Accelerating Electric School Bus Adoption in Canada : Watt's Next?

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Canadian Electric School Bus Alliance

Équiterre

Green Communities Canada

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About CESBA

Led by Équiterre in partnership with Green Communities Canada, the Canadian Electric School Bus Alliance (CESBA) is an initiative that brings together various provincial and federal school bus stakeholders, including school boards, environmental organizations, and bus manufacturers. Their goal is to advocate for policies that can accelerate the transition from fuel-powered school buses to electric school buses, aligning with Canada's climate targets. With the support of a steering committee, CESBA gathers insights and best practices to formulate recommendations and implement engagement strategies aimed at mobilizing decision-makers and increasing awareness of the issue. This project, running from January 2022, spans across Canada and draws upon best practices from North America and beyond, with a focus on specific regions or provinces, including Atlantic Canada, Québec, Ontario, and British Columbia.

This project aims to:

- → Mobilize and support stakeholders who wish to advance school bus electrification;
- → Promote the sharing of knowledge and expertise, as well as issues and experiences specific to each province in the area of school bus electrification;
- → Develop strategies and recommendations to accelerate the electrification of school buses across Canada;
- → Be a public voice in favor of accelerating the uptake of electric school buses.

About Équiterre

As one of the main environmental organizations in Québec, Équiterre seeks to make the necessary collective transitions towards an equitable and environmentally sound future more tangible, accessible, and inspiring. Since 1993, Équiterre has worked with citizens, organizations, and governments to develop projects in transportation, agriculture, energy, consumption, and climate change.

About Green Communities Canada

Founded in 1995, Green Communities Canada (GCC) is a national non-profit association of 20 community-based environmental organizations working together for a vibrant, equitable, and sustainable future. GCC connects community-based climate action groups through a national network to share resources, inspire innovative programming, and elevate our collective impact.

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List of Acronyms and Symbols

$	Canadian dollars
$M	Million(s) dollars
$B	Billion(s) dollars
B.C.	British Columbia
CESBA	Canadian Electric School Bus Alliance
CRFC	Clean Fuel Regulation Credits
CIB	Canada Infrastructure Bank
CO_2	Carbon Dioxide
DC	Direct Current
ESB	Electric School Bus
EV	Electric Vehicle
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWh	Gigawatt Hour
ICE	Internal Combustion Engine
MFSAB	Multifunction School Activity Bus
MHDV	Medium- and Heavy-Duty Vehicle
MTMD	Ministère des Transports et de la Mobilité durable
N.B.	New Brunswick
N.S.	Nova Scotia
OEM	Original Equipment Manufacturer
P.E.I.	Prince Edward Island
PETS	*Programme d'électrification du transport scolaire*
STB	School Transportation Board
V2G	Vehicle-to-Grid
ZEBI	Zero-Emission Buses Initiative
ZETF	Zero-Emission Transit Fund
ZEV	Zero-Emission Vehicle
ZEVAI	Zero-Emission Vehicle Awareness Initiative
ZEVIP	Zero-Emission Vehicle Infrastructure Program

Executive Summary

In Canada, about 70% of the 50,000 school buses run on diesel, while there are only around 900 electric school buses, comprising less than 2% of the fleet.

Shifting entirely to electric school buses, starting with aged buses which need to be replaced, could reduce greenhouse gas emissions by at least 1.17 million tonnes annually and save over 601 million dollars in healthcare costs over 12 years, the average lifespan of a school bus. In other words, each year, a fleet entirely composed of electric models would eliminate as many greenhouse gases as 260,360 gasoline-powered passenger vehicles driven over the same period. Electrifying school buses mitigates health risks such as acute respiratory symptoms and asthma exacerbations by reducing diesel-related air pollutants. This electrification also reduces noise exposure and enhances students' mental health by addressing climate change.

Electric school buses are also highly cost-effective as they require 80% less energy and 50% less maintenance due to their design. In addition to the economic opportunities in manufacturing, electric school bus operators can generate up to $8,000 in annual potential revenues per bus through the Clean Fuel Regulation Credits and vehicle-to-grid participation.

The electrification of school bus fleets is not without challenges and barriers. **Complex application processes and program structures** impede the adoption of electric school buses by fleet operators due to delays and limited access to financial support. Additionally, the electrification of school bus fleets faces **significant financial hurdles**, with Type C electric school buses costing $250,000 more than their diesel counterparts. Additionally, charging infrastructure is often inadequate, leading to connectivity issues and delays in connecting to electric grids. Furthermore, **charging infrastructure is inadequate**, resulting in connectivity issues and delays in connecting to electrical grids. **Logistical hurdles** like range limitations, also affect the economic viability of electric fleets, especially for lengthy routes and extracurricular activities. Moreover, the **shortage of electric school bus maintenance training and limited fleet manager knowledge** causes extended bus downtime and operational inefficiencies.

While some regions have taken steps towards electrification targets and funding, the Canadian Electric School Bus Alliance (CESBA) urges the acceleration of school bus fleet electrification that would prioritize aged buses which need to be replaced, offering key recommendations:

RECOMMENDATIONS

1. Enact policy standards to integrate electrification within current frameworks;
2. Increase provincial subsidies to cover the full capital costs of electric school bus fleets;
3. Extend federal funding programs for electric school buses;
4. Review and streamline funding program structures;
5. Increase accessibility to charging infrastructure and improve network connectivity;
6. Explore the economic and energy potential of electric school buses in vehicle-to-grid technology;
7. Review the retirement standards of internal combustion engine buses;
8. Revise existing contracts with fleet operators;
9. Invest in training programs for electric school bus operation, and maintenance;
10. Increase awareness of electric school bus benefits and existing funding programs;
11. Systematize data collection and information sharing.

Introduction

The famous yellow North American school bus has been transporting children to school since the 1930s, fueled almost exclusively by fossil fuels. 90 years later, nearly all school buses in Canada still rely on these carbon-emitting energy sources.

The first section of this report outlines the range of benefits offered by electric school buses (ESBs). It shows that ESBs contribute to achieving greenhouse gas (GHG) emission reduction targets set by Canadian jurisdictions, in addition to reducing diesel-related air pollution and associated respiratory illnesses. The transition to ESBs also generates economic spin-offs, creating employment opportunities and reducing the operational costs associated with buses. ESBs are thus an essential tool for tackling climate, health and economic challenges.
The second section paints a picture of the school transportation sector in Canada. It begins by presenting the latest data on the distribution, age, types and electrification share of the Canadian school bus fleet. It then provides an overview of federal and provincial policies and funding programs that have contributed to the adoption of ESBs in certain regions of the country.

The third section explains the complexity of acquiring ESBs, ranging from logistical issues such as range limitations to administrative obstacles related to costs and financing of ESBs, as well as barriers related to charging infrastructure and workforce training issues.

In the fourth section, the report outlines CESBA's goal of achieving a complete transition to ESBs by 2040, covering all 51,000 buses responsible for transporting children across Canada and aligning with Canada's targets of respectively achieving 100% of total medium- and heavy-duty vehicle (MHDV) sales as zero-emission vehicles (ZEVs) by 2040.

As part of the final section, the report offers a comprehensive set of recommendations to realize CESBA's goal, ranging from funding measures to lower the cost of ESBs and to install more charging infrastructure, to policy proposals to reduce administrative burden and logistical intricacies.

1. Why Canada Should Embrace ESBs

In the context of the ongoing global climate and health crisis, electrifying the Canadian school bus fleet presents a unique opportunity to make significant strides towards decarbonizing the transportation sector (IPCC, 2023; Health Effects Institute, 2020). This would support the necessary energy transition, while generating health and economic benefits for the country.

Indeed, the shift to ESBs could be seen as a low-hanging fruit, as this helps reduce GHG emissions, improve air quality, foster economic development, and generate savings in the long run. This section delves into the climate, health and economic benefits of transitioning away from diesel school buses for society, but more specifically for governments and school transportation stakeholders in Canada.

1.1. CLIMATE BENEFITS

To this day, Canadian school bus fleets are still powered primarily by diesel. Along with other MHDVs, school transportation contributes to 30% of GHG emissions within Canada's transportation sector, which, in turn, accounts for 22% of total national emissions (ECCC, 2021; Government of Canada, 2023b).

Electrifying school buses presents a promising opportunity to **reduce GHG emissions** associated with fossil fuel combustion, in line with the GHG reduction targets set forth by various Canadian jurisdictions (**Table 1**).

