Electric School Buses

The benefits to British Columbians and options for accelerating the transition

June 2022

Prepared for:

PEMBINA institute

Prepared by:

dunsky Energy + Climate

With support from:

Vancity

Submitted to:

Pembina Institute

Communities and Decarbonization Group
555 West Hastings Street, Suite 1124
Vancouver, BC
V6B 4N6 Canada
T: 604-874-8558
www.pembina.org

Prepared by:

Dunsky Energy + Climate Advisors
50 Ste-Catherine St. West, suite 420
Montreal, QC, H2X 3V4

www.dunsky.com | info@dunsky.com
+ 1 514 504 9030

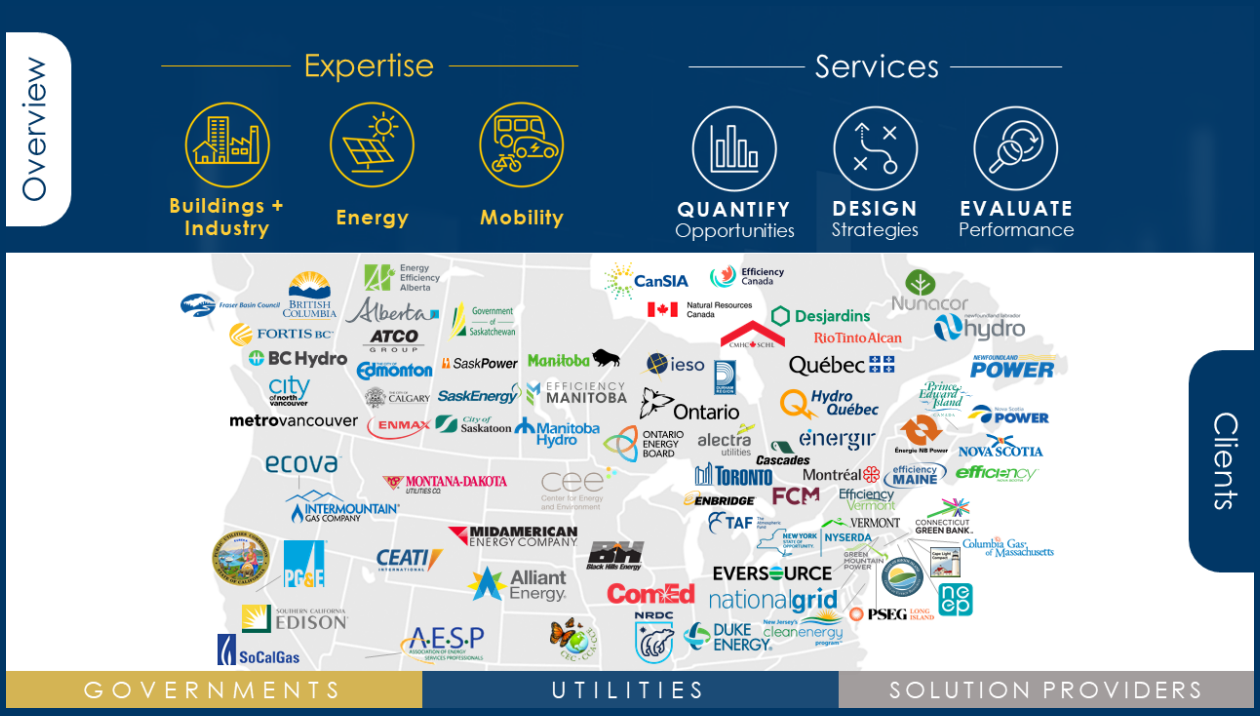
With support from:

Thank you to School District 68, Nanaimo-Ladysmith, for generously providing the photos used in this report.

About Dunsky

Founded in 2004, Dunsky supports leading governments, utilities, corporations and non-profits across North America in their efforts to **accelerate the clean energy transition**, effectively and responsibly.

Working across buildings, industry, energy and mobility, we support our clients through three key services: we **quantify** opportunities (technical, economic, market); **design** go-to-market strategies (plans, programs, policies); and **evaluate** performance (with a view to continuous improvement).



Dunsky is proudly Canadian, with offices and staff in Montreal, Toronto, Vancouver, Ottawa and Halifax.

EXECUTIVE SUMMARY

Electric school buses offer opportunities not only to **mitigate climate change**, but also to **reduce harmful health effects on children and drivers** and to reap a range of other benefits, including **lower maintenance costs**, **reduced fuel costs**, and an **improved and quieter driving experience**. In the context of rapidly rising fuel prices, the fuel savings are particularly attractive to school transportation operators.

The Government of British Columbia (BC) provides **significant financial supports** for the purchase of electric school buses and associated charging infrastructure through both the Ministry of Education and Child Care and Clean BC (administered by the Ministry of Energy, Mines, and Low Carbon Innovation). Combined financial support from the ministries ranges from $100,000 to over $200,000 per bus, depending on the bus size and cost. CleanBC funding has helped several school transportation operators, both urban and rural, make the decision to purchase an initial batch of electric school buses, and **momentum is growing**—just over 50 buses have been purchased in the province so far. There are opportunities within reach to refine the funding structure and offer other supports to help accelerate the uptake of electric school buses so that the benefits are enjoyed sooner by BC communities.

Benefits of Electric School Buses

We assessed and quantified the significant potential **health, emissions, and energy security benefits** of adopting electric school buses across BC. We found that replacing BC's publicly-operated public school fleet of 1,280 school buses with battery electric vehicles could, over the bus lifetime of 12 years:

- Result in **$15 million in health care cost savings from avoided air pollution** (nitrogen oxides, sulphur oxides, and particulate matter), which cause premature deaths, respiratory illness, cancer, and impede the development of children's lungs;
- Eliminate **428 thousand tonnes CO2e** in carbon emissions, which cause **climate change**; and
- Eliminate **$98 million in crude oil imports** and switch to **locally generated electricity**.

These benefits would be even larger when considering the privately-operated public school bus fleet (close to 600 additional buses) and the school bus fleet operated by private and First Nations Band-operated schools (over 1,300 additional buses).

The Current Funding Landscape

Despite their benefits, electric school bus adoption will be slow without supportive policies, funding, and capacity building. A significant barrier to adoption is the high purchase price: a typical new electric school bus costs over $400,000, plus approximately $15,000 for the equipment and installation of a Level 2 EV charger. By comparison, a conventional diesel bus costs about $150,000. Schools in the public system receive core bus funding from the Ministry of Education and Child Care at a rate that fully covers the cost of a diesel bus but does not cover the full cost of an electric bus.

However, there are several additional provincial funding streams available to school transportation operators for the purchase of electric school buses. When core bus funding and other electric bus funding from the Province of BC is stacked, **the remaining additional capital to be paid by public school districts can range from about $60,000 to $147,000 for an electric bus,** depending on the vehicle type and whether it is the first electric bus purchased by the district. Figure 1 shows the available funding for a typical Type C school bus in the public system, and the remaining capital cost that school districts need to cover (just over $110,000 in this case).

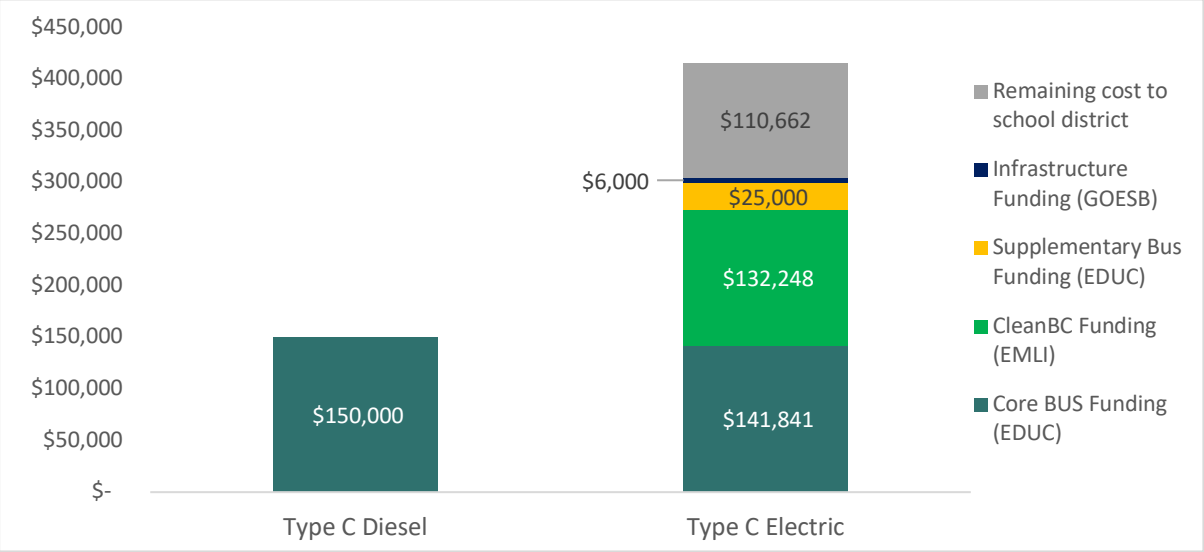


Figure 1. Breakdown of funding sources for Type C school buses

The outstanding capital cost can be financed by low-interest loans from the Canadian Infrastructure Bank (CIB) or potentially funded by the federal Zero-Emissions Transit fund. No school districts in BC have yet accessed this option.

