Opportunities for Accelerating School Bus Electrification in Ontario

White Paper

By Pollution Probe, The Delphi Group and Canadian Partnership for Children's Health and Environment

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1.0 Introduction

There is an important opportunity for the Government of Ontario to transition to an electric school bus fleet across the province, and to stop the use of diesel-fueled buses. The electrification of the provincial school bus fleet would help to combat climate change and protect the health of Ontario's children and other vulnerable residents by improving air quality.

There are approximately 20,000 diesel school buses operating in Ontario which travel a total of 1.8 million kilometres every single school day. Air pollution from these school buses jeopardizes the most vulnerable to chronic and acute health impacts: our children. Recent studies have found that exposure to transportation-related air pollutants such as nitrogen dioxide (NO_2) and fine particulate matter ($PM_{2.5}$) is associated with cognitive development disorders in school-aged children (1,2). Diesel exhaust is carcinogenic to humans, contributes to cardiovascular and respiratory disease, and is linked to many other adverse health effects. It also contributes to ground-level ozone pollution and acid rain.

In addition to reducing impacts to human health and the environment, electrification of Ontario's school bus fleet would also deliver deep reductions of greenhouse gases (GHGs) given the province's low-carbon electricity grid, making a significant contribution to the fight against climate change.

Transitioning to electric school buses also promises to generate economic development opportunities for the province's manufacturing sector. A recent study found that converting all Quebec school buses to locally produced electric vehicles (EVs) would improve the province's trade balance sheet by $50-100 million. As Ontario has nearly twice as many school buses on the road as Quebec, electrification could represent a significant economic opportunity in areas such as EV and battery manufacturing, and in the provision of EV charging equipment. Further, unlike petroleum products, electricity used in Ontario is predominantly produced within the province, and its greater utilization will support new electricity sector jobs.

Pollution Probe, Canadian Partnership for Children's Health and Environment, and The Delphi Group are releasing this White Paper to urge the Government of Ontario to immediately catalyze the transition to electric school buses in the province. The health of our children and the threat of the climate emergency demand this action. The time to get dirty diesel school buses off the road is now.

2.0 Ontario's School Bus Fleet and its Pollutants

There are approximately 20,000 school buses in Ontario. They travel a total of 1.8 million kilometres every school day to transport over 833,000 students (3). The fleet is predominantly powered by fossil fuels with 93% of buses operating on diesel and 5% on gasoline. In 2017, a total of 13 electric school buses (ESBs) were deployed in Ontario as part of a provincial climate change initiative (4). Since then, at least 200 ESBs have been ordered by fleet operators and are expected to be delivered between 2022 and 2026 (5).

School buses represent a medium and heavy-duty vehicle (MHDV) market segment which is highly regulated for both emissions and safety. They are classified based on size and passenger capacity. Table 1 presents the proportion of each type of school bus in Ontario along with their capacity specifications.

Table 1: School bus type distribution in Ontario

Bus Type	Capacity	Market Penetration
A	16-30	6,903 (33%)
C	60-72	13,960 (67%)

Table 2 presents the age distribution of the fleet in Ontario. These estimates were collected through surveys completed by provincial and territorial school bus safety authorities as part of a study aimed at strengthening school bus safety in Canada in 2020 (6). 15% of school buses in Ontario are more than 10 years old and are close to reaching their average 12-year lifespan.

Table 2: Fleet age in Ontario

Age of Bus	Number of Buses (proportion of provincial fleet)
0-5 Years	10,618 (51%)
6-10 Years	7,096 (34%)
+10 Year	3,119 (15%)

Diesel- and gasoline-fueled school buses emit harmful air pollutants (criteria air contaminants, or CACs) and GHG tailpipe emissions. Exposure to diesel exhaust emissions such as fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), ground level ozone (O_3) and other toxic chemicals has been linked to various health impacts. In terms of climate impact, a diesel school bus emits around 90 tonnes of carbon dioxide (CO_2) over its 12-year expected lifespan, which is equivalent to the GHG emissions from 23 passenger vehicles over the same timeframe (7). CO_2 emissions associated with gasoline-based school buses are even higher.

