes are typically operated out of the home of the drivers.

Figure 1-1 presents the governance and stakeholders involved in this ESB feasibility study.

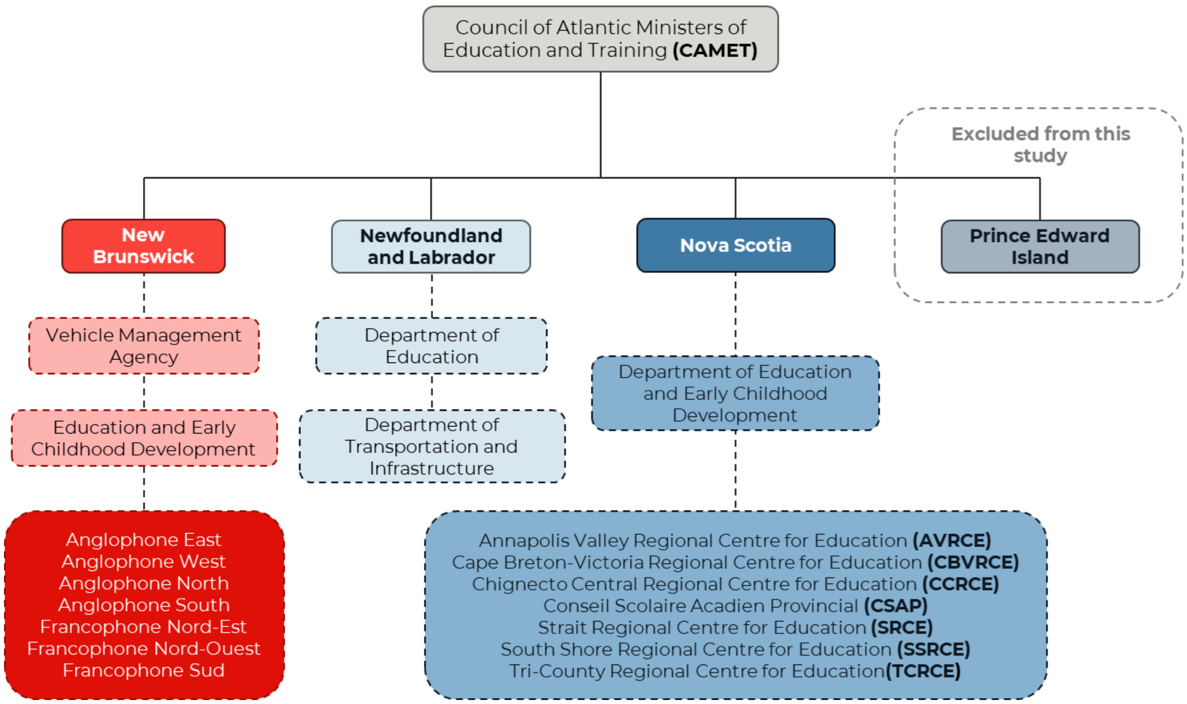


Figure 1-1 Organization chart for the Atlantic provinces

1.2 LIMITATIONS

This study is based on information received from school districts across the three provinces. It is assumed that information provided by the provinces provides an accurate portrayal of the school bus fleet and the services it offers. Assumptions can be found in Appendix A.

The analysis is conducted on the assumption that the provinces assume responsibility for the accuracy and quality of all data provided. Historical fleet data is used to help establish a baseline on the current school bus operations to make comparisons against electric school buses. Fleet statistics such as fuel economy, fuel expenditures and fleet maintenance costs are referenced from historical data to help develop lifecycle cost assessments of school buses. Utilization information provided was in the form of vehicle kilometres travelled and number of stops. Idle time was not considered in this study.

Analysis of ESBs are subject to change due to the nature of continuing innovations in alternative propulsion technologies. The availability of market data on electric school buses is based on present conditions in 2024, providing a current snapshot of specifications which may change over time.

1.3 HOW TO READ THIS REPORT

ATLANTIC PROVINCES FLEET BASELINE & CANADIAN ESB OVERVIEW

This feasibility study starts by presenting a baseline of operations from the provinces' school bus, to grasp a deeper understanding of the current state of operations. Following this province-specific baseline, a Canadian electric school bus overview provides insightful considerations about different Canadian regions that have started their transition towards electric school buses.

ROUTE ELECTRIFICATION

Following the overview of the current condition and the assessment of the ESB Canadian market, the electrification feasibility piece is presented. This section investigates the electrification of the route, separated from the assets.

ASSET ELECTRIFICATION & SITE MODIFICATIONS

After the assessment of the electrification of the routes, this study presents the impact of electrification on the physical assets (i.e., the buses and charging stations) and the site modification that will be required to allow for electrification.

PROJECT COST AND OPERATIONAL SAVINGS

This section provides insights into the financial requirements to transition towards electric school buses, along with the operational savings that would result from this transition.

RISK MANAGEMENT & FUNDING OPPORTUNITIES

These sections present some findings relating to ensuring the mitigation of multiple risks that would occur from the transition, as well as an assessment of government funding, financing, and cost-offsetting opportunities for school bus owners' operators.

ADDITIONAL NOTES

The province's fleet consists of both active vehicles and spare/parts vehicles. These spares/parts vehicles are important to ensure continuity in the service when active buses are unable to complete their routes. This feasibility study is looking into the transition towards electrification and therefore, focuses on in-service active assets. Spares/parts vehicles will not be included in the report (*exception is made for Figure 1-2).*

Following discussions on the operations of school buses with each of the provinces, it was determined that the school buses operated are generally not tied to a specific route. This means that buses may complete different routes throughout the school year. This consideration is important when completing an electric feasibility study and transition plan, as routes which are deemed "electrifiable" do not require buses to reach their useful life to be electrified. Similarly, this consideration means that a fossil fuel powered bus which has reached its useful life can be replaced with an electric school bus, even if the route it was previously operating on is not considered "electrifiable".

Separating the buses from the routes allowed WSP to assess both the electrification of the routes and the electrification of the assets as two separate entities.

> The baseline and costing sections are based on the assets themselves within each province, while the electrification feasibility is based on the routes.

1.4 CURRENT FLEET BASELINE

1.4.1 ATLANTIC PROVINCES

The fundamental objective behind investigating the current conditions is to derive estimates of the total cost and greenhouse gas (GHG) emissions associated with the existing school bus fleet used by the provinces. The following sections establish the baseline for this study.

The Atlantic provinces have a total of 2,632 school buses distributed across three provinces. Based on the available data provided, these buses are a mix of Type A (3) and Type C (2,629) school buses. Figure 1-2 presents the breakdown of the asset inventory by provinces for the school bus fleet, for both the active buses, as well as the spares and/or for parts. Spares and parts vehicles are presented in hatched in the figure, and account for 17% of New Brunswick's fleet, 19% of Newfoundland and Labrador's fleet, and 22% of Nova Scotia's fleet.

Spare vehicles are important to ensure a smooth and efficient service and can be helpful when active buses are unable to complete their daily routes (due to maintenance, outstanding events, etc.). While spare fleets are included in the figure above, this study is looking into the transition towards electrification and therefore, focuses on in-service active assets, excluding the spare vehicles from the remainder of the analysis, allowing for analysis of daily usage from normal operations only.

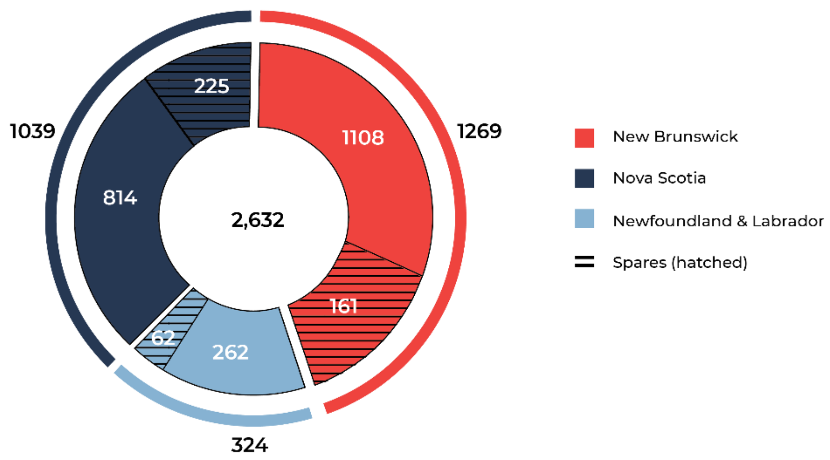


Figure 1-2 Asset inventory by province including spare buses

For the remainder of the feasibility study, the spare buses will be excluded from the analysis. This fleet baseline section is based on asset-specific data provided by the provinces.

The provinces recognize that the industry standard for the average useful life of a school bus is set at 12 years. In accordance with the expected useful life (EUL) acknowledged by the provinces, Figure 1-3 below presents the ratio of vehicles that have exceeded their useful life as of November 2023, along with the vehicle count.

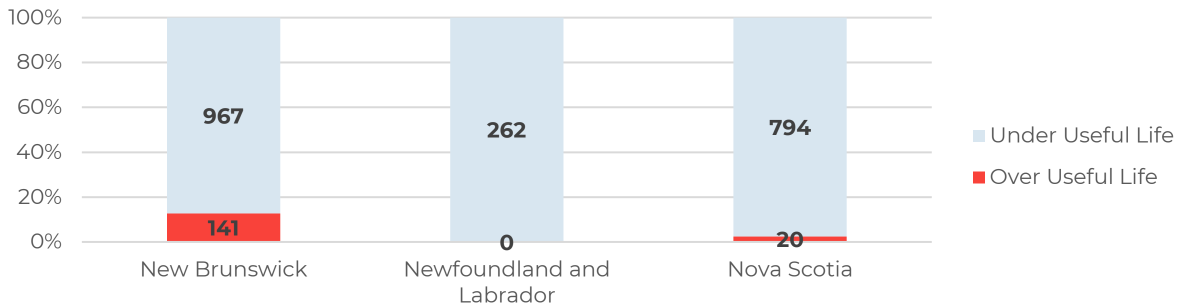


Figure 1-3 Vehicles Exceeding their Expected Useful Life

Just over five percent (108 buses) of the total number of assets are running past their useful life. Running over their useful life can lead to more frequent maintenance requirements, higher operational costs, and lower fuel efficiency when compared to vehicles running in their prime life (under its determined end of useful life).

The usage of the fleet can be measured by the distance vehicles travel in kilometres (known as VKT). Combined, the provinces have 2,184 active assets, and the school buses travel on average approximately 48 million kilometres annually. Figure 1-4 below illustrates the breakdown of these kilometres across the provinces.

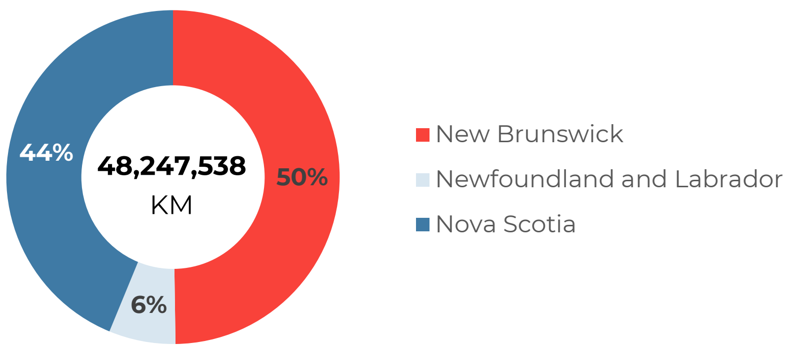


Figure 1-4 Total Yearly Travelled Distance

As Figure 1-4 provides the VKT travelled in a year, it is directly impacted by the count of buses and number of routes (Figure 1-2). Nova Scotia's school buses represent 37% (814 assets) of the total active fleet while accounting for over 44% (21.1 million km) of the annual travelled distance. This suggests that Nova Scotia's buses are being driven over longer distances, on average, compared to the other provinces. Longer driving distances may have implications for electrification of operations, due to defined battery sizes in electric buses. To account for the number of buses for each province, Table 1-1 presents a more granular view of fleet utilization.

Table 1-1 Fleet Utilization

	TOTAL YEARLY TRAVELLED DISTANCE (KM)	AVERAGE YEARLY TRAVELLED DISTANCE (KM)	DAILY MAXIMUM (KM)	ROUTE LENGTH AVERAGE (KM)
New Brunswick	24.01 M	21,770	234.8	85.8
Newfoundland and Labrador	3.12 M	11,908	220.0	70.5
Nova Scotia	21.12 M	27,637	317.5[3]	166.2
Total	**48.25 M**	**22,092**	**257.4**	**119.3**

1.4.2 GREENHOUSE GAS BASELINE

By conducting this assessment, the baseline accurately reflects the current state of the provinces' school bus fleet and serves as a reference point against which the success of future initiatives, aimed at achieving a transition towards electric school buses, can be measured. The data-driven insights gleaned from this evaluation will aid the provinces in devising targeted and effective strategies to reduce their carbon footprint and operational costs.

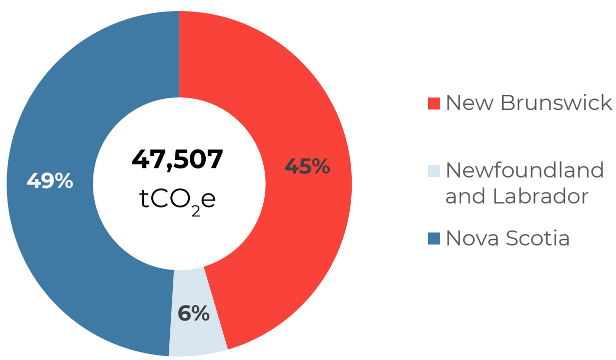


Figure 1-5 Breakdown of the annual emissions per province

Combining the total quantity of fuel (diesel, gasoline and propane) used by the provinces with GHG emission factors (see Appendix A for assumptions), it is estimated that the current school bus operations for the provinces produce over 47,507 tonnes of CO_2e (tCO_2e) on an annual basis. Figure 1-5 breaks down the annual emissions per province. The breakdown of annual emissions per province compared to the vehicle count (Figure 1-2) and the travelled distance (Figure 1-4) is insightful. This suggests that a higher amount of fuel is consumed for Nova Scotia's operations[4], and a technology transition of Nova Scotia's buses would have the largest impact on the emissions.

[3] CCRCE presented outliers regarding the daily travelled distance, for instance, vehicle #39 is presenting the highest daily mileage (815 km), taking on 407 km of service in the morning and 407 km in the afternoon including deadheads. In the calculation of service distance carried out for CCRCE, WSP identified the route assignment for each vehicle and computed the total distance by multiplying the route length with the number of trips taken. This analysis shows that 13 vehicles exceeded the daily operational distance benchmark of 500km. Notably, bus "39" stood out with a service distance surpassing 800km.

[4] Note that this could also be due to the data gaps that were mitigated with assumptions. See Section 1.2 to understand the assumptions that were used.

1.4.3 FINANCIAL BASELINE

The provinces provided data related to the maintenance and fuel cost which was used to create a snapshot of annual operational costs. Based on a single year[5], the annual operational expenses account for approximately $41.6 M, of which, 40% ($16.8 M) is related to maintenance costs, while the remaining 60% ($24.8 M) is related to fuel costs. A breakdown of the operational cost by province is provided in Figure 1-6.

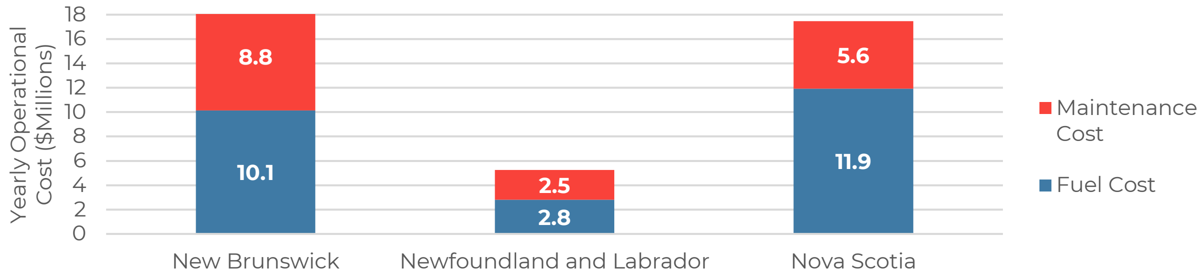


Figure 1-6 Breakdown of Annual Operational Cost

Maintenance cost is highest ($8.8 M) in New Brunswick[6], which could potentially be explained by the higher number of buses in service either past or near their useful life (over 20% of the fleet is 12 years of age or more). Where possible, these vehicles should be prioritized for replacement with zero-emission vehicles to reduce both emissions and maintenance costs.

Operational cost in Nova Scotia accounts for 42% ($17.5 M) of the total operating cost, which is directly attributed to the higher amount of fuel consumed by kilometres and the travelled distance. Table 1-2 presents the operating cost per kilometre travelled for the different provinces.

Newfoundland and Labrador have the highest operating cost on a per kilometre basis, partially due to the higher fuel cost[7] and lower kilometres travelled per route, as well as the required routine maintenance work[8].

Table 1-2 Operating Cost per KM

	TOTAL ANNUAL TRAVELLED DISTANCE (KM)	TOTAL FUEL COST ($)	TOTAL MAINTENANCE COST ($)	OPERATING COST PER KILOMETRE ($/KM)
New Brunswick	24.0 M	10.1 M	8.80 M	**0.79**
Newfoundland and Labrador	3.12 M	2.8 M	2.46 M	**1.68**
Nova Scotia	21.1 M	11.9 M	5.55 M[9]	**0.83**
TOTAL	**48.2 M**	**24.8 M**	**16.8 M**	**0.85**

[5] Single year costs were captured by either dividing the lifetime cost with the number of years it has been in service, or using the yearly cost provided by the operators, for the 2022-2023 school year depending on available data.

[6] New Brunswick's maintenance cost per asset includes internal labour and part costs, as well as commercial costs (i.e. vendor supplied parts, vendor supplied service). Commercial costs account for approximately 40% of the total maintenance costs. The level of granularity of data included for New Brunswick could be one explanation for the higher registered cost over other provinces.

[7] Annual fuel cost for the 2022-2023 school year was provided for Newfoundland and Labrador. The assumption of $1.68/L was used whenever data was missing. Compared to Nova Scotia and New Brunswick over the last three years, fuel cost in Newfoundland and Labrador was $0.13/L higher.

[8] Newfoundland and Labrador's maintenance cost per asset includes internal labour and part costs, and commercial costs (i.e., vendor supplied parts, vendor supplied service). Additionally, Newfoundland and Labrador's provided data included non-revenue trips, such as school field trips, which could have impacted operating cost.

[9] Nova Scotia maintenance cost does not include labour cost, as repairs are performed by salaried staff.

Table 1-3 below presents a summary of the total cost of ownership (TCO) for current operations within each of the provinces. The TCO is calculated by combining the capital cost of acquisition with the operational costs for the expected lifetime of the assets (12 years).

Table 1-3 Total Cost of Ownership

	AVERAGE PER ASSET				TOTAL ACTIVE FLEET
	Capital Expense ($)	**Fuel Cost ($)**	**Maintenance Cost ($)**	**Total Cost of Ownership ($/bus)**	**Total Cost of Ownership ($)**
New Brunswick	95,793	109,871	95,261	300,926	333.4 M
Newfoundland and Labrador	105,616	128,176	112,534	346,327	90.7 M
Nova Scotia	94,418	175,808	81,824	358,869	286.6 M
				Provincial Total Cost of Ownership	**710.7 M**

Due to the recent purchases (47% of the fleet were purchased after 2018) and the routine maintenance requirements, the capital and maintenance costs are higher for Newfoundland and Labrador. However, the longer distance travelled from Nova Scotia impacts the average lifetime fuel cost and the total cost of ownership. Therefore, in addition to the environmental benefits, Nova Scotia would see the greatest benefits in the financial aspects from the transition towards electric school buses.

1.5 NEW BRUNSWICK

While Section 1.4 provided information for the whole province, tables 1-4 to 1-6 below provide additional information specific to New Brunswick and more detail to understand the baseline for each school district.

Table 1-4 presents the current state of the fleet, highlighting the count of vehicles, and the average age and the number of buses above their average useful life for each operator in New Brunswick.

Table 1-4 Current State of the Fleet for New Brunswick School Districts

	COUNT	AVERAGE AGE (YEARS)	OVER USEFUL LIFE (COUNT)	UNDER USEFUL LIFE (COUNT)
Anglophone East	127	8.65	39	88
Anglophone North	128	6.80	15	113
Anglophone West	267	6.46	24	243
Anglophone South	232	6.66	22	210
Francophone Nord-Est	107	7.74	16	91
Francophone Nord-Ouest	61	7.18	9	52
Francophone Sud	186	6.39	16	170
TOTAL	**1,108**	**7.13**	**141**	**967**

New Brunswick is the province with the highest number of buses currently running past their useful life, with Anglophone West presenting the highest count. Table 1-5 presents the utilization of the fleet, highlighting annual kilometres travelled, and fuel consumption and greenhouse gas emissions produced by each school district.

Table 1-5 Utilization of the Fleet for New Brunswick School Districts

	COUNT	TOTAL ANNUAL TRAVELLED DISTANCE (KM)	AVERAGE ANNUAL TRAVELLED DISTANCE (KM)	ROUTE LENGTH AVERAGE (KM)	ANNUAL FUEL CONSUMED (L)	ANNUAL GHG EMISSIONS (TCO_2E)
Anglophone East	127	2.75 M	21,672	157.3	0.96 M	2,386
Anglophone North	128	3.04 M	23,766	121.5	1.00 M	2,599
Anglophone West	267	5.27 M	19,730	150.2	1.88 M	4,839
Anglophone South	232	5.09 M	21,958	119.7	1.89 M	4,799
Francophone Nord-Est	107	2.28 M	21,315	124.3	0.77 M	2,005
Francophone Nord-Ouest	61	1.27 M	20,824	155.3	0.48 M	1,226
Francophone Sud	186	4.30 M	23,125	149.5	1.48 M	3,739
TOTAL	**1,108**	**24.01 M**	**20,881**	**139.7**	**8.46 M**	**21,593**

Anglophone West is the school district travelling the most kilometres on an annual basis but is not the highest fuel consumer across the province. This could be due to Anglophone West buses using more diesel than gasoline (diesel being more efficient than gasoline). The usage of diesel, however, generates higher greenhouse gas emissions when compared to gasoline, which would explain why Anglophone West is producing the most emissions.

Table 1-6 presents the financial breakdown of the New Brunswick school bus fleet, for annual fuel and maintenance cost, and capital cost and total cost of ownership for each school district.

Table 1-6 Financial Baseline for New Brunswick School Districts

	COUNT	ANNUAL FUEL COST ($)	ANNUAL MAINTENANCE COST ($)	TOTAL CAPITAL COST ($)	TOTAL COST OF OWNERSHIP ($)[10]	AVERAGE TOTAL COST OF OWNERSHIP ($/ASSET)
Anglophone East	127	1.11 M	1.17 M	12.63 M	39.99 M	0.31 M
Anglophone North	128	1.20 M	1.08 M	11.99 M	39.35 M	0.31 M
Anglophone West	267	2.29 M	1.95 M	25.22 M	76.03 M	0.28 M
Anglophone South	232	2.30 M	1.80 M	22.93 M	72.07 M	0.31 M
Francophone Nord-Est	107	0.92 M	0.93 M	9.66 M	31.82 M	0.30 M
Francophone Nord-Ouest	61	0.57 M	0.41 M	5.52 M	17.29 M	0.28 M
Francophone Sud	186	1.76 M	1.46 M	18.19 M	56.87 M	0.31 M
TOTAL	**1,108**	**10.14 M**	**8.80 M**	**106.14 M**	**333.43 M**	**0.30 M**

[10] Note that the cost of ownership is presented for each school district for analysis purposes but is covered directly by New Brunswick's VMA.

1.6 NEWFOUNDLAND AND LABRADOR

Tables 1-7 to 1-9 below provides additional information for Newfoundland and Labrador.

Table 1-7 presents the current state of the fleet, highlighting the count of vehicles, and the average age and the number of buses above their useful life for Newfoundland and Labrador.

Table 1-7 Current State of the Fleet for Newfoundland and Labrador

	COUNT	AVERAGE AGE (YEARS)	OVER USEFUL LIFE (COUNT)	UNDER USEFUL LIFE (COUNT)
Newfoundland and Labrador	262	7.18	0	262

Table 1-8 presents the utilization of the fleet, highlighting annual kilometres travelled, and fuel consumption and greenhouse gas emissions produced by Newfoundland and Labrador.

Table 1-8 Utilization of the Fleet for Newfoundland and Labrador

	COUNT	TOTAL ANNUAL TRAVELLED DISTANCE (KM)	AVERAGE ANNUAL TRAVELLED DISTANCE (KM)	DAILY AVERAGE (KM)	ANNUAL FUEL CONSUMED (L)	ANNUAL GHG EMISSIONS (TCO_2E)
Newfoundland and Labrador	262	3.12 M	11,908	70.5	1.01 M	2,626

Table 1-9 presents the financial breakdown of the school bus fleet, for annual fuel and maintenance costs, and capital cost and total cost of ownership for Newfoundland and Labrador.

Table 1-9 Financial Baseline for Newfoundland and Labrador

	COUNT	ANNUAL FUEL COST ($)	ANNUAL MAINTENANCE COST ($)	TOTAL CAPITAL COST ($)	TOTAL COST OF OWNERSHIP ($)	AVERAGE TOTAL COST OF OWNERSHIP ($/ASSET)
Newfoundland and Labrador	262	2.70 M	2.46 M	27.7 M	89.6 M	0.34

1.7 NOVA SCOTIA

Tables 1-10 to 1-12 below provides additional information for Nova Scotia and allow us to go into more detail to understand the baseline for each operator.

Table 1-10 presents the current state of the fleet, highlighting the count of vehicles, and the average age and the number of buses above their average useful life for each operator in Nova Scotia.

Table 1-10 Current State of the Fleet for Nova Scotia School District

	COUNT	AVERAGE AGE (YEARS)	OVER USEFUL LIFE (COUNT)	UNDER USEFUL LIFE (COUNT)
AVRCE	118	4.78	2	116
CBVRCE	80	7.14	3	77
CCRCE	259	5.78	4	255
SRCE	117	5.27	0	117
SSRCE	90	5.77	8	82
TCRCE	97	5.17	1	96
CSAP	53	5.42	2	51
TOTAL	**814**	**5.63**	**20**	**794**

Table 1-11 presents the utilization of the fleet, highlighting annual kilometres travelled, and fuel consumption and greenhouse gas emissions produced by each operator.

Table 1-11 Utilization of the Fleet for Nova Scotia School Districts

	COUNT	TOTAL ANNUAL TRAVELLED DISTANCE (KM)	AVERAGE ANNUAL TRAVELLED DISTANCE (KM)	DAILY AVERAGE (KM)	ANNUAL FUEL CONSUMED (L)	ANNUAL GHG EMISSIONS (TCO_2E)
AVRCE	118	3.94 M	33,381	159.5	0.85 M	2,166
CBVRCE	80	1.81 M	22,589	177.6	0.53 M	1,413
CCRCE	259	5.06 M	19,528	161.2	1.78 M	4,758
SRCE	117	3.49 M	29,842	151.4	3.37 M	9,042
SSRCE	90	2.17 M	24,193	133.2	0.76 M	1,941
TCRCE	97	2.78 M	28,586	155.4	0.72 M	2,206
CSAP	53	1.87 M	35,340	174.6	0.66 M	1,762
TOTAL	**814**	**21.12 M**	**27,637**	**168.8**	**8.77 M**	**23,288**

When compared provincially, all school districts in Nova Scotia consistently show a higher daily average. Particularly, CBVRCE and CSAP school districts both present the highest daily average linked to a combination of multiple buses travelling longer distances on a daily basis and the small fleet size. Some buses in CBVRCE have a daily mileage of 750 km. Table 1-12 presents the financial breakdown of the Nova Scotia school-bus fleet, for annual fuel and maintenance cost, as well as capital cost and total cost of ownership for each operator.

Table 1-12 Financial Baseline for Nova Scotia

	COUNT	ANNUAL FUEL COST ($)	ANNUAL MAINTENANCE COST ($)	TOTAL CAPITAL COST ($)	TOTAL COST OF OWNERSHIP ($)	AVERAGE TOTAL COST OF OWNERSHIP ($/ASSET)
AVRCE	118	1.25 M	0.75 M	10.63 M	34.54 M	0.29 M
CBVRCE	80	0.81 M	0.50 M	7.36 M	23.08 M	0.29 M
CCRCE	259	2.72 M	1.29 M	24.52 M	72.66 M	0.28 M
SRCE	117	3.39 M	0.56 M	10.83 M	58.30 M	0.50 M
SSRCE	90	1.17 M	0.82 M	8.17 M	32.03 M	0.36 M
TCRCE	97	1.04 M	1.28 M	10.22 M	38.04 M	0.39 M
CSAP	53	1.01 M	0.36 M	5.12 M	21.56 M	0.41 M
TOTAL	**814**	**11.39 M**	**5.55 M**	**76.86 M**	**258.45 M**	**0.36 M**

2 CANADIAN ESB OVERVIEW

2.1 CANADIAN CONTEXT

There are currently over 51,000 school buses in Canada, primarily fuelled with diesel. These buses are responsible for the daily transportation of over 2.2 million children to and from school-related activities. There are different types of school buses currently being used in Canada, as presented below. School bus types are identified by the federal CSA D250 standards, which specify the chassis and body requirements and safety equipment requirements for school buses.

Table 2-1 Type and Count of School Buses in Canada[11,12]

BUS TYPE	CANADA		NEW BRUNSWICK		NEWFOUNDLAND AND LABRADOR		NOVA SCOTIA	
A1/A2	12,960	25%	-	-	3	1%	-	-
B	139	<1%	-	-	-	-	-	-
C	36,920	71%	1,108	100%	259	99%	813	99%
D	1,169	2%	-	-	-	-	-	-
MFSAB[13]	483	1%	-	-	-	-	1	<1%
TOTAL	**51,670**	**100%**	**1,108**	**100%**	**262**	**100%**	**814**	**100%**

Type C school buses are predominant across Canada, accounting for over 71% of the whole fleet composition. The routes are variable across Canada; Forty-five percent of buses operate in an urban environment, 51% commute in a rural environment, and approximately 4% are a mix of urban and rural routes[14].

As of 2023, only a small number of electric school buses have been deployed[15], accounting for a total of over 900 ESBs distributed across different provinces, with Quebec being at the forefront of the transition (766 in Quebec, 82 in Prince Edward Island, 52 in British Columbia and 20 in Ontario)[16]. However, it is important to note that some provinces are currently waiting to receive additional electric school buses. For example, New Brunswick ordered 20 ESBs for 2023-2024, while Ontario is anticipating delivery of over 200 ESBs until 2026.

According to the School Transportation Policies from the Department of Education of the Government of Newfoundland and Labrador, the age of a bus used for the transportation of school children must be under twelve (12) model years, unless otherwise approved by the Minister.[17] Older buses can be used as spares and/or to mitigate any operational constraints.

School bus operations present excellent potential to undergo the transition towards zero-emission alternatives, as they are often used to complete predictable and shorter routes, and there is the possibility to return to a central location to enable charging, if needed between shifts.

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[11] Task Force on School Bus Safety, "Strengthening School Bus Safety in Canada", February 2020. Online: https://comt.ca/Reports/School%20Bus%20Safety%202020.pdf

[12] New Brunswick, Newfoundland and Labrador and Nova Scotia numbers are from data gathered for this specific study.

[13] Multifunction School Activity Bus

[14] Task Force on School Bus Safety, "Strengthening School Bus Safety in Canada", February 2020. Online: https://comt.ca/Reports/School%20Bus%20Safety%202020.pdf

[15] Limited data available as of November 2023.

[16] Équiterre, "Accelerating Electric School Bus Adoption in Canada: Watt's next?", November 2023. Online: https://cms.equiterre.org/uploads/313-_Recommendations-Report-EN.pdf

[17] School Transportation Policies, Department of Education, Government of Newfoundland and Labrador. Available : https://www.gov.nl.ca/education/files/k12_busing_transportation_policies.pdf

ESBs also present additional benefits such as:

- **Climate benefits:** As most school buses are powered by fossil fuel, a switch towards ESBs would significantly reduce GHG emissions. As presented in Section 2, the transition could help the provinces reduce over 46,086 tonnes of CO_2e annually.
- **Health benefits:** Electrification of school buses provides an opportunity to decrease diesel-related air pollutants (nitrous oxides, sulphur oxide, and particulate matter), directly impacting students, drivers and members of the community. Transitioning to electrified buses can have a meaningful impact on the cognitive functions of students[18], while reducing the cancer risk associated with diesel exhaust pollution[19]. ESBs also reduces noise exposure, due to their utilization of electric motors instead of internal combustion engines (ICE). Those motors produce minimal vibrations and are inherently quieter than their ICE alternative.
- **Financial benefits:** Operations are significantly cheaper when looking at electric school buses, mainly due to their higher engine efficiency and lower cost of electricity. Studies show that it would cost, on average, 80% less to power an ESB than to fuel its ICE counterparts. Additionally, due to their fewer moving parts and regenerative braking capability, maintenance cost is also reduced by 50%. Research suggests that compared to a new ICE school bus, ESBs can save an average of USD 6,000 every year (CAD 8,150) on operational expenditures, depending on circumstances[20].

2.2 JURISDICTIONAL REVIEW

As of 2023, different provinces across Canada are currently working on implementing ESBs as part of their student transportation services. Below is an overview of initiatives across various jurisdictions within Canada, along with some consideration from actual operations, when available.

PRINCE EDWARD ISLAND, CANADA

Prince Edward Island (PEI) is leading the transition in Atlantic Canada, with over 25% (82 buses) of its public school bus fleet being electrified, as of 2022. The province of PEI has directed its school boards to procure only electric school buses going forward, which will lead the province to reach a completely electrified fleet within the next ten years[21]. The target for PEI is to have 100% of its public school bus fleet electrified by 2030.

The transition of the fleet that has been accomplished thus far is due to the substantial financial support from both the federal and provincial governments. Both governments are contributing through the Green Infrastructure stream of the Investing in Canada Plan, which allows the governments to pay for half the cost of each bus, and half the cost of the charging infrastructure ($12.78 million in total, which funded the acquisition of 35 buses and related charging infrastructure)[22]. The public school branch and French Language School Board manage the school buses while the provincial government procures and owns the buses. This centralized ownership structure allows for simplified planning, funding, and procurement processes, helping accelerate the conversion rate. The transportation department also worked with external partners to ensure a seamless adoption of electric buses. For instance, discussions with first responders set clear measures to follow in the event of an accident, as well as support from the drivers and union leaders were crucial in getting the school bus transitioned quickly.