With the exception of the core bus funding, these other electric bus funding streams are available to private and First Nations Band-operated schools as well; however, this report focuses on the business case for public school districts with publicly-operated school transportation.

Business Case for Electric School Buses

Electric school buses are less costly to operate compared to diesel buses because they avoid the use of most fuel (diesel heaters are often included on electric buses) and are cheaper to maintain. We assessed bus operating costs in BC, based on current local fuel and electricity costs and other province-specific factors. We found that an average bus in BC, over its 12-year lifetime, would:

- Save **$166,000 in energy costs**, by avoiding most fuel costs and using cheaper electricity; and
- Save **$36,000 in maintenance costs**, since EVs are cheaper to maintain.

This means that despite the initial upfront capital cost that school districts need to cover for electric buses[1], the total cost of ownership (capital and operating costs) over the 12-year lifetime is more attractive

[1] Because of the core bus funding, the upfront cost to school districts of a diesel bus is $0.

for electric buses than for diesel buses (Figure 2). More specifically, at current funding rates for public school districts, Type C electric buses pay back the initial investment relative to diesel buses after **6.6 years** of operation.[2] The total cost of ownership under this scenario is $184,000 for an electric bus compared to $275,000 for a diesel bus over the lifetime of the bus.

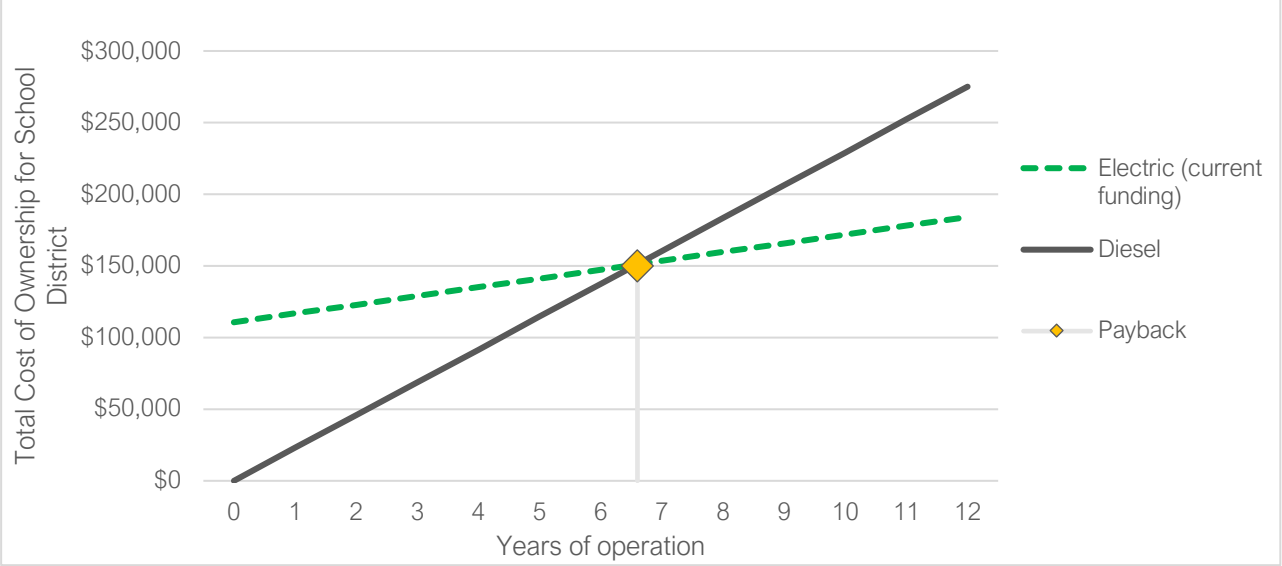


Figure 2. Up-front and operating costs to school district over the 12-year bus lifetime for Type C buses

BC's Low Carbon Fuel Standard (LCFS) improves further the business case for electric school buses, since vehicle charging site operators can receive financial credits under the system. If school transportation operators opt to collect these benefits, at current credit rates (we assumed $400/credit), one bus could generate approximately $8,600 in LCFS credit revenue per year, resulting in a positive revenue stream from the bus over and above operating costs (Table 1). This improves the business case further, taking the relative payback period from 6.6 years to **4.4** years (Figure 3).

Table 1. Impact of LCFS credit revenue on operating costs (for one bus)

Cost type		Diesel bus operating costs	Electric bus operating costs
Annual	Total operating costs	($23,000)	($6,000)
	LCFS credit revenue	--	$8,600
	Net	**($23,000)**	**$2,600**
Lifetime (12 years)	Total operating costs	($275,000)	($74,000)
	LCFS credit revenue	--	$103,307
	Net	**($275,000)**	**$29,307**

[2] A parallel analysis for Type D buses was also conducted and is included in the report body. Findings are similar.

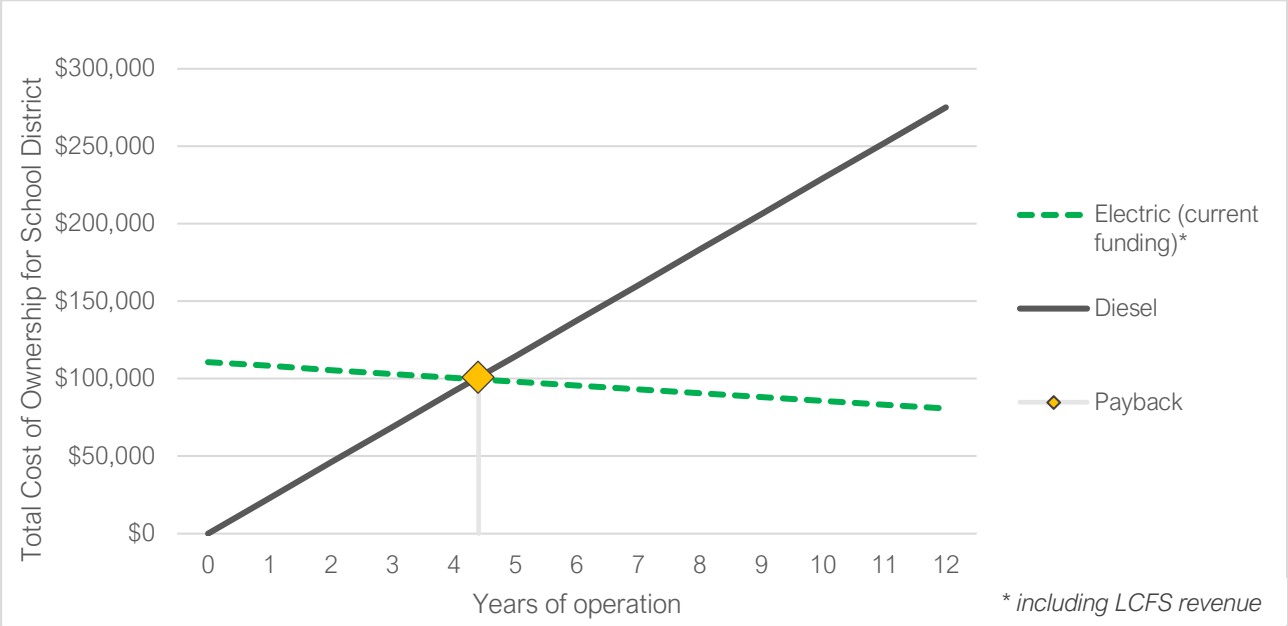


*Figure 3. Up-front costs, operating costs, **and LCFS revenues** for school district over the 12-year bus lifetime for Type C buses*

Accelerating the shift

When provincial and federal funding opportunities, LCFS credits, and operational costs savings are considered, electric buses clearly offer a more attractive business case than diesel buses for school districts and other school transportation operators. There are, however, some other barriers that remain: school districts are unaccustomed to acquiring debt, need knowledge about the available funding streams, and require technical support to select, install and operate the appropriate charging infrastructure. Based on the interviews we conducted and best practice in other jurisdictions, additional options for BC and federal actors to respond to these challenges and opportunities are provided in Table 8. Table 2.