GHG and CAC emissions from new school buses have declined over the past 20 years as new fuel and engine emissions standards were introduced by the Government of Canada (8). Serious concerns remain regarding the climate change and health impacts of diesel combustion, however. Given Ontario's low-carbon electrical grid, ESBs provide an opportunity to simultaneously address the adverse health and climate change impacts associated with the emissions of fossil fuel-based school buses.

3.0 Protecting Human Health

The bright orange-yellow of a school bus is an iconic image in Canadian communities. For many, it symbolizes childhood, education, and community commitment to ensuring that all children can get to school. The diesel-powered engines that still power most school buses, however, are also associated with important threats to health and well-being, affecting children, drivers, school personnel, local neighbourhoods, and the society at large, including future generations, with disproportionate impacts on marginalized communities. In this section, we summarize the human health risks posed by diesel and GHG emissions, and the anticipated physical and mental health benefits of switching to electric-powered school buses as a visible and demonstrable step in reducing pollution and addressing the climate emergency.

3.1 Health Effects of Diesel Exhaust

Diesel exhaust emissions have significant direct effects on human health contributing to hundreds of deaths and millions of illnesses every year in Canada. Some contaminants in diesel exhaust, such as $PM_{2.5,}$ have no safe level of exposure. Effects are assumed to occur at all levels of exposure (9).

The health effects of diesel exhaust on people and communities have been studied extensively with the most recent assessment by Health Canada reconfirming the urgent need to reduce emissions. The conclusion of Health Canada's risk assessment, and other agencies including the United States Environmental Protection Agency and the World Health Organization, is that diesel exhaust is a human carcinogen, it causes respiratory inflammation and reduces lung capacity, and it is linked to many other adverse health effects including respiratory effects, cardiovascular effects, central nervous system effects, immunological effects and reproductive and developmental effects (9).

While everyone is at risk from adverse health effects from exposure to diesel exhaust, sensitive groups such as children, the elderly, and asthmatics are at much greater risk. Children exposed to traffic-related diesel exhaust are at greater risk of developing asthma. Diesel emissions have been estimated to cause 2,200,000 acute respiratory symptom days, 170,000 asthma symptom days and 3,000 child acute bronchitis episodes every year in Canada (10).

Health Canada's Human Health Risk Assessment has concluded that exposure to diesel exhaust causes lung cancer and is linked to bladder cancer. Some studies have also shown a link between exposure to diesel exhaust and other types of cancer (10). Exposure to traffic-related air pollution is linked to childhood leukemia and breast cancer in adults (10).

Both acute and chronic exposures to diesel exhaust are linked to various adverse respiratory symptoms including reduced lung function and inflammation of the airways. Exposure to diesel exhaust increases the risk of asthma development in children and the risk of chronic obstructive pulmonary disease (9). Acute and chronic exposures are also linked to adverse cardiovascular conditions including increased risk of heart disease, arrhythmia, ischemia and myocardial infarction (9).

Diesel exhaust exposure can cause immunological effects and has been linked to increased risk of allergic sensitization to outdoor allergens and indoor endotoxins. Studies have shown that exposure to diesel exhaust can increase the immune system response to several allergens in healthy individuals (9).

Diesel exhaust exposure has been linked to reproductive and developmental effects. Toxicological studies have shown that exposure to diesel exhaust can alter hormone levels and gene expression, and may play a role in changes to male and female reproductive systems and in developmental neurotoxicity (9).

A growing body of evidence is raising concern about the effects of diesel exhaust exposure on brain function, including children's neurodevelopment and learning ability, as well as cognitive decline in older people. Acute diesel exhaust exposure has been linked to central nervous system effects with some toxicological studies showing effects of diesel exhaust exposure on spatial learning and memory deficits (9). Some epidemiological studies have shown a link between long-term exposure to outdoor air pollution and cognitive ability as people become older, as demonstrated in cognitive performance on verbal and math tests (11). Prenatal and early childhood exposures to TRAP are thought to contribute to neurodevelopmental disorders, such as attention-deficit/hyperactivity disorder (ADHD) (12). Researchers have found associations between TRAP and deficits in intelligence, memory, attention and behaviour, as

well as symptoms of anxiety and depression (13). A study of school children's exposure to traffic-related pollution found that children with higher exposures to nitrogen dioxide and black carbon in fine particulate matter, two constituents of diesel exhaust, had slower response time than children who were less exposed (1).