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[18] Austin W., Heutel G., Kreisman D., Economics of Education Review, "School bus emissions, student health and academic performance". Online: https://doi.org/10.1016/j.econedurev.2019.03.002.
[19] Electric School Bus Initiative, "Why we need to transition to Electric School buses". Online: https://electricschoolbusinitiative.org/why-we-need-transition-electric-school-buses
[20] Ibid.
[21] Electric School Bus Initiative, "The Electric School Bus Series: Progress from Our Northern Neighbors in Prince Edward Island, Canada", May 2022. Online: https://electricschoolbusinitiative.org/electric-school-bus-series-progress-our-northern-neighbors-prince-edward-island-canada
[22] Prince Edward Island, "Electric School Buses", September 2021. Online: https://www.princeedwardisland.ca/en/information/education-and-lifelong-learning/electric-school-buses

PEI's ESBs are strategically deployed based on route length. Shorter city routes, which carry more students while making fewer stops, are given priority when electrifying. However, the province is planning on ordering buses with bigger battery capacity to serve longer rural routes.

In addition to having chargers at the depot, PEI is currently installing chargers at schools so that ESBs can charge between trips, in addition to installing chargers at the homes of the drivers[23]. Installing charging infrastructure directly at the homes of the drivers has helped reduce the need for depot electrical upgrades, which would be costly, according to PEI. The province recommends preparing the depots to support more ESBs than initially planned and to install the full complement of chargers at the time of installation to avoid delays and take advantage of economies of scale.

QUEBEC, CANADA

Quebec currently holds the highest count of electric buses across Canada. As of April 2021, Quebec's government implemented a regulation stating that all new school bus purchases must be electric, with a target of 65% of the school bus fleet being electric by 2030[24].

Both the Federal and Provincial governments provide financial support to school transport providers for the purchase of electric school buses, as well as charging infrastructure. Various funding sources can help the operators with the capital expenses but also hire specialists who will assist in the planning replacement, charging procurement and energy management. The rolling stock provincial grant covers $100,000 until 2024 and is paid directly to the supplier, meaning that the school bus operator does not need to advance the total amount, and only needs to pay the difference[25].

To accommodate the aging fleet and ensure that retired buses can be replaced by an electric alternative, Quebec's government extended the retirement age to 14 years (instead of the traditional 12-year age limit previously applied in Quebec) for operators who could be waiting for the delivery of their ESBs.[26] This will help operators in Quebec's particular context, where all the school bus purchases need to be electric.

Autobus Transco, which provides school transportation to over 75% of the students on the island of Montreal, equipped three out of their four depots with electric vehicle (EV) charging stations for electric buses. Autobus Transco installed over 180 Level 3 chargers to accommodate the 260 ESBs.

BRITISH COLUMBIA, CANADA

The Government of British Columbia provides significant financial support for the purchase of ESBs and associated charging infrastructure, through the Ministry of Education and Child Care and CleanBC, ranging from $100,000 to $200,000 per electric school bus. CleanBC's funding has helped several school transportation operators reach the financial capacity to acquire electric school buses. BC is still in the process of setting some targets for medium and heavy-duty vehicles. It is expected that these targets will be in alignment with California; all new trucks and buses are to be electric by 2045.[27]

A key player and resource for school transportation operators in BC is the Association of School Transportation Services of BC (ASTSBC). This organization is useful to facilitate joint procurement of conventional school buses among BC school districts, to help secure a more attractive price. In recent years, the ASTSBC has helped to kickstart the transition to electric school buses by taking several key actions, such as developing and issuing standing offer procurement for electric school buses usable by any school district, collecting telematics and other data from the buses

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[23] Conservation Council of New Brunswick, "PEI's Electric School Bus Build-Up: Lessons from one of Canada's Leading Jurisdictions", August 2022. Online: https://www.conservationcouncil.ca/wp-content/uploads/2022/08/PEI-bus-Fact-Sheet-E-1.pdf

[24] Équiterre, "Pathways for Canadian Electric School bus Adoption", April 2023. Online: https://cms.equiterre.org/uploads/Fichiers/CESBA_STUDY_Pathways-for-electrification_May-2023-ENG1juin.pdf

[25] Propulsion Québec, "Guide Transporteur +: Electric from school to home", June 2022. Online: https://propulsionquebec.com/wp-content/uploads/2022/06/2022-06-14-TransporteurPlus-GuideComplet-EN.pdf

[26] Équiterre, "Pathways for Canadian Electric School bus Adoption", April 2023. Online: https://cms.equiterre.org/uploads/Fichiers/CESBA_STUDY_Pathways-for-electrification_May-2023-ENG1juin.pdf

[27] Ibid.

in service, administering and distributing CleanBC funds, providing information and training modules for school bus operators across the province, etc.[28] Additionally, another key player is BC Hydro, which offers an overnight fleet charging electricity rate with reduced demand charges for EV charging sites.

BUSINESS MODELS TO INTEGRATE ELECTRIFICATION

Electrification presents the opportunity to assess the existing arrangement of roles, responsibilities, and financial obligations (business models) and consider new options that could address unique challenges and opportunities associated with electric school buses. Examples of different business models for electric school transportation are presented in Table 2-2. This table does not encompass all potential combinations of roles or business model variations for the provision of ESB transportation but allows for a benchmarking exercise to present what is used across different operators.

Table 2-2 Electric School Transportation Business Models[29]

BUSINESS MODELS

	Roles within all business models		Roles that are specific to electrification			
	Bus owner (and maintenance)	**Bus operation**	**Charger owner (and maintenance)**	**Energy manager (software)**	**Electricity Customer**	**Federal Clean Fuel Credits**
School Ownership	Province	School District	Province or School District	School District or External	School District	External
Lease	External	School District	School District	School District or External	School District	External
Charging-as-a-Service	School District	School District	External	External	School District	External
Turnkey asset management	External	School District	External	External	External	External
Transportation-as-a-service	External	External	External	External	External	External

External refers to any entity that is not a school district, including original equipment manufacturers (OEMs), school bus contractors, private energy companies, a local electric utility, etc.

Roles specific to electrification are described below.

The **charger owner** describes the entity that holds the charger on its books as a capital asset. Additional infrastructure (e.g., conduit, panel, etc.) might be required on the customer's side of the meter. In some cases, the entity responsible for charger maintenance may be a distinct entity from the owner of the charger.

Energy manager includes the entity providing charging and energy management services (monitoring state of charge, scheduling, planning, charging needs, etc.). While underserved districts may not have the capacity to dedicate

[28] Pembina Institute, "the benefits to British Columbians and options for accelerating the transition", June 2022. Online: https://www.pembina.org/reports/electric-school-bus-adoption-in-bc-rev.pdf

[29] Adapted from Electric School Bus Initiative, World Resources Institute, "Electric School Bus Business Models Guide", nd. Online: https://electricschoolbusinitiative.org/sites/default/files/2022-11/Electric%20School%20Bus%20Business%20Models%20Guide.pdf

themselves to energy management tasks, some chargers' hardware providers include charging management software as part of their services.

Electricity customer describes the entity that pays for the electricity consumed by the chargers. While this is similar to the actual fuel customer (entity paying for the fuel consumed), it's important to consider the flexibility in operating budgets required to accommodate monthly variability in electricity prices.

2.3 SUITABLE TECHNOLOGICAL OPTIONS

Electrifying the school bus fleet in the Atlantic provinces poses distinct challenges. The region's varied weather conditions, particularly harsh winters impacting electric vehicle performance, along with the rural and remote nature of bus routes that demand extended distances, present barriers to electrification for school bus operators aiming to transition to zero-emissions buses. Prince Edward Island reports that extreme conditions (such as hills with snow and strong headwinds in below-zero temperatures) reduce the advertised range of their ESBs by about 55-58%. This aligns with the assumptions used in Section 3 to complete the route electrification. However, it is important to note that, by comparison, harsh conditions also impact the experienced range of fossil fuel buses[30].

Additional technical specifications must be fulfilled by the school buses and need to be validated with the OEMs during the acquisition process. Those specifications[31] may include but are not limited to:

- Meet or exceed the current mandatory requirements of the Canadian Motor Bus Safety Standards & Regulations, the Canadian Standards Association CSA D250, or specifics, and all legislative requirements applicable in the provinces;
- Must provide one or more service & repair centres in each province to provide support for both body and drivetrain;
- Warranty considerations for the battery pack components, such as the battery modules, the battery cooling system, the enclosure, the interfaces, etc.;
- Provide technical training for the maintenance staff to familiarize provincial maintenance staff with any technological changes or repair procedures relevant to the body, chassis, and powertrain.

Electric school buses are gaining market popularity, and different OEMs are starting to produce common types of electric school bus vehicles. Examples of electric school buses available on the Canadian market are presented in the sections below for Type A and Type C school buses.

[30] Electric School Bus Initiatives, "The Electric School Bus Series: Progress from Our Northern Neighbors in Prince Edward Island, Canada", May 2022. Online : https://electricschoolbusinitiative.org/electric-school-bus-series-progress-our-northern-neighbors-prince-edward-island-canada

[31] Some of the specification examples are from the Atlantic Canada School Bus Purchase for 2024 Delivery request for proposal.

2.3.1 TYPE A ELECTRIC SCHOOL BUS



Make[32]	Lightning eMotors	GreenPower	Blue Bird
Model	Lightning ZEV4	Nano BEAST	Micro Bird G5 Electric
Specifications	L: 258” W: 96" H: 77" GVWR[33]: 14,200 lbs	L: 300” W: 92" H: 125" GVWR: 14,330 lbs	L: 283” W: 96" H: 113-118" GVWR: 14,500 lbs
Passenger Capacity	24	24	30
Level 2 maximum charging acceptance rate	13.2 kW	19 kW	13.2 kW
Level 3 maximum charging acceptance rate	80 kW	65 kW	50 kW
Battery size	120 kWh	118.2 kWh	88 kWh
Advertised range	240 km	190 km	160 km
Advertised Energy Efficiency	0.5 kWh/KM	0.62 kWh/KM	0.55 kWh/KM
Approximate price[34]	$265,000	$335,000	$320,000

[32] All Type A and C electric school buses are available to purchase in Canada.
[33] GVWR stands for “Gross Vehicle Weight Rating”.
[34] Prices are from World Resources Institute’s *Electric School Bus U.S. Buyer’s Guide 2023,* based on state contracts, and are subject to change.

2.3.2 TYPE C ELECTRIC SCHOOL BUS

Make	Lion	Thomas Built Buses	Blue Bird
Model	LionC	Saf-T-Liner C2 Jouley	Vision Electric
Specifications	L: 473" W: 96–102" H: 122" GVWR: 31,000 lbs	L: 396" W: 96" H: 144" GVWR: 33,000 lbs	L: 477" W: 96" H: 123" GVWR: 33,000 lbs
Passenger Capacity	77	81	77
Level 2 maximum charging acceptance rate	19.2 kW	-	19.2 kW
Level 3 maximum charging acceptance rate	50 kW	90 kW	80 kW
Battery capacity	126-168 kWh	244 kWh	155 kWh
Advertised range	150-250 km	240 km	210 km
Advertised Energy Efficiency	0.84 kWh/KM	1.02 kWh/KM	0.74 kWh/KM
Approximate Price[35]	$420,000	$420,000	$420,000

2.4 CHALLENGES TO ADOPTION

The transition to electric operations presents advantages such as higher engine efficiency and lower energy cost which align well with school bus routes; typically short and predictable. However, the adoption of electric alternatives includes several barriers to the adoption. These obstacles range from high up-front costs, technology limitations, route

[35] Prices are from World Resources Institute's *Electric School Bus U.S. Buyer's Guide 2023,* based on state contracts, and are subject to change. Prices were converted to Canadian dollars and checked against relevant quotes by OEMs. Considerations for bulk purchase discounts not included in the estimation.

profiles that may affect range, charging infrastructure, environment, and perceptions. Overcoming these barriers requires a multifaceted approach that will be part of the considerations / assumptions in the table below.

Table 2-3 Challenges and Barriers to the Adoption of Electric School Buses

TYPE	CHALLENGES/ BARRIERS	DESCRIPTION	MITIGATION/CONSIDERATION
Upfront costs	Higher capital costs	• Higher up front costs relative to a traditional internal combustion engine. • Potential uncertainty relative to government policies, incentives, or regulations. • Securing funding—aligning incentives at multiple levels of government.	• A full life cycle analysis of operational benefits offsetting higher upfront costs. • Secure available funding and leverage government incentive regimes.
Technology	Range	• Mismatch between battery capacity and operational needs. • Battery technology—battery degradation from underestimating the number of charging cycles throughout the asset's life.	• Identify battery capacities that ensure sufficient operational buffer. • Implement a charging strategy that optimizes the number of charging cycles and maintains a rate of charge safe for the battery pack. • Monitor the battery's state of health to prevent failures.
	Operational flexibility	• The range of electric school buses is lower than the range of their diesel counterparts, reducing the flexibility in case of route detours, and exceptional events. • Completion of external activities and afterschool program	• Identify battery capacities that ensure sufficient operational buffer. • Charging strategies to ensure electric school bus can complete the external activity or the afterschool run.
	A limited number of ESB manufacturers	• Supply chain issues. • Unfavourable contractual conditions. • Spare part availability. • Unknown reliability of the new manufacturer. • Risks associated with higher interest rates as some new players rely on cheaper capital.	• Favour manufacturers with a track record during the RFP procurement process. • Increased levels of spare parts to mitigate downtime and obsolescence. • Favour manufacturers with a good warranty on the battery and bus

Route profiles	High number of unproductive kilometres	• Longer distances between overnight charging locations and the school bus route. • Atlantic Canada's population is less dense which may not provide the most efficient vehicle.	• Appropriate battery pack capacity contingency.
Charging Infrastructure	Limited charging infrastructure	• Issues associated with missing a planned charging opportunity. A charger may be occupied. • Distance between charging stations—charging availability within an operational route. • Short charging windows, reliance on peak periods. • Reliance on overnight charging at a bus driver's home for smaller operators.	• Opportunity charging (daytime charging) • Leverage the central nature of midday downtime for charging, such as charging at schools. • Cover electrical upgrades for home charging, and electric utilities costs.
Environmental Conditions	Effects of colder weather on battery performance	• Issues during cold periods • Terrain influences range and may not be uniform across the Atlantic provinces. • Varying snow conditions across the Atlantic provinces • Higher air salinity that may cause premature battery degradation.	• More frequent charging • Opportunity charging (daytime charging) • Level-3 chargers • Monitor through visual inspection signs of corrosion. • Precondition vehicles through auxiliary power prior to journey commencement • auxiliary heating to reduce the impact of cold weather on the batteries.
Perception	Lack of awareness and understanding of the technology	• Underestimating operational and maintenance benefits of electrical vehicles. • Rural perceptions associated with longer travel distances between communities.	• Highlight favourable school bus operation characteristics such as long downtime periods, lower speeds, and light acceleration that make it a good transport solution. • Reinforcing that good driving habits will have a good outcome on the ESB range.

In summary, the barriers to adoption are multifaceted and may mitigate operational risks with the following key takeaways:

- Consider a full lifecycle analysis where energy costs offset higher upfront costs.
- Address range limitations with an appropriate battery capacity contingency, to limit range issues, and a reliance on opportunity charging.
- Implement a charging strategy that limits battery degradation.
- Favour reliable manufacturers with good warranties to ensure business continuity (supply chain).
- Implement a route electrification assessment that suits varying scales of operation, home charging for smaller operators, central depots for larger operators, and school charging infrastructure to ensure diversity of sources.

3 ROUTE ELECTRIFICATION

This section is based on daily route operations. The result from this section provides the provinces with an understanding of the ability to electrify certain routes.

3.1 ROUTE PROFILE ASSESSMENT

This section aims to examine the feasibility of electrifying routes and vehicles in three Canadian provinces—Nova Scotia, New Brunswick, and Newfoundland & Labrador. The primary focus is to determine the electrification index under two scenarios: 1) Overnight-only charging and 2) Overnight + Midday charging. The route profile assessment consists of an evaluation of the feasibility of the electrification for the different routes, based on the total distance for each route and on the energy efficiency of the electric school buses.

3.1.1 ASSUMPTIONS

To accomplish this objective, the study incorporates key assumptions related to energy efficiency and usable battery capacity. Energy efficiency, measured as kWh/km, represents the anticipated energy consumption per kilometre travelled. For this analysis, a standardized energy efficiency value of 1.00 kWh/km has been adopted, derived from discussions with electric school bus manufacturers and a composite of past feasibility studies involving 40' electric buses and empirical data collected from the operational performance of electric school buses in the U.S.[36,37] The standardized energy efficiency value of 1.00 kWh/km includes an auxiliary heater powered by diesel. This diesel-burning auxiliary heater will provide thermal comfort for passengers under cold weather conditions while maintaining the operational range otherwise reduced by electric heating. However, using diesel burners means that the electric school buses are not completely zero-emission, as they will still produce exhaust pollutants[38].

The usable battery capacity is a pivotal metric in understanding the operational capabilities of each vehicle. Extreme weather, mainly cold weather and winter conditions have effects on the usable battery capacity. While the usage of auxiliary heating will reduce the impact of cold temperatures on the range, snowy and icy roads can affect the driving efficiency of the vehicles. Additionally, snowy conditions lead to low traction from the vehicle, however, the added weight from the batteries on ESB can improve the traction in these conditions. To account for these considerations, the usable battery capacity is calculated using a conservative approach, deducting safety margin, efficiency, and winter condition considerations (20%, 6%, and 20%, respectively) from the nominal battery capacity. The effective battery capacity for Type A buses is established at 89 kWh, derived from a nominal battery capacity of 120 kWh. Similarly, for Type C buses, the usable battery capacity is determined to be 124 kWh, considering a nominal battery capacity of 168 kWh. Procuring buses with larger battery capacities will result in different and potentially more favourable results for the electrification of routes.

3.1.2 METHODOLOGY

The feasibility of electrifying routes was assessed through two distinct scenarios in this study.

In **Scenario 1**, known as **Overnight-Only Charging**, the ability to electrify vehicles was determined by calculating the estimated total energy consumption. This calculation involved multiplying the average daily travel distance (in

[36] https://cloudinary.propane.com/images/v1655498780/website-media/Propane-vs.-Electric-School-Bus-Dont-Rush-to-Judgement/Propane-vs.-Electric-School-Bus-Dont-Rush-to-Judgement.pdf?_i=AA

[37] https://www.veic.org/Media/default/documents/resources/reports/veic-ma-doer-electric-school-bus-pilot-project.pdf

[38] Pettinen, R.; Anttila, J.; Muona, T.; Pihlatie, M.; Åman, R. Testing Method for Electric Bus Auxiliary Heater Emissions. Energies 2023, 16, 3578. https://doi.org/10.3390/en16083578

kilometres) of each vehicle by its energy efficiency, a value standardized at 1.00 kWh/km for all vehicles in this study. If the resulting energy consumption fell within the usable battery capacity of 124 kWh, the vehicles were considered electrifiable under this scenario.

Scenario 2, labelled **Overnight + Midday Charging**, introduced the assumption that vehicles could charge their batteries an additional 50% during the day. This led to a new battery capacity equivalent to 1½ times the original usable battery capacity, allowing for extended operational capabilities. This option should be followed if the province or operator can already accommodate midday charging within its operations, or if it is willing to make substantial operational changes to allow for midday charging.

The outcomes of the two scenarios offer a comprehensive analysis of the potential for electrification within the operational contexts of Nova Scotia, New Brunswick, and Newfoundland & Labrador. The subsequent sections of this report delve into the results and observations derived from this multifaceted assessment.

3.1.3 RESULTS

Table 3-1 offers a comprehensive summary of the electrification analysis for the various school districts within each province. It provides electrification indices for two distinct scenarios: "Overnight-Only Charging" and "Overnight + Midday Charging"[39]. The "route count" column represents the total number of routes completed by each operator, based on data received for this study. The "average daily travel distance" provides the typical distance covered by the routes in a day. This information is critical for a thorough assessment of electrification needs.

Additionally, the table presents key insights through columns such as "electrifiable routes," which specifies the number of routes that could potentially be completed by electric school buses. Conversely, the "non-electrifiable routes" identifies the number of routes that could not be completed by an electric school bus. Resulting from those two previous columns, the "completion %" shows the percentage of the routes that could be electrified under each scenario, offering a comprehensive view of the electrification potential for different school districts. Furthermore, the "improvement" column quantifies the percentage increase in "completion %" attributed to midday charging.

Figure 3-1 shows the completion percentages for each operator within the three provinces under scenarios 1 and 2. This figure is derived from Table 3-1.

[39] The energy consumption and feasibility of replacing ICE vehicles with electric vehicles depend on many factors including route topography, speed, stop frequency, among other factors. The electrifiable and non-electrifiable vehicles for this study are assessed based on the assumptions highlighted in earlier section of the report, designing to provide high-level overview on the possibility of electrification.

Figure 3-1 Fleet completion by operator and province

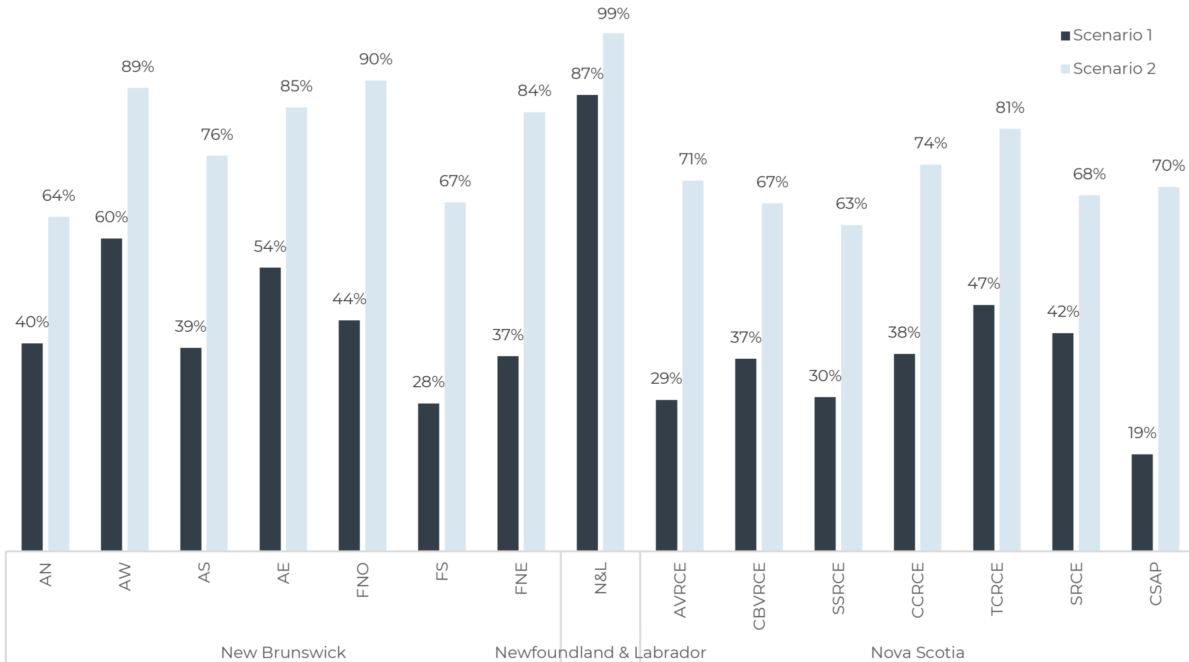


Table 3-1 Summary of Electrification Analysis for School Districts in Nova Scotia, New Brunswick, and Newfoundland & Labrador

PROVINCE	OPERATOR	ROUTE COUNT	TOTAL CONSUMPTION (MWH)	AVERAGE ROUTE DISTANCE (KM)	SCENARIO 1			SCENARIO 2			
					Electrifiable Route Count	Non-electrifiable Route Count	Completion (%)	Electrifiable Route Count	Non-electrifiable Route Count	Completion (%)	Improvement
New Brunswick	AN	128	20.14	157.37	51	77	40%	82	46	64%	24%
	AW	267	32.20	121.50	158	107	60%	235	30	89%	29%
	AS	231	34.28	150.24	66	113	37%	135	44	75%	39%
	AE	127	16.20	119.70	60	43	58%	92	11	89%	31%
	FNO	61	7.97	124.28	13	11	54%	21	3	88%	33%
	FS	187	30.54	155.26	21	43	33%	45	19	70%	38%
	FNE	107	15.26	149.51	16	30	35%	37	9	80%	46%
	Total	1,108	156.6	141.49	490	618	43%	872	236	79%	36%
Newfoundland & Labrador	N&L	262	18.46	70.46	229	33	87%	260	2	99%	12%
Nova Scotia	AVRCE	100	15.95	159.49	29	71	29%	71	29	71%	42%
	CBVRCE	84	14.92	177.57	31	53	37%	56	28	67%	30%
	SSRCE	88	14.18	161.19	26	62	30%	55	33	63%	33%
	CCRCE	185	28.01	151.42	70	115	38%	137	48	74%	36%
	TCRCE	89	11.85	133.19	42	47	47%	72	17	81%	34%
	SRCE	110	17.10	155.43	46	64	42%	75	35	68%	26%
	CSAP	43	9.61	174.59	8	35	19%	30	13	70%	51%
	Total	699	111.62	158.98	252	447	34%	496	203	70%	36%
Provincial Total		**2,069**	**286.67**	**144.92**	**971**	**1,098**	**47%**	**1,628**	**441**	**79%**	**32%**

3.1.4 KEY INSIGHTS

According to the data presented in Table 3-1, the province of Nova Scotia currently operates a total of 699 routes daily. Within this fleet, it is projected that 252 routes (36% of the routes) could be completed by electric buses based on the overnight charging (scenario 1), with the potential to increase this number to 496 (71% of the routes) by incorporating midday charging (scenario 2).

New Brunswick operates a larger number of routes than Nova Scotia and Newfoundland & Labrador, with over 809 routes. Among these, it is anticipated that 385 routes (48%) could be completed with an electric school bus, with solely overnight charging. This number could rise to 647 (80%) with a combined overnight and midday charging strategy.

Newfoundland and Labrador operates 262 routes. Under scenario 1, 229 of those routes (87%) are suitable for electrification, while under scenario 2, a total of 260 routes (99%) could make the transition.

Note that the complete results of the route electrification for both scenarios for the different operators are available in Appendix B. Those results, presented as graphs, allow for a visual understanding of which routes are suitable for electrification.

4 ASSET ELECTRIFICATION

4.1 CHARGING INFRASTRUCTURE

4.1.1 *CHARGER SPECIFICATIONS*

All electric vehicles (EVs), including ESBs, require recharging of the onboard Energy Storage Systems (ESS) which is conducted using Electric Vehicle Supply Equipment (EVSE), commonly referred to as EV chargers. The EVSE is further supported by the associated electrical infrastructure. There are three (3) levels of EV charging commercially available: Level 1, Level 2, and DCFC (or also known as Level 3), with Level 1 charging being the slowest and Level 3 being the fastest. As a rule of thumb, the higher the level of charging, the faster the charging process, which is completed through a higher rate of power delivery to the vehicle.

Table 4-1 Charging Infrastructure Specifications

	LEVEL 1 (AC)	LEVEL 2 (AC)	LEVEL 3 (DCFC)
Output	120V, 1 kW	240V, 3-22 kW	480+V, 50-350 kW[40]
EVSE & Installation Cost Per Port	$500—$1500	$2,500—$12,000	$50,000—$300,000
Typical Use	Level 1 charging uses 120-volt (V) alternating current (AC), delivered by a standard three-prong household plug. Existing outlets can provide easy access to charging where Level 2 is not available. Level 1 charging is the slowest of all charging levels and can take up to 16 hours to charge a vehicle with a 400 km range.	Level 2 charging uses 240-volt and can provide between 30 and 50 km of range per hour. Level 2 charging stations are the most common for at-home charging, and many allow for networking, and/or incorporation into electric vehicle energy management systems.	Level 3 charging, also known as Direct Current Fast Charging (DCFC) uses high-voltage electricity to deliver charging that can be up to 30 times faster than Level 2. The higher cost of equipment and upstream infrastructure make this level impractical for most residential applications and is better suited for depots and/or schools.
Charge Time[41] (200 km range / 150kW battery)	Up to 150 hours	6-7 hours	0.5 – 4 hours
Suitability for Electric School Bus Operations	**Not suitable** for school bus operations, the charging time is not operationally viable.	**Suitable** for school bus operations. Level 2 chargers offer charging solutions at a lower price than their Level 3 counterparts, and the operational model of school buses allows for sufficient charging times (i.e., overnight charging).	**Suitable** for school bus operations, DCFCs offer rapid charging and could be used by multiple buses as a midday solution to increase the range. **However**, the operational model of school buses (only during the morning and the afternoon, allowing for long charging time), might not make DCFC chargers financially optimal.

[40] DCFCs can range widely in charging power and costs.

[41] Dependent upon various factors such as battery size, onboard charging speeds, state of charge, etc.

Level 2 charging equipment is much cheaper than Level 3 chargers and usually requires fewer electrical infrastructure upgrades and subsequently results in much lower overall capital and operating costs. The typical capital and operating costs associated with the use of EVSE are listed below for reference:

- EVSE hardware/equipment
- EVSE electrical infrastructure/gear
- Installation/ Civil Work
- Utility Demand Charges
- Utility Energy Charges
- Networking Software Subscription
- Periodic and Corrective Maintenance
- Additional Warranty
- Transaction Fee (billing, invoicing, tax reporting, and user support, if applicable)

Additionally, chargers can be defined as "networked" and "non-networked". A networked charger for electric vehicles refers to a charging station that is connected to a network, allowing for remote monitoring, management, data collection and analysis. Higher upfront costs are associated with networked chargers when compared to un-networked. However, while a non-networked charger is often cheaper to purchase and operate, there can be downsides to this simpler technology, including the lack of access to data. Networked chargers allow for remote monitoring, management and control (i.e., scheduling charging time), data collection (i.e., energy consumption, information on future infrastructure planning, etc.) and smart grid integration (managing the electricity demand and high-peak moments).

CSA Group is a global organization dedicated to safety, social good and sustainability, providing advancement of standards in the public and private sectors. The Canadian Electrical Code (CE Code), published by CSA Group, plays a key role in specifying the safe installation of the charging infrastructure. Safety standards for the installation and maintenance of electrical equipment, including the charging infrastructure are also covered in the CE Code. Additionally, the Electric Vehicle Energy Management Systems can be seamlessly integrated into the electrical grid following the discrete product safety certification standards, as specified in the CE Code[42].

4.1.2 CHARGING RECOMMENDATIONS

Scenario 1:

To implement charging infrastructure following this scenario, it is recommended to follow a 1:1 vehicle-to-charger ratio. It is proposed to opt for a Level 2 charger capable of charging at a 19.2 kW rate. This scenario allows for a 7.5hour or more charging window (from the moment the bus route is completed). This is based on the assumption that operations that would begin at 6 a.m. It is recommended to maximize the usage of dual port chargers in locations with more than one bus where possible to reduce infrastructure costs in the future.

Scenario 2:

In addition to the recommendations from the scenario 1 implementation, scenario 2 is based on midday charging. DCFC chargers could be beneficial if they are centralized and easily accessible to a high number of electric school buses. While DCFCs could be a useful addition, they are not required to fulfill the operations planned with the Scenario 2. The long period between the morning and the afternoon runs would still make the operation viable on a level 2

[42] CSA Group, "The Role of Codes and Standards in Electrifying the Transportation Sector", 2024. Available : https://www.csagroup.org/article/the-role-of-codes-and-standards-in-electrifying-the-transportation-sector/
Additional electrical installation requirements related to BEVs are specified in sections 8 and 86 of the Canadian Electrical Code (Part I).
- The product safety certification standard for an EVSE providing AC power to an on-board charger of a BEV is CSA–C22.2 NO. 280.
- EVSE is used with plugs, receptacles, vehicle inlets, and connectors for which the product safety certification standard is CSA-C22.2 No. 282
- EVSE installations have accessible parts that can pose shock hazards. CSA-C22.2 NO. 281.1

charger, with a charging period of over four hours to bring the buses to a half-charge. In these circumstances, operations across school districts would likely need to change to ensure electric buses are returning to their designated charge location midday or to another location such as a school to charge.

CHARGING PORTS REQUIRED

The charging infrastructure required to support the electric school bus fleet is based on Level 2 charging, providing a minimum of 19.2 kW. This requires a 7.5-hour charge window based on the capacity of the school buses estimated within this study.

Table 4-2 presents the number of charging ports (pistol) required to accommodate the operations, based on the different scenarios. For locations where there are two school buses at one location, one dual-port charger may be used to reduce costs associated with infrastructure and electrical demand. A dual-port charger would allow for sequential charging, one at a time, over a charge window of 15 hours. This would assume that the operators can leave the buses charging for 15 hours, or the buses have slightly different charge windows.

Table 4-2 Number of Charging Ports based on the Scenarios (assuming 1 bus per route)

	New Brunswick							Newfoundland and Labrador	Nova Scotia						
	AN	AW	AS	AE	FNE	FS	FNO		AVRCE	CBVRCE	CCRCE	CSAP	SRCE	SSRCE	TCRCE
Scenario 1	51	148	89	69	39	53	27	193	29	31	70	8	46	26	42
Scenario 2	82	225	174	108	89	125	55	235	71	56	137	30	75	55	72
Complete electrification	128	267	231	127	107	187	61	262	100	83	185	43	110	87	89

Complete electrification presents the number of charging ports required if the whole fleet could be electrified, without the technology or facility barriers (range, available power, etc.). The number of charging ports in this table could be used for strategic planning before moving forward with infrastructure modifications.

When using Table 4-2, it will be important to multiply the numbers provided with the anticipated number of buses per route. The numbers given assume only one bus per route.

4.1.3 ENERGY AND POWER NEEDS

Table 4-3 presents the total daily energy consumption per operator. The energy consumption is calculated by multiplying the vehicle count by the average daily travel distance by the average energy consumption (1.00 kWh / km), outlined in section 3.1.1.

Table 4-3 Energy consumption

PROVINCE	OPERATOR	ROUTE COUNT	AVERAGE ROUTE LENGTH (KM)	TOTAL CONSUMPTION (MWH)
New Brunswick	AN	128	157.37	20.14
	AW	267	120.59	32.20
	AS	231	148.40	34.28
	AE	127	127.55	16.20
	FNE	61	130.58	7.97
	FS	187	163.30	30.54
	FNO	107	142.64	15.26
Newfoundland & Labrador	N&L	262	70.46	18.46
Nova Scotia	AVRCE	100	159.49	15.95
	CBVRCE	84	177.57	14.92
	SSRCE	88	161.19	14.18
	CCRCE	185	151.42	28.01
	TCRCE	89	133.19	11.85
	SRCE	110	155.43	17.10
	CSAP	43	174.59	9.61

To translate the energy demand to a peak power demand, the following assumptions were used:

— All vehicles are connected to a level 2, 19.2 kW charger.
— **The midday charging window length is 3.25 hours.** With 19.2 kW chargers, it will add 62.4 kWh of energy to the batteries. This corresponds to 50.2% of the 124.32 kWh useable battery capacity.
— **The overnight charging window length is 8 hours.**
— The charging is done exclusively at their dedicated parking location.
— A charge management system is used to maintain a constant power demand during the duration of the charging windows. This system can remotely control the chargers to allow a limited number of chargers to be active at any given time.