Table 2. Options for next steps

Challenge/Opportunity	Options	Key Actor(s)
Multiple funding opportunities are administratively burdensome to school transportation operators	• Streamline the provincial funding programs • Offer direct or automatic access (not via an application) to the new Zero-Emission Transit Fund • Support capacity building for school districts and other school transportation operators and conduct education and	• BC Ministry of Education and Climate Change; BC Ministry of Environment, Mines and Low Carbon Innovation • Infrastructure Canada

Challenge/Opportunity	Options	Key Actor(s)
	outreach to help them become aware of funding opportunities	
Funding does not cover full cost of electric bus	• Increase the subsidy to cover the full capital cost for a limited number of years to accelerate uptake and overcome risk aversion	• BC Ministry of Education and Climate Change; BC Ministry of Environment, Mines and Low Carbon Innovation
School districts hesitant to take on CIB loans	• Conduct outreach and education on the mechanisms offered by the CIB with school district board members and staff, as well as staff at First Nations Band-operated and independent schools	• ASTSBC • CIB
LCFS credits significantly improve the business case	• Move forward with plans to collect and distribute LCFS credits on behalf of participating school districts	• ASTSBC
Commit to net-zero operations across the school system	• Adopt net-zero commitments at the school district board level to help prioritize investments in electrification	• School district boards

Table of Contents

1. Introduction

1.1 Context

Across North America, school transportation operators are choosing electric over conventional diesel school buses, not only to meet their **net-zero commitments**, but also to **reduce harmful health effects on children and drivers** and to reap a range of other benefits, including **lower maintenance costs**, **reduced fuel costs**, and an improved and quieter driving experience. In the context of rapidly rising fuel prices, the fuel savings are particularly attractive to operators.

Figure 4. Electric school buses at School District 68, Nanaimo-Ladysmith. The District has purchased four electric school buses to date, and is committed to growing its fleet.

Despite their benefits, electric school bus adoption will be slow without supportive policies, funding, and capacity building. A significant barrier to adoption is the **high purchase price**: a typical new electric school bus costs over $400,000, in BC, compared to about $150,000 for a conventional vehicle. Unlike transit buses, which are often used around the clock, school buses are typically only in used for the journey to and from school and occasional field trips. With this shorter duty cycle, it takes longer for **fuel savings** to accrue to pay back the price premium. Well-designed funding and financing options (for buses and charging infrastructure), along with education and capacity building, can help school transportation operators and school district decision-makers to adopt this new technology. Governments are well-placed to play this role.

Thanks to supportive government policy and financial incentives, British Columbia (BC) leads the country in consumer electric vehicle (EV) sales rates: in the last quarter of 2021, 28% of the EVs sold in Canada were sold in BC.[i] The Government of BC has also announced that it will develop sales targets for medium- and heavy-duty vehicles by 2023 and is expected to follow in the footsteps of California and the District of Columbia in doing so.[ii]

Despite its rising EV sales rates, BC is not yet the leader in Canadian electric school bus adoption. On the other side of the country, the Government of Quebec has made a clearer commitment to electrifying its school bus fleet. In Spring 2021, it announced $250 million in funding specifically for school bus electrification and set the target that **65% of the school bus fleet in the province will be electric by 2030.** Starting in 2023, all new school buses entering into service in the province must be electric. The Government offered a $150,000 subsidy for school bus purchases in the 2021-22 fiscal year (that subsidy is now reduced to $125,000 for the 2022-23 fiscal year). The Government expects not only to see emissions reductions and health benefits, but also to generate economic benefits from the use of locally generated electricity and the local manufacturing of electric buses. The province's school bus fleet had 130 electric buses in 2021[iii], and the share of electric buses has been growing since.

Like Quebec, the Government of BC provides **significant financial supports** for the purchase of electric school buses and associated charging infrastructure through both the Ministry of Education and Child Care and Clean BC (administered by the Ministry of Energy, Mines, and Low Carbon Innovation).

Figure 5. Dashboard of an electric school bus. Driver training is a key component of electric school bus adoption.

Combined financial support between ministries ranges from $100,000 to over $200,000 per bus, depending on the bus size and cost and whether it is the first electric school bus purchase. CleanBC funding has helped several schools, both urban and rural, make the decision to purchase an initial batch of electric school buses, and **momentum is growing**.

However, uptake remains uneven across the province and **barriers** (financial and non-financial) preventing electric school buses from scaling up in BC remain. Removing these barriers will be essential to improve health outcomes for BC children, drivers, and communities, while making progress toward climate reduction commitments and heavy-duty vehicle electrification targets made in the CleanBC Roadmap to 2030.[iv]

Electric school bus adoption to date in BC

In BC in 2019 there were **1,860** school buses serving the public school system. Of those, 1,280 are publicly operated while 580 are privately operated.[v] Another 1,306 buses were operated by private and First Nations schools, for a total of 3,166 school buses.[vi]

In 2021, existing programs helped **13 school districts,** both urban and rural, purchase **18 electric school buses.**[vii] The next year, another **34 buses** have been purchased.[viii] Momentum is building, and more are expected to be purchased in the coming year.

1.2 Methodology

To quantify the potential emissions, health, and economic benefits of electric school bus adoption in BC, we used primary data from the Government of Canada and the Province of BC along with secondary data from academic, peer-reviewed studies.

To understand the policy options to accelerate adoption used in other jurisdictions, we conducted a desktop jurisdictional scan, presented in Section 4.

Finally, to understand the realities of electric school bus adoption in BC today, we interviewed four organizations including School Districts and electric bus manufacturers. The list of interviewees is presented in Appendix A and the findings are included throughout this report.

1.3 Report Structure

The remainder of this report is structured as follows:

2. What are the benefits of Electric School Buses? In this section we outline the potential health, emissions, and trade benefits of Electric School Buses in the province of BC.

3. What is the status of Electric School Bus adoption in BC? In this section we highlight the existing funding and mechanisms for electric school bus procurement in BC, for school districts and other actors. We explore successes to date, drawing on interviews with experiences on the ground.

4. What are other jurisdictions doing? In this section we explore alternate approaches to financing electric school bus adoption in Quebec and three US jurisdictions.

5. What would accelerate the shift to Electric School Buses in BC? In this section, we outline key recommendations for accelerating the uptake of electric school buses so that the benefits are enjoyed sooner by BC communities.

2. What are the benefits of Electric School Buses?

A summary of the benefits of electric school buses in BC:

	1 electric bus (12-year lifetime)	BC's public school fleet of 1,280 electric buses (12-year lifetime)
Health benefits	• Up to $5,500 in health cost savings from reduced NOx • Up to $1,400 in health cost savings from reduced SOx • Up to $5,000 in health cost savings from reduced $PM_{2.5}$ • **$11,800 total health cost savings** • Quieter operation	• Up to $7 million in health cost savings from reduced NOx • Up to $1.7 million in health cost savings from reduced SOx • Up to $6.4 million in health cost savings from reduced $PM_{2.5}$ • **$15 million total health cost savings** • Quieter operation
CO_2 Climate benefits	• Eliminate 334 t CO_2e • 92% fewer operational GHG emissions[3]	• Eliminate 428 thousand t CO_2e • 92% fewer operational GHG emissions
Use of locally generated energy	• Eliminate use of 130,000 L of diesel	• Eliminate use of 170 million L of diesel • Eliminate $98 million in crude oil imports and switch to locally generated electricity
Operational cost savings	• Save $166,000 in energy costs • Save $36,000 in maintenance costs • Earn up to $100,000 in clean fuel credits from charging	• Save $212 million in energy costs • Save $46 million in maintenance costs • Earn up to $132 million in clean fuel credits from charging

[3] The remaining 8% is attributed to the carbon intensity of BC's electricity consumption which is 19 gCO2e/kWh according to Canada's 2022 National Inventory Report, as well as the use of diesel heaters on electric buses.

2.1 Health Benefits

Many jurisdictions, including California, electrify their school buses primarily to improve local air quality and reap the associated health benefits (particularly for children and bus drivers).

Since they run on diesel, traditional school buses emit air pollutants that are harmful to human health, including nitrogen oxides (NOx), carbon monoxide (CO), sulphur oxides (SOx), and particulate matter ($PM_{2,5}$). Air pollution is one of the largest risk factors for premature death and disability in Canada and internationally.[ix] Notably:

- In BC, there are 1,900 **premature deaths** every year from poor air quality (nitrogen dioxide (NO_2), ground-level ozone and $PM_{2,5}$).[x]
- While the harmful health effects of these pollutants have been documented for decades, research continues to reveal links between air pollution and asthma and other **respiratory illness, cancer, adverse birth outcomes**[xi], and dementia and Alzheimer's disease.[xii]
- NOx emissions from traffic-related air pollution **impede the development of children's lungs.** A recent study measured a 5% reduction in the lung capacity of children who were exposed to NOx.[xiii]
- Exposure to diesel exhaust exposure is significantly higher for passengers on the school bus compared to outside the bus. In California, the exhaust levels on school buses were found to be 23 to 46 times higher than levels considered to be a significant cancer risk according to the US Environmental Protection Agency and US federal guidelines.[xiv]

Table 3 presents the reductions in air pollution, and the associated health care savings, that could be achieved in BC if all 1,280 school buses were converted from diesel to electric.