Table 1. Summary of GHG emissions reduction target per jurisdiction

Jurisdiction	GHG Emissions Reduction Target
Canada	40-45% reduction in GHG emissions below 2005 levels by 2030; net zero emissions by 2050 (2030 Emissions Reduction Plan)
British Columbia (B.C.)	40% reduction in GHG emissions by 2030 and 80% by 2050; 27-32% reduction in transportation emissions by 2030 (CleanBC Roadmap to 2030)
Ontario	30% reduction in GHG emissions below 2005 levels by 2030 (Made-in-Ontario Environment Plan)
Quebec	37.5% reduction in GHG emissions by 2030; 40% reduction in petroleum consumption by 2030; net zero by 2050 (2030 Plan for a Green Economy)

Prince Edward Island (P.E.I.)	40% reduction in GHG emissions below 2005 levels by 2030 (Climate Leadership Act)
New Brunswick (N.B.)	46% reduction in GHG emissions below 2005 levels by 2030; net zero by 2050; 20-40% reduction in GHG emissions from vehicles fleets by 2030 (New Brunswick's Climate Change Action Plan)
Nova Scotia (N.S.)	53% reduction in GHG emissions by 2030; net-zero emissions by 2050 (Nova Scotia's Climate Change Plan for Clean Growth)

In fact, manufacturers estimate that the replacement of a standard diesel bus with an ESB reduces GHG emissions by 23 tonnes, which is equivalent to taking five cars off the road (Government of P.E.I., 2021b). Nationwide, this would mean that electrifying Canada's entire bus fleet has the potential to remove 1.17 million tonnes of GHG emissions annually, the equivalent of avoiding 1.66 million one-way flights from Halifax to Vancouver every year (Curb6, n.d.) (see **Appendix A**).
Put differently, annually, a school bus fleet consisting entirely of ESBs would have the same emissions reduction impact as 260,360 gasoline-powered passenger vehicles being driven for the same duration, considering an average annual distance traveled of 18,538 kilometers per vehicle (EPA, 2023). Additionally, an entirely ESB fleet would eliminate around 243,000 liters of fossil fuel that the school transportation sector consumes annually (Statistics Canada, 2023).

In provinces, such as Quebec, where electricity emits very little GHG, the reduction in emissions during the use phase of an ESB could reach 92% (Équiterre, 2019). The Government of Quebec estimates that, by electrifying 65% of the school bus fleet by 2030, it could avoid nearly 800,000 tons of GHG emissions (MTMD, 2023). In N.S., a fleet of 100% ESBs would save almost 23,000 tons of carbon dioxide (CO_2) per year (Ecology Action Centre, 2022).

1.2. HEALTH BENEFITS

In addition to GHG emissions, the electrification of school buses provides a significant avenue to **decrease diesel-related air pollutants**, including nitrous oxides (N_2O), sulfur oxide (SO), and particulate matter (PM). This reduction directly translates to mitigated health risks, such as acute respiratory symptoms, asthma flare-ups, cardiovascular diseases, and cancers (CCNB, 2022). According to Health Canada (2022), the collective impact of traffic-related air pollution results in approximately 1,200 premature deaths annually, as well as 2.7 million instances of asthma symptoms and 210,000 asthma symptom days.

Moreover, ESBs **reduce noise exposure**, leading to a range of health benefits. Indeed, ESBs reduce noise levels mainly due to their utilization of electric motors in lieu of internal combustion engines (ICE). They produce minimal vibrations when contrasted with the mechanical components inherent to ICE vehicles. Thus, unlike traditional diesel engines that produce noise through combustion, electric motors are inherently quieter. This alleviates annoyance, enhances sleep quality, supports better cognitive development in children and even improves school attendance (Snider, 2022; Pedde & al., 2023).

Reduced noise and air pollution could particularly benefit school bus drivers and the 2.2 million children conveyed daily across the country (Task Force on School Bus Safety, 2020), as well as marginalized communities who are often located near major roadways and bus routes.

In regards to mental health, electrifying school bus fleets offers a chance for schools to embody active hope through climate action. This further inspires a sense of collective purpose and empowerment among students and fostering a more sustainable future (Delphi Group, Pollution Probe & CPCHE, 2022). Above all, the transition to 100% ESBs helps to **combat climate change and mitigate its effects on students' mental health**, including post-traumatic stress after climate change-induced natural disasters, climate anxiety, feelings of government betrayal and moral injury (Delphi Group et al., 2022)

1.3. ECONOMIC BENEFITS

By alleviating air pollution and its burden on the healthcare system, electrifying school buses could **generate significant savings in health costs**. The shift to ESBs could yield annual healthcare savings of approximately 1 million dollars ($M) in Quebec (Équiterre, 2019) and $7.2M in Ontario (Delphi Group et al., 2023). Similarly, by electrifying its public school bus fleet, B.C. could see savings of up to $15M over a 12-year bus life, or $11,800 per bus (Pembina Institute, 2022). Scaling this impact to encompass the entire Canadian school bus fleet, potential healthcare savings would exceed $601M over 12 years (see **Appendix A**).

Transitioning to ESBs also has the potential to **drive economic growth**. In Quebec, if all school buses were converted to electricity, it is estimated that the trade balance could improve by an annual amount ranging from $50M to $100M (Équiterre, 2019). This means that Quebec's financial situation, particularly its imports and exports, could benefit by this significant amount each year due to its concentrated production of ESBs with major ESB constructors such as Girardin Blue Bird and Lion Electric. For example, it is estimated that Lion Electric's new plant dedicated to the production of lithium-ion batteries for MHDV will create 135 permanent jobs in the province (Pavic, 2023). In Ontario, the electrification of 65% of its school bus fleet by 2030 promises to generate 10,800 jobs and 1.5 billion dollars ($B) in gross domestic product (GDP), This estimate exclude the 2,400 extra jobs and an additional $300M to the GDP generated by the manufacturing and installation of recharging infrastructure only (Smith, Jantz & Lloyd, 2023).

For fleet operators, ESBs provide significantly **reduced operational expenses**. In comparison to ICE buses, ESBs cost 80% less to power due to their higher engine efficiency and the lower cost of electricity. There is also an estimated 50% reduction in maintenance costs due to fewer moving parts (Dunsky Energy + Climate, 2023a). ESBs also **offer potential revenue sources**, such as the Clean Fuel Regulation Credits (CFRC), which provide credits to operators of electric vehicle (EV) charging sites when they opt to power their vehicles with clean fuel. At an assumed credit rate of $300, ESB operators can harness the CFRC to generate over $5,000 in revenue per ESB per year (Dunsky Climate + Energy, 2023a).

ESB operators can further generate income by using vehicle-to-grid technology (V2G), which utilizes the vehicle's onboard energy storage system to provide power back to the grid. The annual average revenue for V2G participation is estimated at $3,000 per ESB per year, thereby reducing the payback period of an ESB by 2 to 3 years (Dunsky Climate + Energy, 2023b).

Box 1: Explanation of V2G technology and its application to ESBs

Context	In a context where power outages are expected to increase with extreme weather events, the use of ESBs equipped with V2G technology appears more relevant than ever.
What is V2G?	V2G services function similarly to a battery storage system, offering a wide range of benefits. On the utility side, V2G allows EV batteries to serve as reserve generation system capacity, rapidly responding to changes in overall demand. It also facilitates the acquisition and storage of inexpensive electricity during off-peak hours, enabling the sale of electricity during peak demand periods when prices are at their highest. On the customer side, V2G-capable vehicles can help restore power to the grid during outages. Additionally, V2G participation can assist in reducing peak load and demand charges by utilizing the energy stored in EVs equipped with bidirectional chargers.
Why are ESBs perfect for this?	ESBs are well-suited for V2G participation due to their significant amount of downtime. On average, **school buses are only used for 4-5 hours per day and approximately 190 days per year**. In other words, they spend 80% of weekdays during the school year sitting idle, and for nearly 50% of the year they're not used at all. This provides ample opportunity to harness the energy stored in ESBs for grid benefits.

Source: Dunsky Energy + Climate (2023b)

2. Mapping Canada's School Bus Landscape

This section delves into the current state of school bus electrification in Canada, exploring the opportunities, challenges, and policy measures in place to accelerate this transition. To gain a comprehensive understanding, we examine the Canadian school bus fleet, its electrification progress, and the support mechanisms offered at both provincial and federal levels.

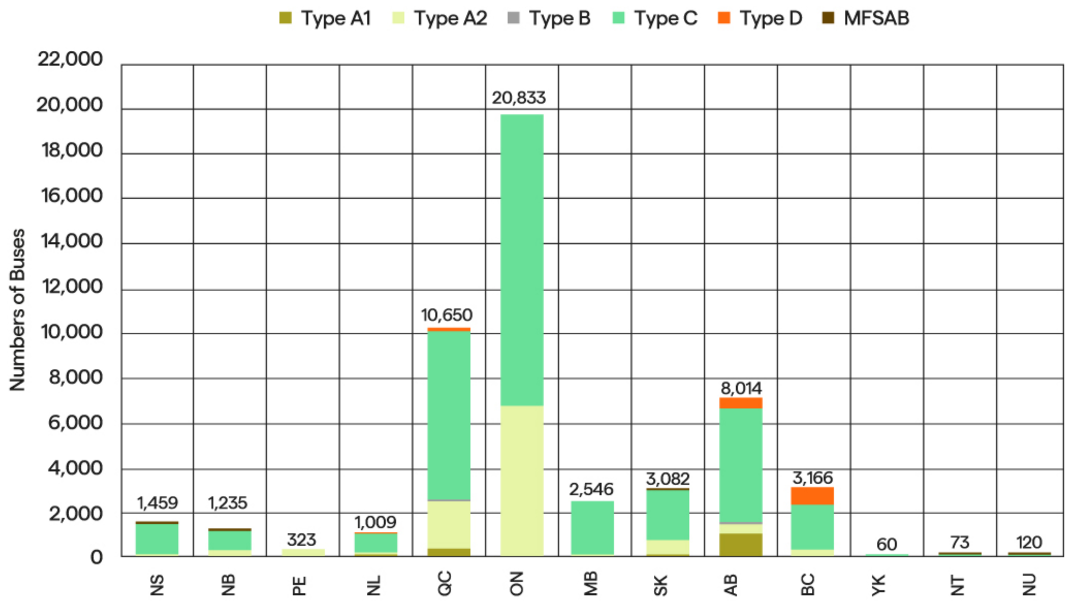
2.1. CANADA'S SCHOOL BUS FLEET

Across Canada, there are **between 45,000 and 50,000 school buses**, with approximately **70% using diesel fuel** (Statistics Canada, 2023; Kozelj, 2022). School buses are mostly concentrated in Ontario (20,833), Quebec (10,650) and Alberta (8,014) (Task Force on School Bus Safety, 2020).