In scenario 1 the charging process occurs overnight. The peak power demand is obtained by dividing the total energy by the length of the charging window. For example, with operator AVCRE in Nova Scotia, 26.52 MWh divided by 8 hours yields a peak power demand of 3.31 MW. Figure 4-1 presents the peak power demand for scenario 1.

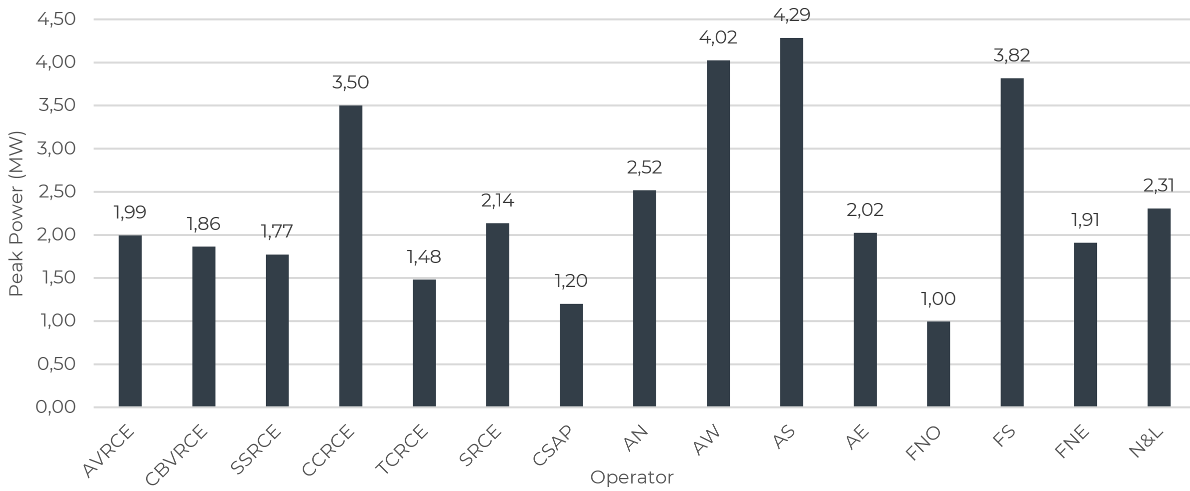


Figure 4-1 Peak Power Demand for Scenario 1

In scenario 2, it is assumed that only the vehicles that cannot complete their daily route on a single charge are being charged midday. An example of a calculation for the midday peak is available in Appendix A.

The values of the mid-day and overnight peaks are presented in Figure 4-2.

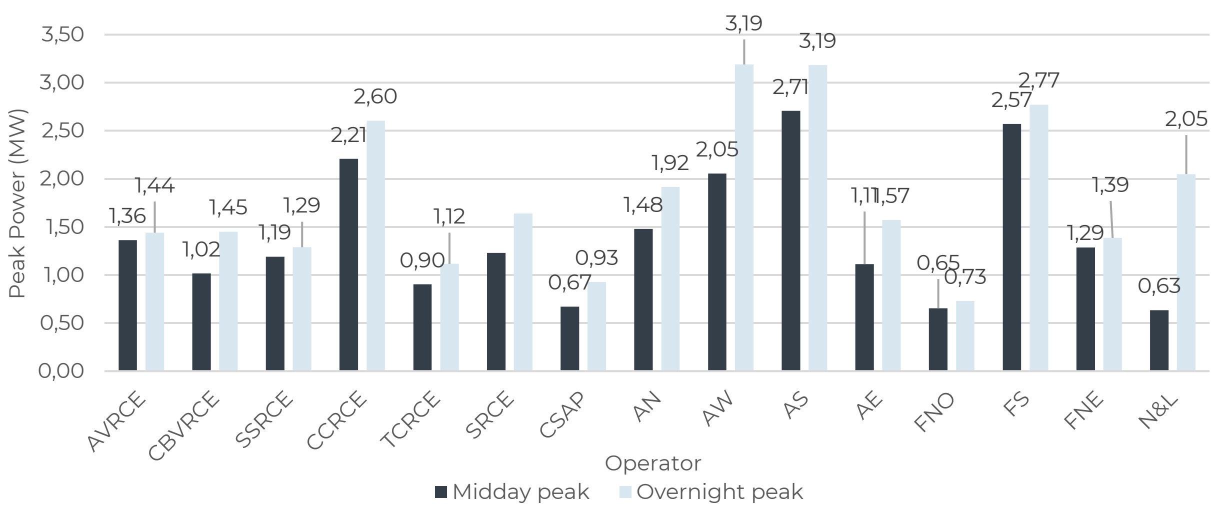


Figure 4-2 Peak Power Demand for Scenario 2

The numbers presented in the figures above give an order of magnitude of the peak power demand for both scenarios. Some factors will influence the power demand when the fleets are completely electrified. Amongst them:

– **OPEX optimization**: Many utilities use dynamic pricing where the price of electricity will vary based on the time of day. The estimates presented above consider a constant power demand throughout the charging windows. To reduce the OPEX for electricity, it may be beneficial to increase the power demand at certain times of day and reduce it at others.

- **Increased ridership:** The electrification of the fleets will occur over a period of many years, potentially 10 to 20 years. The values provide a picture of the present day. Over the transition period, it can be expected that ridership will increase, and more buses will be added to the fleets, leading to an increased power demand.
- **Pre-conditioning:** In cold weather, the vehicles can be preconditioned to preheat the cabin and keep the batteries at their optimal operating temperature. If it is used, preconditioning will increase the energy and power demands.

The cumulative peak power demand is important information to share with electricians and utilities when installing the chargers. As most chargers will be dispersed over various sites (i.e., individual residences), and therefore the peak power demand will also be dispersed widely. However, early engagement with utilities is highly recommended for sites with many buses in one location.

The provinces are supplied electricity through different utilities. Appendix A presents an overview of the utility's mechanism and particularities.

4.2 MAINTENANCE AND OPERATIONS

4.2.1 CHARGING INFRASTRUCTURE MAINTENANCE

The operating costs of the charging infrastructure include charger maintenance. The chargers considered in this study are level 2 and level 3 chargers. Preventive maintenance includes visual inspections of the chargers and cables for any signs of damage, keeping the chargers clean and free from debris and visual inspection of the connector's contacts for any signs of corrosion or damage. Additionally, level 3 chargers often have a forced air-cooling system that requires the replacement of air filters. The replacement frequency will vary depending on the operating conditions. For instance, filters will be replaced more frequently in an outdoor dusty environment versus in an indoor setting.

When a charger becomes inoperable, troubleshooting and corrective maintenance should always be performed by a certified electrician who has received training from the charger's manufacturer. Operators should also ensure that spare parts are readily available, either by keeping them in stock or working with a local distributor. Alternatively, the operators can decide to include a service contract with the purchase of the chargers. These plans can be fixed-term, renewable and included in the cost of the equipment. The plan should include a maximum response time, time for a given repair, as well as an overall uptime requirement.

4.2.2 BUS MAINTENANCE

For electric vehicles, most of the general maintenance procedures related to the chassis will remain the same as for their diesel bus counterpart. The main difference relates to components such as batteries, converters, and inverters. Some electric bus models may require frequent battery balancing, which entails handling high-voltage equipment and specialized training.

An electric vehicle requires significantly fewer maintenance steps than an internal combustion vehicle[43]. Because of the electrical drivetrain, the need for specialized liquid refills is minimized. Break wear and tear maintenance is also reduced due to regenerative braking capabilities; the break lifespan could even increase.

Specialized testing and diagnostic equipment are required to perform maintenance on electric vehicles. Furthermore, protective equipment to work around high-voltage equipment is key to a safe operation. Should an electric vehicle malfunction during operation, the asset should be towed on a platform truck to limit damage to the powertrain.

[43] Propulsion Quebec, "Electric from school to home. A technical guide to the electrification of Quebec School buses for a successful transition", 2022

Additionally, specialized training and qualifications are required for mechanics to work on the more complex components of an electric vehicle, such as electric drivetrains, control systems and the battery. Advanced diagnostic tools can also be used to perform in-depth repairs. Training programs are offered at different learning institutions and can vary in duration, program complexity and price, the ASE (Automotive Service Excellence), for example, provides EV Safety Certifications for electrical safety awareness and technician electrical safety. These certifications vary in price. For example, it can cost approximately USD 50, or roughly CAD 68, to complete an xEV Technician Electrical Safety Level 2 certification[44]. OEMs often provide free courses to train mechanics for basic maintenance on their vehicles[45].

Due to battery deterioration, the operator should account for one battery replacement during the life of the vehicle. Even though operational data on degradation is scarce, it is estimated that there is a 1.5–2% loss of total battery capacity per year of operation. Furthermore, degradation can be accelerated by factors like overutilization of the battery requiring discharges under 20% of the stored energy. Overcharging is an additional action that accelerates battery deterioration; however, the battery management system has built-in functionality to prevent it. At the end of their life, batteries can be recycled or reused for other second-life applications. Different school bus manufacturers offer options in their contracts to take back batteries for recycling.

4.2.3 DATA COLLECTION AND PERFORMANCE

The telemetry on battery-electric vehicles is purposely developed to monitor the operation of the vehicle remotely. A network of sensors onboard an electric vehicle allows the operator to monitor not only real-time but also historical data on the operation of the asset. This system allows the operator to monitor features such as location and time at stops, battery charge level, problems encountered with the drivetrain, energy consumption, and life of the drivetrain components (to monitor replacement).

EQUIPMENT AND INTERFACE

The school bus operator should consult with the vehicle's OEM about the data collection and monitoring capabilities to find out what is included as part of the asset's purchase. This collection and monitoring capabilities include:

- Device reporting status;
- What features are monitored in each device (ex. battery state of health);
- Rate at which the devices are reporting;
- Alarms set to monitor low performance on each one of the devices; and
- the monitoring system (in the cloud or/and local).

This monitoring system is the interface the operator should have access to, to monitor and analyze the performance of the vehicle. This can be done through a third party if needed as there are companies specialized only in monitoring systems. For an additional cost, the school may need to acquire a monitoring system solution separately in case the vehicle's purchase does not include one.

Some of the requirements for such a monitoring system are:

- Interface set-up and maintenance on a local machine or in the cloud, depending on where the monitoring system is deployed. It is common practice to have the interface to the monitoring system deployed on the cloud and accessible to on-site machines via an HTTP server (ex. on the browser).
- Cloud storage or local storage set-up and maintenance, depending on where the data storage is located in general, is a best practice to utilize cloud storage.

[44] xEV Safety Certifications, https://www.ase.com/ev

[45] https://electricschoolbusinitiative.org/reskilling-workforce-training-needs-electric-school-bus-operators-and-maintenance-technicians

- Internet connection on board the electric school bus or at the point where the data transfer to the monitoring system is to be performed regularly. For the project, given the small size of the fleet, real time monitoring might not be required.

  There are multiple options when it comes to fleet management for electric school buses, such as LionBeats, Ampcontrol's CMS, Simply Fleet, etc. The capabilities of these tools may vary but can often be used to manage the aspects of the ESB fleet while optimizing the operations. Such systems often include route planning, real-time fleet management, driver training, charge and energy management, maintenance, and diagnostics, and provide safety features. These tools can often be used to measure electric vehicle performance, including energy consumption (in kWh/km), operating costs and savings, and driver behaviour. Using these telematic tools, it is possible to understand the real-life impact of the transition while tracking progress, and the environmental and financial impact of the ESBs.

PERFORMANCE MONITORING

In addition to the technical features that are monitored in any vehicle (fluid levels, mileage, auxiliary battery level), to evaluate the performance of the electric school bus deployment, key considerations include but are not limited to the following:

- *Energy consumption*: Monitoring this can reveal energy losses during the operation of the electric vehicle.
- *Battery state-of-health*: this feature will indicate the deterioration of the battery capacity as time passes. There is no need for a high sampling rate. It would be ideal to have a monthly aggregated measurement of the state of health. A yearly consolidated value will inform of the need for replacement and compliance with the warranty.

ELECTRICITY CONSUMPTION METERING

With the operation of ESBs, electricity replaces diesel and now occupies a greater portion of the operating expenses. Operators may be able to monitor and log the electricity consumption of the charging infrastructure, excluding all other loads. A few options are available based on the feasibility and precision of metering required.

- Dedicated utility feeder: If allowed by the utility, the site can be connected to a second feeder dedicated to the charging infrastructure. This has the advantage of integrating a revenue grade meter and getting a precise dollar amount on the electricity bill.
- Built-in power meter: Most level 2 and level 3 chargers are equipped with a built-in power meter and data logging capabilities. The metering accuracy will typically be between 0.5% and 3%, and data logging frequency is measured in minutes. Depending on the intended usage of the data, the level of accuracy may or may not be sufficient.
- External power meter: In the case where the accuracy and/or logging frequency of the built-in power meters is insufficient, an external power meter can be installed. The power meter should be installed on the feeder to the charging infrastructure to measure the electricity consumption for vehicle charging only.

4.3 ENVIRONMENTAL BENEFITS

Fossil fuel-powered school buses have negative environmental and health impacts for both the students being transported to school and the drivers. Exhaust pollution produced by fossil fuels is linked to negative cognitive development impacts and poses a risk for serious conditions such as cancer, heart disease and asthma.[46] Additionally, fossil fuel buses are responsible for the production of greenhouse gases.

Electric school buses, on the other hand, are considered zero-tailpipe emissions vehicles. Students, drivers, and members of the community will be exposed to significantly less harmful emissions while reducing the amount of

[46] https://electricschoolbusinitiative.org/why-we-need-transition-electric-school-buses

greenhouse gas emissions produced when switching to ESBs. Beyond air pollution, battery electric buses also reduce noise pollution, which is harmful to the students, the drivers, and the local neighbourhood[47]. It is important to note that the addition of auxiliary heaters for maintaining adequate cabin temperature will have an impact on the emissions related to the operations of electric school buses. Assumptions related to the diesel auxiliary heater consumption are presented in Appendix A.

The ensuing section allows for a deeper understanding of the impacts of ESBs on greenhouse gas emissions, criteria air pollutants and noise reduction.

4.3.1 GREENHOUSE GAS EMISSIONS ANALYSIS

Appendix A presents the assumptions used to complete the greenhouse gas (GHG) emissions analysis.

LONG-TERM VIEW OF FOSSIL FUELS

To complete a realistic estimation of the environmental impacts of diesel school buses, the GHG analysis included a long-term view of fossil fuels. The Federal Clean Fuel Regulations (CFR) has been considered within this analysis, as it is a primary mechanism to reduce the carbon intensity of fossil fuels gradually over time, leading to a decrease in the carbon intensity of gasoline, diesel, and propane of approximately 15% below 2016 levels by 2030. It is assumed that fuel producers will reduce their carbon intensity by paying high penalties for not adhering to these regulations.

ANNUAL EMISSIONS PER BUS

Table 4-4 presents the annual GHG emissions based on the average fuel consumed, travelled kilometres, fuel type and province, considering the distinct operations of the buses. To meet ZETF's requirements from GHG+ Plus Guidance Modules, the average emissions per bus presented below includes the emissions related to the production of the fuel (or electricity) as well as the operation of the bus. Emission factors for the production and operation of the different fuels and different provinces are available in Appendix A. Additionally, note that annual emissions for the average bus per operator are also available in Appendix A.

[47] https://www.epa.gov/cleanschoolbus/benefits-clean-school-buses

Table 4-4 Annual Average Emissions per Fuel per Bus

	NEW BRUNSWICK				NEWFOUNDLAND AND LABRADOR			NOVA SCOTIA		
	Diesel	Gasoline	Propane	Electricity	Diesel	Gasoline	Electricity	Diesel	Gasoline	Electricity
2023	20.94	25.68	20.39	7.36	10.87	13.27	0.98	24.27	21.30	14.57
2024	20.54	25.10	19.63	7.48	10.66	12.97	0.96	23.81	20.82	14.70
2025	20.15	24.52	18.87	7.41	10.46	12.67	0.93	23.35	20.34	14.69
2026	19.75	23.94	18.11	7.40	10.25	12.37	0.92	22.89	19.86	13.35
2027	19.35	23.37	17.36	7.33	10.04	12.08	0.90	22.43	19.38	12.87
2028	18.96	22.79	16.60	7.00	9.84	11.78	0.89	21.97	18.91	12.37
2029	18.56	22.21	15.84	6.84	9.63	11.48	0.86	21.51	18.43	11.69
2030	18.16	21.63	15.08	4.02	9.42	11.18	0.84	21.05	17.95	4.94
2031	18.16	21.63	15.08	3.85	9.42	11.18	0.84	21.05	17.95	4.89
2032	18.16	21.63	15.08	4.02	9.42	11.18	0.86	21.05	17.95	4.78
2033	18.16	21.63	15.08	3.78	9.42	11.18	0.84	21.05	17.95	4.69
2034	18.16	21.63	15.08	4.00	9.42	11.18	0.84	21.05	17.95	4.58
Total	**229.05**	**275.78**	**202.20**	**70.51**	**118.87**	**142.52**	**10.67**	**265.48**	**228.79**	**118.12**

GHG savings will vary between provinces, due to the differing utilization and the number of internal combustion engine buses. The table below presents the average annual and cumulative GHG emissions savings when comparing electric alternatives with the average operation of fossil fuel-powered school buses.

ZETF funding application requires an understanding of the GHG emissions savings, per bus, which would result from the project. ZETF requires that this saving in emissions encompass both the production of the fuel and the electricity, as well as the operation of the bus.

Table 4-5 Average Annual and Cumulative GHG Emissions Savings per Bus

	NEW BRUNSWICK	NEWFOUNDLAND & LABRADOR	NOVA SCOTIA
Average Annual GHG Emissions Savings (tCO_2e)	13.89	9.39	11.31
Cumulative GHG Emissions Savings (tCO_2e)	166.74	112.67	135.69

While Table 4-4 and Table 4-5 present the annual and cumulative GHG savings for an average bus[48] in each province, Table 4-6 below presents the total annual and lifetime GHG reduction that would result from a complete fleet transition.

Table 4-6 Total Annual and Cumulative GHG Emissions Savings for the Complete Fleet

	NEW BRUNSWICK	NEWFOUNDLAND & LABRADOR	NOVA SCOTIA
Average Annual GHG Emissions Savings (tCO_2e)	15,317	2,431	9,427
Cumulative GHG Emissions Savings (tCO_2e)	183,799	29,175	113,125

4.3.2 CRITERIA AIR POLLUTANTS

In addition to GHG emissions, fossil fuels are also responsible for the production of air pollutants. The five most common air pollutants are called "criteria" air pollutants and include carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter (PM) and volatile organic compounds (VOC). Exposure to these pollutants has been associated with health effects such as coughing and wheezing, aggravation of respiratory illnesses including asthma, and neurodevelopmental effects. Children may be particularly susceptible to adverse effects as their lungs and other organ systems are still developing and because they may experience higher exposure due to their activities such as outdoor play.[49] Table 4-7 below presents the emission factors for the air pollutants based on the fuel used.

Table 4-7 Emission Factors for Criteria Air Pollutants (g/km)[50]

	CO	NO_2	SO_2	PM	VOC
Diesel	0.23	0.50	0.04	0.02	0.33
Gasoline	0.47	0.34	0.03	0.01	1.07
Propane	0.02	0.50	0.02	0.02	0.53

Combining the emission factors presented in Table 4-7 with the distance travelled, total air contaminants pollution can be calculated and is presented in Table 4-8 below. The table below presents the total reduction for air contaminants pollution per province, as well as the total reduction, assuming a 12-year useful life.

[48] This is a weighted average based on the number of buses using each fuel type.

[49] Environments and Contaminants—Criteria Air Pollutants

[50] Emission Factors from GHGenius

Table 4-8 Air Contaminants Pollution Reduction per Province (Tonnes)

	CO	NO_2	SO_2	PM	VOC
New Brunswick	6.66	11.19	0.90	0.43	11.76
Newfoundland and Labrador	0.67	1.20	0.10	0.05	1.12
Nova Scotia	4.34	8.30	0.67	0.33	6.88
Annual Reduction	**10.08**	**17.86**	**1.44**	**0.69**	**17.06**
Total Reduction	**121.00**	**214.28**	**17.28**	**8.30**	**204.75**

4.3.3 NOISE REDUCTION

Table 4-9 summarizes the average noise levels expected from internal combustion and battery electric technologies, as well as the maximum noise level any worker can be subject to. As expected, fossil fuel-powered buses are noisier than battery electric school buses by an average of 30 dBA.

Table 4-9 Noise level comparison

ITEM	VALUE	SOURCE
Noise from an ICE bus (dBA)	80	City of Edmonton pilot project[51]
Noise from an ESB (dBA)	50	City of Edmonton pilot project
Maximum limit of noise allowed for a worker (dBA)	85	Canadian Centre for Occupational Health and Safety[52]

Environmental noise pollution is impactful for children, as noise pollution is linked to various effects, such as hearing loss, sleep disorders, hypertension, and others.[53] Bus drivers are also subject to noise pollution. Hearing loss is caused by sensory-neural damage that develops during years of being faced with noise. A study on the noise pollutants specifically for heavy-vehicle drivers presented that over 26.8% of the drivers have hearing loss.[54]

[51] City of Edmonton, Electric buses set to roll out on streets of Edmonton, https://transforming.edmonton.ca/electric-buses-set-to-roll-out-on-streets-of-edmonton/

[52] Canadian Centre for Occupational Health and Safety, Noise—Occupational Exposure Limit in Canada, https://www.ccohs.ca/oshanswers/phys_agents/noise/exposure_can.html#top

[53] Pourabdian, S., Yazdanirad, S., Lotfi, S. et al. Prevalence hearing loss of truck and bus drivers in a cross-sectional study of 65,533 subjects. Environ Health Prev Med (2019). https://doi.org/10.1186/s12199-019-0831-7

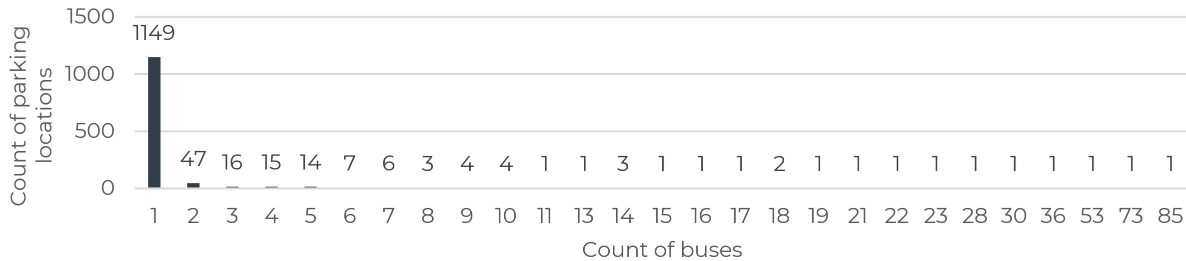
[54] Idem.

5 SITE MODIFICATIONS

5.1 SITE INFRASTRUCTURE UPGRADES

5.1.1 BUS PARKING LOCATIONS

Figure 5-1 presents the number of parking locations compared to the number of buses at each location. This helps understand the power capacity that will be required at each overnight parking facility. For example, Figure 5-1 shows that there are 1,142 parking locations where only one bus is parked (an example of single bus parking would be drivers' home), and there is one parking location where 13 buses are parked (i.e. Blakeny Street Bus Garage in Moncton, New Brunswick).



Based on the information provided by the provinces, there are over 1,277 different parking locations, ranging from one to 85 buses, with over 50% of the fleet being parked in a single site.

The following table (Table 5-1) shows the count of parking locations with the number of buses it accommodates.

Figure 5-1 Number of parking locations based on the count of buses

Table 5-1 Number of Different Parking Locations

	New Brunswick							Newfoundland and Labrador	Nova Scotia						
	AN	AW	AS	AE	FNE	FS	FNO		AVRCE	CBVRCE[55]	CCRCE	CSAP	SRCE	SSRCE	TCRCE
1 Bus	106	189	156	52	100	28	65	48	89	-	27	53	109	84	54
2 Buses	5	9	2	-	2	-	-	15	9	-	-	-	-	2	3
3 to 9 Buses	-	5	7	6	-	8	-	25	2	2	1	-	3	-	6
10 to 20 Buses	-	2	3	1	-	1	-	5	-	1	2	-	-	-	1
20 or more Buses	-	1	-	-	-	2	-	-	-	2	3	-	-	-	-

[55] WSP received email feedback in July 2024 that CBVRCE has 33 buses parked at single-bus parking locations. Data received to date does not indicate this, and therefore it should be noted that some buses move around from the parking depot year after year.

5.1.2 BUS PARKING ARCHETYPES

To provide the provinces with an understanding of the charger installation needs, different parking archetypes were created. Using archetypes helps to summarize the various parking locations encountered across the provinces. These archetypes can be used as a tool for the operators to understand what electrical upgrades might be needed at their site and provide a rough order of magnitude of costs.

Two archetypes were developed: 1) At-home Charging, and 2) Depot and School Charging. The description of these archetypes is shown below.

AT-HOME CHARGING

This installation is used for at-home charging, where the buses stay at the drivers' residences overnight. This is representative of most parking sites encountered in this study. To avoid the need for a system where the operator would repay the driver for electricity, this involves the installation of a feeder dedicated to bus charging, with the electricity bill sent directly to the operator. This installation is all done outdoors, separate from the existing residence. As such, it can easily be removed and installed at another location.

The following components are mounted to the plywood backplane:

- 100A outdoor-rated panel
- 20A Outdoor rated, duplex receptacle (non-GFI)
- Level 2 charger, 19.2kW
- 20–30-watt LED lights, outdoor rated with dusk to dawn feature.
- Civil works

Figure 5-2: At-home charging solution demonstrated in Prince Edward Island (Photo Credit: PEI)

DEPOT AND SCHOOL CHARGING

Based on a high-level analysis of the various multi-vehicle sites considered in this study, most of them are either schools or maintenance and storage facilities. The buses are parked outside, typically in a gravel or asphalt parking lot. Both types of sites require similar upgrades to install chargers. The exact upgrades required are site-dependent and should be evaluated more thoroughly on a case-by-case basis.

Depending on the size and power draw of the current installation, it may be possible to install up to 5 chargers, potentially up to 10 chargers, on the current electrical distribution with minimal upgrades. The required upgrades would include:

- Concrete mounting pads for the chargers
- Duct banks between the distribution panel and chargers
- Cabling between distribution panel and chargers
- Civil works (digging, trenching, surfacing, etc.)

Adding several chargers greater than 10 to a site will likely entail the following supplemental upgrades:

- New main distribution panel to accommodate the new utility feeder
- Sub-panel to connect the chargers

600V/208V step-down transformer in case service is provided at 600 V.

5.1.3 UTILITY UPGRADES

Engagement with the utility companies must occur early in the facility design process. Depending on the depot location, the level of power required may not be readily available and may require a distribution infrastructure upgrade on the utility side. Depending on the location and power level required, this process can potentially take up to a few years in the worst-case scenario. Typically, sites with a multiplicity of chargers will require the largest power upgrades and have the longest lead time for upgrades.

Typically, when the power demand is below 144 kW (600A at 240 V_{AC}), customers are provided with a single-phase service at 240 V_{AC}. The transformers are utility-owned and installed on electrical poles. When the power demand exceeds that level, a concrete pad-mounted transformer is installed on the customer's property and provides a three-phase service at either 208 V_{AC} or 600 V_{AC}. Utilities will want to be provided with a power-level increase timeline to determine which options are available to the customers and prepare for the upcoming increases.

In the case of home charging, the recommended setup involves having a separate electrical feeder dedicated to vehicle charging. This has been the preferred method within PEI for various reasons, including increased ease of billing, power requirements, and access. However, this option may not be readily available with all utilities, as some do not allow a second service on one site. Early engagement will ensure that the feasibility is known and will give sufficient time for the decision-making process if exceptions are to be made.

Engagement with Nova Scotia Power and New Brunswick Power has occurred during this feasibility study process, and they are looking forward to working with the provinces to help achieve their electrification goals.

5.1.4 OPTIONAL SITE UPGRADES

Optional upgrades include the following:

- **Generators:** As demonstrated in this report, electrical school buses need to be charged daily. During a power outage, the best-case scenario sees some buses completing their daily service and others completing only their AM or PM service. Depending on the level of service that needs to be offered in case of a prolonged power outage and the level of resiliency required, a generator could be installed to provide power to the charging infrastructure.

  In areas where natural gas infrastructure is present, this type of fuel can be considered due to its cost-effectiveness, lack of external storage tank requirements and availability during a power outage. When natural gas is not an option, gasoline, diesel and propane can be considered, each requiring an external fuel tank and refuelling from a third party. For generators that will only see sporadic use, propane should be the preferred choice as it has an unlimited shelf life.
- **Battery Energy Storage System (BESS):** A BESS allows the storage of electrical energy in the form of stationary batteries. If the electricity provider cannot allocate the required power, a BESS can be used to store energy when the depot demand is low, and then discharge its energy during the charging windows to reduce the power demand on the grid. In the case of dynamic pricing, a BESS can also be used to store energy when the price is low and discharge when the price is high. An energy study would have to be conducted to ensure that the peak demand coincides with high prices and that low demand periods coincide with low pricing.
- **Charge Management System (CMS):** Also called smart charging system, it is an intelligent and efficient system that optimizes the charging process to enhance overall performance and reliability. Without a CMS, a charging session starts as soon as a bus is connected to a charger, without taking into consideration what is happening with the other chargers. This may lead to a very high peak power demand if a high number of chargers are all active at the same time, increasing electricity costs.

  A CMS will dynamically manage the overall electrical load of the charging process to keep the peak power demand as low as possible. It can do this by either delaying the start of charging sessions or reducing the output power of specific chargers. In regions where the power utility provider uses dynamic pricing, the CMS can also optimize the charging schedule to find the right balance between peak power demand and energy cost to reduce the total cost of electricity.

To ensure interoperability with a CMS, the use of chargers compatible with the open charge point protocol (OCPP) framework, or smart chargers, is recommended. This feature comes at a minimal cost increase and ensures future-proofing of the charging infrastructure.

For sites with a limited number of buses, a CMS can be replaced by programming the charging schedule directly into the vehicle's software. This feature is available on certain buses but may not be standard. This option requires manual coordination between the various vehicles on-site and needs to consider the replacement of vehicles that are out of revenue service for maintenance or any other reason. Relying on vehicle software charging schedule is the preferred method that was adopted for the transition of Prince Edward Island's electric school bus[56].

The first phase of the infrastructure upgrades should include the installation of the pad-mounted transformer, new electrical service entry and new distribution panel(s). All the civil work should also be carried out to a point where the work left to be done includes mostly the installation of the chargers and associated cabling.

The subsequent phases will include the installation of the chargers at a rate following the arrival of ESBs and the installation of the cabling interconnecting the chargers and distribution panels, as all the duct banks have been installed in the previous phase.

[56] Confirmation received following discussion with PEI on the 23rd of January 2024.

6 PROJECT COSTS AND OPERATIONAL SAVINGS

Financial modelling covers a 20-year project span which captures ESB initial procurement, a midlife overhaul and an end-of-life replacement cycle. Analysis has a start year of 2023, and costs are escalated at 3%, which is a percentage above the Bank of Canada's long-term target inflation rate. The incremental project cost is established by comparing a business-as-usual diesel vehicle to its electric equivalent.

As part of the common assumptions, all provinces can expect the same vehicle purchase price, useful life, and midlife overhaul. Two types of chargers are considered single home charging and depot charging when there are multiple buses at one location. Roll out of the charging infrastructure is aligned with ESB transition on a bus-to-charger basis.

Table 6-1 Common model assumptions

Model assumptions	
Start Year; base year	2023
Model length	20 years
Periodicity	Yearly
Indexation	3%
Vehicle assumptions	
ZEB Purchase Cost	$400,000
Diesel Bus Purchase Cost	$150,355
ZEB average useful life	12 years
ZEB midlife overhaul	6 years
Capital costs per charger	
Single-Home charging	$40,070
Depot	$86,384

Operational assumptions are province-specific, considering local diesel prices and specific utility payment mechanisms. Maintenance costs are presented on an average dollar ($) per kilometre; these averages have been derived from maintenance records provided by each of the provinces. Operational costs are a blend of energy and maintenance costs based on data received.

Table 6-2 Province-specific operational assumptions[57]

	NEW BRUNSWICK	NEWFOUNDLAND AND LABRADOR	NOVA SCOTIA
Fuel cost	$1.56/L	$1.68/L	$1.53/L
Fossil Fuel School Bus operational costs (fuel and maintenance)	$0.79/km	$1.65/km	$0.80/km
Electric School Bus operational costs (energy and maintenance)	$0.39/km	$0.63/km	$0.24/km

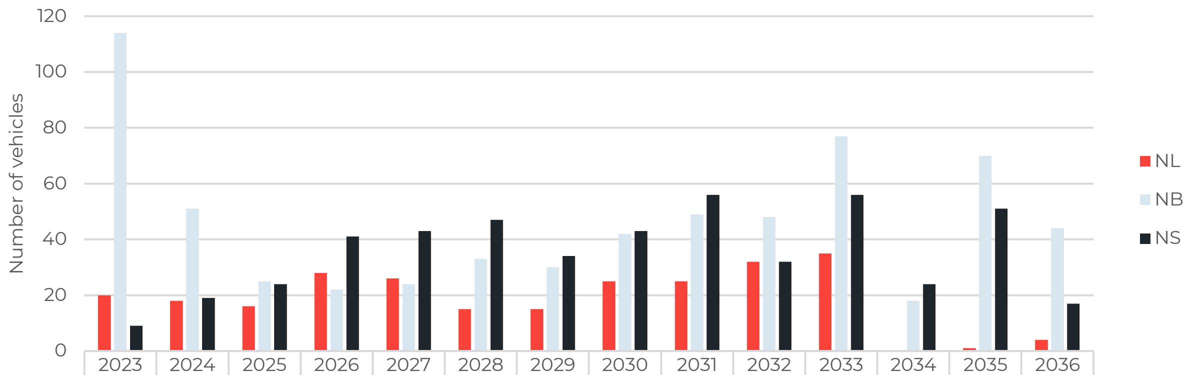
[57] The assumptions presented in Table 6-2 are derived from both external sources and the data received to complete this study. The fuel cost is based on an average of the provincial fuel price for the last three years. Fossil Fuel School Bus operational costs are based on the current fleet baseline (See Current Fleet Baseline Section), and the Electric School Bus operational costs is based on the asset-specific electricity price, its associated energy consumption, and the expected maintenance cost.