Table 3. Health benefits of electric school buses in BC

	Avoided air pollution and health care costs[4] from shifting to electric buses	
Air pollutant	**One electric bus (12-year lifetime)**	**BC's fleet of 1,280 electric buses (12-year lifetime)**
Nitrogen oxides (NOx)	280 kg[xv] $2,400 to $5,500[xvi]	354 tonnes $3 million to $7 million
Sulphur oxides (SOx)	1.6 kg $600 to $1,400	2 tonnes $766 thousand to $1.7 million
Particulate matter ($PM_{2.5}$)	3.7 kg[5] $2,200 to $5,000	5 tonnes $2.8 million to 6.4 million

[4] Health care savings calculated based on the two methods presented in Wolfe et al (2019) (see endnotes). A range is provided because the benefits are calculated using two distinct methods.
[5] While electric buses do not generate tailpipe emissions, they do—like all on-road vehicles—still generate non-exhaust emissions (from tires, brakes, surface wear) that contribute a portion of PM2.5. Our calculations for avoided air pollution count only the portion of PM2.5 that is generated from the tailpipe.

2.2 Climate Benefits

Like all other electric vehicles, electric school buses are a key part of climate change mitigation because they emit much fewer greenhouse gas (GHG) emissions than fossil-fuel powered buses. BC has committed to reduce transportation-related GHGs by 27-32%[xvii], and to reduce economy-wide GHGs by 40% by the year 2030.

Electric school buses have no tailpipe emissions, but they do indirectly produce GHG emissions from the generation of the electricity used to charge the vehicle. In BC, where electricity is mostly generated from hydropower and has a low carbon intensity,[xviii] this contribution is relatively small. In Canada, most or all electric school buses are equipped with a diesel heater for rider comfort, which also produces a relatively small amount of GHG emissions.[6] Table 4 shows the avoided GHG emissions when transitioning from diesel to electric school buses in BC.

Table 4. Climate benefits of electric school buses in BC

Air pollutant	Avoided operational carbon emissions from shifting to electric from diesel school buses	
	One electric bus (12-year lifetime)	BC's fleet of 1,280 electric buses (12-year lifetime)
GHG emissions	334 t CO_2e[xix]	428 thousand t CO_2e
	92% reduction in GHG emissions	

The results above are for operational emissions savings and do not include lifecycle emissions from the production of electric school buses and batteries. A study conducted in Colorado on the life cycle emissions of medium- and heavy-duty vehicles showed that GHG emissions reductions associated with electric vehicles compared to gas vehicles are closer to 66% when lifecycle emissions are considered.[xx]

2.3 Energy Security

The electrification of transportation can have an impact on the trade balance of BC. While BC produces oil, it also imports much of the oil consumed within the province. Meanwhile, it produces most of the electricity consumed within the province.[xxi]

A full transition to electric school buses would mean avoiding the use of approximately 170 million litres of diesel over the bus fleet's lifetime. At current crude oil import prices, this amounts to about $98 million in imports that could be avoided, with locally generated electricity used instead.[7]

[6] School Districts interviewed for this report confirmed that heaters are considered a mandatory feature, and are typically used for most of the school year (approximately 8 months each year).
[7] We approximate that electrifying BC's public school fleet would result in the consumption of approximately 644 GWh of electricity over the fleet's 12-year lifetime.

3. What is the status of Electric School Bus adoption in BC?

3.1 Funding Landscape

The Government of BC provides financial support for the purchase of electric school buses and associated charging infrastructure through both the Ministry of Education and Child Care and CleanBC Go Electric Program[xxii] (administered by the Ministry of Energy, Mines, and Low Carbon Innovation). Available funding ranges from $100,000 to over $200,000 per bus depending on the bus size and cost, per the list below. The core bus funding is available only for publicly-operated buses in public school districts. The other funding streams are available these operators as well as private operators serving public school districts, private and independent schools, and First Nations Band-operated schools.

Available Funding for Electric School Bus Purchases in BC

- Core bus funding from the Ministry of Education and Child Care (available for publicly-operated buses in public school districts only)
- 33% of the pre-tax purchase price, up to $150,000, through CleanBC
- An additional $25,000 to $30,000 (depending on bus size) from Ministry of Education and Child Care over and above the core bus funding
- One-time grant of $50,000 through the Ministry of Education's Carbon Neutral Capital Program, if not previously accessed for another project
- 75% of equipment, installation, and electrical upgrade costs for new Level 2 charging equipment, up to $6,000 per station, through the CleanBC Go Electric Program

When this funding is stacked, the remaining additional capital to be paid by school districts can still range from about $60,000 to $147,000 for the bus, including charging infrastructure, as shown in Figure 6.

Through a program from the **Canadian Infrastructure Bank (CIB),**[xxiii] school transportation operators can access financing to cover this remaining capital cost of electric school buses. These direct loans are repaid as savings are realized compared to diesel buses. In most other cases, school districts are not permitted to take out loans, so this program represents a new and unfamiliar kind of financing option.

Finally, in 2021, Infrastructure Canada announced a new, $2.75 billion **Zero-Emission Transit Fund**[xxiv] which will provide grants to public school districts and other school transportation operators to help defray the remaining upfront costs associated with electric bus purchases. These actors must apply to the Fund, and applications will be considered in tandem by the CIB and Infrastructure Canada. If school districts' applications are successful, this funding could be meaningful in terms of covering the outstanding additional cost of electric buses in BC.

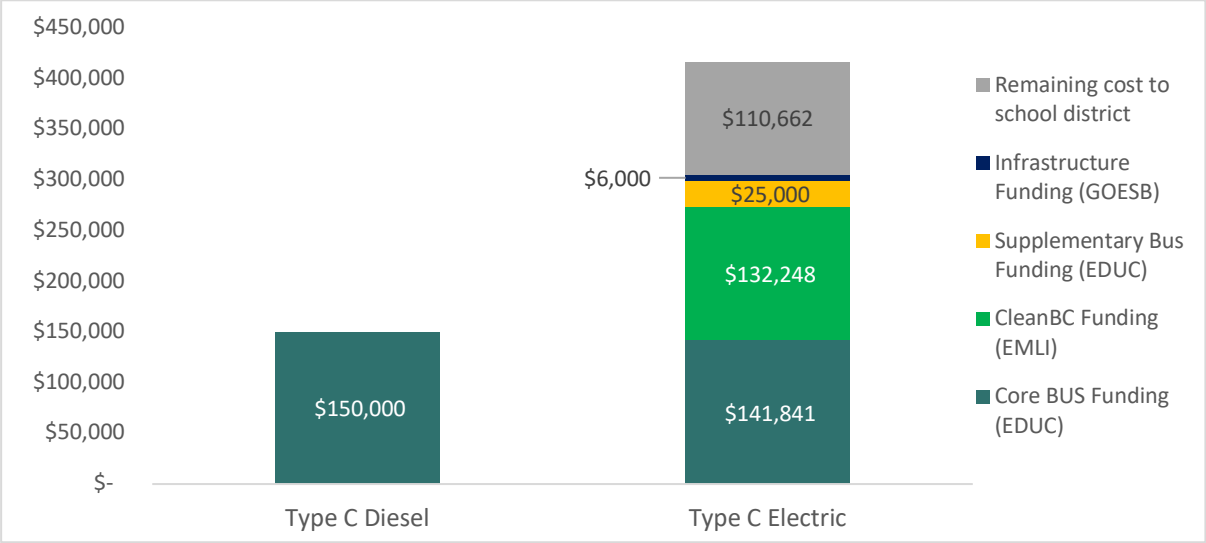


Figure 6. Breakdown of funding sources for Type C school buses

Both school districts interviewed for this study used their own budget to cover the outstanding costs of the electric buses and did not access a CIB loan. Operators in BC have not yet begun to access the Zero-Emission Transit Fund.

3.2 Key Players

Unique to BC, a key player and resource for school transportation operators is the Association of School Transportation Services of BC (ASTSBC). Initially volunteer-run, this organization was created to facilitate joint procurement of conventional school buses among BC school districts, to help secure a more attractive price. In recent years, the ASTSBC has helped to kickstart the transition to electric school buses by taking several key actions. The ASTSBC:

- Develops and issues standing offer procurements for electric school buses that can be used by any school district, which means that individual school districts do not have to develop their own specifications for electric buses or issue their own tenders.
- Collects telematics and other data from the buses in participating school districts to monitor electric school bus performance against the initial specifications.
- Administers and distributes CleanBC funds to school districts.
- Provides information about available technologies and funding opportunities to school districts.
- Has developed an electric school bus training module for school bus operator training across the province.

Both school districts interviewed for this study had benefitted from the ASTSBC's standing offer to procure their school buses.