There are a number of different school bus configurations in service, including types A to D and Multifunction School Activity Buses (MFSABs). To illustrate, Type C and Type D buses have respective passenger capacities of up to 76 and 74 individuals. In contrast, Type A and Type B buses accommodate 10 to 16 passengers and 10 to 30 passengers (Dunsky Climate + Energy, 2023a). MFSABs are designed for specific purposes beyond traditional student transportation (field trips, sports events, etc.). The composition of the school bus fleet varies across provinces and territories. Type C school buses are the most common in Canada, accounting for 71% of registered school buses, while Type B buses and MFSABs are rare (Task Force on School Bus Safety, 2020).

Canada's school bus fleet is relatively young, with **45% of buses being less than five years old** (**Figure 1**). Considering that school buses must be withdrawn from service when they reach an **average age of 12 years old** (after which they are no longer deemed safe for student transportation), these buses will continue to be on the road for another 7+ years. This demonstrates the importance of putting the immediate brakes on the purchase of new ICE buses.

Figure 1. Breakdown of provincial and territory school bus fleets by type



Source: Dunsky Energy + Climate (2023a)

2.2. STATE OF SCHOOL BUS ELECTRIFICATION

In contrast to ICE buses, the number of ESBs operating in Canada so far has been small. Recent data, though limited, indicates a **total of over 900 ESBs**, **representing less than 2% of the total Canadian fleet** (Dunsky Energy + Climate, 2023a). A similar situation prevails in the United States, where ESBs make up about 1% of the school bus fleet, with 5,612 ESBs out of a fleet of more than 500,000 (Freehafer & Lazer, 2023).

In terms of absolute numbers, Quebec is at the forefront with more than 766 ESBs, followed by P.E.I. (82), B.C. (52), and Ontario (20) (SAAQ, 2023; Ross, 2022; ASTSBC, 2022; Ecology Ottawa, 2023). It's worth noting that N.B. ordered 20 ESBs for 2023-2024, while N.S. currently lacks any ESBs (CCNB, 2023). In Ontario, fleet operators have placed orders for a minimum of 200 ESBs, with anticipated delivery dates falling within the 2022 to 2026 timeframe (Elective, 2021).

However, when considering the share of ESBs relative to their respective school bus fleets, P.E.I. emerges as a leader with more than 25% of its fleet now electrified (Ross, 2022). In contrast, Quebec and B.C. have a much lower share of their fleets electrified, at just 5% and 6%, respectively (SAAQ, 2023; ASTSBC, 2022).

This higher number of ESBs in Quebec, B.C. and P.E.I. can be attributed to the adoption of favorable policy measures at the provincial level aimed at accelerating the electrification of their school bus fleet.

2.3. POLICY & FUNDING SUPPORT

Amidst the pursuit of electrifying school bus fleets across the country, specific jurisdictions have taken a proactive stance by adopting specific electrification targets and by allocating dedicated funding to support this mission. This section provides an overview of programs and incentives implemented in B.C., Quebec and P.E.I. that have contributed to achieving the highest provincial share of ESBs compared to other provinces.

2.3.1. British Columbia

The Government of B.C. has adopted new ZEV targets for MHDVs that are in line with California's targets. The proposed regulation would require **MHDV sales to be 100% ZEVs by 2036** (Government of B.C., 2023).

In B.C., the CleanBC Go Electric School Bus Program provides up to 33% of the pre-tax purchase price for ESBs. This program also offers financial support for charging infrastructure and covers the costs of facility assessments. School bus fleet operators are eligible for the following rebates:

→ Up to $150,000 for the acquisition of an ESB;
→ Up to $6,000 for purchasing and installing Level 2 charging stations; and
→ Up to $5,000 for ZEV infrastructure assessments to facilitate the development of facilities for supporting an ESB fleet.

The CleanBC Go Electric Fleets program offers a comprehensive range of support, encompassing training, advisory services, and financial assistance. This assistance includes ZEV fleet advisor services, ZEV fleet assessment, rebates for electrical infrastructure upgrades, telematics tools and facility planning assessments. Additionally, for a limited duration, rebates are available for the purchase and installation of Level 2 charging stations, as well as for the acquisition and installation of fast chargers. The program also offers training sessions, webinars, and access to resources and tools via the West Coast Electric Fleets Toolkit (Plug In BC, n.d.).

Indigenous communities and businesses currently qualify for enhanced incentives, receiving 75% of the expenses covered for acquiring and installing charging equipment at their residences or workplaces. There are also Indigenous-owned direct current (DC) fast charging stations that can access higher incentives, receiving up to 90% of project expenses, with a maximum cap of $130,000 per installation. (Government of B.C., n.d., a).

The Ministry of Education and Child Care allocates core bus funding with an annual budget of $15M for the replacement of buses that have reached the end of their service life. Based on bus size, an additional $25,000 to $30,000 (based on bus size) is offered for each replacement. Further, the *Carbon Neutral Capital Program* offers a one-time grant of $50,000 to empower school districts in lowering their carbon footprint. Combined financial support ranges from $100,000 to over $200,000 per ESB.

2.3.2. Prince Edward Island

As part of its 2040 Net Zero Framework, the Government of P.E.I. (2022a) has set the goal of **decarbonizing at least 40% of registered MHDVs by 2040 and electrifying half of the province's school buses by 2027**.

The government is currently committed to investing $40.3M over the next five years (Government of P.E.I., 2021a). This substantial investment, including $6M from Infrasture Canada as part of the Investing in Canada Plan, has already translated into the purchase of 35 ESBs (Government of P.E.I., 2022b).

2.3.3. Quebec

Quebec has committed to **electrifying 65% of the school bus fleet by 2030**, a target adopted as part of the *Programme d'électrification du transport scolaire* (PETS [School Bus Electrification Program]). This initiative aims to provide financial support to the realm of school transportation, where the *Ministère des Transports et de la Mobilité durable* (MTMD [Ministry of Transportation and Sustainable Mobility]) offers up to $150,000 for the purchase of an ESB and up to $30,000 for the acquisition and installation of a charging station.

This commitment to electrifying school buses is further reinforced by a mandate that took effect on November 1, 2021, **requiring all new school bus purchases to be electric**. Since then, the number of ESB orders has surged to a record-breaking 900 for the 2021-2022 school year, as reported by the MTMD (2023).

Through the program *Transportez ver*t [Green Transportation], the *Ministère de l'Environnement, de la Lutte contre les changements climatiques, la Faune et les Parcs* [Ministry of Environment, Climate Change, Wildlife and Parks] offers up to $150,000 per year for the installation of DC fast chargers, funding for hiring specialists, training in vehicle energy management, and support for school transporters in planning their fleet replacement. The *Ministère de l'Éducation* [Ministry of Education] provides an annual grant of $7,900 to support the acquisition of ESBs and a one-time amount of $5,000 per operated ESB. The amounts are determined based on the subsidies provided by the MTMD.

2.3.1. Federal

While the Government of Canada **has not yet set a specific target for ESBs, they fall within the current target of 35% of total MHDVs sales to be ZEVs by 2030, and 100% by 2040**. However, as this pertains only to the sales of new vehicles, rather than the conversion of the entire fleet to electric by that date, this target falls short compared to those of certain Canadian provinces such as Quebec and P.E.I. (Dunsky Energy + Climate, 2023a).

However, the federal government does offer several programs to support ESB adoption. Infrastructure Canada's Zero-Emission Transit Fund program (ZETF) offers approximately $550M for ICE bus replacement planning, covering upfront vehicle and infrastructure costs by offering up to around $205,000 for the purchase of a Type-C ESB and $2,500 for the infrastructure (Dunsky Climate + Energy, 2023a). The program will end on March 31, 2026 (Government of Canada, 2023c).

Natural Resources Canada administers the Zero-Emission Vehicle Infrastructure Program (ZEVIP), providing $680M for EV charging and hydrogen refueling infrastructure (Dunsky Climate + Energy, 2023a). Commencing in June 2019, ZEVIP is currently scheduled to continue until 2027. Funding allocations per type of EV charger vary, ranging from $5,000 per port for Level 2 chargers to $100,000 per port for Level 3 DC fast chargers. ZEVIP also extends funding opportunities to Indigenous organizations and communities for projects centered on EV charger installation in public areas, on streets, within multi-unit residential complexes, at workplaces, and for vehicle fleets (Government of Canada, 2023d).