The fleet transition has been modelled based on converting an internal combustion vehicle at the end of its useful life to ESB when a route is electrifiable. The table below presents the yearly procurement of the ESBs over ten years. The table below illustrates the portion of the fleet electrified at year 10, Newfoundland and Labrador fleet should be 85% electric; New Brunswick 67% electric; and Nova Scotia 71% electric.

Table 6-3 Yearly transition plan as a percentage of the entire fleet

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
New Brunswick	18%[58]	8%	4%	3%	4%	5%	5%	6%	8%	7%
Newfoundland and Labrador	8%	7%	6%	11%	10%	6%	6%	10%	10%	12%
Nova Scotia	2%	4%	5%	8%	9%	9%	7%	9%	11%	6%

The figure below illustrates the 14-year procurement plan for ESBs and associated chargers. Fourteen years is the number of years to run through the fleet's first replacement to ESB.



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
NL	20	18	16	28	26	15	15	25	25	32	35	0	1	4
NB	114	51	25	22	24	33	30	42	49	48	77	18	70	44
NS	9	19	24	41	43	47	34	43	56	32	56	24	51	17

Figure 6-1 ESB Procurement Schedule

[58] It was assumed that the active school buses currently past their useful life will be replaced in 2023.

6.1 CAPITAL AND OPERATIONAL EXPENSES

Section 6.1 breaks down the total cost of ownership which estimates capital expenses for acquiring buses and necessary charging infrastructure for an ESB compared to an internal combustion engine equivalent. The analysis, over the long term, highlights the operational benefits of an electrified fleet, primarily through reduced fuel and maintenance costs. With electricity being typically cheaper per kilometre than diesel fuel and ESBs requiring less maintenance due to fewer moving parts. Cash flows have been modelled based on cash transactions without considering financing or leasing.

In section 6.2, two ZETF scenarios are presented showing Funding Benefits.

6.1.1 NEW BRUNSWICK

CAPITAL EXPENSES

Table 6-4 New Brunswick CAPEX

	DIESEL	ESB	DELTA	DELTA (%)
Charging infrastructure	-	43,200,412	43,200,412	N/A
Bus Procurement	197,664,734	525,861,417	328,196,684	166%
Number of buses	**647**	**647**		
Total	**197,664,734**	**569,061,829**	**371,397,096**	**188%**

OPERATIONAL EXPENSES

Table 6-5 New Brunswick OPEX

	DIESEL	ESB	DELTA	DELTA (%)
Operational costs	152,654,842	76,247,075	(76,407,766)	(50%)
Midlife Overhaul (lifecycle)	56,542,039	86,493,093	29,951,054	53%
Total	**209,196,881**	**162,740,168**	**(46,456,713)**	**(22%)**

6.1.2 NEWFOUNDLAND AND LABRADOR

CAPITAL EXPENSES

Table 6-6 Newfoundland and Labrador CAPEX

	DIESEL	ESB	DELTA	DELTA (%)
Charging infrastructure	-	20,283,082	20,283,082	N/A
Bus Procurement	93,750,030	249,409,811	155,659,781	166%
Number of buses	**260**	**260**		
Total	**93,750,030**	**269,692,893**	**175,942,863**	**188%**

OPERATIONAL EXPENSES

Table 6-7 Newfoundland and Labrador OPEX

	DIESEL	ESB	DELTA	DELTA (%)
Operational costs	102,600,471	39,420,455	(63,180,016)	(62%)
Midlife Overhaul (lifecycle)	25,601,247	39,162,560	13,561,313	53%
Total	**128,201,718**	**78,583,015**	**(49,618,703)**	**(39%)**

6.1.3 NOVA SCOTIA

CAPITAL EXPENSES

Table 6-8 Nova Scotia CAPEX

	DIESEL	ESB	DELTA	DELTA (%)
Charging infrastructure	-	31,731,104	31,731,104	N/A
Bus Procurement	155,607,306	413,973,081	258,365,775	166%
Number of buses	**496**	**496**		
Total	**155,607,306**	**445,704,185**	**290,096,879**	**186%**

OPERATIONAL EXPENSES

Table 6-9 Nova Scotia OPEX

	DIESEL	ESB	DELTA	DELTA (%)
Operational costs	108,988,096	32,488,638	(76,499,457)	(70%)
Midlife Overhaul (lifecycle)	44,096,598	67,455,140	23,358,542	53%
Total	**153,084,694**	**99,943,778**	**(53,140,916)**	**(35%)**

6.2 TOTAL COST OF OWNERSHIP WITH ZETF FUNDING

The total cost of ownership incorporates the provinces' CAPEX and OPEX presented in section 6.1. The table below incorporates potential funding from the Zero Emissions Transit Fund (ZETF, see section 8). The ZETF grant covers 50% of eligible costs (fleet procurement and the charging infrastructure) and is a program that runs through 2026.

If ZETF were to be renewed for another five years, New Brunswick could expect an additional $63M in funding, Newfoundland and Labrador could expect an additional $30M in funding and Nova Scotia could expect an additional $49M in funding.

For all provinces, transitioning to an electric fleet would come at greater costs, as it stands today, an ESB is 2.6 times more expensive than its diesel equivalent.

Table 6-10 Adjusted Cost of Ownership with ZETF Funding

	NEW BRUNSWICK	NEWFOUNDLAND AND LABRADOR	NOVA SCOTIA
CAPEX	569,061,829	269,692,893	445,704,185
OPEX	162,740,168	78,583,015	99,943,778
Total cost of ownership	**731,801,997**	**348,275,908**	**545,647,963**
ZETF Funding (program expiring in 2026)	(41,099,257)	(16,607,254)	(18,778,487)
Applicant's Funding	41,099,257	16,607,254	18,778,487
Total cost of ownership with ZETF Funding	**690,702,741**	**331,668,654**	**526,869,476**
Incremental project costs	**283,841,126**	**109,716,906**	**218,177,476**
Total cost of ownership (with funding per bus)	***1,067,547***	***1,275,649***	***1,062,237***
Incremental project costs (per bus)	***438,703***	***421,988***	***439,874***

6.2.1 KEY TAKEAWAYS

- ESBs have a 2.6x premium on internal combustion engine equivalents, although this gap is expected to close over time as battery prices decrease.
- OPEX benefits range between 23 and 39%, partially covering increased CAPEX costs.
- ZETF funding is expected to expire in the spring of 2026. While it is expected that it will be renewed, there are no guarantees. Applications should be expedited if possible.

6.3 PROCUREMENT OPTIONS TO MITIGATE UPFRONT COST

6.3.1 CHARGING AS A SERVICE

Charging as a service (CaaS) is an infrastructure procurement option where a user contracts with a service provider that will manage the installation, operation, and maintenance of the EV charging infrastructure. The two main advantages of this procurement method are that (1) upfront capital costs are amortized over the term of a service agreement which is part of the operational budget, and (2) the performance and delivery of the service are transferred to a service provider. Presented below are the main considerations for CaaS:

1. Service Agreement: The user enters into a service agreement with the EV charging service provider. This agreement outlines the terms and conditions of the service, including pricing, technical requirements and performance standards, and any additional services required. With the federal Clean Fuels Regulation, negotiations for discounted rates with the service provider is recommended as the provider will be receiving clean fuel credits from the charger's use.
2. Installation: The service provider assesses the user's needs and installs the necessary EV charging infrastructure at the user's location. This may include charging stations, associated hardware, and software for monitoring and managing the charging network.
3. Operation and Maintenance: The service provider is responsible for operating and maintaining the EV charging infrastructure. This includes tasks such as monitoring the performance of the charging stations, providing customer support, performing repairs and upgrades as needed, and ensuring compliance with regulations.
4. Billing and Payment: Users typically pay for EV charging services based on usage ($/kWh), either through a subscription model (committed electricity volumes), pay-per-use, or a combination of both. Billing and payment processes are managed by the service provider, and users receive invoices detailing their usage and charges.
5. Software Platform: Many CaaS providers offer a software platform that enables customers to monitor and manage their charging infrastructure remotely. This platform may provide features such as real-time charging status, usage analytics, billing management, and remote diagnostics.
6. Scalability and Flexibility: CaaS offers scalability and flexibility to accommodate the evolving needs of users. As demand for EV charging grows or as technology advances, the service provider can easily scale up the infrastructure or upgrade the hardware and software to meet changing requirements.

6.3.2 CAPITAL LEASE (VEHICLES)

A capital lease is a long-term lease agreement that is structured in a way that effectively transfers the use of an asset without owning the vehicle. The two main characteristics of a capital lease are:

1. Ownership Transfer: A capital lease often includes a provision for the transfer of ownership of the leased asset to the lessee at the end of the lease term.
2. Duration and Terms: Capital leases typically have a longer term than operating leases and may cover a significant portion of the asset's useful life, the agreement can be negotiated to align with an ESB overhaul or warranties). The lease terms may include provisions such as fixed monthly payments and a predetermined purchase price for transferring ownership.

7 RISK MANAGEMENT

7.1 RISK ASSESSMENT AND MANAGEMENT PLAN

Table 7-1 shows several technological, operational, and system-wide risks with corresponding measures to manage and mitigate them.

Table 7-1 Risk assessment and mitigation measures

	RISK	RISK LEVEL	MITIGATION MEASURE
Technological Risks	There is a low risk of fire associated with batteries. However, once occurs the fire itself is more difficult to contain compared to other sources of fire.	Medium. There are action items outside the control of the operator that must be met for the mitigation of this risk.	Consult with your local inspector to review the compliance of your site to the corresponding code related to stationary battery installations. Consider upgrading the zone extinguisher to the corresponding Class that is effective against a fire caused by a lithium-ion battery. Firefighters in your local community must be warned of the risk of battery fire, so that they acquire the necessary equipment. The electric vehicle should be stored at a safe distance from close buildings, and battery performance should be continuously monitored through the vehicle and the charger.
	Level 3 charging stations require specialized maintenance for the cooling system and charging cable. There may not be personnel within the community with the appropriate training to handle the maintenance.	Low. Within the scope of the project, this risk is unlikely to happen.	In the short-term, the plan is to acquire level 2 chargers, which require minimal maintenance. Future deployment phases, considering level 3 chargers should include either the cost of training or moving qualified personnel.
	The cable connecting the dispenser to the battery electric school bus is damaged due to improper handling: the cable drags on the ground increasing the wear and tear.	Low. The action items are under the control of the operator to mitigate this risk.	The personnel handling the connection of the battery electric school bus should be trained on the appropriate ways to handle the cable.

	RISK	RISK LEVEL	MITIGATION MEASURE
Operational Risks	The building insurance premium may become more expensive if the battery-electric school bus is parked inside a garage, or maintenance area, because of the associated increase in a fire risk.	Medium. There are action items outside the control of the operator that must be met for the mitigation of this risk.	In the short term during the long periods of parking time, it is advised that the battery electric school bus is not placed indoors. It is preferable if this zone is reserved for the asset.
	Flammable products are placed close to the location where the charging station has been installed.	Medium. There are action items outside the control of the operator that must be met for the mitigation of this risk.	The space distribution around the charging installation area must re-evaluated to ensure that there is a safe distance from any flammable product to the charging area
	Driver forgets to plug their vehicle after their workday, and the vehicle is not charged sufficiently to complete its routes the following day.	Medium. There are action items outside the control of the operator that must be met for the mitigation of this risk.	All drivers should complete thorough training before receiving their electric school bus, which will highlight the importance of ensuring the bus is connected. Connected charging infrastructure could let the driver know that the vehicle is properly charging.
	A general power outage can prevent electric buses from being fully charged.	Medium. There are action items outside the control of the operator that must be met for the mitigation of this risk.	Generators can be used to mitigate this risk when the power outage is local. The spare ratio could be revised to ensure electric buses can maintain operations in extreme conditions.
	Electric school buses will require additional operational constraints during summer, as they are brought to their depot for summer maintenance.	Low. The mitigation measure is within the control of the operator.	Revising the summer operational plan to ensure that electric school buses are charged and functional. Additional charging infrastructure in the maintenance depot will be required.
	The gasoline bus is kept in operation during the deployment of the battery-electric school bus. There might be risks (ex. fire hazards) associated to the maintenance equipment of both technologies not being properly distributed in the maintenance area.	Low. The mitigation measure is within the control of the operator.	The space distribution around the charging installation area must re-evaluated to ensure both technologies can be operated simultaneously.
	Ability to relocate, train and retrain operators, mechanics and technicians, and the impact of the electrical systems.	Low. The mitigation measure is within the control of the operator	Create a phased-in training plan, conduct provincial electrical training sessions and ensure technicians and operators across the different depots are equipped to complete maintenance work on electrical buses.

	RISK	RISK LEVEL	MITIGATION MEASURE
	The electricity bill exceeds what was planned to reduce the savings margin, necessary for the payback of grant dollars	Medium. There are action items outside the control of the operator that must be met for the mitigation of this risk.	In the short term, the project manager and stakeholders should develop a standard procedure to monitor and train the operators to keep track of the energy consumption of the assets utilized. In the long term, the project manager and stakeholders should consider procuring a smart management system for their fleet so that the electricity used, and capacity allocated to the charging installation is limited to the needs of the fleet.
System-wide Risks	Current electric buses are heavier than their gasoline or diesel counterparts. This may impact the building structure and the maintenance operations.	Low. The mitigation measure is within the control of the operator.	The location of the charging station and the permanent stall for the battery-electric school bus should be assessed as part of a long-term plan, to avoid deterioration. Additional maintenance equipment should be reviewed to ensure they can support the weight of the asset.
	Security of the "at-home" charging stations located in the community.	Low. The mitigation measure is within the control of the operator.	Set a restricted access to limit the usage of the chargers to the operators. Install padlocks to protect the infrastructure.
	The building utility power supply is insufficient to support the charging requirement from the battery electric school bus.	Medium. There are action items outside the control of the operator that must be met for the mitigation of this risk.	The risk of insufficient power supply is considerably low where there are low numbers of buses in one location. The risk should be evaluated considering that either through an automated charge management software or though manually scheduled charging events the risk of insufficient power can be avoided with off-peak charging. If the feeder is assessed as unsuitable to supply the battery-electric school bus, the option for a dedicated power supply should be evaluated.
	The battery electric school bus or the charging stations OEMs do not provide after-sales services. This may negatively impact the electrification transition.	Low. The mitigation measure is within the control of the operator.	This risk must be mitigated prior to the acquisition of the assets and during the evaluation of tenders. After-sales support services should be one of the key aspects when deciding which OEM to choose.
	Lead times in the delivery of the assets (either the battery-electric school bus or the charging station) may impact the service provided to the community.	Low. The mitigation measure is within the control of the operator.	This risk must be mitigated prior to the acquisition of the assets and during the evaluation of tenders. The lead time must be a requirement the tenders commit to, and any risk associated with exceeding leading times should be assumed by the OEMs. For planning purposes, it should be assumed that the delivery lead time for an electric school bus is 12 months.

	RISK	RISK LEVEL	MITIGATION MEASURE
	After the deployment of the technology, the school stake holders have concluded that it does not meet the performance and requirements expected. There are issues with the operation and management of the assets (electric school bus and charging station).	High. The mitigation strategy can not eliminate the impact on the service.	The procurement strategy should include a warranty that protects the owner from battery failure and ensures that by the time most of the ESBs require a battery replacement the OEMs have a solid supply chain to supply these. A turnkey procurement strategy is suggested
	The training provided by the manufacturer is general and not specialize for manipulation of high-voltage equipment. Any issue requiring the attention of specialized personnel will cause delays in the delivery of the service.	High. The mitigation strategy can not eliminate the impact on the service.	The school bus asset manager should locate high-voltage specialized maintenance providers in the local area or elsewhere. This information can be coordinated with the OEMs list of certified vendors. Delays due to corrective maintenance might be unavoidable.

7.2 CLIMATE AND RISK RESILIENCE MEASURES

The following paragraphs describe the climate hazards and resilience plan that the Atlantic Canada Provinces have identified through many years of planning and diligent work with the communities. Much of the relevant statistical information is sourced from the Regional Perspectives Report on climate change for the Atlantic Region[59].

CLIMATE RISKS

Atlantic Canada consists of a variety of coastal ecosystems, encompassing sandy beaches, estuaries, intertidal flats, salt marshes, cobble beaches, cliffs, bluffs, rock shores, and more. The annual temperature across the region has increased by 0.7 ºC between 1948 and 2016, and during the same period, the normalized annual precipitation has increased by 11%. Climate change impacts, for this region are primarily driven by increases in summer temperatures. The three key drivers for this are[60]:

- Increase in the mean temperature;
- Increase in the precipitation over time, and
- changes in climate extremes.

INCREASE IN RELATIVE SEA LEVELS

The region faces particular concern regarding increases in relative sea level, with the projected rise surpassing the global average in most areas of Atlantic Canada. Under a high emissions scenario[61], it is anticipated that the relative sea level for the region will surge by 75–100 cm by 2100. This escalation in sea level is expected to bring about a heightened frequency of coastal flooding events. For instance, in Halifax, a projected 20 cm rise in sea level within the next two to three decades, under all emission scenarios, is predicted to result in a fourfold increase in the occurrence of coastal flooding within the municipality. Additionally, the coastline will experience further impacts due to reduced sea ice in winter, leading to more energetic waves reaching the coast during winter storm events and intensifying the risk of damage to coastal infrastructure and ecosystems.

RISK OF FLOODING

Inland flooding might be impacted by[62]:

- Rain combined with snowmelt and ice jamming in Newfoundland and Labrador;
- Torrential rainfalls, sudden thaws, and infrastructure failures in Nova Scotia;
- Extreme precipitation events, often as a result of extratropical storms in Prince Edward Island; and;
- Rain events, rain-on-snow events, and/or ice jamming in New Brunswick.

Floods occurring on land in Atlantic Canada primarily stem from substantial rainfall during hurricanes, extratropical transitions, autumn storms, ice jams, snowmelt, or a combination of these elements. Under the high emissions scenario (RCP8.5[63]), it is anticipated that the median rise in the 20-year annual maximum precipitation event for Atlantic Canada will be 14% between 2031 and 2050, and 30% between 2081 and 2100.

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[59] Dietz, Sabine; Arnold, Stephanie; Atlantic Region: Regional Perspectives Report https://changingclimate.ca/site/assets/uploads/sites/4/2020/10/Atlantic-Provinces-Chapter-Regional-Perspectives-Report.pdf

[60] Dietz, Sabine; Arnold, Stephanie; Atlantic Region: Regional Perspectives Report https://changingclimate.ca/site/assets/uploads/sites/4/2020/10/Atlantic-Provinces-Chapter-Regional-Perspectives-Report.pdf

[61] RCP are the Representative Concentration Pathways, to describe potential scenarios representing a broad range of climate outcomes, based on a literature review, and are neither forecasts nor policy recommendations. These are reviewed and managed by the Intergovernmental Panel On Climate Change https://sedac.ciesin.columbia.edu/ddc/ar5_scenario_process/RCPs.html. RCP8.5 is the worst-case scenario with an increase in temperature up to 7 ºC by 2100 due to minimal Climate Change initiatives executed by that time.

[62] Dietz, Sabine; Arnold, Stephanie; Atlantic Region: Regional Perspectives Report https://changingclimate.ca/site/assets/uploads/sites/4/2020/10/Atlantic-Provinces-Chapter-Regional-Perspectives-Report.pdf

[63] RCP Intergovernmental Panel On Climate Change https://sedac.ciesin.columbia.edu/ddc/ar5_scenario_process/RCPs.html

As temperatures rise, causing an earlier onset of spring melt and an increase in rain-on-snow events, there is a notable shift towards earlier floods, ice jams, and rain-on-snow occurrences[64]. This shift contributes to a heightened volume of runoff into river and stream systems. The swift runoff, particularly prevalent in regions with thin soil cover, shallow bedrock, and steep slopes—characteristics common in much of Newfoundland and Labrador—can lead to immediate or post-storm flooding. Settlements with historical proximity to rivers and coastlines expose people, infrastructure, and services to escalating flood risks.

IMPACTS ON UTILITIES AND ELECTRICAL INFRASTRUCTURE

With climate change, extreme weather events will become more frequent, with hurricanes and storms being the greatest contributors to the region's hazards[65]. Winter storms (e.g., Christmas 2013 in New Brunswick-NB), post-tropical storms (e.g., storm Arthur in 2014), and ice storms (e.g., ice storm in 2017 in NB), are examples of natural events that when exacerbated by the progression of climate change cause significant disruption (blackouts and power outages) on the power system. The main hazards to the electrical infrastructure are interruptions caused by fallen trees, tree contact, and heavy ice buildup on lines, Poles and cross arms causing Poles' failure. Hundreds of thousands of customers were affected during these events.

IMPACTS ON CIVIL INFRASTRUCTURE

Some of the impacts of flooding (coastal and on land) are the damage to vital transportation infrastructure connecting regions through a single road link. Some examples are the Chignecto Isthmus linking New Brunswick to Nova Scotia, the Canso Causeway to Cape Breton Island, the Trans-Canada Highway traversing southwestern Newfoundland, and the Trans-Canada Highway at Jemseg.

Some communities along the Wolastoqey (Saint John River), including First Nation communities, may be impacted by critical infrastructure failure related to sewage treatment lagoons located near the river. It could be expected that severe spring thaw resulting from snow and ice melt in rivers and flooding could cause contaminated overflow. The result is health hazards for those communities.

7.2.1 CLIMATE RISK IDENTIFICATION

The table below summarizes the relationship between projected climate impacts and risks expected to assets and infrastructure of a proposed electrification project.

[64] Dietz, Sabine; Arnold, Stephanie; Atlantic Region: Regional Perspectives Report https://changingclimate.ca/site/assets/uploads/sites/4/2020/10/Atlantic-Provinces-Chapter-Regional-Perspectives-Report.pdf

[65] Energie NB Power, Extreme Weather Climate Change and Your Power, https://www.nbpower.com/media/1489807/191220-extreme-weather-report_final-en.pdf

Table 7-2 System risks associated with Climate Change events.

CLIMATE CHANGE EVENTS	CLIMATE CHANGE PROJECTED IMPACTS (TIMEFRAME 2021-2040) [66,67]	POTENTIAL SYSTEM RISKS
A. Extreme Heat Events	Days with temperatures above 32°C are projected to increase by 45 minutes. The hottest day is projected to increase by 1.6°C. Days with temperatures above 25°C are projected to increase by 14.4 days.	Added stress to the grid due to increased demand, causing blackouts. This in turn prevents the charging of electric buses and impacts service levels. High temperatures can also impact ESB efficiency, by increasing the use of the onboard HVAC systems, therefore limiting capacity for route completion.
B. Extreme Cold Events	Days with temperatures below -25°C are projected to decrease by 0.5 days per year. The coldest day is projected to increase by 3.3°C.	Low to freezing temperatures can, limit ESB range and route completion, due to the increased use of the onboard HVAC system
C. Extreme Precipitation	Wet days above 20mm are projected to increase by 2.4 days. Maximum 5-day precipitation is projected to increase by 3.4 mm.	Increase the likelihood of blackouts or power outages. This in turn prevents the charging of electric buses and impacts service levels.
D. Flooding	In Atlantic Canada, warmer climates could intensify very wet and very dry climate events, which could increase inland flooding. Inland flooding is often caused by rain events, rain-on-snow events, and/or ice jamming[68].	Flood waters can inundate the chargers and affect accessibility to the charging infrastructure if the water extends into the building. Road and bridge closures will impact the normal operation of the routes. Increase the likelihood of blackouts or power outages. This in turn prevents the charging of electric buses and impacts service levels.
E. High Wind, Snow and Ice Events	For marine winds and storms, globally and in Canada, the assessment of historical winds for the oceans is hampered by limited evidence. This poleward shift indicates that there could be a projected decrease in wind speed and wave heights over marine areas in Atlantic Canada[69]. Snowfall is projected to decrease across Eastern Canada. Ice storms are projected to increase in Atlantic Canada[70].	Debris from high winds can cause damage to the buildings and ESBs. Road and bridge closures will impact the normal operation of the routes. Increase the likelihood of blackouts or power outages. This in turn prevents the charging of electric buses and impacts service levels.
F. Tropical Events	Potential for increased activity and intensity. Model projections of late summer and autumn storms off Atlantic Canada suggest a slight northward shift of storm tracks and a modest reduction in intensities of storms, although extreme storms may have increased intensities[71,72,73]	debris from high winds can cause damage to the buildings and ESBs. Road and bridge closures will impact the normal operation of the routes. Increase the likelihood of blackouts or power outages. This in turn prevents the charging of electric buses and impacts service levels.

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[66] Environment and Climate Change Canada (ECCC). 2023. ClimateData.ca, https://climatedata.ca/download/. The data reflects the case scenario of the City of Saint John, NB
[67] All data based on scenario SSP4.5 (Shared Socioeconomic Pathways 4.5), intermediate GHG emissions: CO2 emissions around current levels until 2050, then falling but not reaching net zero by 2100. Average global temperature will rise to 2.0 °C by 2060 and 2.7°C by 2100
[68] Dietz, Sabine; Arnold, Stephanie; Atlantic Region: Regional Perspectives Report https://changingclimate.ca/site/assets/uploads/sites/4/2020/10/Atlantic-Provinces-Chapter-Regional-Perspectives-Report.pdf
[69] Government of Canada, Canada's Changing Climate Report, 2019, https://changingclimate.ca/site/assets/uploads/sites/2/2020/06/CCCR_FULLREPORT-EN-FINAL.pdf
[70] Dietz, Sabine; Arnold, Stephanie; Atlantic Region: Regional Perspectives Report https://changingclimate.ca/site/assets/uploads/sites/4/2020/10/Atlantic-Provinces-Chapter-Regional-Perspectives-Report.pdf
[71] Jiang, J., and Perrie, W. (2008), Climate change effects on North Atlantic cyclones, J. Geophys. Res., 113, D09102, doi:10.1029/2007JD008749. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2007JD008749
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[73] Guo, L.L., Perrie, W., Long, Z.X., Toulany, B. and Sheng, J.Y. (2015): The impacts of climate change on the North Atlantic wave climate; Atmosphere-Ocean, v. 53, p. 491–509. doi:10.1080/07055900.2015.1103697 https://www.tandfonline.com/doi/full/10.1080/07055900.2015.1103697

7.2.2 CLIMATE RISK ANALYSIS

The following table describes a preliminary risk analysis[74], the likelihood of climate change events happening.

Table 7-3 Probability of occurrence ranking for the Climate Change events.

	PROBABILITY OF OCCURRENCE		
Climate Event	Low (Rarely occurs)	Moderate (Moderately frequent)	High (Almost certain)
A. Extreme Heat Events		X	
B. Extreme Cold Events			X
C. Extreme Precipitation			X
D. Flooding	X[75]		
E. High Wind, Snow and Ice Events			X
F. Tropical Events			X

The following table outlines the consequence levels of each one of the climate change events.

Table 7-4 Consequences ranking for the Climate Change events.

	SOCIAL			ECONOMIC			ENVIRONMENTAL			
Level	Health & Safety	Displacement	Loss of Livelihood	Reputation	Infrastructure Damage	Financial Impact	Air	Water	Land	Ecosystem
Low	B,C	A, B,C,E		D,E,F	A,B,C	A,B,C	A,B,C,D ,E,F	A,B	A,B	A,B
Moderate	A, D, E		A,B,C,D ,E,F	A,B,C	E	E		C	C	C
High	F	D, F			D,F	D,F		D,E,F	D,E,F	D,E,F

To evaluate the impact of the climate change events the risks evaluation matrix utilized is illustrated in the table below.

Table 7-5 Risks evaluation matrix.

		Probability of Occurrence		
		Low	**Moderate**	**High**
Consequences	**Low**	Low	Low	Moderate
	Moderate	Low	Moderate	Moderate/High
	High	Moderate	Moderate/High	High

[74] Summit Enterprises International Inc., Canadian Climate Change Risk Assessment Guide (2014), https://www.iclr.org/wp-content/uploads/PDFS/CC_Risk_Assessment_Guide_Interim2_Jun_8_14_.pdf
[75] The ranking of 'Moderate' assumes that the charging infrastructure will not be built within the 1–100-year floodplain.

Based on and Table 7-4, and the risks evaluation matrix in Table 7-5, the evaluation of the impact of each one of the climate change events is shown in

Table 7-6.[76]

Table 7-6 Climate Change events evaluation.

CLIMATE CHANGE EVENTS	PROBABILITY OF OCCURRENCE	CONSEQUENCE	RISK RANKING	POTENTIAL SYSTEM RISKS
A. Extreme Heat Events	Moderate	Low	Low	Added stress to the grid due to increased demand, causing blackouts. This in turn prevents the charging of electric buses and impacts service levels. High temperatures can also impact ESB efficiency, by increasing the use of the onboard HVAC systems, therefore limiting capacity for route completion.
B. Extreme Cold Events	High	Low	Moderate	Low to Freezing temperatures can, limit ESB range and route completion, due to the increased use of the onboard HVAC system
C. Extreme Precipitation	High	Moderate	Moderate/ High	Increase the likelihood of blackouts or power outages. This in turn prevents the charging of electric buses and impacts service levels.
D. Flooding	Low	Moderate	Low	Flood waters can inundate the chargers and affect accessibility to the charging infrastructure if the water extends into the building. Road and bridge closures will impact the normal operation of the routes. Increase the likelihood of blackouts or power outages. This in turn prevents the charging of electric buses and impacts service levels.
E. High Wind, Snow and Ice Events	High	Moderate	Moderate/ High	Debris from high winds can cause damage to the buildings and ESBs. Road and bridge closures will impact the normal operation of the routes. Increase the likelihood of blackouts or power outages. This in turn prevents the charging of electric buses and impacts service levels.
F. Tropical events	High	High	High	Debris from high winds can cause damage to the buildings and ESBs. Road and bridge closures will impact the normal operation of the routes. Increase the likelihood of blackouts or power outages. This in turn prevents the charging of electric buses and impacts service levels.

[76] The resulting ranking from the consequences matrix results from the average over all consequences items (e.g. Health and safety, displacement, etc.). For the average low, moderate, and high rankings are given a value 1, 2, and 3, respectively. If the average rounding is closer to 1, the consequence ranking is "Low". Otherwise, if the average rounding is closer to 2, the consequence ranking is "Moderate". Finally, if the average rounding is closer to 3, the consequence ranking is "High".

7.2.3 CLIMATE RISKS MITIGATION PORTFOLIO

Based on the risks outlined due to the identified climate change events, the mitigation opportunities are outlined in the following table.

Table 7-7 Mitigation Opportunities

CLIMATE CHANGE EVENTS	RISK RANKING	MITIGATION MEASURE	COST/BENEFITS
A. Extreme Heat Events	Low	On-site electricity generation and energy storage backup power, white roof, charging stations and ESBs kept indoors; air ventilation (doors open, cross breeze) when cooling not available.	Cost of infrastructure vs. independent renewable power generation, energy storage, and lower ambient temperatures
B. Extreme Cold Events	Moderate	On-site electricity generation and energy storage backup power, white roof, charging stations and ESBs kept indoors	Cost of infrastructure vs. independent renewable power generation, energy storage, cost of de-icing equipment and maintaining warmer ambient temperature.
C. Extreme Precipitation	Moderate/ High	On-site electricity generation and energy storage backup power, white roof, charging stations and ESBs kept indoors; porous surfaces, drainage systems, keep drainage systems clear of debris, maintain the slope of the landscape away from the building, determine capacity levels of wastewater and drainage systems in the area.	Cost of infrastructure vs. independent renewable power generation, energy storage, and flood protection/mitigation.
D. Flooding	Low	On-site electricity generation and energy storage, backup power, portable flood barricades, porous surfaces, drainage systems, keep drainage systems clear of debris,	Cost of infrastructure vs. independent renewable power generation, energy storage, and flood protection/mitigation.
E. High Wind, Snow and Ice Events	Moderate/ High	On-site electricity generation and energy storage backup power, white roof, charging stations and ESBs kept indoors	Cost of infrastructure vs. independent renewable power generation, energy storage, and bolstered infrastructural resilience.
F. Tropical events	High	Backup power, emergency forecasting of high winds and tornadoes, emergency plans for the site and responses.	Cost of infrastructure vs. independent, energy storage, and bolstered infrastructural resilience.

7.3 KEY INSIGHTS

A comprehensive risk registry has been compiled, covering a wide array of risks associated with ESBs. These risks span various domains, including safety considerations for handling battery propulsion systems, energy efficiency, operational costs, and system-wide risks related to personnel acquisition and training. Additionally, the registry highlights risks linked to climate change.

This risk registry serves as a foundational resource for provincial authorities. It is intended for use within their respective jurisdictions. Provinces are encouraged to refine their risk management plans, tailoring them to local contexts. Collaboration with operators, stakeholders, and subject-matter experts are crucial during this refinement process. The registry's scope extends beyond the risk categories outlined in this section.

Addressing risks involves several key areas:

- **Operational Considerations**: Provinces should explore best practices for operating and maintaining battery electric technology.
- **Personnel Training**: Adequate training programs are essential for personnel handling ESBs.
- **Fleet Procurement Strategies**: Optimal strategies for procuring and managing the electric bus fleet must be devised.

The identified risks should be customized based on the specific deployment location of ESBs. Tailoring mitigation measures to the unique needs of the served community is critical. Climate-related risks directly impact charging infrastructure and bus operation. To mitigate these impacts:

- **Site Construction**: Charging sites should be built in low-flood-probability areas.
- **Redundant Infrastructure**: Charging installations should incorporate redundancies to ensure uninterrupted electricity supply.
- **Continuous Monitoring**: Real-time monitoring enhances responsiveness during major events.

8 FUNDING OPPORTUNITIES

An assessment of government funding, financing, and cost-offsetting opportunities for school bus owners-operators in New Brunswick, Nova Scotia and Newfoundland and Labrador reveals the following key insights:

1. Infrastructure Canada's (INFC's) Zero Emission Transit Funding (ZETF) funding and Canada Infrastructure Bank's (CIB's) ZEB financing program guidelines create an opportunity to dilute the upfront investment pressure of fleet decarbonization by securing support for up to 100 percent of the costs of zero-emission school bus procurement[77]. Realistically, however, secondary and tertiary external funding sources may need to be considered to bridge gaps left by the actual INFC funding and CIB financing contributions. Notably, actual contributions may vary from a school bus owner's expected contribution depending on the level of alignment between the applicant (i.e., bus owner) and INFC's eligible cost estimates, and the level of alignment between the applicant and CIB's estimate of debt servicing capabilities.

   While the ZETF and CIB programs provide upfront investment support for 100 percent of ZEB procurement costs, they do not provide upfront investment support towards 100 percent of the capital costs of an integrated electrification project, which may include charging infrastructure as well as depot/bus parking facility modifications.