Figure 7. Installation of electrical infrastructure for the electric vehicle supply equipment (chargers) installed at School District 68

3.3 The Current Business Case

Electric school buses are more expensive than diesel school buses due to the relatively high (though declining) cost of batteries, and the fact that electric buses are a relatively new technology. Under the most recent standing offer administered by the ASTSBC, the price ranges from approximately $350,000 to $450,000 for Type C (70-76 passenger) and Type D (84 passenger) electric buses. (The price for diesel buses of the same size is approximately $150,000 or less). In addition, operators must install at least a Level 2 EV charger, which may cost approximately $15,000-$20,000 including installation but excluding major electrical upgrades.[8]

Despite these higher up-front costs, electric school buses generate cost savings over their 12-year lifetime from two main sources:

- **Energy cost savings:** Electric buses use electricity in place of diesel fuel, which is more costly, resulting in significant cost savings.[9]
- **Maintenance cost savings:** Electric buses are easier to maintain, resulting in lower maintenance costs.

Table 5 shows the typical operating costs associated with diesel and electric school buses in BC.

Table 5. Difference in operating costs between diesel and electric buses (for one bus)

Cost type		Diesel bus operating costs	Electric bus operating costs	Savings
Annual	Energy[xxv] (fuel or electricity)	($17,000)	($3,000)	$14,000
	Maintenance	($6,000)	($3,000)	$3,000
	Total operating	($23,000)	($6,000)	**$17,000**
Lifetime (12 years)	Energy (fuel or electricity)	($203,000)	($38,000)	$166,000
	Maintenance	($72,000)	($36,000)	$36,000
	Total operating	($275,000)	($73,000)	**$202,000**

[8] Major electrical upgrades are typically not required for the installation of the first several Level 2 chargers at schools and school bus depots. The school districts interviewed for this study had not needed major upgrades. However, as fleets transition to being fully electric, major upgrades may be required.

[9] To calculate electricity costs, we used BC Hydro's Overnight Fleet Electrification Rate. The price of diesel used for fuel calculations was determined by averaging the retail cost of diesel in BC from April 2021 through April 2022. School bus operations were assumed to be running 4 hours per day, 5 days per week, 4 weeks per month. These calculations do not include any additional bus usage for non-daily routes such as school trips.

Thus, electric buses can pay back some of the initial cost differential over time in operating cost savings. The extent to which they pay back the difference depends on how far the bus is driven. School buses typically only make two trips per day plus some occasional field trips or other activities outside of those trips. As a result, school buses do not accumulate mileage as quickly as transit buses or other fleet vehicles. Therefore, it takes longer for the operating cost savings to pay back the initial additional capital outlay, making purchase subsidies especially important for the business case.

The figures below show the total cost of ownership of one bus for a school district under different levels of funding. As shown in Figure 8, without any subsidies beyond core bus funding, a Type C electric school bus would pay back the initial capital differential over diesel buses after approximately **16 years** of operation. Since the lifetime of a bus is 12 years, this is not a viable financial option for operators. Under the current levels of financial support in BC, however, Type C electric school buses pay back the initial capital differential over diesel buses after **6.6 years** of operation, which makes them a highly financially viable option. If the school district accesses the one-time grant of $50,000 through the Ministry of Education's Carbon Neutral Capital Program, that relative payback period is even better, at **3.6 years** for that first bus. We also assessed a scenario where the Government of BC gives a flat $150,000 subsidy for each purchase, rather than capping the CleanBC purchase subsidy at 33% of the bus cost. In that case, the relative payback period is (predictably) slightly better than the current state, at **5.5 years**.

Assumptions

We assume an **annual distance travelled of 33,000 km**, which was the average for school buses in BC in 2018 in the Federal Government's Comprehensive Energy Use Database.

For electric buses, we include the fuel costs associated with a **diesel heater** installed on the bus, operated for **8 months/year**, a typical use pattern according to our interviews.

We assume **price of diesel of $1.53/L** based on the average price in the past year, although at the time of writing diesel prices are higher.

To support the adoption of electric vehicles, BC Hydro offers an **overnight fleet charging electricity rate** with reduced demand charges for EV charging sites. We assume that school transportation operators are accessing this rate. If charging between 10 pm and 6 am, customers pay 7.5 cents/kWh and no demand charges. Peak demand must be a minimum of 150kW to access this rate, which translates to approximately eight buses charging on one service.

The business case would be improved by a longer distance travelled, a higher cost of diesel, and/or a lower cost of electricity. The business case would be diminished by a shorter distance travelled, a lower cost of diesel and/or a higher cost of electricity.

This analysis includes the capital cost of the bus plus one Level 2 charger for each electric bus. We assume a cost of $15,000 for EV charging equipment and installation, with $6,000 covered by the available EV charging infrastructure grants (major electrical upgrade costs were not included, as they are not typically required for the first several Level 2 chargers). In reality, there may not be a precise one to one ratio between buses and chargers, as charger lifetimes may differ from those of buses, and the infrastructure may be used by other vehicles (such as maintenance or "white" fleets) outside of school bus charging windows.

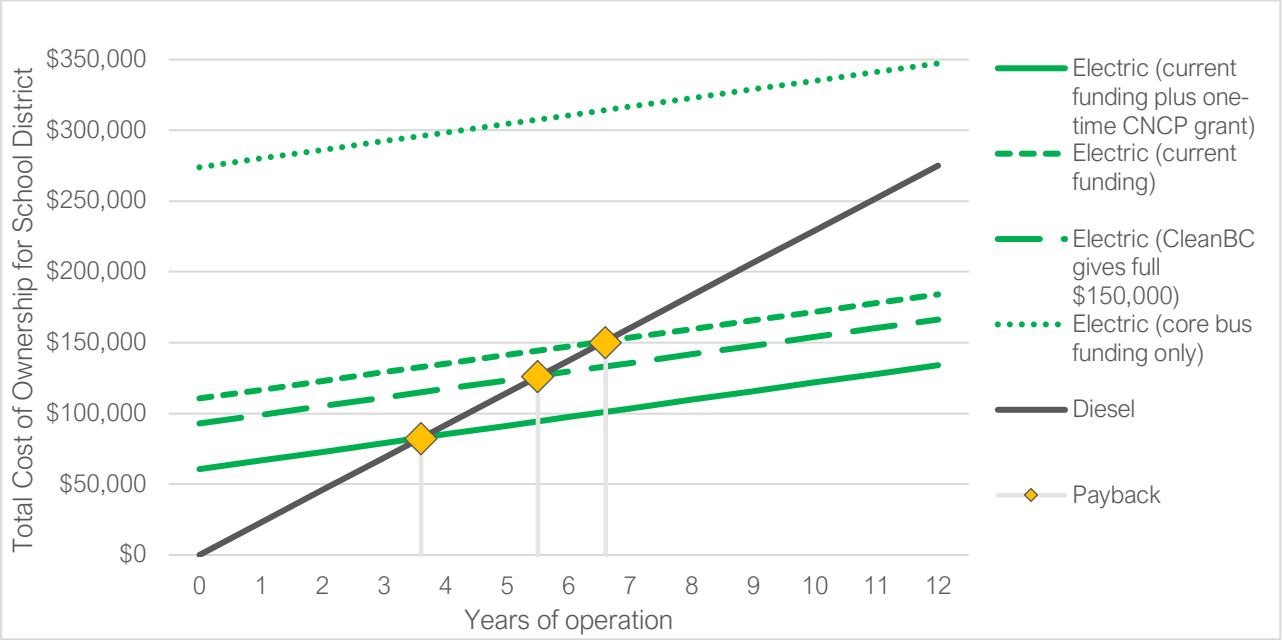


Figure 8. Up-front and operating costs to school district over the 12-year bus lifetime for Type C buses, under different funding scenarios

We conducted the same analysis for Type D buses (Figure 9), which are larger and more expensive than Type C. The payback period for Type D buses with no financial support beyond core bus funding is **19 years**; under the current funding levels it is **8.8 years**, and if the purchaser accesses the one-time CNCP grant it is reduced to **5.8 years**. (There is no scenario where the CleanBC funding is topped up to $150,000 because Type D buses are already accessing this full amount).

