# Pathways for Canadian Electric School Bus Adoption (\*\*\*)

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canadian Electric SchCol BUS Alliance

Équiterre

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## Submitted to:



# Équiterre

Sustainable Mobility Team https://www.equiterre.org/

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# **About Dunsky**



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With deep expertise across the Buildings, Mobility, Industry and Energy sectors, we support our clients in two ways: through rigorous **Analysis** (of technical, economic and market opportunities) and by designing or assessing **Strategies** (plans, programs and policies) to achieve success.



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# List of Acronyms and Abbreviations

CAD	Canadian Dollars		
CAGR	Compounded Annual Growth Rate		
CCA	Capital Cost Allowance		
CESBA	Canadian Electric School Bus Alliance		
CFR	Clean Fuel Regulation		
CIB	Canada Infrastructure Bank		
DCFC	Direct Current Fast Charger		
EPA	Environmental Protection Agency		
ESB	Electric School Bus		
EV	Electric Vehicle		
GHG	Greenhouse Gas		
GWh	Gigawatt Hours		
ICE	Internal Combustion Engine		
kWh	Kilowatt Hours		
MHDV	Medium- and Heavy-Duty Vehicle		
MFASB	Multifunction Activity School Bus		
NA	North American		
NRCan	Natural Resources Canada		
OEM	Original Equipment Manufacturers		
тсо	Total Cost of Ownership		
US	United States		
V2G	Vehicle-to-Grid		
ZETF	Zero Emission Transit Fund		
ZEV	Zero-Emission Vehicle		
ZEVIP	Zero-Emission Vehicle Infrastructure Program		

# **EXECUTIVE SUMMARY**

The Government of Canada intends to work towards 35% of total medium- and heavy-duty vehicle (MHDV) sales being zero-emission vehicles (ZEVs) by 2030 and 100% by 2040, where feasible. School buses, in particular, represent a low-hanging fruit in the transition to zero-emission MHDVs: their routes are predictable and often relatively short and they typically return to a central location between shifts where they can charge, making them ideal candidates for electrification. In addition to reducing GHG emissions, electric school buses (ESBs) present notable health benefits and can significantly reduce operating costs.

Given the considerable benefits that ESBs present, the Canadian Electric School Bus Alliance (CESBA) was founded to support policy commitments at all levels of government to enable a widespread transition towards ESBs by 2040. In this study, we set out to better understand the feasibility of CESBA's goal of a fully electric Canadian school bus fleet by 2040 and whether a more ambitious target is feasible. To determine this, we answer the following questions:

- What ESB targets have other leading jurisdictions set?
- What will a transition to 100% ESBs cost?
- How many ESBs would need to be adopted annually to meet CESBAs tentative target of 100% by 2040 and a more ambitious target of 100% by 2035?
- Is there expected to be a sufficient supply of ESBs to meet either target?
- What policies or programs are needed at the federal level to support this transition?

#### Background

Figure ES1 provides a breakdown of the school bus populations by type across each Canadian province and territory. There are an estimated 45,000-50,000 school buses in operation across the country. The vast majority of these buses are fueled with diesel.



Jurisdictions across Canada and the United States have started making commitments to electrify their school bus fleets. These have taken the shape of sales targets for electric school buses, as well as funding programs to support ESB purchases. While the Government of Canada has not yet set a target specifically for zero-emission school buses, they fall under the current target to achieve 35% of total MHDV sales being ZEVs by 2030 and 100% by 2040, where feasible. Given that this is only 100% of new sales by 2040, and not 100% of the fleet converted to electric by 2040, this target falls short of other leading jurisdictions in Canada and the US.

# The Cost of Transitioning to 100% ESBs

## **Overview of ESB Costs**

The cost of owning an ESB can be broken down into four major components: (1) upfront vehicle costs, (2) electricity costs, (3) maintenance costs and (4) the cost of charging infrastructure. One of the greatest barriers to ESB bus adoption in the near future will be its high upfront cost. ESBs can cost anywhere between 1.5 to 2.5 times an equivalent ICE bus (see Figure ES2).



Figure ES2. Diesel and electric upfront school bus cost

On the other hand, we calculate that it will cost on average 80% less to power and at least 50% less to maintain an ESB versus a diesel bus.

