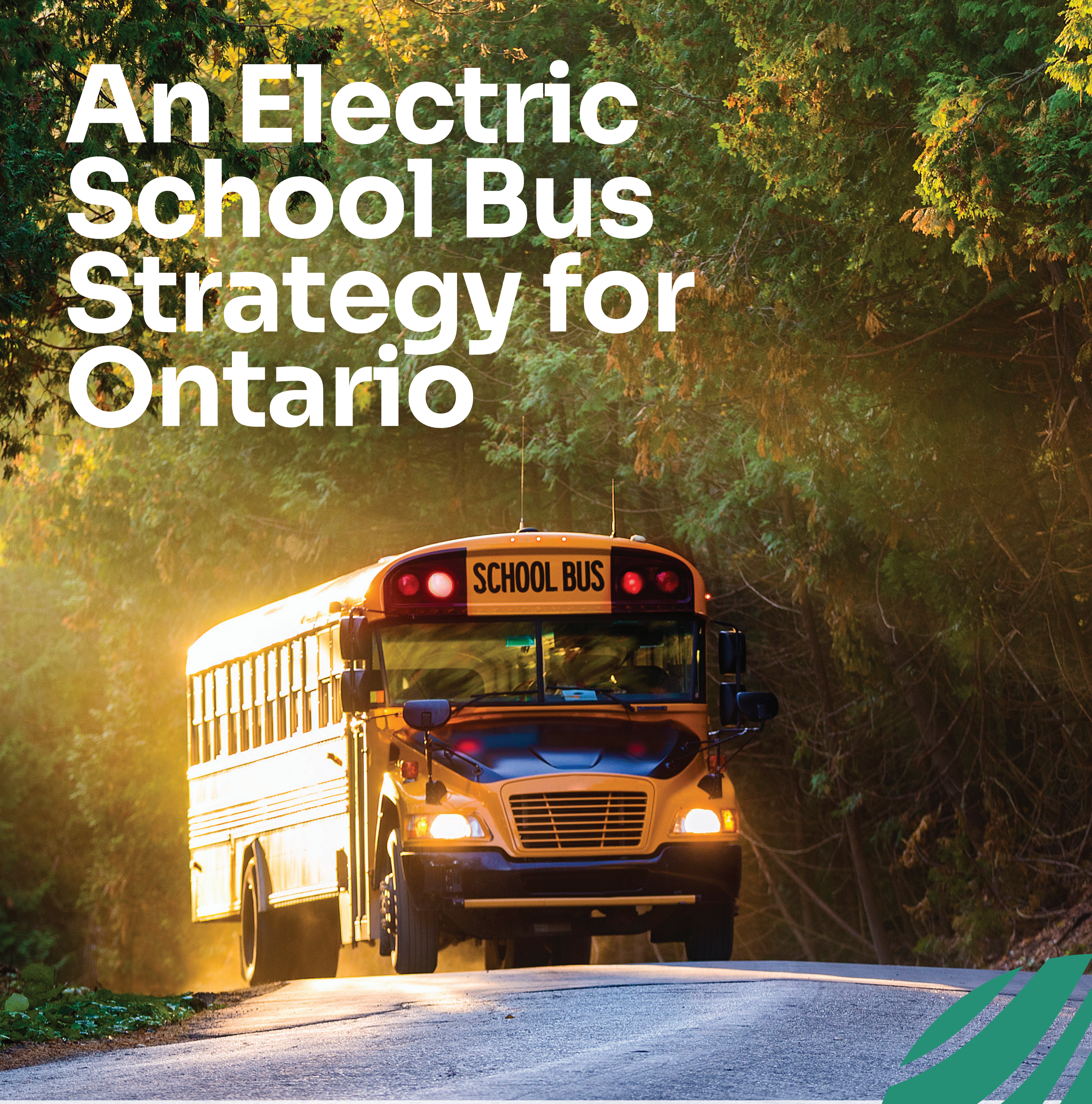
An Electric School Bus Strategy for Ontario



Pollution Probe

Pollution Probe
902 – 130 Queens Quay Easy
Toronto, ON, M5A 0P6,
Canada

TEL: (416) 926-1907
FAX: (416) 926-1601
www.pollutionprobe.org

The Delphi Group
434 Queen Street, Suite 500
Ottawa, ON, K1R 7V7
Canada

TEL: (613) 562-2005
FAX: (613) 562-2008
www.delphi.ca

Canadian Partnership for Children's Health and Environment
www.info@healthyenvironmentforkids.ca
www.healthyenvironmentforkids.ca