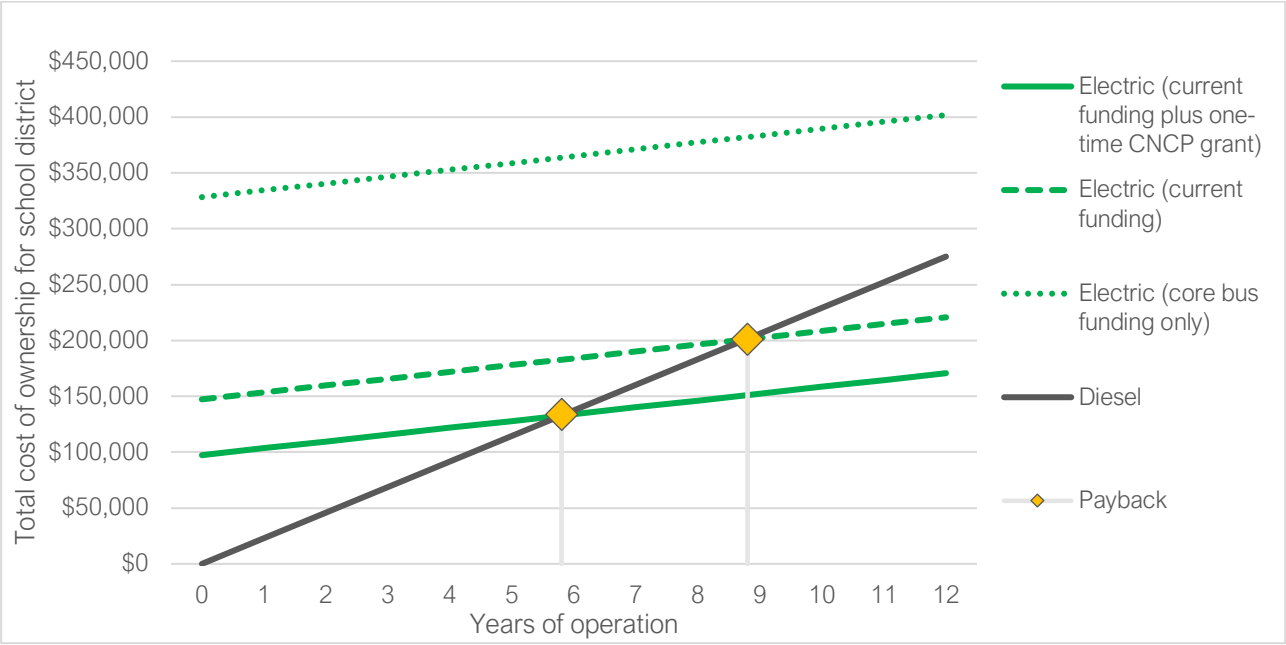


Figure 9. Up-front and operating costs to school district over the 12-year bus lifetime for Type D buses, under different funding scenarios

Low-Carbon Fuel Standard Credits

There is another factor in BC that affects the business case for electric school buses: the Low Carbon Fuel Standard (LCFS). This regulation sets a target for the carbon intensity of fuels used in the province, which declines each year. Under the system, fuel suppliers generate financial credits for supplying fuels with a carbon intensity below the targets and receive debits if they supply fuels that are above the targets. Those credits and debits are then traded on a credit market.

EV charging site operators can receive credits under the system. The ASTSBC is in the process of organizing a way for school districts to apply collectively for credits for EV charging site operation under the LCFS, which would allow districts to collect revenue from charging their electric school buses on an annual basis. Assuming a bus travels an average of 33,000 km/year and the cost of LCFS credits remains around $400/credit, one bus could generate approximately **$8,600 in LCFS credit revenue per year.**[10] This is, notably, higher than the estimated operational cost of $6,000 per year for an electric school bus, resulting in a positive cash flow (Table 6). Over its 12-year lifetime, one electric bus this could generate **over $100,000 in LCFS credits** for the school district or school transportation operator.

Assumptions

We assumed a value of $400/credit in the LCFS system, based on the monthly credit report. This number fluctuates over time; a higher credit value would improve the business case for electric school bus charging site operators. The future value of LCFS credits is uncertain.

Table 6. Impact of LCFS credit revenue on operating costs (for one bus)

Cost type		Diesel bus operating costs	Electric bus operating costs
Annual	Total operating costs	($23,000)	($6,000)
	LCFS credit revenue	--	$8,600
	Net	**($23,000)**	**$2,600**
Lifetime (12 years)	Total operating costs	($275,000)	($74,000)
	LCFS credit revenue	--	$103,307
	Net	**($275,000)**	**$29,307**

As shown in Figure 10, this new LCFS revenue would shift the relative payback for Type C electric buses, to **10.8 years**, which is within the 12-year bus lifetime, even with no additional subsidies beyond the core bus funding. For Type D buses (as shown in Figure 11), the payback is just over the 12-year limit, at **12.9 years**.

[10] ASTSBC has estimated that the LCFS will generate $4,000-6,000 annually per bus being charged, based on a different set of assumptions.

With current subsidies and LCFS credits combined, the relative payback period is shifted to **4.4 years** for Type C and just under **5.8 years** for Type D. LCFS revenue would strongly support the financial case for electric school bus adoption.

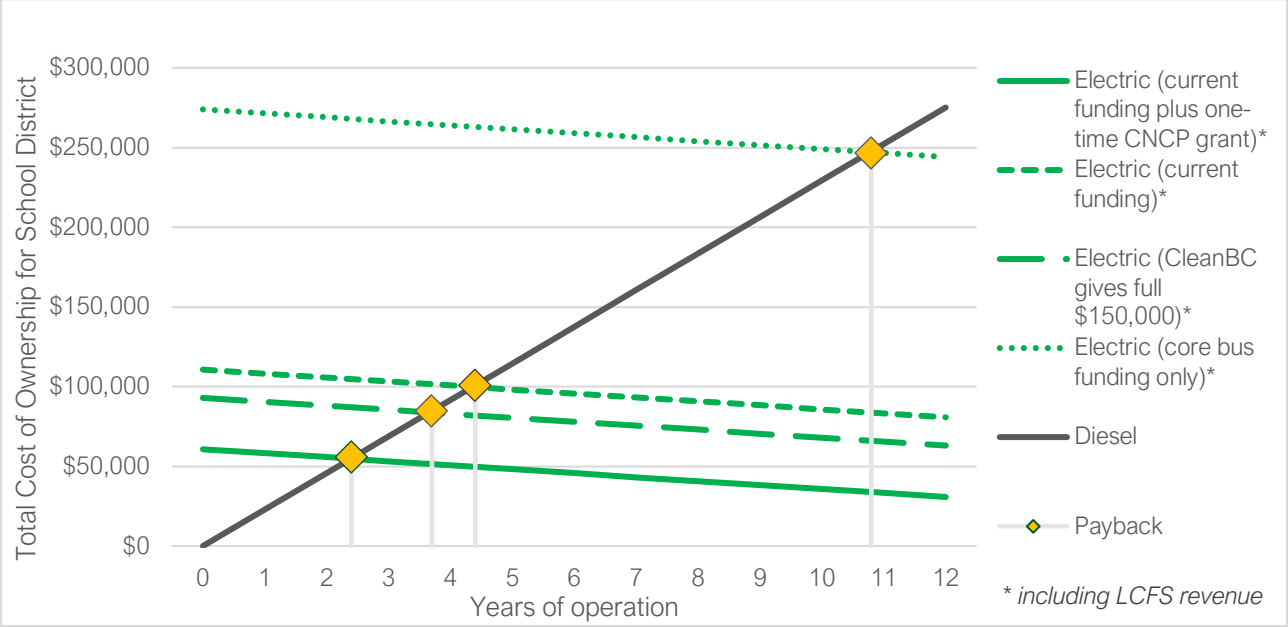


Figure 10. Up-front costs, operating costs, and LCFS revenues for school district over the 12-year bus lifetime for Type C buses

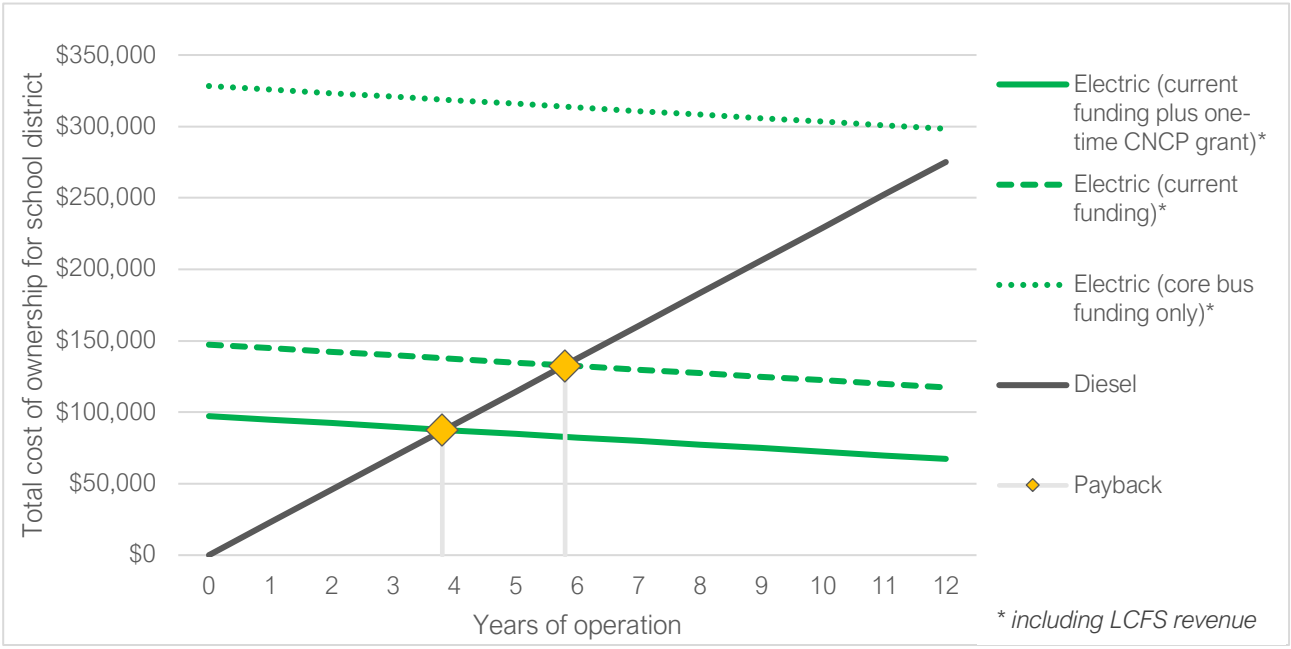


Figure 11. Up-front costs, operating costs, and LCFS revenues for school district over the 12-year bus lifetime for Type D buses