Additionally, the Canada Infrastructure Bank's (CIB) *Zero-Emission Buses Initiative* (ZEBI) offers direct loans to fleet operators to help facilitate ESB implementation. Repayment of CIB's loans through the initiative is directly derived from the savings resulting from the reduced operational expenses of ESBs compared to the higher operational costs of diesel buses. The CIB also provides tax credits under the Accelerated Capital Cost Allowance program. Specifically, zero-emission school buses fall under class 55, allowing profitable companies to deduct a larger portion of their ZEV purchase in the first year, resulting in enhanced tax benefits (Dunsky Energy + Climate, 2023a; Government of Canada, 2023a).

Table 2. Summary of ESB targets and funding programs per jurisdiction

Jurisdiction	ESB Target	Funding Programs
B.C.	Anticipated ZEV targets for MHDVs are set to be formulated in accordance with California's standards, which mandate that all new trucks and buses should transition to electric power by 2036.	Substantial financial assistance, ranging from $100,000 to well over $200,000 per ESB. Additional funding support is available for Indigenous communities and businesses.
P.E.I.	Aiming for full electrification of the Public Schools Branch fleet by 2030.	The Governments of P.E.I. and Canada are jointly allocating $6.3M for the acquisition of ESBs in the province, utilizing the Green Infrastructure stream within the Investing in Canada infrastructure plan.
Quebec	Beginning in November 2021, all new school bus purchases shall be electric, with a goal of achieving 65% ESBs in Quebec by 2030.	Restored financial assistance to $150,000 per ESB purchase for the 2023-2024 fiscal year and extended an extra $25,000 in assistance for bus models equipped with batteries of 155 kWh and beyond.
Federal	No official ESB adoption goal; ESBs fall under the goal of having 35% of MHDV sales as ZEVs by 2030 and 100% by 2040.	Substantial financial assistance is available from the ZETF program to cover ESB cost and ZEVIP to cover EV charging. There are also direct loans to fleet operators from CIB's ZEBI and tax credits from the Capital Cost Allowance program.

3. Hurdles to ESB Adoption

While government funding mechanisms have undoubtedly played a role in subsidizing the electrification of school districts and private fleets, challenges persist in accessing these programs. Purchase incentives are pivotal in facilitating fleet electrification, but they constitute just one aspect of the overall process. This section sheds light on the diverse factors that are impeding the transition to ESBs, encompassing cost and funding, charging infrastructure, administrative hurdles, logistical complexities, as well as training, knowledge, and awareness gaps.

3.1. ADMINISTRATIVE BARRIERS

There are various administrative challenges that school bus operators across different Canadian provinces face when transitioning to ESBs.

Federal funding options, notably the ZETF program and CIB loan program, are encumbered by procedural challenges (Dunsky Energy + Climate, 2023a). At a broader level, the structure of the ZETF program results in prolonged processing times and difficulties in orchestrating timely vehicle replacements. These hurdles are primarily attributed to delays inherent in the approval process, further impeding the seamless incorporation of ESBs.

These challenges often involve navigating complex application processes for subsidies and loans. For instance, operators seeking federal funding for ESBs and charging infrastructure must contend with the requirement to apply to two separate programs, namely ZEVIP and ZETF. In B.C., operators face an even more intricate process, involving applications to three distinct programs: ZEVIP, ZETF, and *CleanBC Go Electric School Bus Program*.

Moreover, despite operators in the Maritimes being eligible for federal programs, many opt not to apply due to the intricacies of the application process, resulting in a notably low number of ESBs in N.B. and N.S. Quebec-based transporters encounter a different challenge, as they lack access to federal programs altogether.

Furthermore, school districts in B.C., for instance, find themselves grappling with the time-consuming and complex application process for obtaining loans from the CIB. Taking loans from the CIB program for these school districts is an unusual practice since they are not permitted to do so under normal circumstances;

therefore, many school districts in B.C. remain hesitant to engage in such financial commitments (Pembina Institute, 2022). The process of applying to multiple funding programs also introduces its own administrative strain, especially in provinces where both federal and provincial funding opportunities coexist.

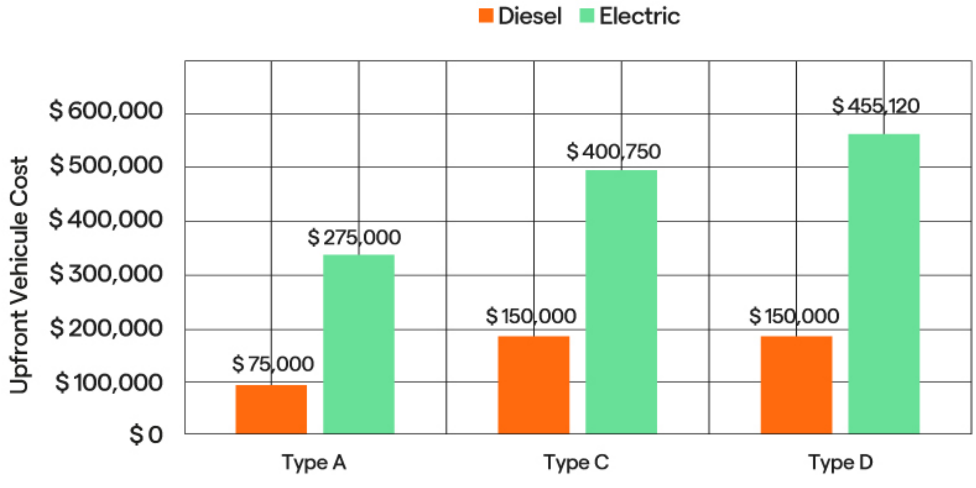
Lastly, the pre-existing contractual framework adds another layer of complexity to the transition process. Typically, contracts between school bus companies and school boards possess a relatively short duration, spanning around 5 years (Delphi Group et al., 2023; Équiterre, 2019). This limited contractual time frame does not incite fleet operators to contemplate the adoption of ESBs. Therefore, the short-term nature of these contracts falls short in providing a conducive environment for bus companies to commit to the transition, thereby exacerbating the challenges inherent in altering the composition of school bus fleets.

These administrative complexities can significantly impact the adoption of ESBs in various regions, highlighting the need for streamlined processes and improved accessibility to funding opportunities.

3.2. COST AND FUNDING

The electrification of school bus fleets in Canada encounters substantial financial hurdles. Comparatively, the cost of ESBs looms significantly higher than their diesel counterparts. In general, the purchase price of an ESB before subsidies can cost anywhere between 1.5 to 2.5 times an equivalent diesel bus (**Figure 2**) Certainly, a Type-C ESB typically carries an average price tag of $400,750, while a Type-C ICE school bus comes in at an average upfront cost of $150,000 (Dunsky Energy + Climate, 2023a).

Figure 2. Initial cost of Type A, Type C and Type D ICE buses and ESBs



Source: Dunsky Energy + Climate (2023a)

Federal funding may prove insufficient for fleet operators, particularly those residing in provinces lacking their own provincial funding streams to supplement federal support. This disparity can create financial challenges for operators striving to electrify their fleets.

Certain provinces such as Ontario, N.B. and N.S. do not provide funding options that could be stacked with existing federal funding sources. For example, Ontarian fleet operators must allocate an additional $260,000 compared to diesel-powered school buses; this situation makes it difficult for fleet operators to replace even 10% of their current bus fleets with ESBs (Delphi Group et al., 2023).

While provincial funding sources in certain provinces offer additional assistance, their limitations present a significant obstacle for fleet operators and school districts striving to bridge the cost gap between ICE buses and ESBs. In B.C., core bus funding from the Ministry of Education and Child Care (2022) is only accessible for replacing buses nearing retirement. This leaves new additional buses without the benefit of this funding and requires fleet operators to allocate an additional $60,000 to $147,000 to bridge the gap between diesel and electric models (Pembina Institute, 2022). All fleet operators surveyed in Quebec identify the primary challenge associated with purchasing ESBs as the substantial cost, even after factoring in subsidies (Équiterre & Propulsion Québec, 2023).

In Quebec, another challenge associated with its funding options, particularly PETS, is its requirement for ESBs to be assembled entirely in Canada. This is attested by the majority of surveyed fleet operators who have expressed the need for the expansion of available ESB models within the framework of PETS (Équiterre & Propulsion Québec, 2023). Not only does it restrict the range of eligible models and manufacturers, but also contributes to exacerbating delivery delays in Quebec, which can further hamper the overall adoption of ESBs within the province.

The need for significant investment extends beyond the purchase price, encompassing charging infrastructure and potential electrical upgrades. This poses a challenge, especially for school transportation operators, as these costs can be substantial. For instance, annual maintenance for a Level 3 charger might reach up to $3,000 (Propulsion Québec, 2022). According to a survey by Équiterre and Propulsion Québec (2023), fleet operators expressed concern about additional expenses related to charging infrastructure procurement and installation.

3.3. CHARGING INFRASTRUCTURE

One of the pivotal challenges in electrifying school bus fleets is the inadequacy of charging infrastructure. This deficiency is felt across multiple provinces. In P.E.I., there are only 12 chargers for the fleet of 82 ESBs, caused by installation delays and supply chain shortages (Huntington & Curran, 2022).