For more information, please contact:

Steve McCauley | SENIOR DIRECTOR
smccauley@pollutionprobe.org

Cedric Smith | DIRECTOR, TRANSPORTATION
csmith@pollutionprobe.org

Marc Saleh | PROJECT ADVISOR
msaleh@pollutionprobe.org

Cara LaRochelle | DIRECTOR OF SUSTAINABLE MOBILITY
clarochelle@delphi.ca

Erica Phipps | EXECUTIVE DIRECTOR
erica@healthyenvironmentforkids.ca

Helen Doyle | CPCHE COORDINATING COMMITTEE CHAIR
ONTARIO PUBLIC HEALTH ASSOCIATION REP
helen@healthyenvironmentforkids.ca

ACKNOWLEDGEMENTS
This project was made possible by support from the Trottier Family Foundation. The Delphi Group, Pollution Probe and the Canadian Partnership for Children's Health and Environment are solely liable and responsible for the contents of this report. Inclusion of the names of all external organizations is for acknowledgement purposes only and does not constitute endorsement of contents.

About Partners

Pollution Probe

Pollution Probe is a national, not-for-profit organization that has worked for more than 50 years to improve the health and well-being of Canadians. We pursue environmental gains by working productively with governments, industry, and the public, with a steadfast commitment to Clean Air, Clean Water, and a Healthy Planet. Our niche in the environmental movement lies in our systems approach, which embraces three principal drivers for progress: technology and innovation, rulemaking, and behavioural change.

About CPCHE

The Canadian Partnership for Children's Health and Environment (CPCHE) is a national collaboration of organizations working together since 2001 to advance children's environmental health in Canada. CPCHE's partner and affiliate organizations have expertise in clinical and public health, environmental protection, law and policy, child care, education, disability advocacy, and health equity. CPCHE organizations work across disciplines to synthesize scientific evidence, mobilize knowledge, foster intersectoral solutions, and support informed decision-making on children's environmental health concerns, including toxic chemicals, pollution, and climate change. Our aim is to increase awareness and catalyze action to ensure that all children in Canada have healthy environments in which to live, learn, play and grow.

About Delphi

Proudly Canadian with global impact, Delphi is a boutique consulting firm specializing in climate change, sustainability, and ESG. As a registered BCorp with 30+ years of experience, we don't just know our stuff… we live it. Our clients are private and public sector organizations from all sectors and regions in North America, including many of Canada's top 100 companies. Delphi is part of a collective that includes GLOBE Series, CBSR and Leading Change Canada. Together, we are focused on achieving our vision: to achieve a more sustainable, prosperous, and socially just future in a generation.

Table of Contents

Executive Summary

Electric school buses (ESBs) offer a significant range of opportunities in Ontario for realizing benefits related to air pollutants and human health, climate change mitigation, and economic development.

The purpose of this Strategy is to accelerate ESB adoption in Ontario by firstly exploring the environmental, social and economic opportunities ESBs offer the Province, and secondly by laying out a series of priority actions that can be led concurrently and consecutively by key stakeholder groups.

Ontario is home to more than 20,000 school buses, the vast majority of which are diesel-powered. These buses travel a total of 1.8 million kilometres every school day to transport more than 833,000 students. They are responsible for emitting over 300,000 tonnes of GHGs, 200,000 kg of NOx and 8,000 kg of particulate matter annually. Because school buses operate on relatively short, predictable routes with a significant amount of downtime between runs, they are highly amenable to electrification and as a result many ESB models are currently commercially available.

There have been significant technological advancements over the past decade that have greatly improved the technology readiness and economics of ESBs, with further innovations expected ahead. In addition, an abundance of key minerals for battery production, along with a well-established automotive sector, creates a major opportunity for Ontario in the Canadian electric vehicle ecosystem. However, there are still several prominent challenges that must be addressed by a variety of stakeholder groups before ESB mass adoption can be achieved. These groups include: regulators, boards of education, school bus fleet owners, Original Equipment Manufacturers (OEMs) and their EV supply chain partners, utilities, local advocacy organizations, and community members. Key challenges include: significantly higher purchase prices relative to diesel buses, the need to install charging infrastructure where buses are kept, lack of real-world data in an Ontario context related to ESB energy consumption and operational costs, the need for technician and operator training and certification resources, and the need to refine contracts between bus fleets and school boards to optimize the role of ESBs.