   The implementation process for the combined overall fleet electrification initiative considered in this study must need to be broken down into smaller "projects", i.e., smaller initiatives with their own distinct goals, objectives, project execution leads and beneficiaries, procurement and installation scopes, timelines, budgets, and funding structures. Such a breakdown of the fleet electrification program into smaller projects will be influenced by the deployment location, as well as the ownership structure and procurement responsibilities for the different types of assets and work packages required for the electrification of a school bus fleet. A project may be scoped to involve only ZEB procurement or additional assets and work packages such as charging infrastructure and depot modifications, depending on its definition (i.e., scope statement). In the case of the latter approach, some of the assets or work packages included in a "project" will be ineligible or partly eligible for ZETF funding. A project owner/leader will need to explore additional sources for funding support towards such assets because section 2 of the ZETF Applicant Guide states that ZETF funding for a project will not exceed 100 percent of the eligible costs.[78]
2. When it comes to ZEB procurement, additional funding may be supplemented by the province, funds for which may be secured through the Investing in Canada Infrastructure Program (ICIP), should the fleet owner not contribute an amount equivalent to the cost of purchasing diesel buses in the first place.
3. A portion of the charging equipment and utility infrastructure procurement costs may be supplemented by additional funding from Natural Resources Canada's (NRCan's) Zero Emission Vehicle Infrastructure Program (ZEVIP) or the Federation of Canadian Municipalities (FCM's) Green Municipal Fund (GMF) depending, respectively, on federal stacking limits and confirmation of eligibility.
4. A portion of the bus depot facility retrofit, or upgrade cost may be supplemented by additional funding from FCM's GMF should the school bus electrification project(s) in question qualify for the GMF's municipal and transit fleet electrification funding criteria.
5. Should funds from some of the above-mentioned sources not be available, additional contributions for project assets may be required from the fleet owner or other provincial funding sources.
6. No dedicated provincial funding programs or relevant incentives from local utilities for school bus electrification initiatives exist at the time of writing of this report. School boards (or other fleet asset owners) may need to

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[77] While it is standard practice for a bus owner to contribute at least the equivalent of purchasing diesel buses as part of a ZEB procurement project, the Zero Emission Transit Fund Applicant Guide states that INFC and CIB will provide funding and financing support towards the [full] cost of purchasing ZEBs, and not only towards the cost premium of ZEB versus diesel bus procurement.
[78] Infrastructure Canada (2022), Zero Emission Transit Fund Applicant Guide. Retrieved from: https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/zetf-applicant-guide-demandeur-ftcze-eng.html

advocate for provincial contributions to their respective electrification projects depending on funding gaps and budgeting constraints.

The following sections outline some of the key features of the primary, secondary and tertiary funding and financing programs informing the above insights (presented below in their order of preference while structuring project funds).

8.1 PRIMARY EXTERNAL FUNDING SOURCE(S)

Primary funding sources are programs that are likely to contribute grant or loan capital for a large proportion of the overall assets required for an integrated school bus electrification project. Consequently, the list of go-to primary funding sources includes programs dedicated to school bus electrification projects, zero-emission bus systems, and municipal fleet electrification projects.

8.1.1 ZERO EMISSIONS TRANSIT FUND (ZETF)—INFRASTRUCTURE CANADA

INFC's ZETF program is the principal grant funding source dedicated to school bus electrification projects or programs. The ZETF program funds planning as well as asset procurement and installation through its two streams. Private school bus operators, school boards, provinces as well as non-governmental and not-for-profit organizations are eligible to apply and directly receive funds from this program. Funding decisions by the INFC are processed through two application stages—an expression of interest (EOI) and a stage 2 application for capital project funding or additional funds to complete missing project planning work should the proponent's project be deemed not ready to proceed to the capital funding stage.

The following key features of the ZETF program as the primary funding source will influence the rest of the funding strategy for the Provinces or a school board leading an electrification project:

a **Maximum funding level and amount**

- The planning stream of the ZETF program provides grant funding for up to 80 percent of the eligible costs of school bus fleet electrification planning and design studies.
- The capital stream of the ZETF program provides grant funding for up to 50 percent of the eligible costs of capital projects.
- The total INFC and CIB contribution on capital projects is capped at 100 percent of the eligible costs, with total ZETF contribution limited to $350 million per project.

b **Program funding/reimbursement timeline**

- The ZETF program is currently scheduled to reimburse eligible expenses incurred until March 2026. An extension to the current program timeline is expected but not guaranteed.

8.1.2 ZERO EMISSIONS BUS INITIATIVE—CANADA INFRASTRUCTURE BANK (CIB)

The CIB's ZEB initiative supplements non-repayable grant funding from INFC's ZETF program with flexible low-interest financing dedicated to school bus electrification projects or programs. Financing decisions by the CIB are processed through the same application as that for INFC's ZETF program, which starts with the submission of an EOI.

The following key features of the ZEB initiative as a supplementary financing source will influence the rest of the funding strategy for the Provinces or a school board leading an electrification project:

a **Maximum financing level and amount**

- The ZEB initiative provides flexible low-interest financing for up to 50 percent of the eligible costs of capital projects.
- CIB financing is predicated on the thesis that loans for the higher upfront costs of ZEBs will be paid back through cost savings, especially, maintenance, fuel, and carbon cost savings from operating battery electric instead of diesel buses. While the application guide for the ZETF program implies that it may be feasible to acquire CIB loans for up to 50% of total eligible project costs, loan financing opportunities for asset categories other than ZEBs are likely to be low depending on the debt servicing capacity of ZEB operating cost savings over diesel.

b **Program funding/reimbursement timeline**

- Until further clarity on its own distinct timelines, the ZEB initiative is currently scheduled to finance ZEB (and ESB) procurement until Fall 2025, alongside the ZETF program.

8.1.3 GREEN MUNICIPAL FUND (GMF)—FEDERATION OF CANADIAN MUNICIPALITIES (FCM)

CAMET and the Provinces may consider investigating and discussing funding eligibility from GMF's Municipal Fleet Electrification 'stream', depending on:

- Whether the Provinces are expected to lead and own the assets funded by the school bus electrification projects, and if the nature of its partnership with the local municipalities/communities qualifies it as an eligible recipient of FCM funding; or
- Whether the respective School Boards are expected to lead and own the assets funded by the fleet electrification capital projects, and if the nature of their partnership with the local municipalities/communities qualifies them as eligible recipients for FCM funding; or
- whether student transportation technically qualifies as a municipal service provided by municipally owned fleet assets.

Should the GMF's Municipal Fleet Electrification stream be realized as an accessible option, the following key features will influence its choice as a supplementary primary funding source:

c **Maximum funding level and amount**

- The Municipal Fleet Electrification stream for planning projects provides grant funding for up to 50% of the eligible costs of a fleet electrification planning study, up to a maximum of $200,000.
- For capital projects, the fund provides a combination of grant and loan capital for up to 80% of the total eligible costs of a project, up to a maximum of $10 million.
- The grant component on capital project funding typically constitutes up to 15% of the loan amount.

d **Program funding/reimbursement timeline**

- Until further clarity, planning and capital project funding from the GMF's Municipal Fleet Electrification stream is expected to close only after all of its current funding is allocated.

8.1.4 RURAL TRANSIT SOLUTIONS FUND (RTSF)—INFRASTRUCTURE CANADA

A school board may consider applying to INFC's Rural Transit Solutions Fund (RTSF) instead of the ZETF program, should it be able to demonstrate the rural character of the communities that the electrification project will serve. However, given its maximum contribution limit of $5 million per project for zero-emission transit initiatives, the RTSF may not be a suitable program for projects with large capital values.

The following additional features of the RTSF program will determine its choice as a primary funding source:

e **Maximum funding level and federal stacking guidelines**

- The RTSF will fund up to 80% of *eligible* capital expenses for a project located in a province or applied for by a non-profit organization located in a province. It will allow further stacking of federal funds up to 80% of the *overall* capital costs of a project

f **Program application timeline**

- At the time of writing of this report, the RTSF application portal stated the application deadline being February 28, 2024.

8.2 SECONDARY EXTERNAL FUNDING SOURCE(S)

The following secondary external funding sources are likely to bridge gaps following funding decisions from primary external sources. Go-to secondary sources include funding programs dedicated to charging infrastructure assets e.g., Level 2 chargers for drivers' residences, or federal public transit programs that may fund a larger asset base in an integrated school bus electrification project, however, require provincial intervention in the application and funding process.

8.2.1 ZERO EMISSION VEHICLE INFRASTRUCTURE PROGRAM (ZEVIP)— NATURAL RESOURCES CANADA

NRCan's ZEVIP provides funding for owners/operators of ZEV infrastructure, delivery organizations as well as indigenous organizations. Each opportunity (or 'funding stream') has its distinct application intake approach and timelines.

The Provinces or its constituent/beneficiary school boards are best suited to apply to the stream for owners/operators unless the provincial government departments funding the school boards qualify and consider functioning as delivery organizations. In the case of the former, funding will flow directly from NRCan to the charging infrastructure owners/operators as long as they are the lead applicants. There may be challenges with obtaining funding when installing chargers at driver's homes, and discussions with NRCan should be had before application.

The following key features of the ZEVIP program will dictate its choice as the secondary funding source and influence the rest of the funding strategy:

g **Maximum funding level and amount**

- ZEVIP funding for owners/operators of charging infrastructure has a maximum contribution level of 50% of total project costs[79], capped at $5,000 per level 2 charger and $10 million per project.

h **Program application timeline**

- Applications from owners/operators are accepted through an annual request for proposals (RFP), with the next intake expected to open in Spring 2024 and close in Summer 2024 at the time of writing of this report.

8.2.2 INVEST IN CANADA INFRASTRUCTURE PROGRAM (ICIP)— INFRASTRUCTURE CANADA

The following features of ICIP's Public Transit stream will dictate its choice as a secondary funding source alongside ZEVIP:

i **Provincial intervention on cost-sharing**

[79] It must be noted that INFC contribution limits for the ZETF program are based on the total "eligible costs" whereas those for the NRCan ZEVIP program are based on the total "project costs".

- The 40% federal contribution for municipal projects will be contingent on provinces cost-sharing at a minimum of 33.33% of eligible project costs.

- **Provincial intervention on application timing and funding delivery**
  - The 2022 federal budget signalled the government's intent to accelerate the provincial deadline to commit their remaining ICIP funding allocations by March 31, 2023. While the provincial intake for the program closed on March 31, 2023, INFC intends to continue working with provinces and territories to build new public infrastructure and collaborate with stakeholders on the next generation of programming. Calls for funding for the ultimate recipients, based on the next generation of ICIP programming may be eventually determined by the respective provinces.
    - Lastly, funding is delivered through integrated bilateral agreements between the Government of Canada and the respective province or territory where the project is located, leaving asset procurement exposed to schedule risks arising from an additional layer of administrative steps.

8.3 FUNDING SUMMARY WORKBOOK

Appendix C summarizes key features of relevant funding or financing programs and maps funding sources to asset types or scope items.

9 FINAL CONSIDERATIONS

The transition towards ESBs will play a key role in the decarbonization of the provinces. While this transition will require coordinated efforts amongst different stakeholders, the results from this transition will be beneficial across various factors. It would help to reduce the GHG emissions produced by school transportation, reduce harmful criteria air contaminants (CACs) and help reduce the cost of the operations of school buses and their dependency on fossil fuels.

The study was completed to understand the feasibility, the environmental and financial benefits and the operational constraints that are associated with transitioning to ESBs.

ROUTE ELECTRIFICATION CONSIDERATIONS

Nova Scotia's buses are being driven over longer distances, on average, compared to the other provinces. Those longer distances will have impacts on the ability to electrify routes. Creating shorter routes, opportunity charging and confirming route lengths could increase the ability to electrify these routes. Additionally, as ESB batteries improve over time, larger battery capacities can help to electrify longer routes. It is recommended to review market availability and ESB technologies every few years to determine which additional routes could be electrified.

GHG emissions savings will vary between provinces due to the various utilization rates of the ICE buses. Nova Scotia currently accounts for over 50% of the provincial GHG emissions, therefore their transition towards electric buses would have the greatest impact on the reduction of the provincial emissions if the province was to electrify all of its routes.

CAPITAL AND OPERATING COST CONSIDERATIONS

Transitioning to ESBs incurs a significant initial investment, with the capital cost of these buses being approximately 2.67 times higher than that of conventional diesel buses. Additionally, establishing the necessary charging infrastructure and undertaking associated civil engineering work adds to the financial outlay. However, it's worth noting that over time, the cost of ESBs is expected to decrease as battery prices decline. Furthermore, the expense of the initial civil work is a one-time occurrence, assuming it was appropriately planned and executed.

Transitioning to ESBs would be financially beneficial for all provinces when considering operational expenses alone. Fuel cost is currently the defining factor for operational costs across the provinces, therefore these costs would be sensitive to electricity prices. Energy and power needs will have an impact on electricity pricing. These factors will be impacted by the number of buses parked at the different locations. To reduce the OPEX for electricity, it may be beneficial to increase the power demand at certain times of day and reduce it at others, based on the specific location energy requirements.

Procurement options to mitigate the upfront cost barriers may be explored and weighed against costs and benefits. Procurement options include charging as a service (CaaS) and Capital leases, as mentioned in Section 6.3.

STAKEHOLDER ENGAGEMENT

Engagement with the utility companies must occur early in the facility design process. Depending on the location of the depots, the levels of power required may not be readily available and may require a distribution infrastructure upgrade on the side of the utilities. Because this process can potentially take up to a few years in the worst-case scenario, early engagement would be beneficial. Typically, sites with a multiplicity of chargers will require the largest power upgrades and have the longest lead time for upgrades.

While PEI has had success with installing charging infrastructure at drivers' residences, there is no guarantee that the utilities within the provinces will also allow this setup. Nova Scotia Power has indicated that they may allow it on a case-by-case basis, while New Brunswick Power indicated that they will allow for it with no particular issues. There are various arrangements with regard to who pays for the electrical infrastructure, and it is typically on a case-by-case basis as well. There are other complexities when installing charging infrastructure at drivers' residences. This may include funding eligibility from ZETF and others, as the applicant will be required to demonstrate permanency. Early engagements with utilities and ZETF are highly recommended before embarking on any infrastructure upgrade or application.

Additionally, early involvement with ZETF and CIB is crucial to initiate the funding application process smoothly for the most immediate round of funding. As soon as the province expresses interest in electrifying routes, and even before completing any studies, it's imperative to connect with the funders. This ensures that the most immediate round of funding can be secured effectively and prevent any roadblocks.

NEXT STEPS

This feasibility study offers provinces valuable insights into potential routes for electrification, particularly under overnight and midday charging scenarios.

Part of this feasibility study includes a site-level electrical assessment. This site assessment will help understand external factors required for the implementation, such as available capacity, load profiles, electrical infrastructure, and spatial requirements. Once complete, this location-specific analysis will provide information regarding necessary upgrades and associated costs.

After the site-level assessments, provinces can pursue federal funding applications to procure ESBs and implement the requisite site-level upgrades.

It's recommended to review and update this feasibility study every five years to ensure its alignment with evolving technologies and associated pricing trends.

Appendix A
Assumptions & Calculations

EMISSIONS ASSUMPTIONS

The tables below present the assumptions that were used to conduct this study.

Table 9-1 Emissions and Production Factors

ITEM	ASSUMED VALUE	SOURCE/DESCRIPTION
Diesel Emission Factor	2.68 kg CO_2e/L	Emission Factors and Reference Values, Government of Canada
Diesel Production Factor	0.458 kg CO_2e/L	GHGenius
Gasoline Emission Factor	2.31 kg CO_2e/L	Emission Factors and Reference Values, Government of Canada
Gasoline Production Factor	0.344 kg CO_2e/L	GHGenius
Propane Emission Factor	1.52 kg CO_2e/L	Emission Factors and Reference Values, Government of Canada
Propane Production Factor	0.102 kg CO_2e/L	GHGenius

Table 9-2 Average Production Grid Electricity Emission Intensities (tonnes/mWh)

	2023	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
NB	0.268	0.275	0.273	0.274	0.272	0.258	0.252	0.124	0.116	0.124	0.113	0.123
NS	0.457	0.463	0.464	0.417	0.401	0.384	0.361	0.118	0.116	0.112	0.109	0.105
NL	0.012	0.012	0.011	0.011	0.011	0.011	0.01	0.01	0.01	0.011	0.01	0.01
Source: Infrastructure Canada, The Climate Lens, General Guidance v 2.1												

Table 9-3 New Brunswick Assumptions

ITEM	ASSUMED VALUE	SOURCE/DESCRIPTION
Capital cost	$112,126	Average of the capital cost available for New Brunswick. This value was assumed for the assets which did not present capital cost (118 assets out of 1063).

Table 9-4 Newfoundland and Labrador Assumptions

ITEM	ASSUMED VALUE	SOURCE/DESCRIPTION
1-Year Fuel Quantity	0.351 L/KM	Average of the fuel consumption for the school buses with data available for the Atlantic provinces. This value was assumed for the assets which did not present 1-Year Fuel Quantity (15 assets out of 262).

1-Year Fuel Cost	$1.68/L	Average of the fuel cost per litre for Newfoundland and Labrador for the past 3 years. Available on Statistics Canada. This value was assumed for the assets which did not present 1-Year Fuel Cost (142 assets out of 262).
1-Year Travelled Kilometres	11,907 KM	Average of the yearly travelled distance available for Newfoundland and Labrador. This value was assumed for the assets which did not present 1-Year Travelled Kilometres (14 assets out of 262).

Table 9-5 Nova Scotia Assumptions

ITEM	ASSUMED VALUE	SOURCE/DESCRIPTION
1-Year Fuel Quantity	0.351 L/KM	Average of the fuel consumption for the school buses with data available for the Atlantic Provinces. This value was assumed for the assets which did not present 1-Year Fuel Quantity. From **CCRCE** (259 assets). **CSAP** (53 assets). **SSRCE** (90 assets). **SRCE** (117 assets).
1-Year Fuel Cost	$1.53/L	Average of the fuel cost per litre for Nova Scotia for the past 3 years. Available on Statistics Canada.
1-Year Travelled Kilometres	18,382 KM	Average of the yearly travelled distance available for CCRCE. This value was assumed for the assets from **CCRCE** which did not present 1-Year Travelled Kilometres (165 assets out of 260).
	19,106 KM	Average of the yearly travelled distance available for Nova Scotia. This value was assumed for all the assets from **SRCE** (117 vehicles).

EMISSIONS PER OPERATOR

Table 9-6 Annual Average Emissions per Fuel per Bus for Nova Scotia Operators

	AVRCE		CBVRCE		CCRCE		SSRCE		TCRCE		CSAP	
	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline
2023	21.1	18.9	19.9	17.8	20.6	-	22.7	27.1	25.5	-	37.3	-
2024	20.7	18.5	19.5	17.4	20.2	-	22.2	26.5	25.0	-	36.6	-
2025	20.3	18.1	19.1	17.0	19.8	-	21.8	25.9	24.5	-	35.9	-
2026	19.9	17.7	18.7	16.6	19.4	-	21.4	25.3	24.1	-	35.2	-
2027	19.5	17.2	18.3	16.2	19.0	-	20.9	24.7	23.6	-	34.4	-
2028	19.1	16.8	18.0	15.8	18.6	-	20.5	24.1	23.1	-	33.7	-
2029	18.7	16.4	17.6	15.4	18.3	-	20.1	23.5	22.6	-	33.0	-
2030	18.3	16.0	17.2	15.0	17.9	-	19.7	22.9	22.1	-	32.3	-
2031	18.3	16.0	17.2	15.0	17.9	-	19.7	22.9	22.1	-	32.3	-
2032	18.3	16.0	17.2	15.0	17.9	-	19.7	22.9	22.1	-	32.3	-
2033	18.3	16.0	17.2	15.0	17.9	-	19.7	22.9	22.1	-	32.3	-
2034	18.3	16.0	17.2	15.0	17.9	-	19.7	22.9	22.1	-	32.3	-
Lifetime	231.0	203.5	217.1	191.5	225.3	**-**	247.9	291.3	278.9	**-**	407.7	**-**

Table 9-7 Annual Average Emissions per Fuel per Bus for New Brunswick Operators

	AE			AN		AW		AS		FN		FN		FS		
	Diesel	Gasoline	Propane	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Propane
2023	20.2	24.2	20.2	21.1	26.2	18.9	24.3	21.1	28.3	19.6	25.6	18.6	25.8	20.3	25.2	20.6
2024	19.8	23.7	19.5	20.7	25.6	18.6	23.7	20.7	27.7	19.2	25.0	18.3	25.2	20.0	24.6	19.8
2025	19.4	23.1	18.7	20.3	25.0	18.2	23.2	20.3	27.0	18.8	24.4	17.9	24.6	19.6	24.0	19.0
2026	19.1	22.6	18.0	19.9	24.4	17.9	22.6	19.9	26.4	18.4	23.9	17.6	24.0	19.2	23.5	18.3

2027	18.7	22.0	17.2	19.5	23.9	17.5	22.1	19.5	25.8	18.1	23.3	17.2	23.4	18.8	22.9	17.5
2028	18.3	21.5	16.4	19.1	23.3	17.1	21.5	19.1	25.1	17.7	22.7	16.9	22.9	18.4	22.3	16.7
2029	17.9	20.9	15.7	18.7	22.7	16.8	21.0	18.7	24.5	17.3	22.1	16.5	22.3	18.0	21.8	16.0
2030	17.5	20.4	14.9	18.3	22.1	16.4	20.5	18.3	23.9	17.0	21.6	16.2	21.7	17.6	21.2	15.2
2031	17.5	20.4	14.9	18.3	22.1	16.4	20.5	18.3	23.9	17.0	21.6	16.2	21.7	17.6	21.2	15.2
2032	17.5	20.4	14.9	18.3	22.1	16.4	20.5	18.3	23.9	17.0	21.6	16.2	21.7	17.6	21.2	15.2
2033	17.5	20.4	14.9	18.3	22.1	16.4	20.5	18.3	23.9	17.0	21.6	16.2	21.7	17.6	21.2	15.2
2034	17.5	20.4	14.9	18.3	22.1	16.4	20.5	18.3	23.9	17.0	21.6	16.2	21.7	17.6	21.2	15.2
Lifetime	**221.0**	**260.0**	**200.4**	**231.3**	**281.5**	**207.1**	**260.7**	**231.0**	**304.1**	**213.9**	**275.0**	**203.7**	**276.7**	**222.5**	**270.4**	**204.0**

EMISSIONS CALCULATIONS

ANNUAL EMISSIONS

To calculate the annual average emission per fuel and per bus, the average annual fuel consumption was calculated, for each operator and for each fuel. With those fuel consumptions, the emission factors per fuel were used to understand what emissions are produced annually, including the operations and the productions.

$$AVG\ emissions\ for\ Gasoline\ Vehicle\ for\ AVRCE\ (tonnes) = \frac{Gasoline\ consumed\ by\ AVRCE\ (L)\ X\ (2.31 + 0.344)}{1{,}000}$$

Once the average emissions were calculated for each operator and each fuel, it was possible to approximate the future emissions as well by applying the clean fuel regulations and the electrical grid emissions predictions.

Combining the emissions from the different operators, it was possible to understand the provincial average emission produced for a single bus, depending on the fuel used.

MIDDAY PEAK

The midday peak is calculated as follows:

$$Mid - day\ peak\ (MW) = \%\ incomplete\ routes\ X\ number\ of\ vehicles\ X\ charger\ power$$

The energy corresponding to the midday charging is then deducted from the total energy demand to obtain the overnight energy demand. As with scenario 1. the overnight peak power demand is obtained by dividing the overnight energy by the length of the charging window.

For example. Operator AVCRE. the percentage of incomplete routes is 93%. The midday power peak is:

$$Mid - day\ peak\ (MW) = 93\%\ X\ 118\ X\ 19.2\ kW = \ 2.11\ MW$$

The associated energy is:

$$Mid - day\ energy\ (MWh) = 2.11\ MW\ X\ 3.25\ hrs = 6.86\ MWh$$

The overnight peak is calculated as follows:

$$Overnight\ peak\ (MW) = \frac{(26.52\ MWh - 5.75\ MWh)}{8\ hrs} = 2.46\ MW$$

UTILITIES BILLING MECHANISM

<table>
<tr><th></th><th>UTILITY</th><th>RATES</th></tr>
<tr><td>New Brunswick</td><td>NB Power[80]</td><td>Residential:
Urban: 12.27 cents/kWh $+ 24.57/month
Rural/Seasonal: 12.27 cents/kWh $+ 26.96/month
General/Commercial:
o General Service 1:
$25.65 of service charge.
14.76 cents/kWh for the first 5,000 kWh
10.46 cents/kWh after.
20 kW of demand is free, $11.80/kW after.
o General Service 2:
$25.65 of service charge.
14.76 cents/kWh for the first 5,000 kWh
11.33 cents/kWh after.
First 20 kW of demand is free, $7.88/kW or 3,926 cents/kWh after.
o Small industrial service:
Loads up to 750 kWh.
Demand charge: $7.84/kW
7.07 cents/kWh for the first 100 kWh per kW.
o Large industrial service:
Minimum contractor demand of 750 kWh.
Demand charge: $15.94/kW of the billing demand per month.
5.80 cents/kWh</td></tr>
<tr><td rowspan="2">Newfoundland and Labrador</td><td>Newfoundland Power (NP)[81]</td><td rowspan="2">Newfoundland Power rates are included as a standard example of rates from Newfoundland.

Residential: 13.256 cents/kWh $+ 15.80/month
General/Commercial:
o Rate Class 2.1:
13.116 cents/kWh for the first 3,500 kWh
10.160 cents/kWh after.
o Rate Class 2.3:
11.343 cents/kWh for the first 150 kWh/kVA of billing demand, up to 50,000 kWh
9.385 cents/kWh after.
o Rate Class 2.4:
10.982 cents/kWh for the first 75,000 kWh
9.305 cents/kWh after.</td></tr>
<tr><td>Newfoundland & Labrador Hydro (Hydro)</td></tr>
</table>

[80] https://www.nbpower.com/en/accounts-billing/understanding-your-bill/rate-schedules-and-policies, assessed in January 2024.
[81] https://secure.newfoundlandpower.com/my-account/usage/electricity-rates, assessed in January 2024.

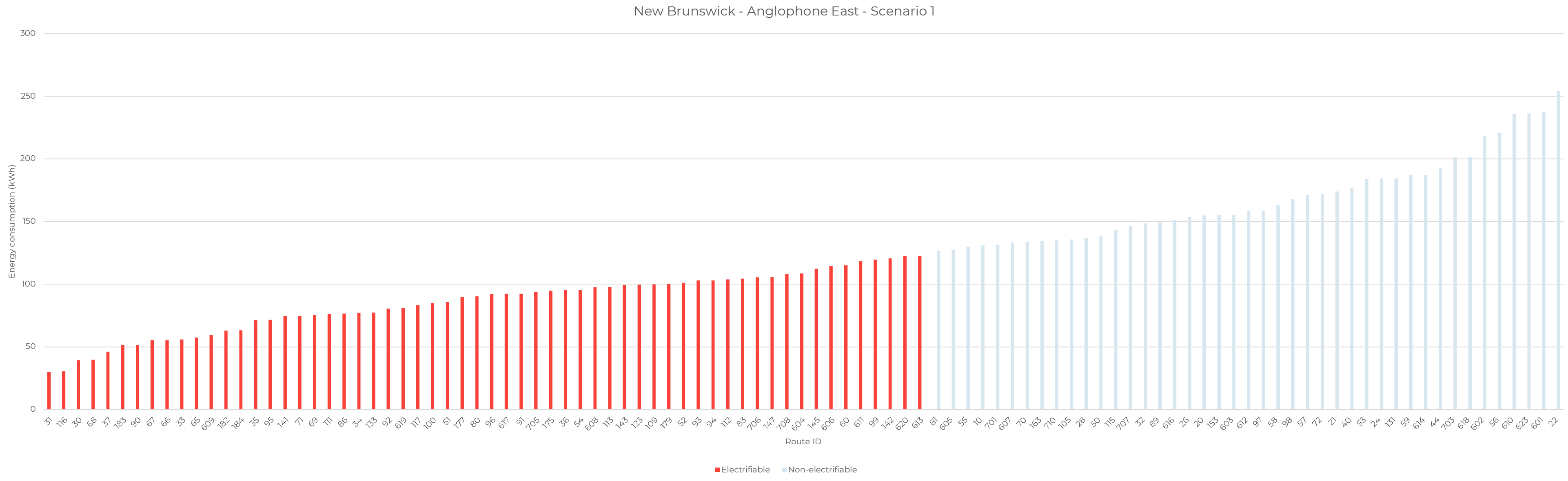
	UTILITY	RATES
Nova Scotia	Nova Scotia Power Incorporated[82]	Nova Scotia Power Incorporated rates are included as a standard example of rates from Nova Scotia. **Residential**: 17.547 cents/kWh $+ 19.17/month **Commercial**: o Small commercial: *Annual consumption is less than 32,000 kWh* $21.28 of service charge. 18.345 cents/kWh for the first 200 kWh per month 16.619 cents/kWh after. o Commercial: *Annual consumption is 32,000 or greater and billing demand is less than 2,000 kVA or 1,800 kW* Demand charge of 10.554$/kW of maximum demand 14.869 cents/kWh for the first 200 kWh per month per kW of maximum demand 11.572 cents/kWh after. o Large Commercial: *Consumption for any use except industrial, where the regular billing demand is 2,000 kVA or 1,800 kW and over* Demand charge of 13,845 per kVA of maximum demand of the current month 11.556 cents/kWh after.
	Antigonish Electric Utility	
	Berwick Electric Light Commission	
	Canso Electric Light Commission	
	Lunenburg Electric Utility	
	Mahone Bay Electric Utility	
	Riverport Electric Light Commission	

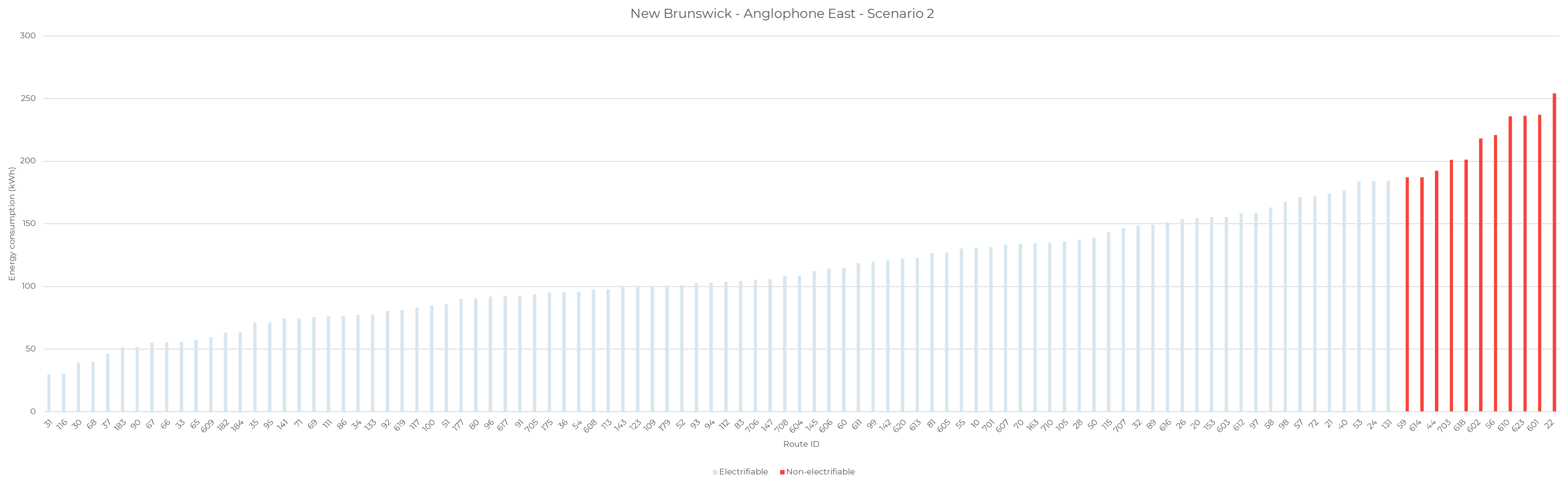
[82] https://www.nspower.ca/about-us/producing/rates-tariffs, assessed January 2024.