Exposure to diesel exhaust is an environmental justice issue. Canadian research has shown that marginalized groups are disproportionately exposed to traffic-related air pollution (14,15). Lower socio-economic status (SES) neighbourhoods are often located closer to major roadways with higher traffic pollution than higher SES neighbourhoods.

3.2 Health Benefits of Electric School Buses

School bus electrification promises multiple physical and mental health benefits for today's children, and will help reduce the health impacts of climate change for present and future generations.

Diesel-powered school buses are a significant source of diesel emissions and children's exposures. Based on studies showing that substantial reductions in diesel emissions from school buses resulted in more than a 30% decrease in childhood bronchitis and asthma cases (16,17), and other studies that demonstrated improvements in cognitive functioning from lower diesel exposure, the elimination of diesel tailpipe emissions from school buses would be expected to provide even greater childhood health benefits.

Switching to ESBs not only improves local air quality and health, but also reduces GHG emissions that are causing climate change. A 2020 study estimated that replacing all public transit buses in the Greater Toronto Hamilton Area with electric buses would prevent 143 premature deaths, provide $1.1 billion in social benefits and reduce 0.3 megatons of GHG emissions every year (18). A 2019 report calculated that replacing all school buses in the United States with electric models could avoid an average of 5.3 million tons of GHG emissions each year (19).

The climate-related physical and mental health impacts our children are currently facing, and will increasingly encounter, is a wake-up call for urgent action to drastically reduce greenhouse gas emissions. Climate change is already impacting the health of Canadians, and children are among the most vulnerable. From asthma, Lyme disease and food insecurity to heat-related illness, the mental health impacts of extreme weather events and climate-anxiety, our children's health is being directly and seriously impacted by climate change (20). According to the World Health Organization, children bear 88% of the burden of disease from climate change (21). One proven solution to reducing greenhouse gas emissions is by electrifying transportation – including school buses.

Children are amongst those most affected by the mental health impacts of climate change, and climate-anxiety is increasing among children and youth. A survey of 10,000 young people around the world revealed that close to 60% felt "very" or "extremely" worried about climate change and over 45% said their feelings about climate change negatively affected their daily lives (22). Health professionals in Canada are seeing an increase in climate-related distress among children (23).

Experts agree that an important way to tackle climate-anxiety is through "active hope" – acknowledging the climate challenge and actively taking steps to help solve it. Children and youth want to be part of the solution and they are demanding climate action globally and in their own communities. As noted in the Hickman et al research, *"Climate change has significant implications for the health and futures of children*

and young people, yet they have little power to limit its harm, making them vulnerable to increased climate anxiety" (22). Travelling on a climate-friendly electric school bus, especially if powered by electricity generation that does not itself contribute to air pollution and a legacy of hazardous waste, can provide both physical and mental health benefits for children. Electrification of school buses also enables schools/school districts to model sustainable practice for students and families, thereby contributing to societal understanding of and action on climate change. By replacing dirty diesel, electric school buses can become a visible icon for children's health protection and a tangible example of climate action in our day to day lives.

4.0 Electric School buses: A Zero Emission Opportunity

4.1 Economic Benefits

Ontario could create high-value jobs and advance a low-carbon economy by expanding its EV manufacturing capacity and developing its local ESB market. The province is well positioned to do so. It has all the ingredients to create a singular EV economy. This includes an abundance of the minerals required to produce batteries, a growing battery recycling sector, leading automotive research programs, and an existing talent pool of skilled labor (24).