The Strategy presented in this study offers rationale and recommendations to increase the uptake of ESBs within the province. Key focus areas include:

- Designing and implementing pilot programs to collect real world data that will inform energy consumption and maintenance cost data, and validate the use of vehicle-to-grid (V2G) and/or vehicle-to-building (V2B) integration technologies in the Ontario context.
- Developing and enacting policies and contracting requirements that accelerate the retirement of diesel school buses and support the purchase of ESBs to replace them.
- Developing funding mechanisms to offset incremental capital costs of ESBs and required charging infrastructure.
- Providing supporting resources including workforce training and public messaging related to ESB deployment.

The Strategy concludes with a Matrix of Actions which summarizes priority actions and proposed roles for key stakeholder groups that will accelerate the rollout of ESBs in the province and help to realize the benefits they offer to all Ontarians. It is recommended that the Government of Ontario adopt this Matrix of Actions as the foundation for a Provincial School Bus Electrification Strategy.

Ontario School Bus Transportation

1. INTRODUCTION

The Government of Ontario has an opportunity to accelerate the transition away from diesel-fueled buses towards a fully electric school bus fleet.

This would protect the health of Ontario's children and other vulnerable residents, reduce climate change-causing greenhouse gas (GHG) emissions and improve air quality. Further, it would spur economic and job growth by leveraging the province's existing resources, manufacturing infrastructure and expertise.

While the iconic yellow school bus is a symbol of childhood, education and community, it is also a source of harmful emissions that cause serious human health impacts and contribute to climate change. Electric school buses (ESBs) not only address these issues, but also serve as a symbol of active hope among younger generations who are grappling with climate anxiety. Travelling on a climate-friendly ESB provides both physical and mental health benefits for children and their communities and demonstrates climate change mitigation strategies in action.

In addition to health and climate benefits, there are strong economic incentives for Ontario to transition to ESBs. Electrification of the province's bus fleet could represent a significant economic opportunity in areas such as electric vehicle (EV) and battery manufacturing, electricity generation and distribution, and the provision of EV charging equipment. The province is well-positioned to use its manufacturing and mining capacity to support both battery and vehicle production. Given Ontario's comparative advantages within the EV supply chain, there is a valuable opportunity for Ontario to capture a piece of the growing ESB market.

i Ontario School Bus Transportation

Given the health, climate and economic benefits that stand to be realized from the electrification of school buses, Pollution Probe, The Delphi Group, and the Canadian Partnership for Children's Health and Environment (CPCHE), with support from the Trottier Family Foundation, are proposing this Electric School Bus Strategy to accelerate the adoption of ESBs within the province. The Strategy offers rationale and recommendations to increase the uptake of ESBs within the province. Key focus areas include:

> Designing and implementing **pilot programs** to collect real-world data that will inform energy consumption and maintenance cost data and validate the use of vehicle-to-grid (V2G) and/or vehicle-to-building (V2B) integration technologies in the Ontario context.

> Developing and enacting **policies** and contracting requirements that accelerate the retirement of diesel school buses and support the purchase of ESBs to replace them.

> Developing **funding mechanisms** to offset incremental capital costs of ESBs and required charging infrastructure.

> Providing **supporting resources** including workforce training and public messaging related to ESB deployment.

The Strategy concludes with a Matrix of Actions outlining proposed roles for a range of stakeholders including regulators, boards of education, school bus fleet owners, OEMs and their EV supply chain partners, utilities, local advocacy organizations, and community members, to be overseen by strong provincial leadership.