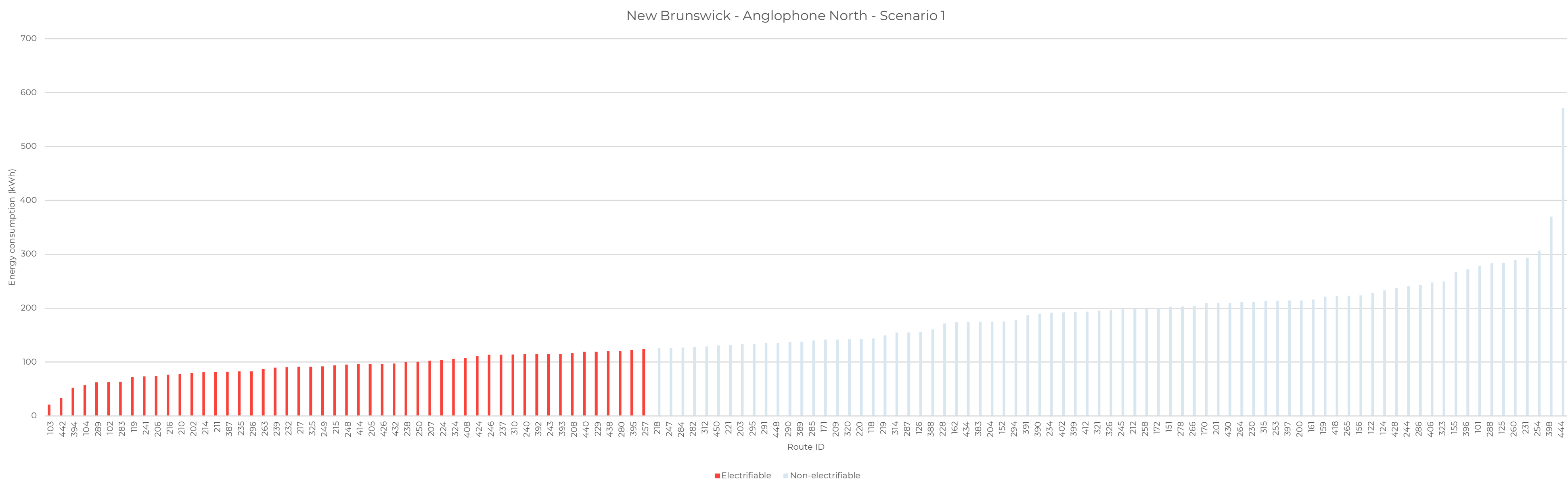
Appendix B

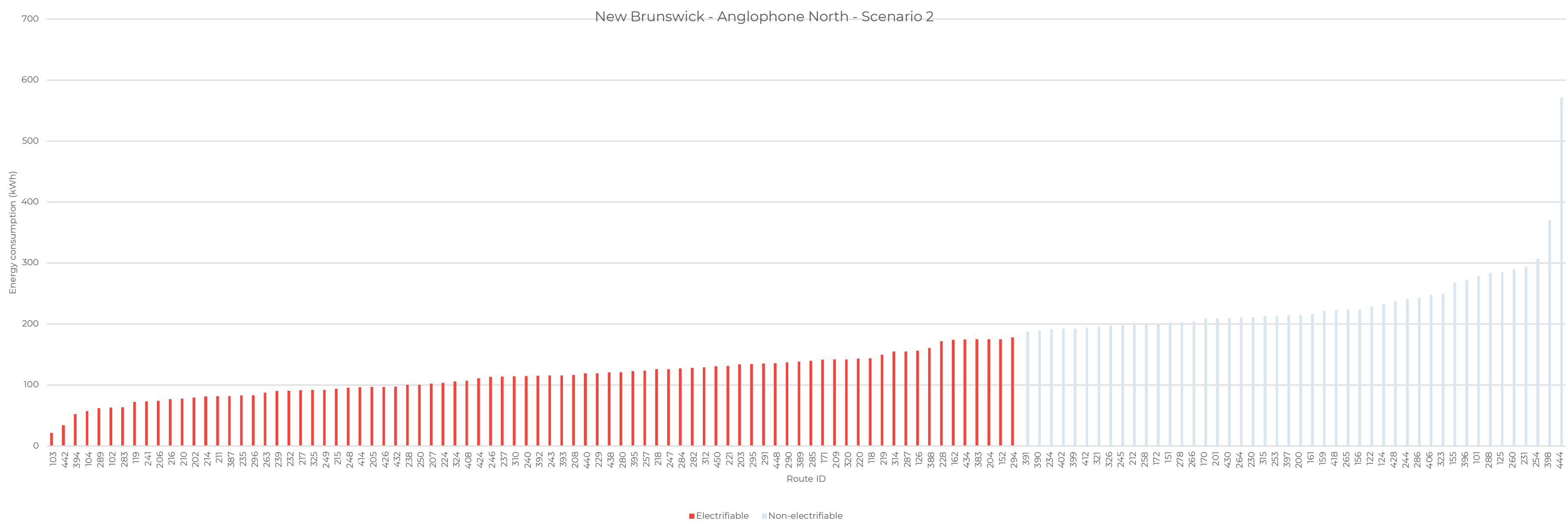
Route Electrification Scenarios

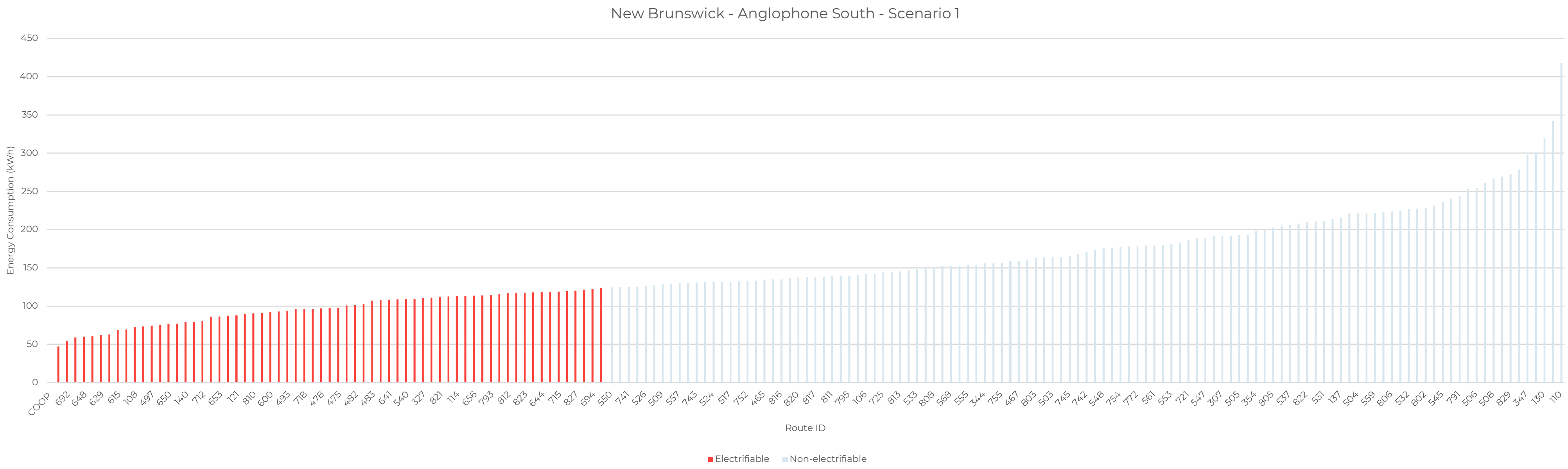
ESB FEASIBILITY STUDY

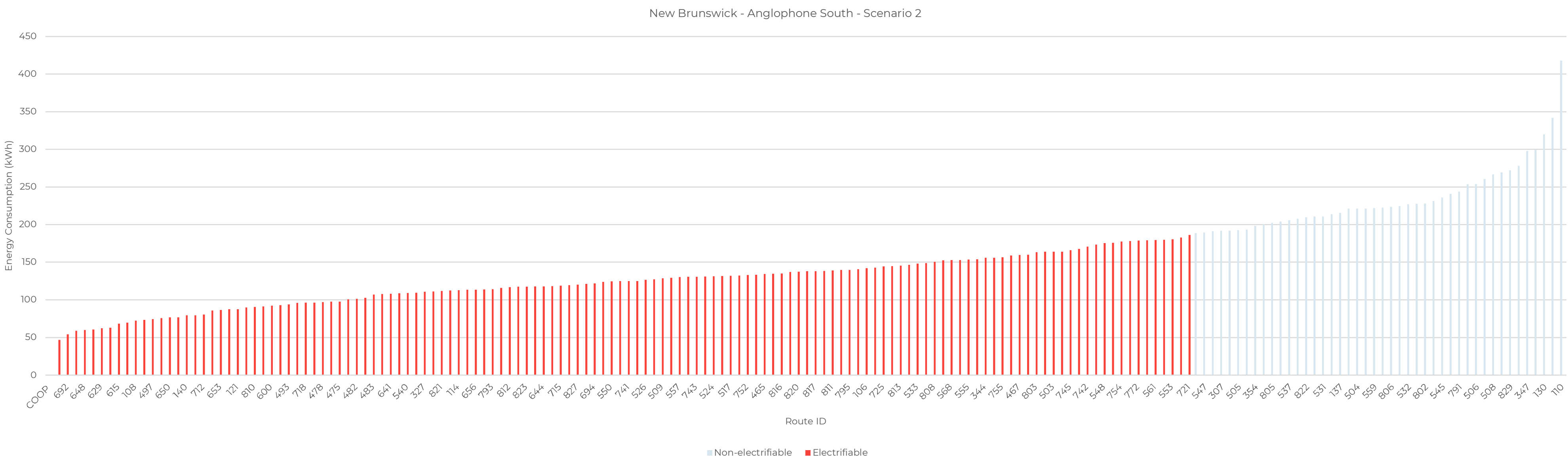

New Brunswick - Anglophone East - Scenario 1
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

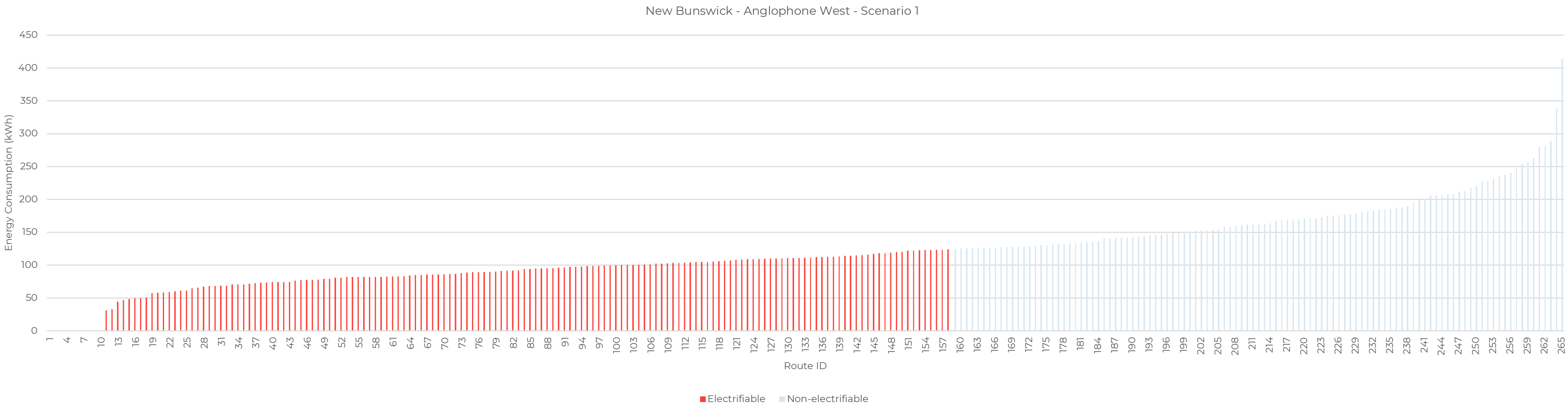

New Brunswick - Anglophone East - Scenario 2
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

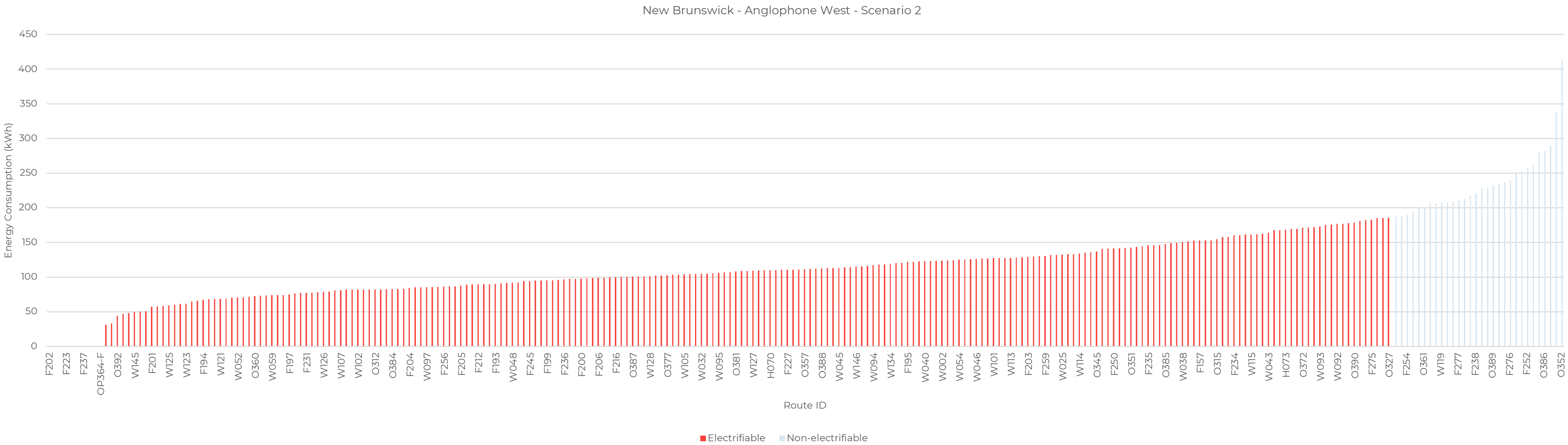

New Brunswick - Anglophone North - Scenario 1
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

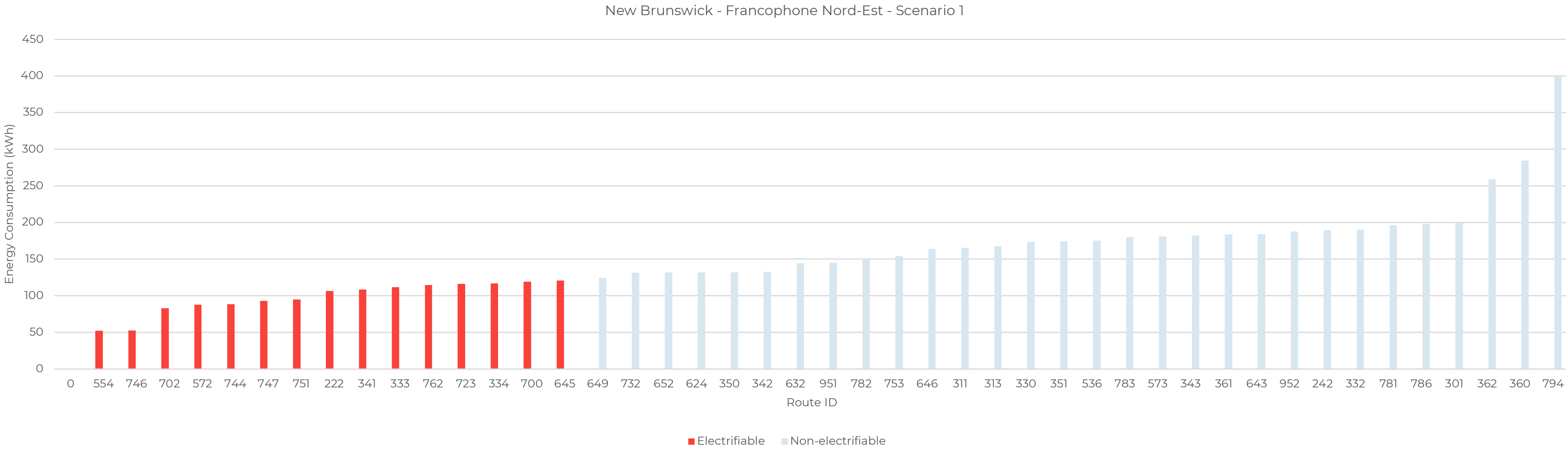

New Brunswick - Anglophone North - Scenario 2
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

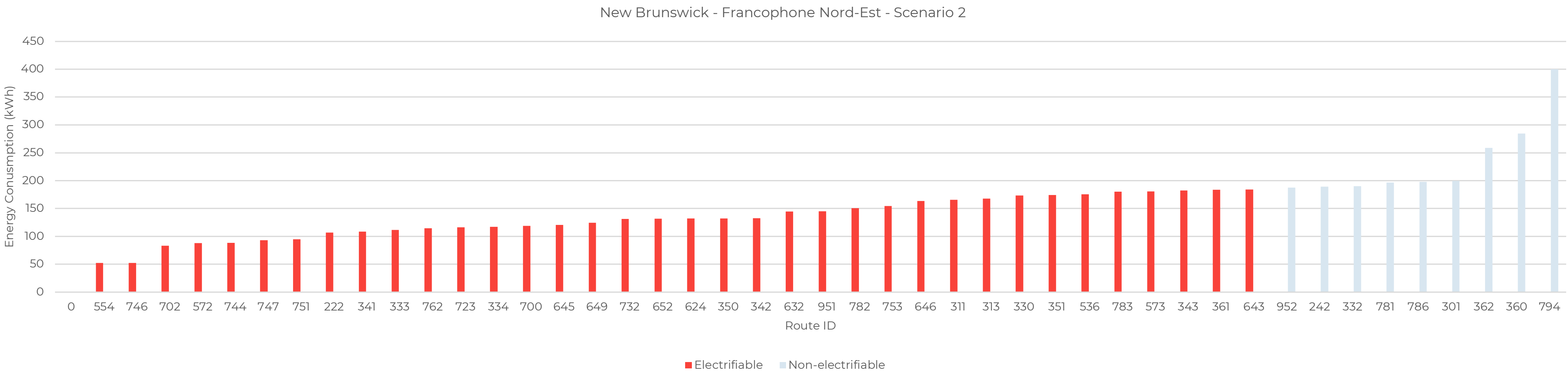

New Brunswick - Anglophone South - Scenario 1
Energy Consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

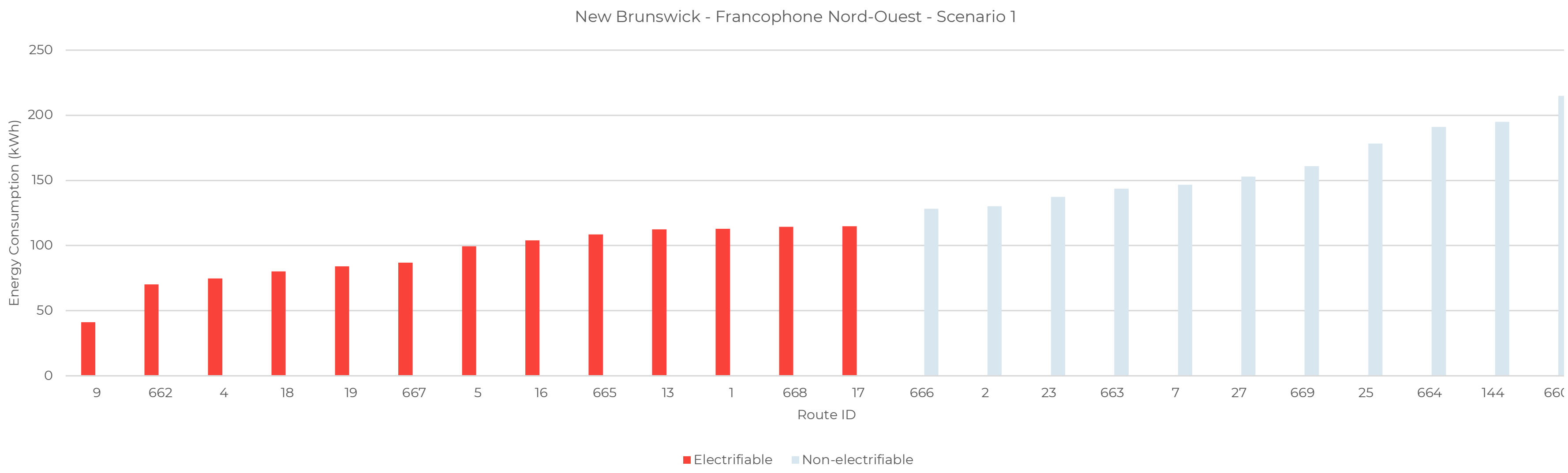

New Brunswick - Anglophone South - Scenario 2
Energy Consumption (kWh)
Route ID
Non-electrifiable
Electrifiable


New Bunswick - Anglophone West - Scenario 1
Energy Consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

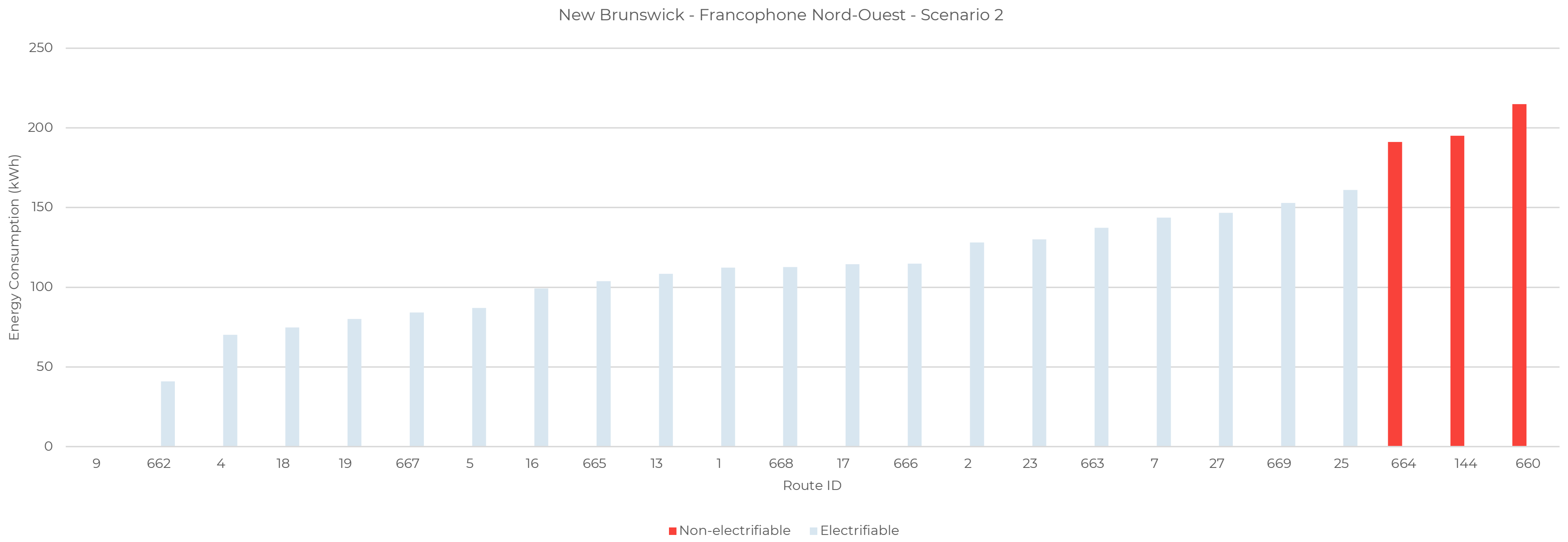

New Brunswick - Anglophone West - Scenario 2
Energy Consumption (kWh)
Route ID
Electrifiable
Non-electrifiable


New Brunswick - Francophone Nord-Est - Scenario 1
Energy Consumption (kWh)
0
50
100
150
200
250
300
350
400
450
0 554 746 702 572 744 747 751 222 341 333 762 723 334 700 645 649 732 652 624 350 342 632 951 782 753 646 311 313 330 351 536 783 573 343 361 643 952 242 332 781 786 301 362 360 794
Route ID
Electrifiable
Non-electrifiable

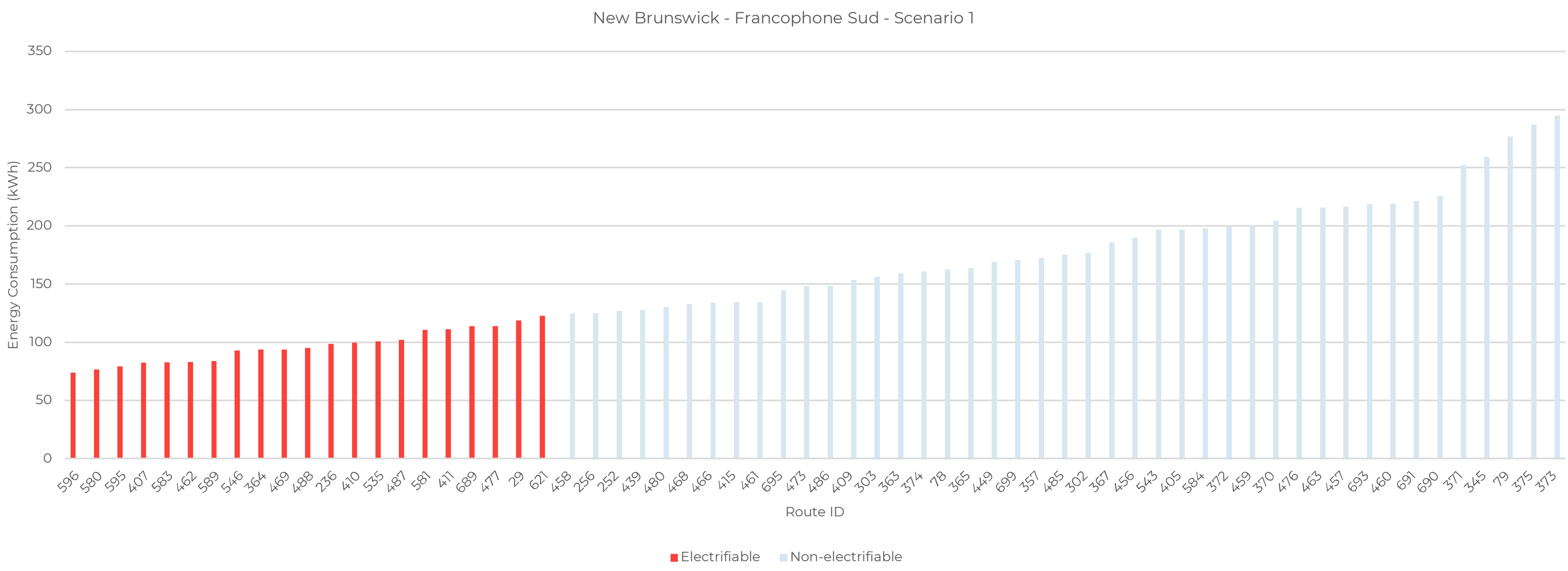

New Brunswick - Francophone Nord-Est - Scenario 2
Energy Conusmption (kWh)
0
50
100
150
200
250
300
350
400
450
0 554 746 702 572 744 747 751 222 341 333 762 723 334 700 645 649 732 652 624 350 342 632 951 782 753 646 311 313 330 351 536 783 573 343 361 643 952 242 332 781 786 301 362 360 794
Route ID
Electrifiable
Non-electrifiable

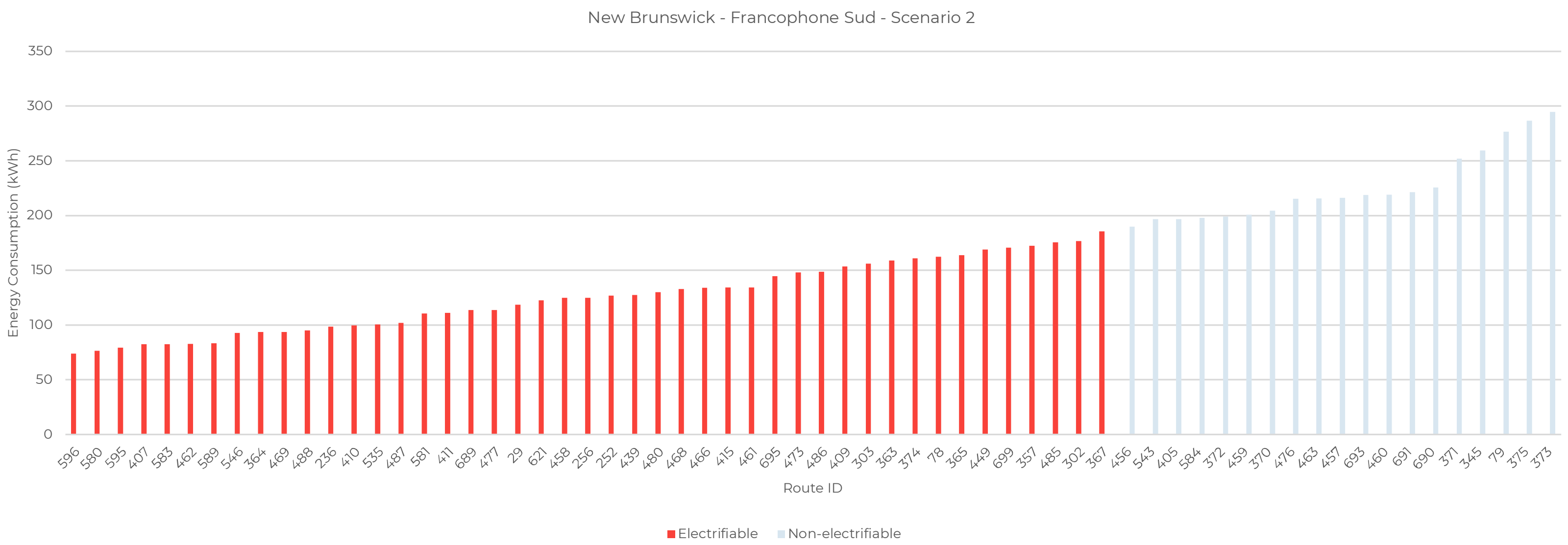


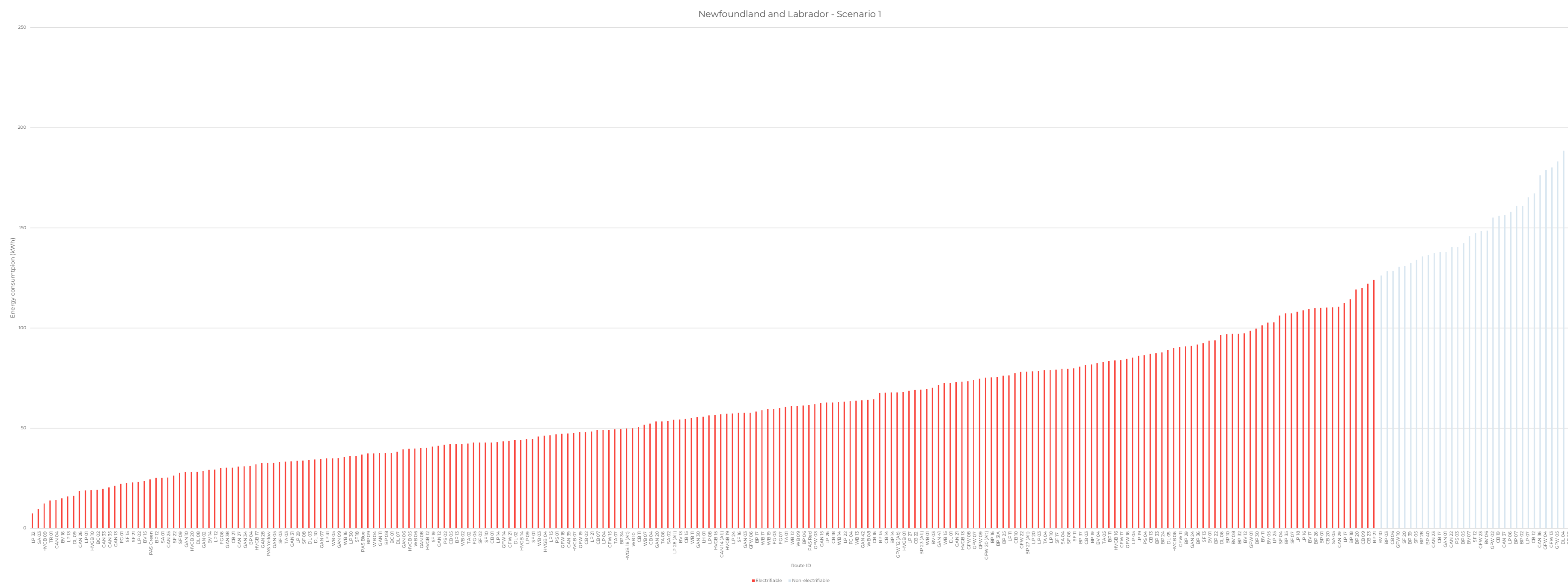
New Brunswick - Francophone Nord-Ouest - Scenario 1
250
200
150
100
50
0
Energy Consumption (kWh)
9
662
4
18
19
667
5
16
665
13
1
668
17
666
2
23
663
7
27
669
25
664
144
Route ID
Electrifiable
Non-electrifiable

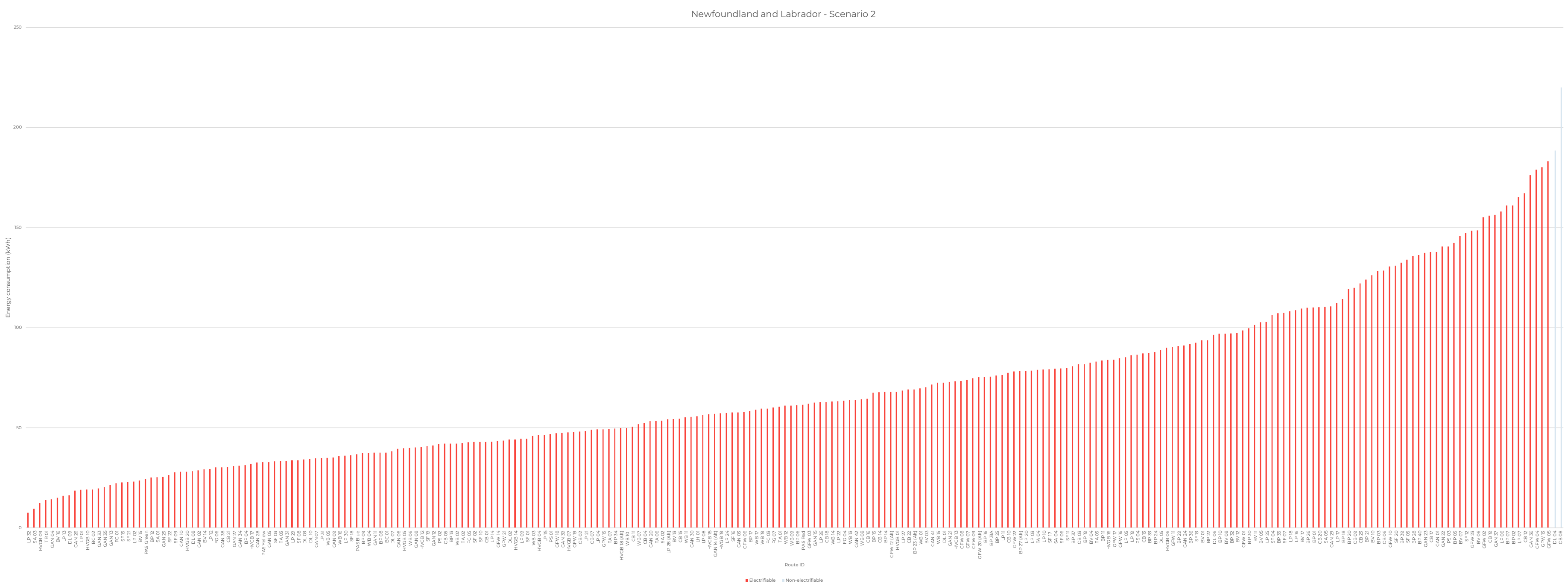


New Brunswick - Francophone Nord-Ouest - Scenario 2
250
200
150
100
50
0
Energy Consumption (kWh)
9
662
4
18
19
667
5
16
665
13
1
668
17
666
2
23
663
7
27
669
25
664
144
660
Route ID
Non-electrifiable
Electrifiable