According to Clean Energy Canada, the clean transport industry will add over 262,000 new jobs by 2030 (25). The expanding electric medium and heavy duty vehicle (MHDV) production in Canada further illustrates the potential for direct job growth through ESB manufacturing. One need look no further than Quebec's Lion Electric Company which has grown to over 650 employees since its inception in 2017 (26,27). Other examples include BYD, a leading Chinese manufacturer of ESBs, which recently opened a transit bus assembly plant in Newmarket, Ontario. BYD has demonstrated accelerating expansion in its Lancaster, California plant, generating over one thousand new jobs since opening in 2013 (28).

4.2 Market Readiness of ESBs

School bus duty cycles are particularly conducive for electrification for three main reasons: low daily kilometres traveled, long down time at depots that can be used for charging, and low speed operations that allow for energy efficiency through regenerative braking technology associated with electric motors (7).

As illustrated in Figure 1 (7), sales of ESBs in North America have increased significantly over the past few years, with a significant portion of the supply driven by Canadian manufacturers Lion Electric (Quebec) and Greenpower (British Columbia).

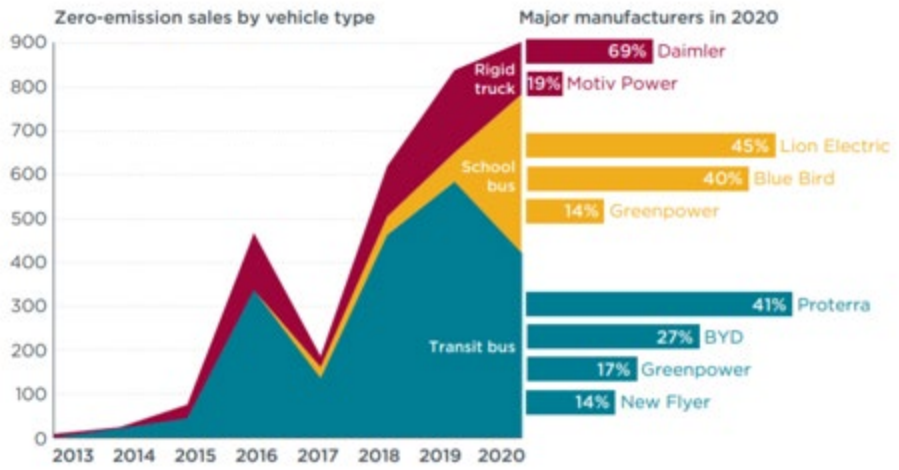

FIGURE 1: CANADA-U.S. ZERO EMISSION VEHICLE SALES BY VEHICLE TYPE

Technology Readiness

School buses are one of the most conducive to electrification among all MHDVs. Improvements in battery cost and performance over the last decade have significantly increased the range capabilities of ESBs. New ESBs in the market have ranges of approximately 160 km, covering the daily travel requirements of most school buses (7). In Ontario, the average distance travelled per day per bus is 90 km, divided into two trips: one in the morning and one in the afternoon (29). This operation schedule adds significant flexibility for charging, allowing operators to take advantage of charging at both mid- and off-peak demand hours, reducing charging costs by up 52% per kWh (30). Additionally, due to the nature of school buses operations - low speed with regular stops and starts - electric drivetrains are ideal from an energy efficiency standpoint as they operate best at low speed and can recover energy through regenerative braking.

Testing has proven that ESBs can handle daily driving ranges and perform well in cold weather (7). ESB manufacturers including Lion Electric, and Thomas Built Buses guarantee their school buses for operation in extreme cold climates (31,32,33).

ESB Market

Currently only 0.2% of Canadian school buses sales are electric. With the advance in electric drivetrain technologies electrification of buses is a promising market in Canada, especially in Ontario where there are almost 20,000 school buses in operation. A majority of these buses will require replacement prior to 2030, and replacing them with diesel buses will lock-in another 12 years of deleterious health impacts for our children, avoidable GHGs for our climate, and missed opportunities for Ontario's economy. As manufacturing capacity increases and reaches economies of scale, production costs will decrease, reducing upfront investments required for ESBs. It is estimated that battery pack prices will also decline. Decreases of up to 65% from 2018 to 2030 are forecasted (34). According to a 2022 Environmental Defense Fund study, by 2027, ESBs will achieve total cost of ownership (TCO) parity within 1 year of vehicle purchase compared to internal combustion engine (ICE) buses (35).