2. ONTARIO'S SCHOOL BUS FLEET

2.1 Description of the current Ontario school bus fleet

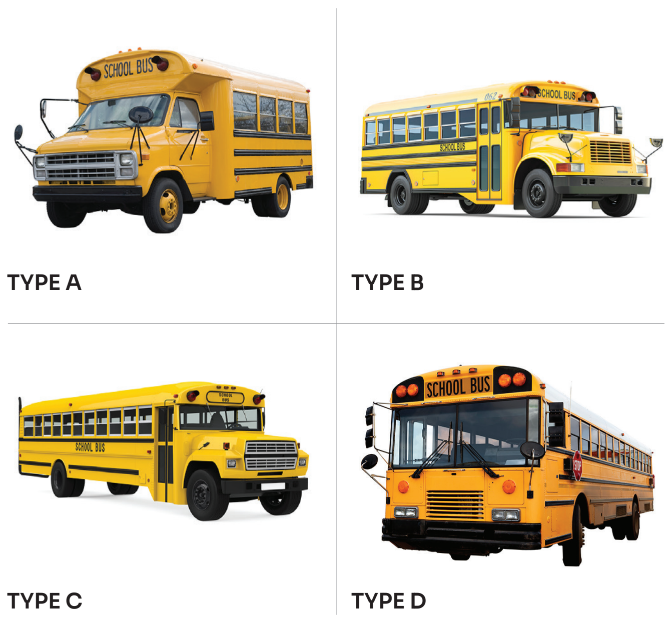
There are approximately 20,833 school buses in Ontario, emitting a total of 307,705 tonnes of carbon dioxide equivalent (CO_2eq), 203,000 kg of nitrogen oxides (NOx) and 8,100 kg of particulate matter annually.[1] They travel a total of 1.8 million kilometres every school day to transport over 833,000 students.[2] The latest estimates indicate that the Ontario school bus fleet is predominantly powered by fossil fuels with 93% of the fleet 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.[3] Since then, at least 200 ESBs have been ordered by fleet operators and are expected to be delivered between 2022 and 2026.[4]

Table 1: School bus type distribution in Ontario

Bus Type	Capacity	Market Penetration
A	16 to 36	6,903 (33%)
C	36 to 78	13,960 (67%)

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

Figure 1: School Bus Types



1 Estimated based on Infrastructure Canada GHG guidance modules. Retrieved from: https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/ghg-modules-ges-eng.html

2 School bus Ontario (2020). School Bus Facts. https://schoolbusontario.ca/school-bus-facts/

3 Province of Ontario (2017). Ontario Fighting Climate Change with New Electric School Buses. https://news.ontario.ca/en/release/45922/ontario-fighting-climate-change-with-new-electric-school-buses

4 Elective (2021). 200 Lion Electric school buses bound for Ontario. https://www.electrive.com/2021/12/16/200-lion-electric-school-buses-bound-for-ontario/

i Ontario School Bus Transportation

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.[5] 15% of school buses in Ontario are more than 10 years old and are close to reaching their average lifespan of 12-years.[6]

Table 2: School bus 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%)
C	36 to 78

2.2 Business Model

There are 72 school boards in Ontario. These are served by 34 Student Transportation Boards/Consortia (STBs), created by the Ontario Ministry of Education in 2006 to coordinate and deliver the transportation of students more efficiently throughout the province. About 150 private fleet operators under contract to the school boards operate 99% of school buses in Ontario. These range from small, family-run operations to large companies. On average, each STB contracts the services of 28 different operators, with some STBs hiring as few as four firms while others hire as many as 81 different firms. With 140 member companies, the Ontario School Bus Association (OSBA) represents about 80% of the school bus service operators in the province. While the number, size and age of school buses in Ontario are collected by the Ontario Ministry of Transportation, this information is not segmented by STB.

Typically, operators aim to turn over 10% of their school bus fleet every year to ensure that older school buses are replaced by regulated, lower emission models, however, this is dependent on budget availability. Despite the increase in funding allocated to STBs from the Ministry of Education in 2007/2008, a 2010 Ontario Public Health Association (OPHA) report indicated that many companies failed to meet the 10% turnover rate due to a lack of funding. As part of the same study, a survey targeted at members of the OSBA also found that the benefits of the additional funding were not equally distributed. Areas in the north of the province where costs associated with school bus transportation are greater were found to have not benefited sufficiently from increased funding.[7]

5 Canada federal, provincial and territorial (FPT) governments (2020). Strengthening School Bus Safety in Canada. https://comt.ca/Reports/School%20Bus%20Safety%202020.pdf

6 CALSTART (2021). Electric School Buses Market Study: A Synthesis of Current Technologies, Costs, Demonstrations, and Funding. https://calstart.org/electric-school-buses-market-study/

7 Kim Perrotta (2010). School Buses, Air Pollution & Children's Health: Follow-up Report. Prepared for the Clean Air Partnership in collaboration with the Ontario Public Health Association (OPHA). Toronto, Ontario. Retrieved from: https://chasecanada.org/wp-content/uploads/2011/07/cap-opha-school-bus-follow-up-report1.pdf

Why Electrify Ontario School Buses?