This scarcity forces fleet managers into the complex task of sharing limited chargers and coordinating charging schedules, especially for buses traversing extended distances. As a strategy to mitigate this issue, P.E.I. is initiating a pilot project to install home charging stations for some bus drivers (Ross, 2022).

Adding to these challenges, school transportation operators in B.C. grapple with issues surrounding network connectivity and charging port availability (Pembina Institute, 2022). For instance, a district faced connectivity problems, leading to overnight charging failures; they addressed it by using a standalone charging station. However, this solution might hinder load management and accessing cost-effective nighttime charging rates for the district. In addition, in Quebec, fleet operators face delays in connecting to the Hydro-Québec network, delaying the transition to 100% ESBs, with the survey findings indicating that one fleet operator experienced a postponement lasting up to 9 months (Équiterre & Propulsion Québec, 2023).

Box 2: Charging issues specific to indigenous communities

Ensuring equitable access to ESBs and the necessary charging infrastructure across Canadian communities is a significant challenge. Remote and northern communities face specific barriers, including a lack of connection to the electrical grid and higher costs for installing charging infrastructure. Many of these communities have a substantial Indigenous population and experience a notable absence of EV charging facilities, despite efforts by certain governments (e.g. B.C. and Government of Canada) to invest in such infrastructure. This lack of charging options is particularly critical because the distances to be covered in Indigenous communities are often more extensive. This situation hinders the adoption of ESBs, even though these communities could potentially benefit the most from the associated environmental and health improvements. Furthermore, it is worth noting that Indigenous communities are disproportionately impacted by the manufacturing of EV batteries.

3.4. LOGISTICAL ISSUES

Logistical intricacies pose significant barriers to the adoption of ESBs across various dimensions.

With the existing technology and infrastructure, ESBs fall short in covering the entirety of routes, particularly those that serve essential educational programs requiring transportation. This challenge is particularly pertinent in B.C., where the issue of range poses constraints on the ability of ESBs to serve all routes while upholding the requisite service quality. Similarly, P.E.I. raises valid concerns about range loss caused by factors such as headwinds, uphill driving, and frequent stops (McEachern, 2022). In Quebec, fleet operators state that inadequate autonomy for ESBs stands as a prominent concern in the transition to 100% ESBs (Équiterre & Propulsion Québec, 2023).

Concerns regarding range and autonomy become significant, particularly in rural areas with extended routes and harsh cold weather conditions. Winter operations are one of the most commonly cited barriers to the adoption of ESBs in Ontario (Burgoyne-Allen & O'Keefe, 2019). Studies show that EV battery energy consumption can vary by up to 40% under winter conditions (Rastani et al., 2019).

3.5. KNOWLEDGE, AWARENESS AND TRAINING

The shortage of appropriate training programs emerges as a significant obstacle hindering the widespread adoption of ESBs.

Across various provinces, a distinct lack of training programs designed for the maintenance of zero-emission MHDVs is evident (Delphi Group et al., 2023). Two notable challenges associated with ESB maintenance training, as reported by surveyed fleets operators from Quebec, are the insufficiency and inadequacy of the provided training programs and the shortage of qualified maintenance workers capable of working with zero-emission MHDVs (Équiterre & Propulsion Québec, 2023). In addition, Ontario colleges currently lack specialized training programs for motive power technicians specializing in zero-emission MHDVs.

Instead, efforts in this direction predominantly stem from private sector initiatives, mainly situated in the US. Merely a handful of original equipment manufacturers extend targeted training to maintenance professionals and drivers within Canada. For instance, Lion Electric stands out by delivering a range of training initiatives for mechanics, drivers, and school district personnel as an integral component of its Learning Academy service.

This deficiency in comprehensive training hampers the readiness of the workforce to effectively manage and maintain ESBs, thereby impeding their seamless integration into the broader fleet operations.

Due in part to the absence of training programs for drivers and technicians, a significant gap in knowledge and awareness emerges as an additional challenge in the journey toward adopting ESBs. In many provinces, fleet managers grapple with the lack of essential information, resources, and logistical support needed for a smooth transition and operational continuity with ESBs. As an instance, school districts within B.C. necessitate understanding the existing sources of funding and demand technical assistance in choosing, setting up, and managing suitable charging infrastructure (Pembina Institute, 2022).

Meanwhile, in P.E.I., the workforce's incomplete understanding of ESB components constitutes a significant concern. This gap in knowledge translates into extended periods of repair and maintenance cycles, directly affecting operational efficiency (Huntington & Curran, 2022).

These deficits underscore the crucial imperative for the development of comprehensive training programs and robust support systems that can facilitate a successful transition to ESBs fleets. This holds significant importance, given that the process of strategizing, procuring, and implementing ESBs by a school bus fleet operator could span over a period of two years or more (Huntington et al., 2022).

4. The Shift to 100% ESBs

The overarching goal of CESBA is to achieve a complete transition to ESBs by 2040. This means ensuring that all 51,000 buses currently responsible for transporting our children are converted to ESBs (Task Force on School Bus Safety, 2020).

This ambitious objective aligns with Canada's broader target of achieving 35% of total MHDV sales as ZEVs by 2030 and transitioning to 100% ZEV sales by 2040. This ambitious goal is part of Canada's overarching strategy to achieve a significant reduction in GHG emissions and effectively combat the pressing issue of climate change. Additionally, transitioning to ESBs offers a multitude of advantages, including significant reductions in air pollution, which in turn leads to improved public health. Furthermore, this transition can stimulate economic growth by creating jobs in the green energy sector and decreasing operational costs associated with traditional diesel buses.

In a report mandated by CESBA, Pathways for Canadian Electric School Bus Adoption, Dunsky Energy + Climate (2023a) has outlined a roadmap towards achieving 100% ESBs. This pathway required the calculation of the annual number of school buses that would need to be converted to electric, factoring in the current age distribution of the fleet and adhering to a standard retirement threshold of 12 years.

4.1. 2040 SCENARIO

In a 100% ESBs scenario by 2040, an average of over 2,850 buses per year would require conversion to electric between 2023 and 2040, ensuring a consistent and gradual rate of ESB replacements during this period. However, the target allows for adaptable ESB replacement rates on a yearly basis, accommodating potential variations. This approach considers the possibility of a slower initial period due to supply chain limitations, followed by progressively higher rates as ESB supply improves over time.

Table 3 outlines the distribution of new school bus purchases as a percentage under a 100% by 2040 target with a consistent annual ESB adoption rate. The table breaks down the yearly retirement count for vehicles in Canada's school bus fleet, along with the corresponding number and percentage of vehicles that should undergo electric conversion to achieve an average of 2,857 ESB replacements per year. In years with fewer retirements and replacements, the electric conversion share of the fleet increases, peaking at a maximum of 85%.

Table 3. Distribution of new school bus purchases as a percentage under a 100% by 2040 target with a consistent annual ESB adoption rate

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Annual School Bus Retirements	5,578	5,578	3,370	3,370	3,370	3,370	3,370	3,890	3,890	3,890	3,890	3,890	3,890	5,578	5,578	3,370	3,370	3,370
ESB Replacements	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857	2,857
ESB Share of Annual Replacements	51%	51%	85%	85%	85%	85%	85%	74%	74%	74%	74%	74%	74%	51%	51%	85%	85%	85%

Source: Dunsky Energy + Climate (2023a)

A substantial amount of capital is needed in the near future to support the nationwide transition to 100% ESBs. This includes funds for the initial purchase of ESBs and the installation of charging infrastructure. To achieve the goal of 100% ESBs by 2040, an estimated total capital investment of over $1.25B will be necessary in 2023, with contributions coming from various stakeholders, including bus operators and government entities. This capital requirement is projected to decrease gradually as ESB costs decrease, reaching approximately $1.01B by 2040. In summary, the total capital needed over the period from 2023 to 2040 amounts to roughly 2.5 times the annual capital expenditures for diesel buses.

Moreover, such ESB deployment requires ESB production to substantially increase. As per Dunsky Energy + Climate (2023a), the anticipated manufacturing capacity of ESBs in the future is not expected to pose a prolonged obstacle to achieving complete electrification of the Canadian school bus fleet.

Indeed, the report even highlights that ESBs are marginal to total EV production and anticipated battery production capacity. Indeed, while the battery production capacity in North America is projected to grow from about 90 gigawatt hours (GWh) to over 800 GWh by 2025, and nearly 1,000 GWh by 2030, the annual GWh required to electrify all ESBs would be 0.5 GWh for full electrification by 2040, assuming an average battery pack capacity of 161 kWh.