3.4 Other Challenges and Opportunities

Based on our interviews, we identified other challenges and opportunities for school districts and other school transportation operators related to electric school bus adoption:

- Although the CIB loans are available to cover the additional capital costs of electric school buses, school districts are unaccustomed to taking on debt because they are otherwise not allowed to do so. The CIB option can therefore be perceived as **risky or administratively difficult** by district boards and staff. Those interviewed opted to use their own capital funding to make up the cost difference, but that funding had to be directed away from other potential capital investments in the district.
- **Core bus funding** from the Ministry of Education and Child Care is only available to **replace buses that are ready for retirement**. If the Government wishes to transition the fleet more rapidly, this framework would need to be modified.
- School districts have experienced **challenges related to selecting and operating charging infrastructure**. One district experienced issues with network connectivity, leading to a failure of the bus to charge overnight. They have addressed this challenge by using a different charging station that operates without a network connection. However, this approach could make it more difficult for the district to leverage load management or access nighttime charging rates. Others noted that the location of the charging port on the vehicle has been changing from one model to the next, causing the district to need to change its parking plan at its yard.
- There is a **more limited range of features, such as heating options,** available for electric buses than diesel buses (although this is changing). One district shared that they need the larger Type D buses for some of their routes, but the one available through the standing offer did not have the heating requirements they needed.
- Some **drivers have been apprehensive at first** to drive a new type of bus. Districts interviewed found that this apprehension wears off quickly, as drivers appreciate the improved "driveability" and quieter operation of electric buses and contributing toward the district's climate goals.
- **Additional driver training is necessary** for drivers to operate and charge electric buses. Driving technique makes a big difference on the range available on a single charge. ASTSBC has developed an additional driver training module.
- Installing the charging infrastructure for electric school buses presents new opportunities for school districts to electrify other components of their fleet. Most districts have a **"white fleet" of trades and vehicles**, typically comprised of cargo vans and passenger vehicles. With the support of BC Hydro, School District 68 has expanded its charging infrastructure study to include its white fleet in addition to its buses.

Figure 12. Charging infrastructure at SD 68

4. What are other jurisdictions doing?

We reviewed the programs offered in four other North American jurisdictions to support the electrification of school transportation. We examined the updated financial assistance program offered by Quebec along with grant programs in California and New York, and a pilot project that ended in 2018 in Massachusetts.

Excluding Massachusetts, the base programs for the remaining three jurisdictions offer financial assistance to cover most or all of the average cost of a standard diesel fuel school bus. No two programs use the same metrics for assessing the amount of aid offered. For example, the Quebec program will only be offered for three years and offers a flat sum between $100,000 - $150,000 CAD dependent on the time of application to incentivize early participation, and more rapid fleet electrification. The California and New York programs are currently not time constrained and distribute funds based on a variety of metrics including bus class/weight, community need, etc. The California program also offers an additional stream of funding (Public School Bus Set-Aside) to qualifying air districts which covers the full cost of a new electric school bus but has additional requirements (vehicle-to-grid and scrappage) not required for the standard funding stream.

Some of the programs offer additional funding for charging infrastructure, however, once again, this varies significantly between jurisdictions. The New York base program requires that an existing diesel bus is scrapped in lieu of a new electric school bus purchase, as does California's Public School Bus Set-Aside funding stream.

Table 7. Electric School Bus Funding Programs in Other Jurisdictions

Jurisdiction and Program	Program Details	Financial Aid Offered *(USD except for Quebec)*	Includes Charging Infrastructure?
Quebec School Transportation Electrification Program *(Prices in CAD)*	**Administrator:** Quebec Ministry of Transportation **Date:** April 2021 – 2024 **Budget:** $250M **Type:** Point-of-sale discounts Rebates for the purchase of electric school buses.	From Apr 2021 - Mar 2022 = $150K **or** From Apr 2022 - Mar 2023 = $125K **or** From Apr 2023 - Mar 2024 = $100K	**Yes** Up to $30K for charging station connected to the building and up to $50K for station powered by a dedicated electrical input.
California Hybrid & Zero-Emission Truck & Bus Voucher Incentive Project (HVIP) + Public School Bus Set-Aside for Small and Medium Air Districts	**Administrator:** California Air Resource Board **Date:** 2007 – present **Budget:** $196.6M (Standard HVIP) **or** $130M (Public School Bus Set-Aside) **Type:** Point-of-sale discounts	**HVIP:** Up to $198K max per bus. Additional disadvantaged community enhancement available. **or** **Set-Aside:** $350K to $400K per bus based on	**No** Program participants are encouraged to explore funding via California Energy Commission's Clean Transportation Program: EnergIIZE Commercial Vehicles

Jurisdiction and Program	Program Details	Financial Aid Offered *(USD except for Quebec)*	Includes Charging Infrastructure?
	Discount on the purchase of electric school buses. The Public School Bus Set-Aside funding stream offers higher amounts and prioritizes fleet owners in rural and underserved communities.	current bus price averages. Designed to cover full cost of zero-emission bus.	(Energy Infrastructure Incentives for Zero-Emission).
New York State Electric Vehicle – Voucher Incentive Fund (NYSEV-VIF) under NY Truck VIP (Voucher Incentive Program)	**Administrator:** Partnership between NYSERDA, NYSDOT, NYCDOT and CALSTART **Date:** 2013 – present **Budget:** $6M **Type:** Point-of-sale discounts Discounts on the purchase of electric school buses.	100% of the incremental cost up to $220K per bus. **or** 80% of the incremental cost up to $150K per bus for purchase of a new BEV school bus domiciled in one of the 30 CMAQ counties[xxvi] and be exempt from the Scrappage Requirements.	**No**
Massachusetts School Bus Pilot Program	**Administrator:** Massachusetts Department of Energy Resources **Date:** 2016 – 2018 **Budget:** $2M **Type:** Pilot program Demonstration of 3 electric school buses over a period of one year, to measure costs, savings, reduction of GHGs and other air contaminants, performance, reliability, V2G and V2B opportunities.	A maximum of $400K per site, including both the bus and Level 2 charging infrastructure.	**Yes** A maximum of $400K (USD) per site, including both the bus and Level 2 charging infrastructure.

Case Study: Montgomery County Public School Board

The state of California has the most electric school buses in the United States. However, the school district with the most committed electric school buses in the nation is the Montgomery Country Public School (MCPS) system in Maryland. In 2021 the MCPS Board approved a $1.3M annual contract to lease electric school buses from Highland Electric Transportation (HET). The agreement will see 326 diesel buses replaced through 2024, and includes the necessary charging infrastructure, charge management, fuel (electricity), driver training, and reimbursement for bus maintenance.

The MCPS circumvented the financial hurdle of fleet electrification by establishing a budget neutral agreement with HET who will assume this burden by purchasing the buses and recovering the costs over time. As per the agreement, HET will own, operate, and maintain the buses and MCPS will continue to spend what otherwise would be spent purchasing, operating, fueling, and maintaining equivalent diesel school buses until the investment is recouped. At this point, the school board's costs will decrease to below the expected costs of operating an equivalent diesel fleet.

5. What would accelerate the shift to Electric School Buses in BC?

BC has the highest total level of funding for electric school buses among Canadian provinces, which has helped to generate significant momentum in the province and led to the initial purchase of over 50 buses—with more on the way. Our analysis demonstrated that this funding makes investment in electric school buses a financially viable option. The options to accelerate uptake in BC include maintaining and streamlining this funding while ensuring widespread awareness, commitment, and capacity building. Options to respond to these challenges and opportunities, based on our interviews and review of best practices in other jurisdictions, are provided in Table 8. below.