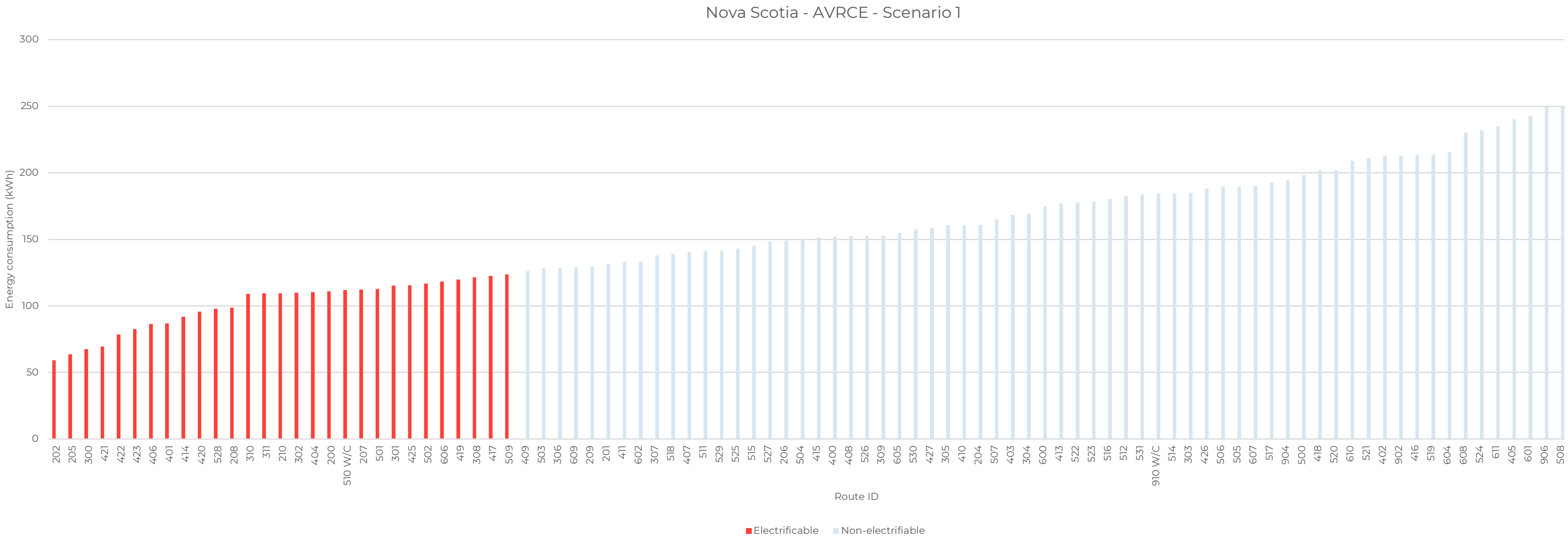

New Brunswick - Francophone Sud - Scenario 1
Energy Consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

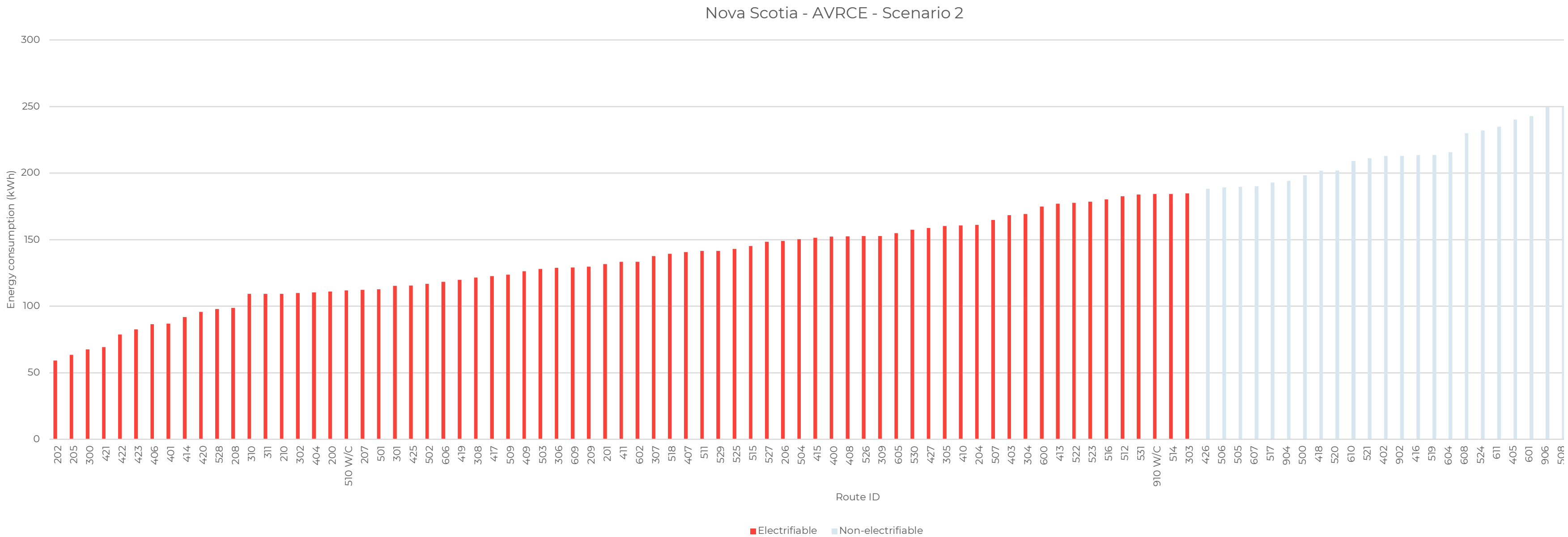

New Brunswick - Francophone Sud - Scenario 2
Energy Consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

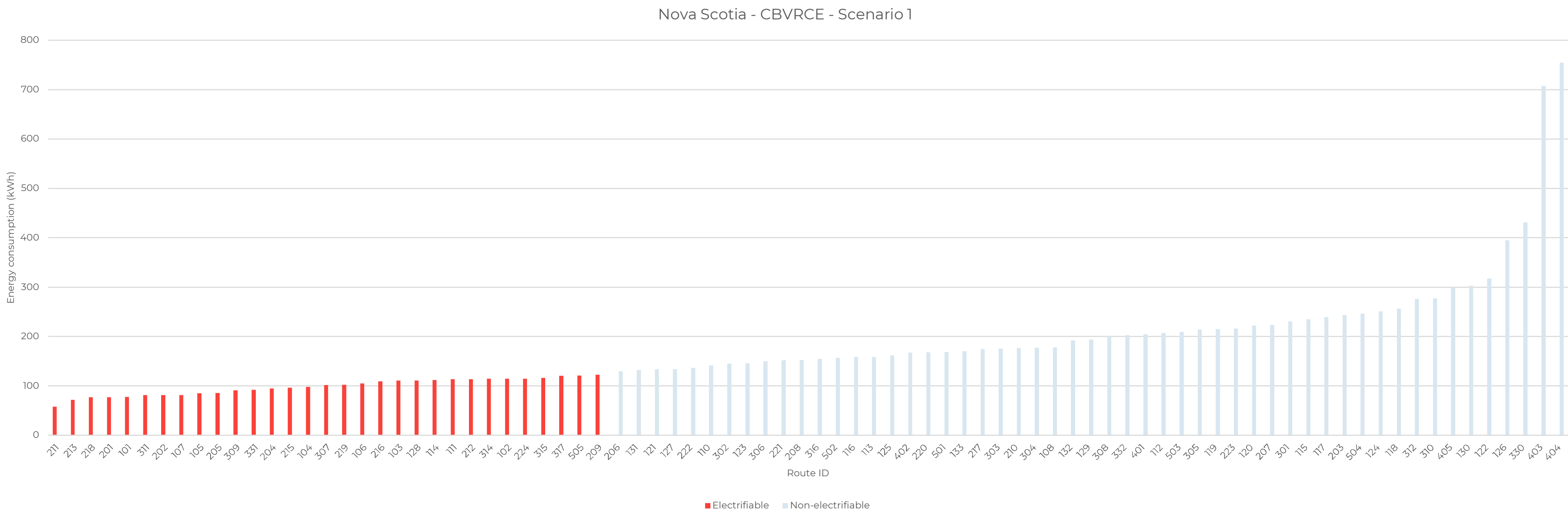

Newfoundland and Labrador - Scenario 1
250
200
150
100
50
0
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

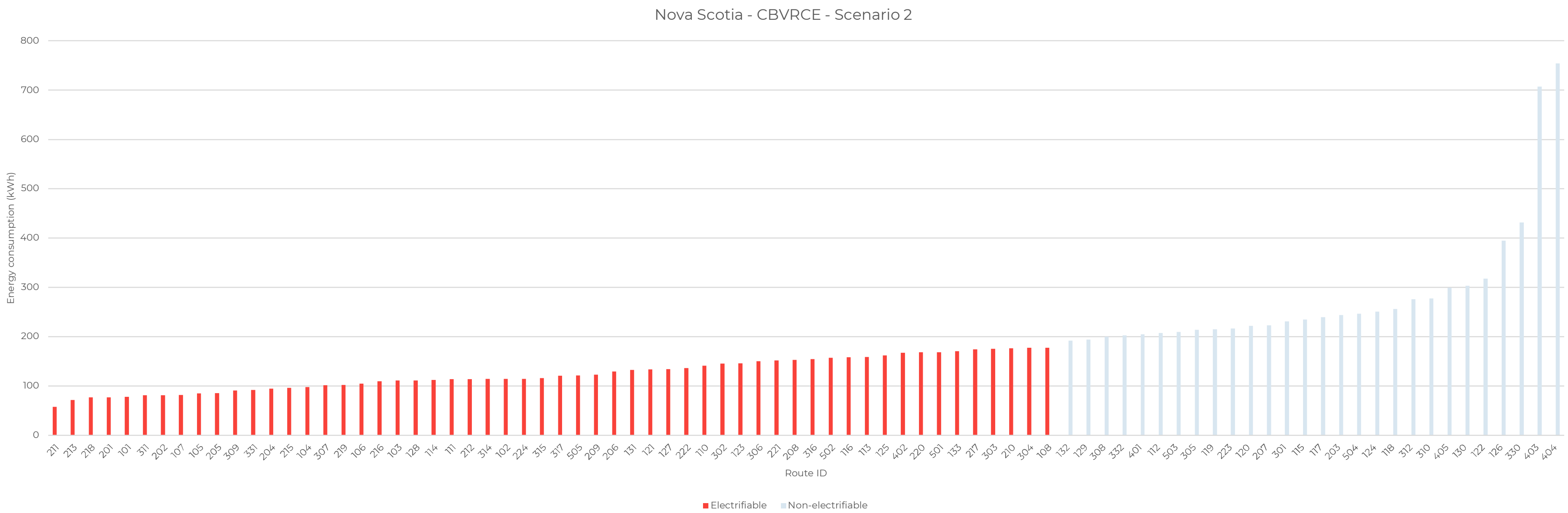


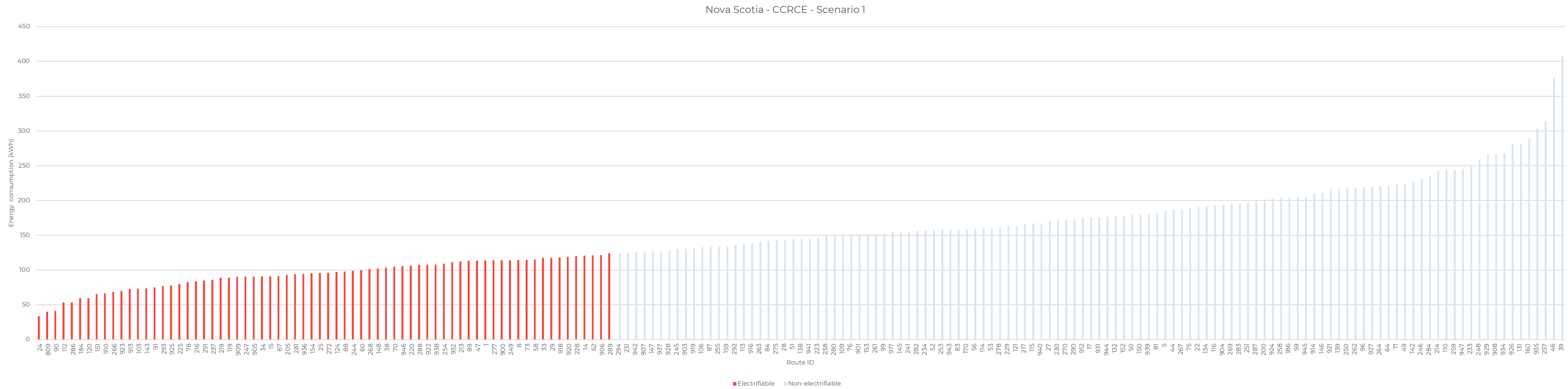
Newfoundland and Labrador - Scenario 2
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable

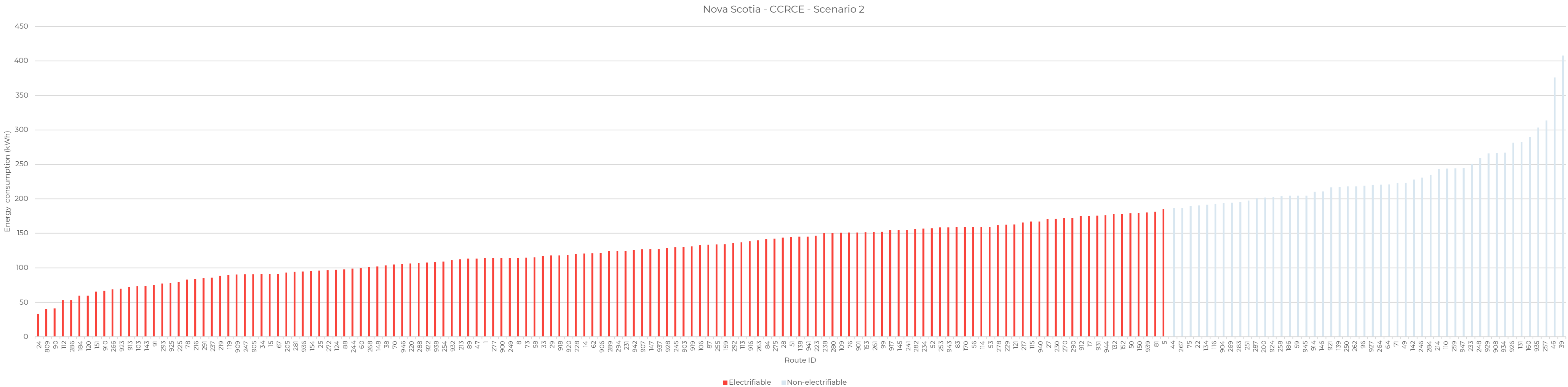

Nova Scotia - AVRCE - Scenario 1
Energy consumption (kWh)
Route ID
Electrificable
Non-electrifiable

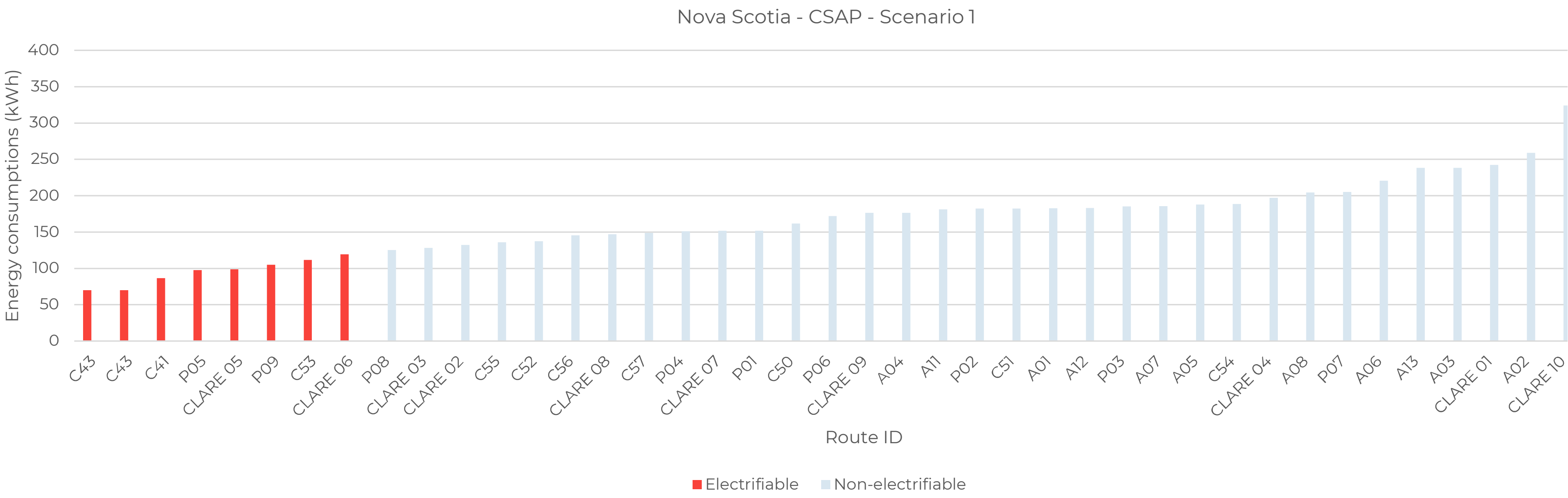

Nova Scotia - AVRCE - Scenario 2
Energy consumption (kWh)
Route ID
Electrificable
Non-electrifiable

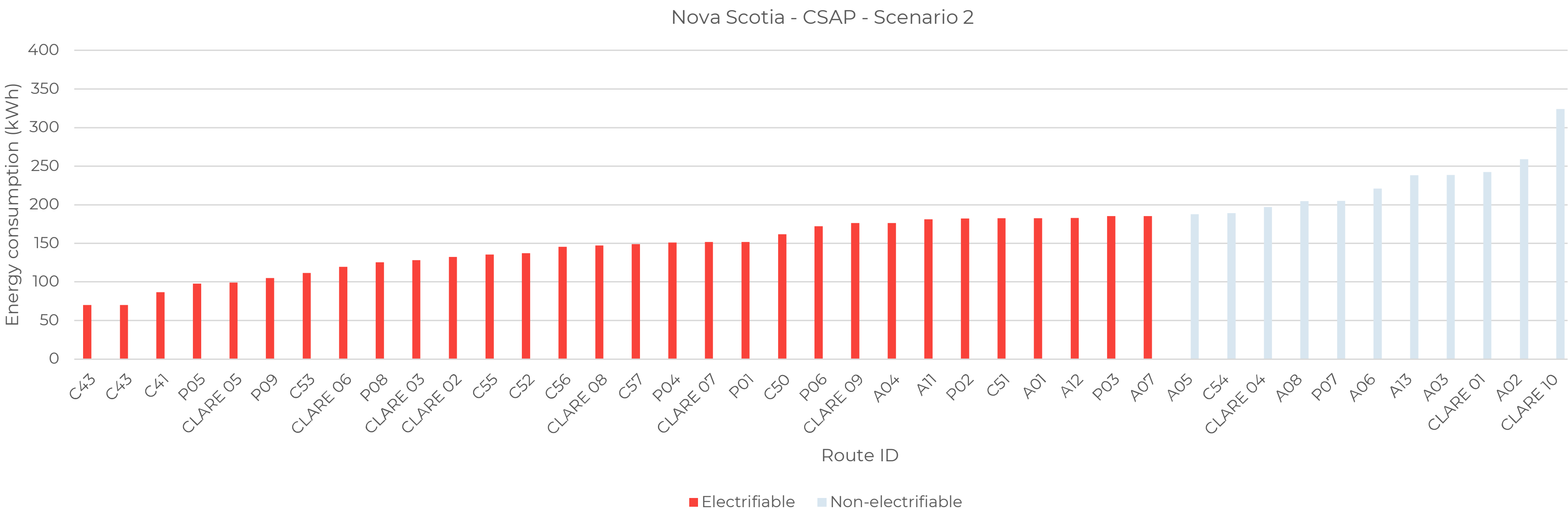

Nova Scotia - CBVRCE - Scenario 1
Energy consumption (kWh)
800
700
600
500
400
300
200
100
0
211 213 218 201 101 311 202 107 105 205 309 331 204 215 104 307 219 106 216 103 128 114 111 212 314 102 224 315 317 505 209 206 131 121 127 222 110 302 123 306 221 208 316 502 116 113 125 402 220 501 133 217 303 210 304 108 132 129 308 332 401 112 503 305 119 223 120 207 301 115 117 203 504 124 118 312 310 405 130 122 126 330 403 404
Route ID
Electrifiable
Non-electrifiable

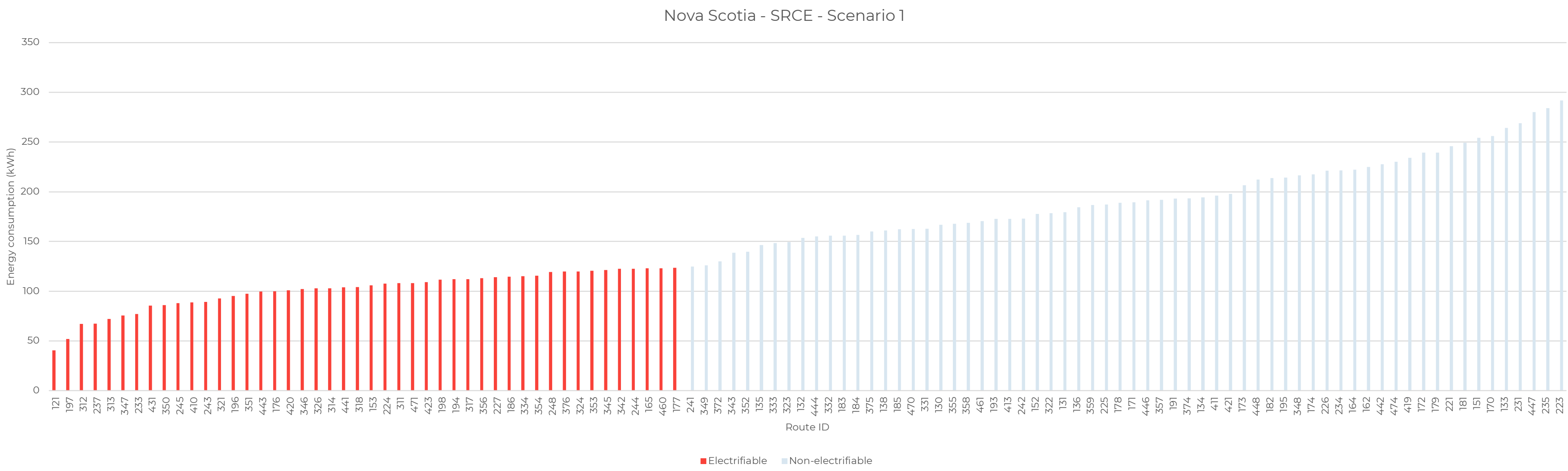

Nova Scotia - CBVRCE - Scenario 2
Energy consumption (kWh)
800
700
600
500
400
300
200
100
0
211 213 218 201 101 311 202 107 105 205 309 331 204 215 104 307 219 106 216 103 128 114 111 212 314 102 224 315 317 505 209 206 131 121 127 222 110 302 123 306 221 208 316 502 116 113 125 402 220 501 133 217 303 210 304 108 132 129 308 332 401 112 503 305 119 223 120 207 301 115 117 203 504 124 118 312 310 405 130 122 126 330 403 404
Route ID
Electrifiable
Non-electrifiable

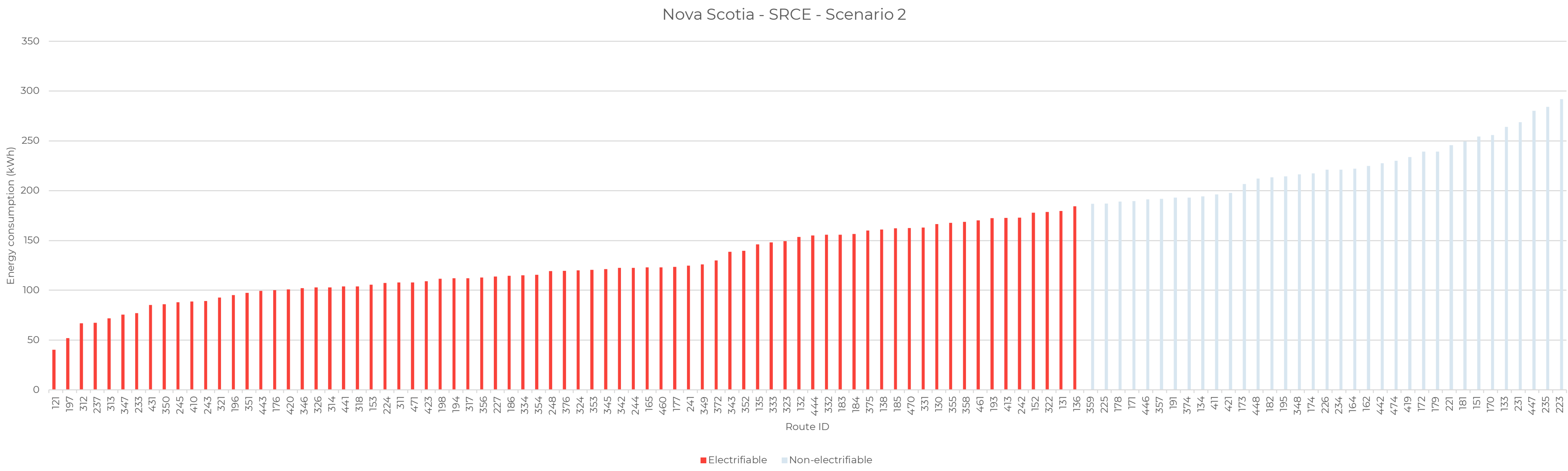

Nova Scotia - CCRCE - Scenario 1
Energy consumption (kWh)
0
50
100
150
200
250
300
350
400
450
Route ID
Electrifiable
Non-electrifiable

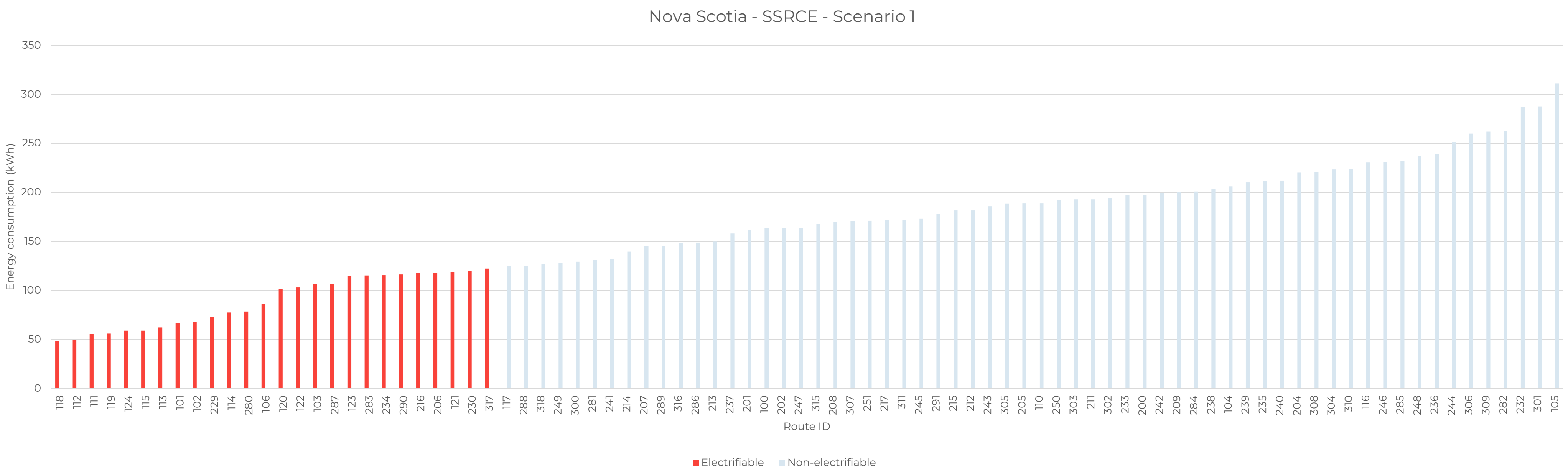

Nova Scotia - CCRCE - Scenario 2
Energy consumption (kWh)
0
50
100
150
200
250
300
350
400
450
Route ID
Electrifiable
Non-electrifiable

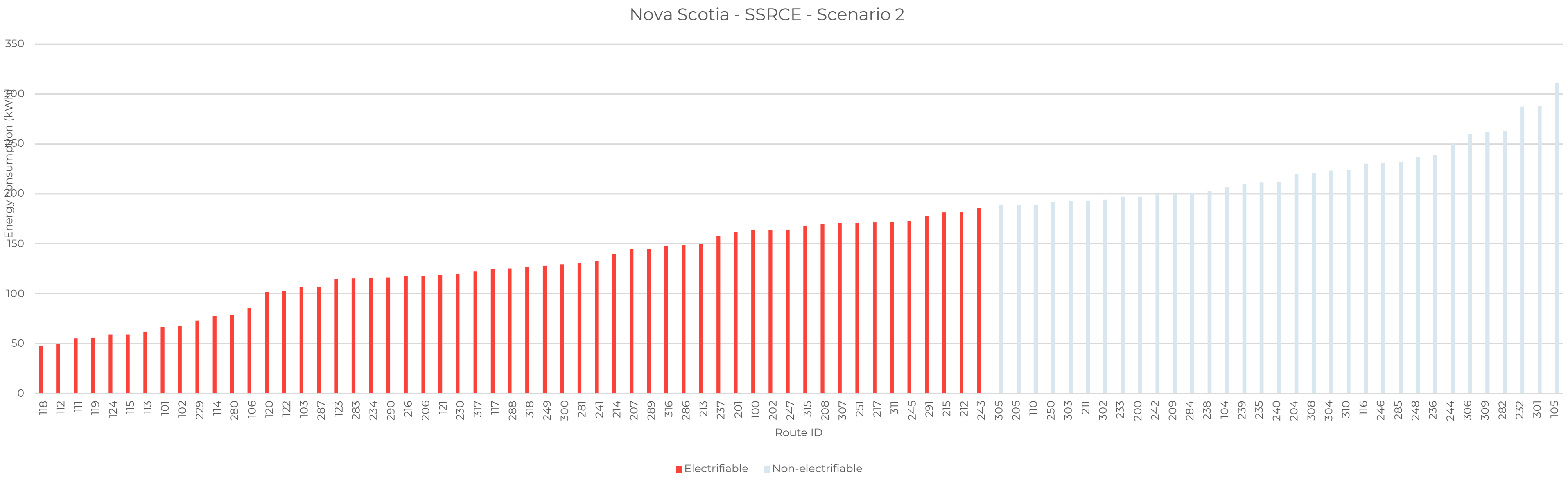

Nova Scotia - CSAP - Scenario 1
Energy consumptions (kWh)
400
350
300
250
200
150
100
50
0
C43
C43
C41
P05
CLARE 05
P09
C53
CLARE 06
P08
CLARE 03
CLARE 02
C55
C52
C56
CLARE 08
C57
P04
CLARE 07
P01
C50
P06
CLARE 09
A04
A11
P02
C51
A01
A12
P03
A07
A05
C54
CLARE 04
A08
P07
A06
A13
A03
CLARE 01
A02
CLARE 10
Route ID
Electrifiable
Non-electrifiable

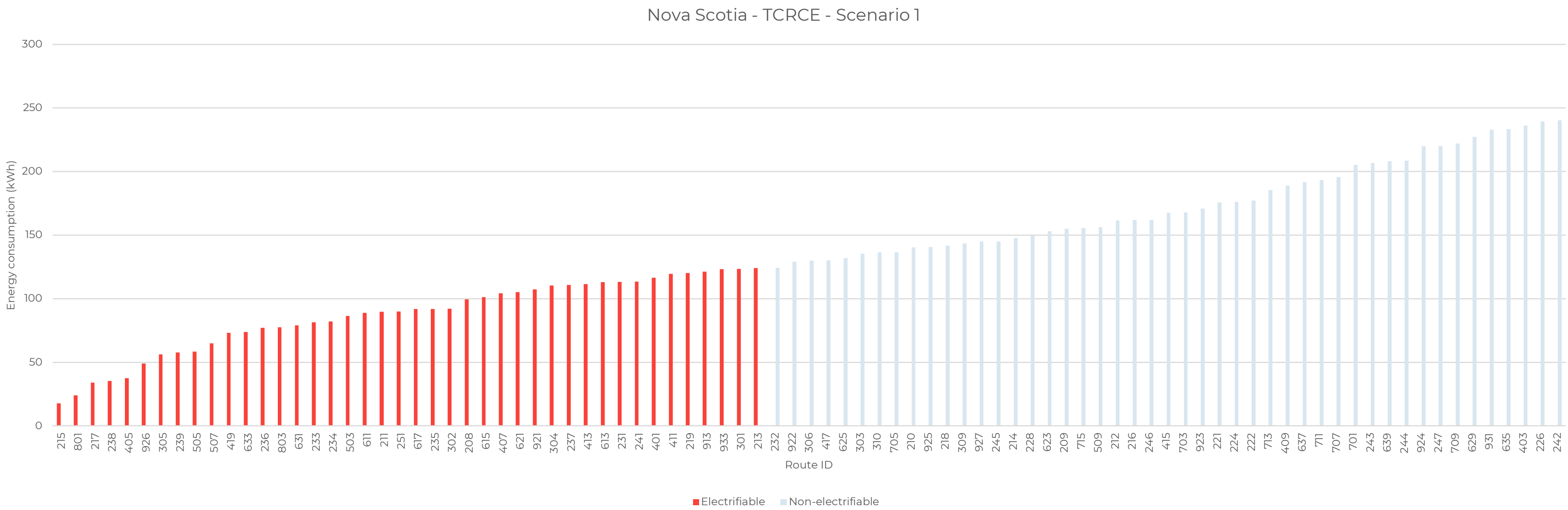

Nova Scotia - CSAP - Scenario 2
Energy consumption (kWh)
400
350
300
250
200
150
100
50
0
C43
C43
C41
P05
CLARE 05
P09
C53
CLARE 06
P08
CLARE 03
CLARE 02
C55
C52
C56
CLARE 08
C57
P04
CLARE 07
P01
C50
P06
CLARE 09
A04
A11
P02
C51
A01
A12
P03
A07
A05
C54
CLARE 04
A08
P07
A06
A13
A03
CLARE 01
A02
CLARE 10
Route ID
Electrifiable
Non-electrifiable

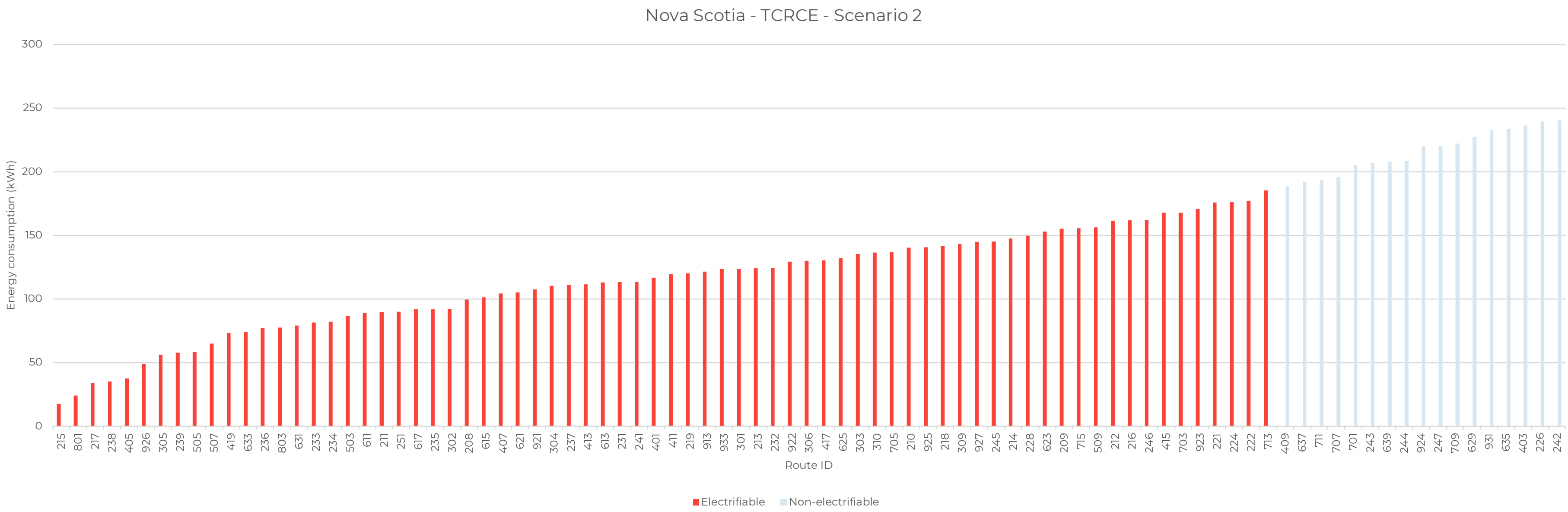

Nova Scotia - SRCE - Scenario 1
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable