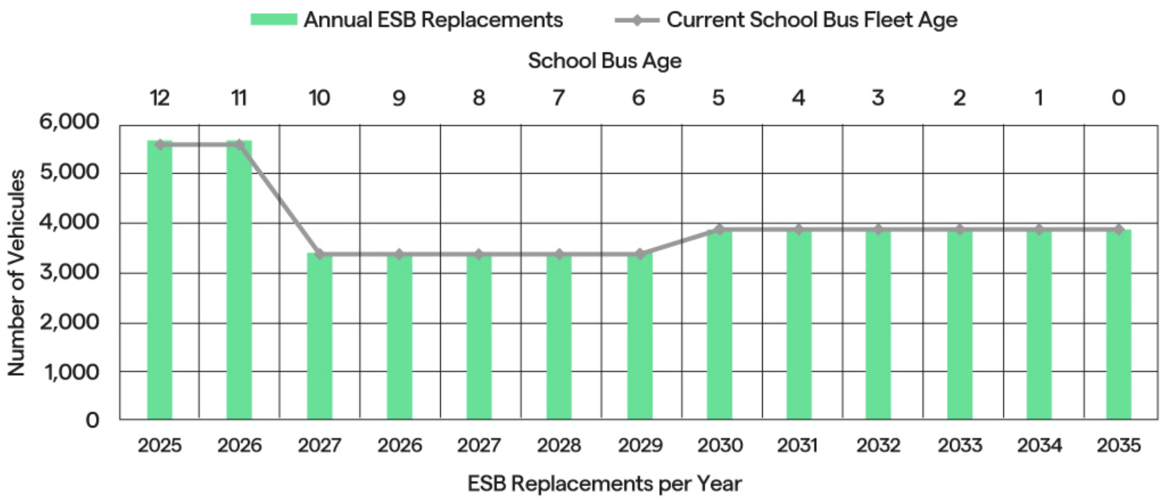
However, ESB manufacturing will still face challenges, notably due to constraints in the supply chain, which has contributed to restricted manufacturing capacity in recent times.

4.2. 2035 SCENARIO

Dunsky Energy + Climate also explored the more ambitious goal of achieving 100% ESBs by 2035. To achieve this latter, every single school bus reaching its 12-year retirement age should be substituted with an electric model starting in 2023. Otherwise, adhering to typical regulations would mean that diesel school buses procured in 2023 might not require replacement until 2036, potentially leading to a target miss.

Figure 3 shows that, due to the current age distribution of Canada's school bus fleet, the peak period for ESB replacements within the 2023-2035 timeframe would happen during 2023-2024. Such near-term deployment targets are not without challenges. Firstly, nationwide mandates for school bus operators to transition to electric models are not uniformly established, limited to specific jurisdictions. Secondly, the global supply chain's constraints are likely to have impacted ESB manufacturing capacity, potentially limiting availability. Lastly, the installation of charging infrastructure should precede ESB deployment; however, if site modifications or infrastructure upgrades are necessary, these could potentially lead to deployment delays.

Figure 3. Annual required ESB replacements to achieve the 100% ESBs objective by 2035



Source: Dunsky Energy + Climate (2023a)

Adopting a more ambitious target of achieving 100% ESBs by 2035 would yield several benefits for our GHG emissions reduction goals. Acting now to reduce a tonne of carbon emissions has a more significant impact on mitigating climate change than delaying action. Additionally, an earlier transition to fully ESB fleets would result in quicker improvements in air quality for communities and cost savings for school bus operators, along with quieter and more comfortable rides.

However, pursuing the 100% by 2035 goal does come with its set of challenges. The primary challenge is the current lack of supply and manufacturing capacity to convert the required number of vehicles to ESBs in the short term. Moreover, accelerating the fleet's transition to ESBs will necessitate more upfront capital.

5. Recommendations for Swift Transition

To make the goal of reaching 100% ESBs by 2040 a reality, Canadian jurisdictions must adopt various proactive measures aimed at promoting and prioritizing the electrification of school bus fleets. A summary of these recommendations and their respective jurisdictions can be found in **Appendix B**. It should be noted that most of the recommendations stem from the work of CESBA's steering committee members.

Policy Standards and Funding

5.1. ENACT POLICY STANDARDS TO INTEGRATE ELECTRIFICATION WITHIN CURRENT FRAMEWORKS

Specific jurisdictions should consider initiating a commitment to transition to a 100% ESB fleet. This entails enacting legislative modifications that firmly embed the electrification of school buses within the policy framework of the respective jurisdictions.

For example, the Government of N.S. could make school buses part of the strategy for transportation electrification alongside transit buses. N.B. could do similarly by expanding its future EV strategy to include school buses and other MHDVs. Ontario could integrate ESB targets within its provincial policies and programs. Embracing this approach, CESBA advises these jurisdictions to articulate the requisite incentives, regulations, policies, and programs essential for achieving their ESB adoption goals.

Simultaneously, as the transition to ESBs fall under the current target to achieve 35% of total MHDVs sales being ZEVs by 2030 and 100% by 2040, there is a call for the Government of Canada to establish a nationwide mandate of 100% ESB sales, as proposed by Dunsky Energy + Climate (2023a). CESBA is confident that this initiative is geared towards ensuring a plentiful supply for the Canadian market, empowering jurisdictions to fully and effectively achieve their commitment to 100% ESB adoption.

In response to short ranging in ESBs, mandating minimum battery capacity for ESBs for bus manufacturers is essential. For example, CESBA suggests that the Government of B.C. should stipulate a minimum 200kWh battery requirement for type C and D ESBs from manufacturers. This could be applied to other jurisdictions such as Quebec where battery production tailored for MHDVs is substantial.

To further mitigate delivery delays as well as ESB short-range challenges, funding programs should extend their scope to include a wider array of ESB models eligible for funding, without confining them solely to assembly within Canada. For instance, CESBA urges the Government of Quebec to broaden the eligibility criteria of PETS, thereby encompassing bus models equipped with more advanced technologies.

5.2. INCREASE PROVINCIAL SUBSIDIES TO COVER THE FULL CAPITAL COSTS

CESBA advocates for an establishment or augmentation of provincial subsidies to fully offset the capital expenses of ESB fleets. This approach alleviates the burden on fleet operators, eliminating the additional costs associated with ESBs in comparison to their diesel counterparts.

This emphasizes CESBA's urging for governments across provincial jurisdictions, regardless of whether they possess very limited or no provincial funding for ESB transitions, to embrace funding initiatives mirroring Quebec’s PETS and CleanBC Go Electric Fleets program.

CESBA also recommends the Government of B.C. and the Government of Quebec to extend their various respective funding sources to further provide ongoing assistance to fleet operators in a context of supply chain disruptions and consequent raw materials price inflation.

As highlighted in **section 3.2**, it is estimated that fleet operators in B.C. face a financial gap ranging from $60,000 to $147,000 when transitioning from diesel to ESBs. Considering that 1,210 school buses in the public fleet of B.C. need to be replaced by 2040, it is recommended that the Government of B.C. bridge this financial gap by allocating an additional funding in the range of $72.6M to $177.9M, which translate to an average annual investment of approximately $6.58M per year.

For example, in Ontario, the government could offer provincial funding that aligns with the federal ZETF program, waive provincial sales tax for ESBs, increase the Ministry of Education budget to launch ESB pilot programs, and extend fleet operators the opportunity to access low-interest financing solutions (Delphi Group et al., 2023). The grants could be phased out when ESBs approach price parity with diesel school buses.

Provinces with existing funding programs, such as Quebec, B.C. and P.E.I, should consider amplifying their provincial funding allocation. For instance, CESBA, responding to fleet operators' concerns about the declining subsidies of PETS amid raw materials inflation, urged the Quebec government to raise the ESB purchase assistance to $150,000 to adjust for inflation. In response, the Quebec Government not only restored financial assistance to $150,000 for the 2023-2024 school year but also extended an extra $25,000 in assistance for bus models equipped with batteries of 155 kWh and beyond.

5.3. EXTEND FEDERAL FUNDING PROGRAMS FOR ESBs

CESBA calls on the federal government to extend existing federal funding programs for ESBs by ensuring additional funds for the ZETF after 2026 and for the ZEVIP after 2027. In the short term, there's a substantial need for capital to support the nationwide transition to 100% ESBs. CESBA recommends allocating an additional $2.5B in dedicated funding for school bus electrification between 2027-2032 for ZETF funding.

5.4. REVIEW AND STREAMLINE FUNDING PROGRAMS STRUCTURE

CESBA advises the federal government to reevaluate funding allocation structures, aiming to mitigate competition between federal and provincial funding initiatives and increase equitable access to ESBs. This approach streamlines application procedures, curbing administrative delays for fleet operators.

The Government of Canada should consider replacing the second phase of the ZETF capital application process with a point-of-sale rebate mechanism. This modification simplifies application procedures and furnishes fleet operators with increased budgetary certainty during the construction phase.

With the aim of streamlining administrative processes, the Government of Canada should also contemplate dividing both ZETF and ZEVIP into distinct funding channels tailored to student transportation and transit electrification endeavors. In a context where a major share of ZETF funding goes to public transit agencies, this strategic division ensures an earmarked funding avenue solely for ESBs, guaranteeing ample financial support for ESB acquisitions. In this division, the ZETF should also earmark funding for Indigenous communities and other higher-needs populations, as is currently done in ZEVIP.

Further steps can be implemented to alleviate the application burden for federal funding, including the establishment of direct or automated access to the ZETF. Reducing the application burden can help to further improve access to funding for Indigenous and/or low-income communities who may have limited resources to complete the current ZETF application process.

CESBA recommends that stakeholders nationwide collaborate to designate a suitable independent entity, which would then apply for funding from Natural

Resources Canada's ZEVIP program. The objective is to create a dedicated funding stream through a third-party delivery organization that focuses specifically on aiding the procurement and installation expenses associated with EV charging infrastructure for school bus operators. This approach leverages government funding to address a critical barrier to ESB adoption.