Table 8. Options for next steps

Challenge/Opportunity	Options	Key Actor(s)
Multiple funding opportunities are administratively burdensome to school transportation operators	• Streamline the provincial funding programs • Offer direct or automatic access (not via an application) to the new Zero-Emission Transit Fund • Support capacity building for school districts and other school transportation operators and conduct education and outreach to help them become aware of funding opportunities	• BC Ministry of Education and Climate Change; BC Ministry of Environment, Mines and Low Carbon Innovation • Infrastructure Canada
Funding does not cover full cost of electric bus	• Increase the subsidy to cover the full capital cost for a limited number of years to accelerate uptake and overcome risk aversion	• BC Ministry of Education and Climate Change; BC Ministry of Environment, Mines and Low Carbon Innovation
School districts hesitant to take on CIB loans	• Conduct outreach and education on the mechanisms offered by the CIB with school district board members and staff, as well as staff at First Nations Band-operated and independent schools	• ASTSBC • CIB
LCFS credits significantly improve the business case	• Move forward with plans to collect and distribute LCFS credits on behalf of participating school districts	• ASTSBC

Commit to net-zero operations across the school system	• Adopt net-zero commitments at the school district board level to help prioritize investments in electrification	• School district boards

References

[i] HIS Markit (2022). "Automotive insights: Q4 2021 – Year End Report." Accessed at: https://cdn.ihsmarkit.com/www/prot/pdf/0222/Canada-EV-Newsletter-Q4-2021.pdf

[ii] Yakub Mehanaz (2021). "New British Columbia 2030 climate plan has most aggressive interim ZEV sales targets in North America." *Electric Autonomy.* Accessed at: https://electricautonomy.ca/2021/10/28/british-columbia-zev-sales-targets/

[iii] Carol Brozozowski (2021). "Battle Lines Drawn in Fight Over Quebec Consumption of Electric School Buses." *School Transportation News.* Accessed at: https://stnonline.com/special-reports/battle-lines-drawn-in-fight-over-quebec-consumption-of-electric-school-buses/

[iv] Government of British Columbia. "CleanBC Roadmap to 2030." Accessed at: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf

[v] School Bus Fleet Management and Maintenance Magazine for School Transportation Fleets: 2019 Canadian Fact Book. Accessed at: http://digital.schoolbusfleet.com/CanFact2019?m=65919&i=696495&p=8&ver=html5

[vi] Transport Canada (February 2020). Report of the Task Force of School Bus Safety. Accessed at: https://comt.ca/Reports/School%20Bus%20Safety%202020.pdf

[vii] BC Gov News (2021). "Fleet of the future: electric school buses coming soon." Accessed at: https://news.gov.bc.ca/releases/2021EDUC0031-000848.

[viii] Interview.

[ix] Government of Canada (2021). "Health Impacts of Air Pollution in Canada: Estimates of morbidity and premature mortality outcomes – 2021 Report." Accessed at: https://www.canada.ca/en/health-canada/services/publications/healthy-living/2021-health-effects-indoor-air-pollution.html#a4

[x] Ibid.

[xi] Sandi Ha, Hui Hu, Dikea Roussos-Ross, Kan Haidong, Jeffrey Roth, Xiaohui Xu, The effects of air pollution on adverse birth outcomes, *Environmental Research*, 2014 Oct; 134:198-204. doi: 10.1016/j.envres.2014.08.002. Accessed at: https://pubmed.ncbi.nlm.nih.gov/25173052/

[xii] Liuhua Shi, Kyle Steenland, Haomin Li, Pengfei Liu, Yuhan Zhang, Robert H. Lyles, Weeberb J. Requia, Sindana D. Ilango, Howard H. Chang, Thomas Wingo, Rodney J. Weber & Joel Schwartz, A national cohort study (2000–2018) of long-term air pollution exposure and incident dementia in older adults in the United States, *Nature Communications* volume 12, Article number: 6754 (2021). Accessed at: https://www.nature.com/articles/s41467-021-27049-2

[xiii] Mudway et al., (2018). Impact of London's low emission zone on air quality and children's respiratory health: a sequential annual cross-sectional study. Lancet Public Health, 2019 Jan; 4(1):e28-e40. doi: 10.1016/S2468-2667(18)30202-0. Accessed at: https://pubmed.ncbi.nlm.nih.gov/30448150/

[xiv] National Resources Defense Council (2001). "Tests Reveal High Levels of Toxics Inside Diesel School Buses." Accessed at: https://www.nrdc.org/media/2001/010212

[xv] Emissions factors from Emission Factors of Air Pollutants from Vehicle Operations in GREET, using MOVES.

[xvi] Health care savings calculated based on the two methods presented in Philip Wolfe, Kenneth Davidson, Charles Fulcher, Neal Fann, Margaret Zawacki, Kirk R. Baker, Monetized health benefits attributable to mobile source emission reductions across the United States in 2025, Science of The Total Environment, Volume 650, Part 2, 2019, Pages 2490-2498, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2018.09.273.

[xvii] Government of BC. “Sectoral Emissions Targets.” Accessed at: https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/sectoral-targets

[xviii] We used a carbon intensity of 19 g CO2e/MJ for BC for consumed electricity. Source: Canada's National Inventory Report 2022 - Part 3 (Table A13-11): 2019 value. https://unfccc.int/documents/461919

[xix] Carbon dioxide equivalent (CO_2e) is a term for describing different GHGs in a common unit. For any quantity and type of greenhouse gas, CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact. Source: https://ecometrica.com/greenhouse-gases-co2-co2e-and-carbon-what-do-all-these-terms-mean/

[xx] DiBiase Eisemann, Maria (2019). “Life-Cycle Emissions and Costs of Medium- and Heavy-Duty Vehicles in Colorado." Accessed at: https://cadmusgroup.com/wp-content/uploads/2019/10/Colorado-Energy-Office-2019-Lifecycle-Emissions-and-Costs.pdf

[xxi] Canada Energy Regulator. “Provincial and Territorial Energy Profiles – British Columbia.” Accessed at: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-british-columbia.html

[xxii] Government of British Columbia. “Go Electric Program.” Accessed at: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program

[xxiii] Canadian Infrastructure Bank. "British Columbia Zero-Emission School Buses.” Accessed at: https://cib-bic.ca/en/projects/public-transit/bc-school-buses/

[xxiv] Government of Canada. “Zero Emission Transit Fund.” Accessed at: https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/index-eng.html

[xxv] Includes fuel costs associated with a diesel heater installed on an electric bus, operated for 8 months/year. Uses an annual distance travelled of 33,154 km per the Comprehensive Energy Use Database, accessed at: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=tran&juris=bct&rn=31&page=0

[xxvi] Congestion Mitigation and Air Quality Improvement Program (CMAQ) is a source of funding apportioned by the Federal Highway Administration (FHWA) and administered by the New York State Department of Transportation. CMAQ must be used in areas that are or were previously classified as non-attainment for one or more of the pollutants that comprise the National Ambient Air Quality Standards (NAAQS) Source: https://portal.nyserda.ny.gov/servlet/servlet.FileDownload?file=00P8z000000nuMvEAI

Appendix A

List of Interviewees

- School District 68 Nanaimo-Ladysmith
- School District 62 Sooke
- Association of School Transportation Services of BC (ASTSBC)
- Lion Electric

Appendix B

Assumptions used in calculations

Rate

BC Hydro's Overnight Fleet Electrification Rate was used for the energy (fuel) calculations. It is assumed that school districts are able to meet the minimum 150kW peak demand to qualify for this rate. Additionally, it is assumed that the charging behaviour of school districts is such that all buses are charging overnight with minimal daytime charging and/or top-ups.

Fuel

The price of diesel used for fuel calculations was determined by averaging the retail cost of diesel in BC from April 2021 through April 2022. Diesel prices are highly volatile and subject to change on both a monthly and yearly basis. The price used in the calculations for this work was 1.53 $/L.

Similarly, the price of crude oil in BC utilized for trade balance calculations was averaged from April 2021 through April 2022 and was equal to 0.58 $/L.

Operations

School bus operations were assumed to be running 4 hours per day (2 in the morning and 2 in the evening), 5 days per week, and 4 weeks per month. These calculations do not include any additional bus usage for non-daily routes such as school trips.

Although different manufacturers have different heating technology options, it was conservatively assumed that all electric buses are currently using diesel fuel heating systems. Based on feedback from school districts, estimated duration of heating months varied between 6 – 10 months of the year. An average of 8 months was used for diesel consumption to run heaters on electric school buses.

Low Carbon Fuel Standard (LCFS)

Values used to assess monetary returns from a LCFS scenario were $400/credit, and 0.000746 credits/kWh.

This report was prepared by Dunsky Energy + Climate Advisors. It represents our professional judgment based on data and information available at the time the work was conducted. Dunsky makes no warranties or representations, expressed or implied, in relation to the data, information, findings and recommendations from this report or related work products.