Collaboration among players can serve to accelerate the transition and reduce costs. One example of innovative partnership is Proterra, a zero-emission transit bus manufacturer, partnering with Thomas Built Buses to produce ESBs (36). Another opportunity to reduce overall costs is vehicle-to-grid (V2G) integration, which enables EVs to provide unused power from vehicle batteries back to the grid, allowing for better grid management during peak hours. School buses are well-suited for V2G, as they remain idle for a significant portion of the day and are not generally active during the evening peak period.

5.0 Best Practices from Other Jurisdictions

5.1 Canada

In 2021, the Government of Canada launched the Zero Emission Transit Fund, investing $2.75 billion to support public transit and school bus operators to transition to zero emission vehicles, from planning to purchasing vehicles and building infrastructure (37).

At the provincial level, British Columbia and Quebec are leading the transition by promoting ESBs as part of climate change strategies. In BC, the Minister of Education and the Minister of Energy, Mines, and Low Carbon Innovation launched a joint initiative to fund school districts in BC to purchase electric buses. The Ministry of Education provided $13 million for 31 school districts toward the purchase of 101 new buses, 18 of them electric. The Ministry of Energy, Mines and Low Carbon Innovation has provided additional funding of up to $150,000 towards capital costs of each electric bus. Adding to those incentives, provincial funding is also provided for charging infrastructure to support CleanBC's target to reduce GHG emissions by 40% by 2030 (38).

In Quebec, the government plans to electrify 65% of its school bus fleet by 2030, as part of Quebec's Plan for a Green Economy 2030. To meet this target, the province is providing $18 million for ESBs in Montreal and buying 120 electric buses from Lion Electric with additional support from the federal government and transport companies (39,40).

Other smaller initiatives are being conducted in other provinces. In late 2021, Prince Edward Island announced a purchase of 35 new ESBs from Lion Electric to replace ICE vehicles, increasing its e-fleet to 47 ESBs (41). In 2017, New Brunswick announced the purchase of two new ESBs to add to its fleet, as part of the Department of Transportation and Infrastructure's pilot program to support the province's climate change action plan (42).

5.2 United States

Compared to Canada, school districts in the United States benefit from a larger number of funding opportunities provided at both the federal and state levels to support the transition to ESBs and close the upfront financial burden. The U.S is also leading other initiatives to foster ESBs. The World Resources Institute (WRI) is partnering with local communities, school districts, NGOs, businesses and governments of all levels to leverage the transition to cleaner school buses (43).

As of December 2021, 354 school districts and private fleet operators have committed to purchasing 1,828 ESBs in the U.S., an increase of 57% since June 2021. Momentum continues to grow: in November 2021, the U.S. Congress announced the Infrastructure Investment and Jobs Act, providing $5 billion over five

years for electric and lower-emission school buses. The funding will be allocated through the Clean School Bus Program, providing an annual amount of $500 million exclusively for ESBs and may prioritize high-need, marginalized schools (44).

6.0 Conclusion

As this White Paper demonstrates, harmful emissions from Ontario's diesel school bus fleet continue to threaten the health and wellbeing of the province's children and many other of our most vulnerable citizens and communities. A zero-emission electric school bus fleet in Ontario would eliminate these health threats and deliver important physical and mental health benefits for our children. Electric school buses also present a significant opportunity to take advantage of Ontario's low-carbon electricity grid and deliver reductions in greenhouse gases to combat the climate emergency. Further, ESBs represent a substantial economic opportunity for Ontario, including the creation of new green jobs. The province's strengths in mining, manufacturing and automotive research can be a foundation for ESB production right here in Ontario. Transit buses are now being built in the province, and there is an opportunity to develop a new ESB manufacturing sector.

Pollution Probe, Canadian Partnership for Children's Health and Environment and the Delphi Group call on the government of Ontario to take the necessary actions that will accelerate the adoption of electric school buses in the province. Our organizations are committed to working with the government as well as other stakeholders to achieve the electrification of the school bus fleet to protect the health of our children and contribute to the fight against climate change.

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