Charging Infrastructure

5.5. INCREASE ACCESSIBILITY TO CHARGING INFRASTRUCTURE AND IMPROVE NETWORK CONNECTIVITY

CESBA urges all jurisdictions to enhance their funding allocations for charging infrastructure. For example, CESBA suggests that the Ontario government broaden its existing $91M commitment towards chargers to encompass the installation of charging stations for ESBs directly at schools.

In N.B., the government could amplify collaboration with NB Power and private partners involved in the eCharge Network particularly concerning the establishment of charging stations dedicated to school buses. This would help to facilitate a seamless transition to ESBs in the province.

Jurisdictions should also make the eligibility conditions for financial assistance for charging infrastructure more flexible. This adjustment would enable the provision of financial assistance for charging infrastructure requests to be provided at the time of order placement to accelerate the start of installation works and the circulation of ESBs. This would mirror Quebec's government recent announcement that allows for the submission of financial assistance applications for charging infrastructure prior to ordering the ESBs.

As the prevalence of ESBs grows, managing charging infrastructure can pose challenges. To address this, jurisdictions are encouraged to partner with their main electric utilities and supplementary service providers to streamline power grid connections and minimize delays. For example, CESBA asks the Government of Quebec to collaborate with Hydro-Québec to expedite power grid connection procedures.

5.6. EXPLORE THE ECONOMIC AND ENERGY POTENTIAL OF ESBs IN V2G TECHNOLOGY

CESBA recommends that governments investigate the economic and energy opportunities offered by V2G technology as they transition towards the full implementation of ESBs.

This might involve assessing factors such as the capacity of ESBs to store and provide energy back to the grid during peak demand periods, the potential cost savings and potential revenue streams for both bus fleet operators and utilities through financial modeling, and the overall impact on grid stability and energy efficiency. This could also lead to establishing systems to monitor and analyze data from ESBs participating in V2G programs, tracking energy flows, vehicle performance, and overall system impact.

CESBA encourages school bus companies and school transportation boards (STBs) to undertake pilot programs to assess technological and regulatory challenges related to V2G implementation, with a special focus on ESBs as a potential application. It is imperative to analyze the regulatory barriers within provincial utility frameworks that may hinder V2G implementation. Such pilot initiatives hold the potential to enhance the economic viability of ESBs, advocate for regulatory modifications, and expedite the widespread adoption of this technology.

As technology advances, the majority of EVs will become eligible for V2G participation. ESBs play a pivotal role in fostering economy-wide V2G integration as they possess predictable and suitable duty cycles for V2G applications. As a substantial portion of EVs, spanning various categories, engage in V2G initiatives, this decentralized energy storage mechanism evolves into a valuable Distributed Energy Resource.

Administrative and Logistical Issues

5.7. REVIEW THE RETIREMENT STANDARDS OF ICE BUSES

Governments are advised to implement policy measures aimed at phasing out aging diesel buses. In the context of Ontario, CESBA advocates for the introduction of a scrappage program (Delphi Group et al., 2023). This program, typically spearheaded by non-profit organizations with federal or regional government support and supervision, provides financial incentives to fleets for the efficient replacement of older ICE school buses with ESBs, fostering fleet modernization. To help retire the current ICE buses in Ontario, CESBA also recommends Ontario's Ministry of Education to end the school bus diesel subsidy at 98¢ over time (Ecology Ottawa, 2023).

CESBA suggests that the federal government collaborate with provinces to temporarily extend the operational lifespan of existing ICE buses. This approach aims to mitigate the sudden surge in demand for new ESBs required in the short term, further preventing potential bottlenecks in supply. To explain, when transitioning to ESBs, there might be a surge in demand for new ESBs, which could create logistical and financial strain on school districts and fleet operators. Extending the retirement age of existing ICE buses temporarily can help manage this transition period more smoothly. By allowing existing ICE buses to remain in service for a limited additional period, it can reduce the immediate need for a massive influx of new ESBs, giving school districts and fleet operators more time to plan for and gradually integrate the new ESBs into their fleets.

Another reason for this policy recommendation is that if there is a sudden push for ESBs, without a reasonable transition plan, fleet operators might be forced to make hasty decisions, including ordering new ICE buses, just to maintain their operations while they wait for ESBs to become available or for the transition process to be adequately planned. This could lock them into a cycle of continuing to use ICE buses for another possible 12 years, delaying the progress toward electrification.

5.8. REVISE EXISTING CONTRACTS WITH FLEET OPERATORS

In order to address the challenge revolving around the current length of contracts that exist with fleet operators, CESBA encourages STBs to increase the duration of contracts from the current 5 years to 10 years. Extending the duration of contracts would diminish the financial uncertainty associated with ESB acquisitions, enabling the utilization of ESBs' operational cost savings over an extended period within the vehicles' lifespan.

CESBA advises the Departments of Education across Canadian provinces and territories to conduct a financial analysis to determine an appropriate ESB allocation within transportation contracts. They should also consider incorporating a requirement into contracts, stipulating that a certain proportion of ESB purchases must be made when ICE buses reach the end of their operational life. Smaller operators may be granted exceptions in this regard.

Moreover, the funding allocated to STBs by Departments of Education for school bus operations should be augmented proportionally to account for the additional costs associated with ESB requisites. This incremental rollout would provide school bus service operators with the opportunity to acclimate to ESB operations and glean valuable insights. This process will equip them to expand ESB adoption as the total cost of ownership steadily approaches equivalence with ICE school buses.

Knowledge, Awareness and Training

5.9. INVEST IN TRAINING PROGRAMS FOR ESB OPERATION AND MAINTENANCE

CESBA encourages governments to offer subsidized ESB maintenance certification programs for existing MHDVs mechanics. With the growing adoption of ESBs, a proficient workforce will become essential for servicing and upkeeping the new ESB fleet.

Recent studies demonstrate that many cities engaged bus manufacturers for maintenance services upon integrating electric buses into public transit systems (Li et al., 2019). This points to a gap in expertise among maintenance personnel in handling electric powertrain technologies; and underscores the necessity for training and certification programs aimed at equipping existing heavy-duty diesel mechanics with the skills required for ESB fleets. Such training and certification not only enhance confidence in the technology but also cultivate advocates within fleet depots, mitigating any apprehension or reluctance toward the transition to ESBs. This approach also helps alleviate potential labor shortages as more bus operators transition to electrifying their fleets.

Jurisdictions without a zero-emission MHDVs maintenance training program can draw inspiration from the approach taken by the government of B.C. Through collaboration with colleges and universities, B.C. is introducing a pioneering EV Maintenance Training program (2022).

CESBA also suggests that fleet operators offer drivers retraining tailored to ESB technology. The objective is to strengthen drivers' acceptance of this technology while promoting driving practices that optimize battery efficiency and minimize operational expenses. This strategy aligns with Quebec's *Transportez Vert* program, which includes subsidizing 50% of costs for eco-driving training, with a cap of $1,000 per session, and providing complimentary training for eco-driving instructors (Gouvernement du Québec, n.d.).

5.10. INCREASE AWARENESS OF ESB BENEFITS AND EXISTING FUNDING PROGRAMS

CESBA suggests endorsing capacity development for school districts and other school transportation stakeholders, while concurrently conducting educational and outreach efforts to enhance their awareness of potential funding avenues. As an instance, the Government of N.S. could undertake outreach and educational endeavors regarding the accessible funding for ESBs in collaboration with the Halifax Regional Centre for Education and other pivotal stakeholders within the province.

Awareness could go beyond funding venues to ensure that fleet operators are well-informed of support mechanisms that can help with planning and strategy development, procurement and infrastructure, equity and community engagement and technological integration, such V2G technology.

For example, the Ontario Government and school boards could initiate the creation of guides and toolkits aimed at facilitating the transition to ESBs. These resources might encompass aspects like formulating strategies for fleet electrification, procuring vehicles, pinpointing funding outlets, and exploring potential regional charging partnerships for field trips and sporting events. With the aim of maximizing public messaging to the public, the Government of Ontario and the non-profit sector could collaborate to produce public education and awareness materials focusing on the health advantages of ESBs.

CESBA also suggests that the federal government develop awareness campaigns, utilizing initiatives like the Zero-Emission Vehicle Awareness Initiative (ZEVAI), to ensure that school bus operators are well-informed about the advantages of ESBs, as well as the funding programs and potential revenue sources accessible to them. In addition, appropriate third-party organizations could offer technical assistance to school bus fleets in provinces to facilitate access to federal ZETF funding.

CESBA encourages strong support to stakeholders in enhancing their knowledge about ESBs by providing comprehensive guidance on best practices for successful adoption, and by actively engaging with stakeholders to streamline their access to technical assistance.

5.11. SYSTEMATIZE DATA COLLECTION AND INFORMATION SHARING

CESBA advises the establishment of a centralized database for operational data of ESBs. This database would facilitate data collection and knowledge exchange among provinces, reducing the necessity for repeated pilot projects. Managed at the federal level, it would enhance accessibility to ESB operational data concerning battery performance in diverse temperature conditions and the resilience of electric components in challenging weather environments, like snow and salt.