Given the nature of school bus operations - the fact that they tend to return to a central facility between shifts where they have a significant amount of downtime - ESBs are well-suited to charging at their "home base" using a Level 2 charger. We estimate that the cost to procure and install a Level 2 charger is \$10,000 per charger, excluding the cost of any electrical upgrades that are required to support the additional load.

## **Potential Revenue Sources**

In addition to the operational cost savings offered by ESBs, there is also the possibility that ESB operators may leverage the Clean Fuel Regulation (CFR) coming into effect nationwide in 2023, as well as utility-led vehicle-to-grid (V2G) programs to generate revenue. At an assumed credit rate of \$300, one bus could generate over \$5,000 in credit revenue per year under the CFR and on the order of \$1,200-\$4,000 through V2G programs should they be established.

#### **Federal Sources of Funding**

There are two primary sources of non-repayable funding at the federal level: the Zero Emission Transit Fund (ZETF) and the Zero-Emission Vehicle Infrastructure Program (ZEVIP). In addition to these sources of non-repayable funding, the Canada Infrastructure Bank offers direct loans through the Zero-Emission Buses Initiative, and tax credits are available through the accelerated capital cost allowance program. Provincial sources of funding are also available in select provinces and territories.

#### Comparing the Total Cost of Ownership (TCO) of Electric and Diesel Buses

While ESBs offer significant operational cost savings over their diesel counterparts, their high upfront costs may act as a significant barrier to adoption. Without adequate funding, each of the major types of ESBs is currently expected to have a higher TCO than an equivalent diesel bus (see Figure ES3).



Figure ES3. Total cost of ownership comparison of diesel and electric school buses by type

Federal programs can significantly reduce the upfront cost of an ESB. If ZETF, ZEVIP and the CIB loan are all leveraged, fleets can end up paying less than an equivalent diesel bus to cover the upfront capital costs of ESBs (see Figure ES4).



Figure ES4. Type C upfront diesel and electric school bus costs with maximum federal funding

Similarly, by participating in the CFR and V2G programs as they become available, school bus operators can further reduce the payback period of ESBs (see Table ES1). For Type C school buses, which represent 71% of school buses in Canada, by leveraging maximum amounts of federal funding as well as revenue from the CFR and V2G, an operator could reduce the payback period of an ESB from 19.3 years to 2.7 years.

Table EST. Payback period of ESBs under different funding and revenue-generating scenarios			
	Туре А	Туре С	Type D
No funding or additional revenue	20.7 years	19.3 years	23.3 years
Federal funding (ZETF + ZEVIP)	7.0 years	4.4 years	6.4 years
Federal funding + CFR revenue	5.3 years	3.2 years	4.6 years
Federal funding + V2G revenue	5.4 years	3.6 years	4.6 years

#### Table ES1. Payback period of ESBs under different funding and revenue-generating scenarios

#### **Charting a Pathway to 100% ESBs**

#### **School Bus Fleet Turnover Rates**

We calculated the number of school buses that would need to be converted to electric each year to reach CESBA's supposed objective of 100% ESBs on the road by 2040 and to determine what it would take to reach a more ambitious target of 100% by 2035. This took into account the existing age distribution of the fleet and a typical retirement threshold of 12 years.

- 1. 100% ESBs by 2040: over 2,850 buses would need to be converted to electric annually, on average, between 2023 and 2040. This reflects 51-85% of school bus retirements each year.
- 2. 100% by 2035: 100% of school buses that have reached their retirement age of 12 years would need to be replaced with an electric model starting in 2023. Given the current age distribution of Canada's school bus fleet, the greatest number of ESB replacements over the 2023-2035 period would occur over 2023-2024 (approximately 5,600 per year).

#### **ESB Supply Forecasts**

To better understand whether there is expected to be a sufficient supply of ESBs to meet either a 100% by 2035 or 2040 target, we have examined forecasts for battery production capacity as a proxy for how the electric vehicle (EV) ecosystem is expected to evolve over time.

The annual GWh needed per year to electrify all ESBs is 0.5 GWh to reach full school electrification by 2040, or 0.5-0.9 GWh to reach an earlier target of 2035. The local GWh capacity needed to meet the projected sales of all EVs in 2025 and 2030 is estimated at 140 GWh and 290 GWh respectively. Not only is this well within the range of forecasted battery manufacturing capacity in North America, but it highlights that ESBs are marginal ( $\leq$ 1%) to total EV production and anticipated battery production capacity (see Figure ES5).