Nova Scotia - SRCE - Scenario 2
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable


Nova Scotia - SSRCE - Scenario 1
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable


Nova Scotia - SSRCE - Scenario 2
Energy consumption (kWh)
Route ID
Electrifiable
Non-electrifiable


Nova Scotia - TCRCE - Scenario 1
300
250
200
150
100
50
0
Energy consumption (kWh)
215 801 217 238 405 926 305 239 505 507 419 633 236 803 631 233 234 503 611 211 251 617 235 302 208 615 407 621 921 304 237 413 613 231 241 401 411 219 913 933 301 213 232 922 306 417 625 303 310 705 210 925 218 309 927 245 214 228 623 209 715 509 212 216 246 415 703 923 221 224 222 713 409 637 711 707 701 243 639 244 924 247 709 629 931 635 403 226 242
Route ID
Electrifiable
Non-electrifiable


Nova Scotia - TCRCE - Scenario 2
300
250
200
150
100
50
0
Energy consumption (kWh)
215 801 217 238 405 926 305 239 505 507 419 633 236 803 631 233 234 503 611 211 251 617 235 302 208 615 407 621 921 304 237 413 613 231 241 401 411 219 913 933 301 213 232 922 306 417 625 303 310 705 210 925 218 309 927 245 214 228 623 209 715 509 212 216 246 415 703 923 221 224 222 713 409 637 711 707 701 243 639 244 924 247 709 629 931 635 403 226 242
Route ID
Electrifiable
Non-electrifiable

Appendix C

Funding & Financing Programs

ESB FEASIBILITY STUDY

Atlantic School Bus Electrification Feasibility Study
Funding Opportunities - Summary of Key Features

Funder	Fund Name	Funded Initiative (i.e. phase of project / commercial readiness lifecycle)	Primarily Funded Asset Types / Work Packages	Fund Purpose / Expected Output	Funding Amount	Application Opening	Application / Program Deadlines	Eligible Recipients
Federation of Canadian Municipalities	**Green Municipal Fund - Municipal Fleet Electrification**	Feasibility Study	1. ZEB feasibility and implementation Studies	Reduction of fossil fuels in fleets Transportation networks and community options	Grant: Up to 50% of eligible costs to a maximum of $175,000	Applications are accepted year round, though this offer will close when all the funding has been allocated.	Until all funding has been allocated.	1. All Canadian municipal governments 2. Their project partners, which includes: Private sector entities Indigenous communities Municipally-owned corporations A regional, provincial or territorial organization delivering municipal services Non-governmental organizations Not-for-profit organizations Research institutes (e.g., universities)
Federation of Canadian Municipalities	**Green Municipal Fund - Municipal Fleet Electrification**	Pilot Project	1. Zero-emission vehicles (ZEVs), including: - Battery-electric - Plug-in hybrid electric - Hydrogen fuel cell vehicles (if the project demonstrates a low carbon intensity level for hydrogen production, defined as a threshold of 4 kg CO2e per kg of hydrogen) 2. EV supply equipment (EVSE). 3. Upgrades to existing buildings / facilities. GMF will consider multipronged capital	Reduction of fossil fuels in fleets Transportation networks and community options	Grants up to $500,000	Applications are accepted year round, though this offer will close when all the funding has been allocated.	Until all funding has been allocated.	1. All Canadian municipal governments 2. Their project partners, which includes: Private sector entities Indigenous communities Municipally-owned corporations A regional, provincial or territorial organization delivering municipal services Non-governmental organizations Not-for-profit organizations Research institutes (e.g., universities)
Federation of Canadian Municipalities	**Green Municipal Fund**	Pilot Project	1. Zero-emission vehicles (ZEVs), including: - Battery-electric - Plug-in hybrid electric - Hydrogen fuel cell vehicles (if the project demonstrates a low carbon intensity level for hydrogen production, defined as a threshold of 4 kg CO2e per kg of hydrogen) 2. EV supply equipment (EVSE).	Transportation networks and commuting options	Grant: Up to $500,000 to cover up to 50% of eligible costs (Municipalities and municipal partners with a population of 20,000 or under may qualify for a grant of up to 80 per cent of eligible project costs under certain conditions. Contact us to find out if your municipality is eligible.)	Applications are accepted year round, though this offer will close when all the funding has been allocated.	Until all funding has been allocated.	1. All Canadian municipal governments 2. Their project partners, which includes: Private sector entities Indigenous communities Municipally-owned corporations A regional, provincial or territorial organization delivering municipal services Non-governmental organizations Not-for-profit organizations Research institutes (e.g., universities)

Funder	Fund Name	Eligible Projects / Key Criteria	Stacking Limits	Contact Names and Info	Website Link	Date that information was retreived / last updated in-house	Date of latest revision of application guidelines at the time of latest in-house update / retreival of information	Notes
Federation of Canadian Municipalities	**Green Municipal Fund - Municipal Fleet Electrification**	Your study may compare several options or assess the capacity of one option to do at least one of the following: Reduce the number of vehicles on the road, the number of kilometres they travel, or the amount of time they spend transporting people or goods Get people to use their vehicles more efficiently or switch to less polluting forms of transportation (i.e., a modal shift to public transit, walking, or cycling). Your feasibility study should assess the feasibility (e.g., technical, financial) of an initiative as well as its potential environmental, economic and social impacts.	Not specified.	programs@fcm.ca	https://fcm.ca/en/funding/gmf/study-transportation-networks-commuting-options			
Federation of Canadian Municipalities	**Green Municipal Fund - Municipal Fleet Electrification**	Pilots and capital projects to reduce fossil fuel use in fleets should target a reduction in GHG emissions by at least 20% compared to an existing or modeled baseline measurement. All classes of vehicles are eligible for funding, including light-duty and specialized fleet (i.e. all municipally owned vehicles such as police cruisers and fire trucks) and private vehicles that deliver a municipal service.	Not specified.	programs@fcm.ca	https://fcm.ca/en/funding/gmf/pilot-project-reduce-fossil-fuel-use-in-fleets			
Federation of Canadian Municipalities	**Green Municipal Fund**	Pilot projects to reduce pollution in Canadian communities by improving transportation systems and networks or encouraging people to switch to less polluting transportation options. Your pilot will compare several options or assess the capacity of one option to do at least one of the following: - Reduce the number of vehicles on the road, the number of kilometres they travel, or the amount of	Not specified.	programs@fcm.ca	https://fcm.ca/en/funding/gmf/pilot-project-transportation-networks-commuting-options			

Funder	Fund Name	Funded Initiative (i.e. phase of project / commercial readiness lifecycle)	Primarily Funded Asset Types / Work Packages	Fund Purpose / Expected Output	Funding Amount	Application Opening	Application / Program Deadlines	Eligible Recipients
Federation of Canadian Municipalities	**Green Municipal Fund - Municipal Fleet Electrification**	Capital Project	1. Zero-emission vehicles (ZEVs), including: - Battery-electric - Plug-in hybrid electric - Hydrogen fuel cell vehicles (if the project demonstrates a low carbon intensity level for hydrogen production, defined as a threshold of 4 kg CO_2e per kg of hydrogen) 2. EV supply equipment (EVSE). 3. Upgrades to existing buildings / facilities. GMF will consider multipronged capital	Electrification of municipal and transit fleets to help municipalities achieve net-zero transportation emissions, reducing operational and embodied GHG emissions wherever possible. A capital project that achieves a partial or complete transition of your municipal and/or transit fleet to zero-emission vehicles.	Maximum award: - Combined grant and loan for up to 80% of eligible costs - Combined grant and loan up to a maximum of $10M - Grant for up to 15%** of loan amount ** Proponents with exceptional projects may qualify for a higher loan and grant amount. Note: The grant contribution is determined as a function of the loan and cannot be separated.	Applications are accepted year-round, though this offer may close when all funding has been allocated.	Until all funding has been allocated.	1. Canadian municipal governments (e.g., towns, cities, regions, districts, and local boards). 2. Municipal partners, which include: - Private sector entities - Municipally-owned corporations - Regional, provincial or territorial organizations delivering municipal services - Non-governmental organizations - Not-for-profit organizations - Research institutes (e.g., universities) - An Indigenous community is an eligible lead applicant if they are partnering with a Canadian municipal government on an eligible project, or if they have a shared service agreement with a Canadian municipal government related to municipal infrastructure,
Federation of Canadian Municipalities	**Green Municipal Fund: Net-Zero Transformation**	Capital Project	Not specified. Understood to be flexible, depending on alignment to the purpose of the fund and its expected outputs.	Deploy a full scale best-in-class GHG reduction solution i.e., a capital project that has the potential to result in a significant contribution to net-zero.	Maximum award: - Combined grant and loan for up to 80% of eligible costs - Combined grant and loan to a maximum of $10M - Grant up to 15%** of the total loan amount - Additional 5% grant available if the project involves the remediation of a brownfield site ** Proponents with exceptional projects may qualify for a higher loan and grant amount. Note: The grant contribution is determined as a function of the loan and cannot be separated.	Applications are accepted year-round, though this offer may close when all funding has been allocated.	Until all funding has been allocated.	1. Canadian municipal governments (e.g., towns, cities, regions, districts, and local boards). 2. Municipal partners, which include: - Private sector entities - Municipally-owned corporations - Regional, provincial or territorial organizations delivering municipal services - Non-governmental organizations - Not-for-profit organizations - Research institutes (e.g., universities) - An Indigenous community is an eligible lead applicant if they are partnering with a Canadian municipal government on an eligible project, or if they have a shared service agreement with a Canadian municipal government related to municipal infrastructure,
Infrastructure Canada + Canada Infrastructure Bank	**Zero Emission Transit Funding (ZETF) Program** **+** **ZEB Initiative** **Planning Projects Stream**	Planning and Design Study	1. ZEB feasibility and implementation studies	Infrastructure Canada has established the $2.75 billion Zero Emission Transit Fund (ZETF) which offers support to public transit and school bus operators across Canada who are electrifying their fleets. To account for the importance of robust planning, Stage II Planning is comprised of two subcomponents (Transit Bus Deployment Planning and School Bus Deployment Planning), and will provide support for planning studies necessary to ensure the successful future deployment of ZEBs.	The maximum contribution towards planning projects is up to 80% of the total eligible costs.	Applications will be accepted on a rolling basis until the funding available is fully allocated.	Until the funding available is fully allocated. Eligible expenses must be claimed by Fall of 2025, unless otherwise specified in a contribution agreement between the recipient and Infrastructure Canada.	1. Municipalities, local and regional governments established under provincial or territorial statute, including service districts 2. Provinces or Territories 3. Public sector bodies that are established by or under provincial or territorial statute or by regulation or are wholly-owned by a province, territory, municipal or regional government (including transit agencies and school boards). 4. Indigenous governing bodies including but not limited to: - A band council within the meaning of section 2 of the Indian Act.

Funder	Fund Name	Eligible Projects / Key Criteria	Stacking Limits	Contact Names and Info	Website Link	Date that information was retreived / last updated in-house	Date of latest revision of application guidelines at the time of latest in-house update / retreival of information	Notes
Federation of Canadian Municipalities	**Green Municipal Fund - Municipal Fleet Electrification**	Projects should replace one or more existing vehicles with ZEVs. Funding decisions are based on the following criteria: 1. Resilience 2. Equity considerations 3. Multi-solving	Not specified.	gmfinfo@fcm.ca 1-877-417-0550	Home Page: https://greenmunicipalfund.ca/funding/capital-project-municipal-fleet-electrification Application Guide: https://media.fcm.ca/documents/programs/gmf/mfe-application-guide-gmf.pdf	8 février 2024	1 janvier 2024	
Federation of Canadian Municipalities	**Green Municipal Fund: Net-Zero Transformation**	Projects should provide support for municipalities in constructing innovative infrastructure that has the potential to result in a significant contribution to net-zero. GMF capital projects are usually composed of physical assets as defined by the generally accepted accounting principles (GAAP). To be eligible, you must have completed an assessment of the GHG reduction potential of your project using verifiable evaluation processes. There are no pre-set environmental targets or thresholds for this funding offer. Funding decisions are based on the following criteria: 1. Innovation	Not specified.	gmfinfo@fcm.ca 1-877-417-0550	Home Page: https://greenmunicipalfund.ca/funding/capital-project-net-zero-transformation Application Guide: https://media.fcm.ca/documents/programs/gmf/nzt-application-guide-gmf.pdf	8 février 2024	1 janvier 2024	For consideration and further discussion with FCM only in the case that school bus fleets do not qualify for funding from the Municipal Fleet Electrification 'stream', and if: - CAMET is expected to lead the fleet electrification capital project(s) and the nature of its partnership with the local municipalities / communities qualifies it as an eligible recipient of FCM funding; or - The respective School Boards are expected to lead their fleet electrification capital projects and the nature of their partnership with the local municipalities / communities qualifies them as eligible recipients for FCM funding; or
Infrastructure Canada + Canada Infrastructure Bank	**Zero Emission Transit Funding (ZETF) Program** **+** **ZEB Initiative** **Planning Projects Stream**	Eligible projects include studies, modelling and feasibility analysis that will support the future deployment of ZEBs. Planning projects may be administered differently depending on whether the applicant is a transit or school bus operator in order to best support their needs. The Expression of Interest (EOI) (Stage 1) is the mandatory first stage in the application process. It allows the applicant to submit the required information for review by Infrastructure Canada and the CIB to determine the applicant's eligibility, assess the current level of project planning, identify support for project planning to increase the readiness of the project(s), and determine if funding can meet the applicants near-term and long-term needs.	Not specified.	ZETF-FTCZE@infc.gc.ca.	Overview: https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/index-eng.html#2 Application Guide: https://www.infrastructure.gc.ca/alt-format/pdf/zero-emissions-trans-zero-emissions/applicant-guide-demandeur-	8 février 2024	1 juin 2022	

Funder	Fund Name	Funded Initiative (i.e. phase of project / commercial readiness lifecycle)	Primarily Funded Asset Types / Work Packages	Fund Purpose / Expected Output	Funding Amount	Application Opening	Application / Program Deadlines	Eligible Recipients
Infrastructure Canada + Canada Infrastructure Bank	**Zero Emission Transit Funding (ZETF) Program** **+** **ZEB Initiative** **Capital Projects Stream**	Capital Project	1. ZEBs (including, warranties and OEM training) 2. Charging / hydrogen refueling equipment (including warranties and OEM training) 3. Construction of or improvements to facilities 4. Owner-operator staff expansion	The objective of the $2.75 billion Zero Emission Transit Fund (ZETF) is to advance the Government of Canada's commitment to help procure zero emission public transit and school buses, in close partnership with the Canada Infrastructure Bank (CIB). This funding will help communities to electrify their school and transit bus fleets, while reducing emissions and operational costs over the long-term. The ZETF targets investments across Canada that support clean transportation by investing in the vehicles, infrastructure and organizational readiness that make fleet electrification possible.	The maximum non-repayable Infrastructure Canada contribution is up to 50% of the total eligible costs. Total combined Infrastructure Canada funding and CIB financing may not exceed 100% of eligible costs. The maximum amount payable through the ZETF will be $350M for a project, unless otherwise agreed to by the Government of Canada.	Applications will be accepted on a rolling basis until the funding available is fully allocated.	Until the funding available is fully allocated. Eligible expenses must be claimed by Fall of 2025, unless otherwise specified in a contribution agreement between the recipient and Infrastructure Canada.	1. Municipalities, local and regional governments established under provincial or territorial statute, including service districts 2. Provinces or Territories 3. Public sector bodies that are established by or under provincial or territorial statute or by regulation or are wholly-owned by a province, territory, municipal or regional government (including transit agencies and school boards). 4. Indigenous governing bodies including but not limited to: - A band council within the meaning of section 2 of the Indian Act.
Infrastructure Canada	**Rural Transit Solutions Fund** **Planning and Design Projects Stream**	Planning and Design Study	1. ZEB feasibility and implementation studies	The Rural Transit Solutions Fund is the first federal fund to target the development of transit solutions in rural and remote communities. Launched in 2021, the Fund supports the development of locally-driven transit solutions that will help people living in rural communities get to work, school, appointments, and to visit loved ones. The Rural Transit Solutions Fund is part of the Government of Canada's Permanent Public Transit Program, which allocates $14.9 billion over the next eight years for public transit projects. The Permanent Public Transit Program also provides support for major infrastructure projects,	There is no limit to the cost of a planning project, however, the maximum grant available under the Rural Transit Solutions Fund is limited to $50,000. The total funding allocated under the Rural Transit Solutions Fund and from all federal sources cannot exceed 100% of the total costs of the planning and design project. Infrastructure Canada will not provide additional funding over the amount agreed upon in the grant agreement.	Applications to the Rural Transit Solutions Fund's planning and design projects stream are being accepted via Infrastructure Canada's online applicant portal. Implied that applications are accepted on a rolling basis.	Infrastructure Canada will provide notification on its website in advance of the closure of the application intake. Planning and design projects must be completed before March 31, 2026.	1. Municipalities, local and regional governments established under provincial or territorial statute, including service districts 2. Public sector bodies that are established by or under provincial or territorial statute, or by regulation, or are wholly-owned by a province, territory, municipal or regional government, including but not limited to: a. Municipally-owned corporations b. Provincial or territorial organizations that deliver municipal services; and c. Any other form of local governance that exists outside of the municipality description 3. Indigenous governing bodies, including but not limited to:
Infrastructure Canada	**Rural Transit Solutions Fund** **Capital Projects Stream**	Capital Project	Flexible as long as the asset type or work package is part of a transit solution. The project assets must constitute an integrated transit solution and not be standalone installations.	The Rural Transit Solutions Fund is the first federal fund to target the development of transit solutions in rural and remote communities. Launched in 2021, the Fund supports the development of locally-driven transit solutions that will help people living in rural communities get to work, school, appointments, and to visit loved ones. The Rural Transit Solutions Fund is part of the Government of Canada's Permanent Public Transit Program, which allocates $14.9 billion over the next eight years for public transit projects. The Permanent Public Transit Program also provides support for major infrastructure projects,	There is no limit to the cost of a capital project; however, the maximum contribution from the Rural Transit Solutions Fund is limited to: - $3 million for conventional solutions (e.g., internal combustion engine or hybrids) - $5 million if the project incorporates zero-emission solutions Organizations intending to present more than one project may contact INFC to confirm how to apply. Maximum Rural Transit Solutions Fund contribution (% of capital eligible expenses) if: - Applicant is located in a province or is a not-for-profit organization: 80% - Applicant is located in a territory and/or an Indigenous recipient: 100%	Applications to the Rural Transit Solutions Fund's capital stream will be accepted via Infrastructure Canada's online portal starting on January 20, 2023.	Applications will be accepted under this stream until February 28, 2024, at 3:00 p.m. EST.	1. Municipalities, local and regional governments established under provincial or territorial statute, including service districts 2. Provinces or Territories 3. Public sector bodies that are established by or under provincial or territorial statute, or by regulation, or are wholly-owned by a province, territory, municipal or regional government, including but not limited to: a. Municipally-owned corporations b. Provincial or territorial organizations that deliver municipal services c. Any other form of local governance that exists outside of the municipality description

Funder	Fund Name	Eligible Projects / Key Criteria	Stacking Limits	Contact Names and Info	Website Link	Date that information was retreived / last updated in-house	Date of latest revision of application guidelines at the time of latest in-house update / retreival of information	Notes
Infrastructure Canada + Canada Infrastructure Bank	**Zero Emission Transit Funding (ZETF) Program** **+** **ZEB Initiative** **Capital Projects Stream**	Eligible capital projects support ZEB deployment and include the procurement of buses, charging and refueling infrastructure, and other ancillary infrastructure needs. ZEBs are vehicles that have the potential to produce no tailpipe emissions such as battery-electric and hydrogen fuel cell powered vehicles. They may still have a conventional internal combustion engine, but must be able to operate without using it. Retrofits of conventional fuel buses to ZEBs are also eligible. The applicant must include supporting documentation (studies, analysis etc.) for all assertions and any information deemed necessary by Infrastructure Canada to assess the eligibility and merit of projects.	Not specified.	ZETF-FTCZE@infc.gc.ca.	Overview: https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/index-eng.html#2 Application Guide: https://www.infrastructure.gc.ca/alt-format/pdf/zero-emissions-trans-zero-emissions/applicant-guide-demandeur-	8 février 2024	1 juin 2022	
Infrastructure Canada	**Rural Transit Solutions Fund** **Planning and Design Projects Stream**	Proposed planning and design projects are intended to assess and/or develop a rural transit solution that is appropriate for the local community. Eligible planning projects can include assessing routes and modes of travel, feasibility studies, public and stakeholder engagement and surveys. Projects will be evaluated according to the following merit criteria: 1. Need 2. Scope 3. Viability In the Project Rationale section of the application, applicants must demonstrate how their projects will meet the merit criteria, including why the project is	The total funding allocated under the Rural Transit Solutions Fund and from all federal sources cannot exceed 100% of the total costs of the planning and design project.	RTSFFSTCR@infc.gc.ca 1-833-699-2280	Overview: https://www.infrastructure.gc.ca/rural-trans-rural/index-eng.html Application Guide: https://www.infrastructure.gc.ca/alt-format/pdf/rural-trans-rural/plan-guide-eng.pdf	14 février 2024	4 décembre 2023	
Infrastructure Canada	**Rural Transit Solutions Fund** **Capital Projects Stream**	Proposed capital projects can support a range of transport modes and types of systems, including traditional solutions such as fixed-route buses, as well as non-traditional solutions such as ride-share and on demand services requiring the purchase of minivans, small craft, non motorized and zero-emission fleets, the construction of intermodal hubs, the installation of charging stations or the purchase of software. To be eligible, under the Rural Transit Solutions Fund, all fixed assets or rolling stock must be part of a transit solution. Capital project requests must: - Contribute to the establishment or expansion of a transit solution/transit system	Maximum Federal Contribution from all sources (% of capital expenses) if: - Applicant is located in a province or is a not-for-profit organization: 80% - Applicant is located in a territory and/or an Indigenous recipient: 100% - Applicant is a	RTSFFSTCR@infc.gc.ca 1-833-699-2280	Overview: https://www.infrastructure.gc.ca/rural-trans-rural/index-eng.html Application Guide: https://www.infrastructure.gc.ca/rural-trans-rural/capital-immo-guide-eng.html	14 février 2024	4 décembre 2023	

Funder	Fund Name	Funded Initiative (i.e. phase of project / commercial readiness lifecycle)	Primarily Funded Asset Types / Work Packages	Fund Purpose / Expected Output	Funding Amount	Application Opening	Application / Program Deadlines	Eligible Recipients
Infrastructure Canada	**Investing in Canada Infrastructure Program** **Public Transit Stream**	Capital Project	Understood to be flexible until specified as part of the next provincial calls for projects.	The program provides long-term, stable funding delivered by Infrastructure Canada to: - Help communities reduce air and water pollution, provide clean water, increase resilience to climate change and create a clean-growth economy - Build strong, dynamic and inclusive communities - Ensure Canadian families have access to modern, reliable services that improve their quality of life. Under the program, over $33-billion in funding is being **delivered through provinces or territories based on bilateral**	Funding through this stream is allocated according to a formula based on ridership and population, which balances the demand on existing systems, while providing support for expected population growth. The Government of Canada will invest up to: - 40% of municipal* and not-for-profit projects in the provinces; - 50% of provincial projects; - 75% for projects in the territories and for projects with Indigenous partners; - 25% of for-profit private sector projects (except in the Community, Culture and Recreation Stream, where for-profit private sector projects are not eligible).	Call for funding based on the next generation of ICIP programming may be determined by the respective provinces.	The provincial intake for the Program closed on March 31, 2023. Territories have until March 31, 2025, to submit their projects.	Funding is delivered to municipal, not-for-profit sector, provincial, territorial or for-profit sector projects through bilateral agreements between Infrastructure Canada and each of the provinces and territories.
Natural Resources Canada	**Zero Emission Vehicle Infrastructure Program (ZEVIP)** **- For Owners / Operators of ZEV Infrastructure**	Capital Project	1. Charging infrastructure / hydrogen refueling stations	The ZEVIP is a $680 million program that addresses a key barrier to the adoption of zero-emission vehicles (ZEV)—the lack of charging and refuelling stations in Canada— by increasing the availability of localized charging and hydrogen refuelling opportunities where Canadians live, work, and play. Larger EV charging or hydrogen refuelling projects above $20 million and carried out by the private sector will be redirected to the Canada Infrastructure Bank's Charging and Hydrogen Refuelling Infrastructure Initiative for funding consideration.	NRCan's contribution through ZEVIP will be limited to a maximum of 10 million dollars ($10,000,000) per project. ZEVIP will pay up to 50% of Total Project Costs for owners/operators, up to maximum amounts as shown below: - Level 2 EV Chargers (208 V or 240 V) 3.3 kW to 19.2 kW Up to 50% of total project costs, to a maximum of $5,000 per connector - Level 3 EV Fast Chargers 20 kW to 49 kW Up to 50% of total project costs, to a maximum of $15,000 per charger	Closed at the time of updating this information. Next annual RFP for owners / operators of ZEV infrastructure is planned for Spring 2024.	Closing date for next annual RFP is Summer 2024.	To be considered for funding under ZEVIP, applicants must be legal entities validly incorporated or registered in Canada or abroad, including not-for-profit and for-profit organizations such as: - Electricity or gas utilities - Companies - Industry associations - Research associations - Standards organizations - Indigenous businesses and community groups - Academic institutions - Provincial, territorial, regional, or municipal governments or their departments or agencies where applicable
NB Power (New Brunswick)	**Plug-in NB Charging Rebates for Business**	Capital Project	1. Charging infrastructure	Rebates for commercial charging stations for New Brunswick businesses, organizations and communities. Funding for the program is provided through Natural Resources Canada's Zero Emission Vehicle Infrastructure Program (ZEVIP). The objective of the program is to increase the availability of charging stations where New Brunswickers live, work and play.	The program will pay up to 50% of total Eligible Costs, up to maximum amounts as follows: - Level 2 (208 / 240 V) connectors 3.3 kW to 19.2 kW (maximum of 3 units per application) Up to 50% of total Eligible Expenditures, to a maximum of $5,000 per connector - Fast charger 20 kW to 49 kW (maximum of 1 unit per application) Up to 50% of total Eligible Expenditures, to a maximum of $15,000 per fast charger OR - Fast charger 50 kW and above (maximum of 1 unit per application) Up to 50% of total Eligible Expenditures, to a	Funding is limited and will be offered on first-come, first-served basis.	Funding fully allocated at the time of writing of this report.	- Electric or gas utilities - Companies - Industry associations - Research associations - Standard organizations - Indigenous and community groups - Academic institutions - Provincial, territorial, regional or municipal governments or their departments or agencies

Funder	Fund Name	Eligible Projects / Key Criteria	Stacking Limits	Contact Names and Info	Website Link	Date that information was retreived / last updated in-house	Date of latest revision of application guidelines at the time of latest in-house update / retreival of information	Notes
Infrastructure Canada	**Investing in Canada Infrastructure Program** **Public Transit Stream**	The Government is investing in the construction, expansion, and improvement of public transit infrastructure, for projects that: - Improve the capacity of public transit infrastructure; - Improve the quality or safety of existing or future transit systems; and - Improve access to a public transit system.	Federal funding stacking limits not specified. Total federal and provincial funding for municipal and not-for-profit projects in the provinces will not exceed 73.33% of total eligible project costs.	Updated provincial contacts may be available at the time of announcement of the next provincial calls for projects.	Program Overview: https://www.infrastructure.gc.ca/plan/icp-pic-INFC-eng.html	14 février 2024	20 décembre 2023	
Natural Resources Canada	**Zero Emission Vehicle Infrastructure Program (ZEVIP)** **- For Owners / Operators of ZEV Infrastructure**	To be considered for funding, projects must meet the following requirements: 1. Increase localized charging or hydrogen refuelling opportunities in public places, on-street, in multi-unit residential buildings, at workplaces, or for vehicle fleets. 2. The work performed must be in compliance with all applicable local codes (for example, building and electrical) and bylaws (for example, zoning and parking). 3. For EV charging infrastructure projects, your proposal must include: - A minimum of one (1) charger of 200 kW and above; or	Total funding from all levels of government (e.g. federal, provincial, territorial or municipal) cannot exceed 75% of the Total Project Costs. If the applicant is a provincial, territorial or municipal government or their departments or agencies, the stacking limit is 100%	zev-infra-vez@nrcan-rncan.gc.ca.	Program Overview: https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876 Funding for owners / operators of charging infrastructure: https://natural-	8 février 2024	26 octobre 2023	
NB Power (New Brunswick)	**Plug-in NB Charging Rebates for Business**	Eligible charger types: - Level 2 (208 / 240 V connectors 3.3 kW to 19.2 kW), - Fast charger 20 kW to 49 kW, and - Fast charger 50 kW and above. Eligible Charging Sites: - Public places, - On-street, - Multi-unit residential buildings, - Workplaces, and - Light-duty fleets.	Total funding from all levels of government (e.g. federal, provincial, territorial or municipal) cannot exceed 75% of the Total Project Costs. If the applicant is a provincial, territorial or municipal government or their departments or agencies, the stacking limit is 100%	pluginbranche@nbpower.com 1-800-663-6272	Overview: https://www.nbpower.com/en/products-services/electric-vehicles/plug-in-nb/charging-rebates-for-business/ Program Guidelines: https://www.nbpower.com/media/1491861/pluginnb-businessguidlines_03-2022.pdf	22 février 2024	29 mars 2022	

Atlantic School Bus Electrification Feasibility Study
Funding Map: Sources and Contribution Levels by Asset Type or Scope Item

Sr. No.	Asset Type / Scope Item / Work Package	Contributing Organization	Contributing Organization Type	Contributing Program	Contributing Stream (if applicable)	Contribution Type	Maximum Contribution Level (%*)**	Maximum Contribution Amount per Project****** ($)
1	**Fleet Electrification Feasibility Study and Roadmap**							
		INFC	Federal Government	ZETF	Planning Projects	Grant	80%	-
		INFC	Federal Government	RTSF	Planning Projects	Grant	100%~	$50 000
2	**Zero Emission Buses (ZEBs)**							
		INFC	Federal Government	ZETF	Capital Projects	Grant	50%	$350 million
		CIB	Federal Government	ZEB Initiative	-	Loan	50%	-
		INFC	Federal Government	RTSF	Capital Projects	Grant	80%~~	$5 million
		INFC	Federal Government	ICIP	Public Transit	Grant	40%~~~	-
		FCM	Intergovernmental Organization	GMF	Municipal Fleet Electrification: Capital Projects	Loan + Grant for 15% of loan amount	80%	$10 million
3	**Charging Infrastructure (Level 2 Chargers)**							
		INFC	Federal Government	ZETF	Capital Projects	Grant	50%	$350 million
		CIB	Federal Government	ZEB Initiative	-	Loan	50%***	-
		INFC	Federal Government	RTSF	Capital Projects	Grant	80%~~	$5 million
		INFC	Federal Government	ICIP	Public Transit	Grant	40%~~~	-
		NRCan	Federal Government	ZEVIP	For Owners / Operators of Charging Infrastructure	Grant	50%~	$10 million ($5,000 per charger)
		FCM	Intergovernmental Organization	GMF	Municipal Fleet Electrification: Capital Projects	Loan + Grant for 15% of loan amount	80%	$10 million
4	**Utility Infrastructure**							
		INFC	Federal Government	ZETF	Capital Projects	Grant	50%	$350 million
		CIB	Federal Government	ZEB Initiative	-	Loan	50%***	-
		INFC	Federal Government	RTSF	Capital Projects	Grant	80%~~	$5 million
		INFC	Federal Government	ICIP	Public Transit	Grant	40%~~~	-
		FCM	Intergovernmental Organization	GMF	Municipal Fleet Electrification: Capital Projects	Loan + Grant for 15% of loan amount	80%	$10 million
5	**Bus Depot / Facility****							
		INFC	Federal Government	ZETF	Capital Projects	Grant	50%	$350 million
		CIB	Federal Government	ZEB Initiative	-	Loan	50%***	-
		INFC	Federal Government	RTSF	Capital Projects	Grant	80%~~	$5 million
		INFC	Federal Government	ICIP	Public Transit	Grant	40%~~~	-
		FCM*****	Intergovernmental Organization	GMF	Municipal Fleet Electrification: Capital Projects	Loan + Grant for 15% of loan amount	80%	$10 million

Notes:

*	Percentage of eligible costs unless otherwise noted.
**	Percentage values for each asset type / scope item / work package may not sum up to 100% because this table provides a list of all potential funding sources. The most appropriate combinations of funding sources are expected to evolve as the key project proponent(s), CAMET's overall scope of capital equipment and infrastructure, and project definitions are established.
***	While the Application Guide for the ZETF program implies that it may be feasible to acquire CIB loans for up to 50% of total eligible project costs, CIB financing opportunities for asset categories other than ZEBs are likely to be low depending on the debt servicing capacity of ZEB operating cost savings over diesel.
****	While listed separately, equipment, activities or expenses falling within this asset category / scope item / work package overlap with those within the Charging Equipment and Utility Infrastructure categories. For the purpose of this table, the term Bus Depot is intended to cover all depot retrofitting or greenfield engineering, procurement and construction activities in addition to civil, structural, electrical and instrumentation works related to charging and utility equipment installation.
*****	Only facility retrofits or upgrades qualify for funding from this stream. Construction of new operations or maintenance facilities is not funded through this GMF stream. Proponents may consider investigation of GMF's Sustainable Municipal Buildings stream for such funding.
******	Unless otherwise noted, maximum contribution amounts stated in this column represent maximums per project and not per asset type, scope item or equipment unit.
~	The maximum contribution level is a percentage of total project costs, and not eligible costs.
~~	Maximum contribution level outlined here is for the case where the applicant is located in a province or is a not-for-profit organization.
~~	The federal contribution level outlined here is contingent on a minimum provincial contribution of 33.33% of eligible project costs.