CESBA further suggests standardizing field data collection and promoting information sharing among school transportation providers within provinces.

CESBA advises governments to allocate funds for research focused on the conversion of school transportation systems. Investing in research in the field of conversion for school transportation is crucial because it can provide insights into the most effective and efficient methods of transitioning from ICE buses to ESBs. Such research can help identify technological advancements, operational considerations, and financial implications associated with the conversion process. Additionally, research in this area can facilitate the development of standardized practices, guidelines, and best practices that contribute to a smoother and more successful adoption of ESBs.

Conclusion

The journey towards achieving a complete transition to ESBs in Canada by 2040 is laden with opportunities and challenges. This report has underscored the multifaceted landscape surrounding the adoption of ESBs.

The benefits of transitioning to ESBs are manifold. ESBs offer a promising avenue for Canada to align with its targets of reducing GHG emissions. By promoting cleaner air, reducing noise pollution, and stimulating economic growth, the adoption of ESBs can result in healthier communities and more sustainable transportation systems. These buses are not only a step towards a greener future but also a pathway to job creation in the green energy sector and cost savings associated with traditional diesel buses.

However, realizing this vision faces several important challenges that highlight the intricate relationship between technology, infrastructure, and operational demands in the transition to ESBs. The overall cost of ESBs and their charging infrastructure remain one of the most important challenges that fleet operators, STBs and other stakeholders face. Logistical intricacies, such as limited range and the impact of harsh winter conditions, and administration barriers such as burdensome funding applications pose significant hurdles for ESB adoption. Additionally, the lack of training programs for maintenance workers, coupled with knowledge gaps among fleet managers and bus drivers, impedes the seamless integration of ESBs into school bus fleets.

To accelerate the transition, this report has provided a comprehensive set of recommendations aimed at addressing these barriers and promoting the adoption of ESBs. They call for increased government subsidies to cover the full capital cost of ESB fleets, along with extending federal and provincial funding programs. Enhancing accessibility to charging infrastructure and improving network connectivity are also vital aspects of the transition. Administratively, there is a need to streamline funding programs and review contract structures with school transportation operators. Moreover, investing in training programs for maintenance and operation, as well as providing driving retraining adapted to ESB technology, is essential to bridge the knowledge gap. Heightening awareness among stakeholders about ESB benefits and existing funding programs is also crucial.

Looking forward, CESBA's ambitious vision of achieving 100% ESBs by 2040 in Canada aligns with broader environmental and economic objectives. To navigate the complexities and challenges associated with this transition, proactive measures and collaborative efforts are imperative. By implementing the recommendations outlined in this report, Canadian jurisdictions can work towards a greener, more sustainable, and healthier future for the generations to come.

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Appendices

APPENDIX A. METHODOLOGIES FOR CALCULATIONS

GHG emission reduction estimate across Canada

We took the Government of P.E.I's estimate that replacing a conventional diesel bus with an ESB can reduce GHG emissions by 23 tonnes (Government of P.E.I., 2021b). To calculate the total GHG reduction for the entire Canadian school bus fleet, we multiply the per-ESB reduction by the total number of school buses in the fleet. In this case, it's 23 tonnes per ESB multiplied by approximately 51,000 ESBs (Task Force on School Bus Safety, 2020). The result of this calculation is that electrifying Canada's entire bus fleet has the potential to remove approximately 1.17 million tonnes of GHG emissions annually.

Potential healthcare savings across Canada

This calculation was determined by multiplying the estimated healthcare savings per ESB over 12 years, which is $11,800, by the total number of school buses in the Canadian fleet, which is 51,000 (Pembina Institute, 2022). This multiplication provides an insight into the potential healthcare savings that could be realized if the entire Canadian school bus fleet were to transition to 100% ESBs.

Number of one-way flights from Halifax to Vancouver

The calculation involves finding the equivalent of 1.17 million tonnes of GHG emissions avoided annually, which results from having a 100% ESB fleet, in terms of the GHG emissions produced by one-way flights between Halifax and Vancouver, which is approximately 706.8 kilograms of CO_2 per flight.

To perform this calculation, you would divide the annual GHG emissions avoided by the emissions from one flight:

$$Equivalent\ Flights\ Avoided\ = \frac{Annual\ GHG\ emissions\ Avoided\ after\ full\ electrification\ (CO2e)}{Emissions\ per\ flight}$$

Substituting the values:

$$Equivalent\ Flights\ Avoided\ = \frac{1\ 173\ 000\ tonnes\ CO2e}{0.7068\ kg\ CO2e}$$

When you do this calculation, you'll find the equivalent of 1.66 million one-way flights avoided from Halifax to Vancouver every year due to the GHG emissions reductions achieved by having a 100% ESB school bus fleet. This means that the reduction in GHG emissions is equivalent to the emissions produced by 1.66 million flights between these two cities annually.

Range of total investment required to achieve 100% ESBs in B.C

To calculate the total investment required to achieve Pembina's goal of 100% ESBs in B.C. by 2040, we need to determine the number of buses that need to be replaced during this period, which is 1,210 buses according to data from the Association of School Transportation Services of B.C. (2022). Then, we can estimate the investment range by multiplying this number by $60,000 (representing the lower end) and $147,000 (representing the higher end). The average annual investment required over 16 years was calculated by subtracting the lower funding range ($72.6M) from the upper funding range ($177.9M) to determine the total funding range ($105.3M). This total funding range was then divided by the number of years (16) to arrive at an average annual investment of approximately $6.58M per year

Appendix B. Summary table of recommendations with examples according to specific jurisdiction.

Barriers	Recommendations	Jurisdictions	Examples
Policy Standards and Funding	(1) Enact policy standards to integrate electrification within current frameworks	Federal	Establish a nationwide mandate of 100% ESB sales
		N.S.	Make school buses part of the strategy for transportation electrification
		N.B.	Expand future EV strategy to include school buses and other MHDVs
		All	Set a minimum battery capacity for ESB models to be eligible for grant programs
		Quebec	Expand criteria for models eligible under PETS
	(2) Increase provincial subsidies to cover the full capital costs	Quebec, B.C. and P.E.I.	Extend existing funding sources
		Ontario	Offer provincial funding
			Waive provincial sale tax for ESBs
			Offer low-interest financing solutions for ESB purchase
	(3) Extend federal funding programs	Federal	Ensure additional funds for the ZETF after 2026 and for the ZEVIP after 2027
	(4) Review and streamline funding programs structure	Federal	Reevaluate ZETF's and ZEVIP's funding allocation structure to mitigate competition between federal and provincial funding initiatives
			Replace the second phase of ZETF capital application process with a point-of-sale rebate mechanism
			Divide both ZETF and ZEVIP into distinct funding channels for transit and school transport electrification
			Establish direct or automated access to ZETF
			Designate a third entity or government agency in charge of managing and transferring funding demands for ZEVIP
Charging Infrastructure	(5) Increase accessibility to charging infrastructure and improve network connectivity	All	Increase funding for charging infrastructure
			Make eligibility conditions for financial assistance for charging infrastructure more flexible, notably by permitting applications to be submitted prior to ordering ESB
			Partner with public utilities and private electricity providers to streamline and accelerate connection of charging stations to the power grid
		Ontario	Broaden the existing $91M commitment towards chargers

	(6) Explore the economic and energy potential of ESBs in V2G technology	All	Evaluate the capacity of ESBs to meet peak electricity demand and generate income for fleet owners
			Encourage school bus companies and STBs to undertake pilot programs to examine technological and regulatory challenges related to V2G implementation
Administrative and logistical issues	(7) Review the retirement standards of ICE buses	All	Implement policy measures aimed at phasing out aging diesel buses
		Federal	Collaborate with provinces to temporarily prolong the lifespan of existing ICE buses in order to meet to ESB delivery delays
		Ontario	Introduce a scrappage program to provide financial incentives in replacing ICE buses by ESBs
			End the school bus diesel subsidy at 98¢
	(8) Revise existing contracts with fleet operators	All	Encourages STBs to increase the duration of current contracts with fleet operators from 5 to 10 years
			Conduct a financial analysis to determine an appropriate ESB allocation with transportation contracts
			Include contract clause mandating ESB purchases when ICE buses reach end-of-life
			Increase funding to STBs for the operationalization of ESBs
Knowledge, Awareness and Training	(9) Invest in training programs for ESB operation and maintenance	All	Develop or fund ESB maintenance certification programs for personnel working on ICE MHDV, including school buses
			Develop or fund driver training programs adapted to ESB technology
	(10) Increase awareness of ESB benefits and existing funding programs	All	Support capacity building for school districts and other school transport stakeholders regarding ESB funding
			Raise awareness of available funding options through information campaigns
		N.S.	Develop an awareness and education campaign on ESB funcing in collaboration with the Halifax Regional Centre for Education and other relevant stakeholders
		Ontario	Collaborate with school districts and the non-profit sector to produce information tools designed to facilitate the transition to ESBs for school bus operators and the general public
		Federal	Finance, via ZEVAI, awareness-raising campaigns for school bus operators on the benefits of ESBs and the available support measures

	(11) Systematize data collection and information sharing	Federal	Establish a centralized database of ESB operational date to facilitate data collection and access, and knowledge exchange between provinces
			Invest in research focused on the conversion of ICE buses