While these targets and announcements suggest that future ESB manufacturing capacity will not act as a long-term barrier to reaching full electrification, ultimately supply chain constraints have led to limited manufacturing capacity in recent years.



Figure ES5. Left: Forecasted EV battery capacity requirements in Canada and the US vs North American (NA) battery manufacturing capacity; Right: Annual battery capacity needed to reach 100% ESBs in Canada by 2035

#### **Capital Required to Support 100% ESB Adoption**

While supply chain constraints may act as a barrier to ESB adoption in the near-term, capital may act as a longer-term barrier. There is a significant amount of capital required in the near term to support a Canada-wide transition to 100% ESBs. This includes capital to cover the upfront purchase of ESBs, as well as the purchase and installation of charging infrastructure. Under a 100% by 2040 target, over \$1.25 billion would be required from all stakeholders in 2023, whether from bus operators or other stakeholders (e.g., government). This is expected to decrease over time alongside declining ESB costs to approximately \$1.01 billion by 2040 (see Figure 10). The total capital required over the 2023-2040 period is equivalent to approximately 2.5 times the annual capital requirements for diesel buses.

#### **TRADE-OFFS OF 2035 AND 2040 TARGETS**

The sooner Canada's school bus fleet is converted to electric, the sooner Canadians will be able to reap the benefits, including GHG emissions reductions, air quality improvements and operational cost savings. Achieving a more ambitious target of 100% ESBs by 2035 would have positive implications on our carbon budgets and GHG emissions reduction goals as a tonne of carbon reduced today will have a greater impact on climate change mitigation than one reduced in the future. Moreover, the sooner our school bus fleets are fully electric, the sooner communities will benefit from improved air quality, and school bus operators will be able to reduce their operating costs and benefit from a quieter, more comfortable drive.

However, achieving 100% by 2035 also presents challenges. Most importantly, we lack the supply and manufacturing capacity to convert the necessary number of vehicles to ESBs in the near term. This means that either vehicle retirement ages will need to be extended beyond their typical 12-year lifespan (like what Quebec has done), or alternatively, more diesel buses will need to be purchased in the near term and retired early to be replaced with an ESB. Furthermore, transitioning the fleet to ESBs sooner will require more capital. As the cost of ESBs declines with decreasing battery costs and with increasing economies of scale, less capital will be required year-over-year to support the transition.

## **Recommendations: The Federal Government Should Consider Increased Support for ESBs**

The findings of this analysis demonstrate that, particularly in the near term, the business case for ESBs is weak without substantial government support. To reap the invaluable benefits these buses can offer – on climate, local air quality, and from an operational cost savings perspective – action needs to be taken at the federal level to support school bus operators across the country to make the switch. The following recommendations have been identified as key to supporting ESB adoption:

# 1. Set Canada-wide ESB sales targets.

Federal funding for ESBs can be complemented by nationwide sales targets that will ensure there is sufficient ESB supply for school bus operators across the country to make the switch.

# 2. Extend existing federal funding programs for ESBs.

Given that ESBs are not expected to reach price parity with diesel buses between now and 2040, the federal government should consider continuing to help make ESBs more affordable by allocating additional funds to the ZETF program after it expires in 2025. Similarly, funding through ZEVIP should be extended past the 2027 end year.

# **3. Ensure federal funding for ESBs and charging infrastructure is sufficient and easily accessible.**

Given that the upfront cost of ESBs represents the largest incremental cost for fleet operators (barring any major on-site electrical upgrades), the federal government should consider offering point-of-sale rebates on ESB purchases to provide more certainty to fleet operators as they build their budgets.

# 4. Work with provinces to explore the possibility of temporarily extending the retirement age of diesel school buses to support the near-term adoption of ESBs.

By temporarily extending the lifespan of diesel buses, it would be possible to smooth out the spike of ESB replacements that would be needed in 2024-2025 to meet a 100% by 2035 target.

# 5. Lead or fund education and awareness campaigns that promote the benefits of ESBs.

These campaigns are key to ensuring that school bus operators understand the multitude of benefits that ESBs present, as well as the various financial supports that are available to them across the country.