3. 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 engines that still power most school buses, however, emit harmful air pollutants which pose significant threats to health and well-being. Exposure to diesel exhaust emissions has been linked to various health impacts affecting children, drivers, school personnel, local neighbourhoods, and society at large. This has been shown to have disproportionate impacts on marginalized communities due to what is often their close proximity to high-traffic areas. In this section, we summarize the human health risks posed by air pollution and GHG emissions from diesel exhaust, and from traffic noise, and the anticipated physical and mental health benefits of switching to ESBs as a visible and meaningful step in reducing pollution and addressing the climate emergency.

3.1 Health impacts of Diesel Pollution

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 fine particulate

ii Why Electrify Ontario School Buses?

matter ($PM_{2.5}$) have no safe level of exposure.[8] Effects are assumed to occur at all levels of exposure. In addition to $PM_{2.5}$ which affects breathing, heart and blood functions, diesel exhaust includes gases that are harmful to human health including nitrogen dioxide (NO_2), carbon monoxide (CO) and gaseous hydrocarbons. Diesel exhaust also contributes to the formation of ground-level ozone (O_3), which irritates the eyes, nose and throat, causes shortness of breath and decreases lung function. Diesel engines are a significant source of traffic-related air pollution (TRAP), which scientists identify as an important public health concern that demands greater attention and action.[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 other respiratory effects, cardiovascular effects, central nervous system effects, immunological effects, and reproductive and developmental effects.[10]

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. They are also at greater risk for acute lower respiratory infections.[11] Each year in Canada, diesel emissions are estimated to cause:

- 2.2 million acute respiratory symptom days
- 170,000 asthma symptom days, and
- 3,000 child acute bronchitis episodes linked to exposure to traffic pollution.[12]

Diesel exhaust is a human carcinogen. 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. Exposure to TRAP is linked to childhood leukemia and breast cancer in adults.[13]

Both acute and chronic exposures to diesel exhaust are linked to various adverse respiratory symptoms, including asthma. Exposure to diesel exhaust increases the risk of asthma in children. It is also associated with reduced lung function, inflammation of the airways, and increased risk of chronic obstructive pulmonary disease.[14] Studies show that

8 Health Canada. 2016. Human Health Risk Assessment for Diesel Exhaust. https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

9 Long, E., Carlsten, C. Controlled human exposure to diesel exhaust: results illuminate health effects of traffic-related air pollution and inform future directions. Part Fibre Toxicol 19, 11 (2022). https://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-022-00450-5#citeas

10 Health Effects Institute. 2022. Panel on the Health Effects of Long-Term Exposure to Traffic-Related Air Pollution. Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution. Special Report 23. https://www.healtheffects.org/publication/systematic-review-and-meta-analysis-selected-health-effects-long-term-exposure-traffic

11 Health Canada. 2016 and Health Effects Institute, 2022

12 Health Canada. 2016. Human Health Risk Assessment for Diesel Exhaust. https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

13 Health Canada 2022

14 Health Canada, 2016

ii Why Electrify Ontario School Buses?

combined exposure to both diesel exhaust and ozone produces strong compounding effects on airway inflammation.[15] Acute and chronic exposures are also linked to adverse cardiovascular conditions including increased risk of heart disease, arrhythmia, ischemia, and myocardial infarction.[16]

Diesel exhaust exposure can cause immunological effects and has been linked to an 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.[17] The evidence of the augmented impact of co-exposure of diesel exhaust with environmental allergens is even more troubling considering the increasing risk of exposure to airborne allergens, as climate change and warming temperatures expand the geographic range of certain plant species, extend the pollen season, and increase pollen count.[18]

Diesel exhaust exposure has also 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 developmental neurotoxicity.[19] The implications of this research are particularly concerning in the context of the array of neurodevelopmental disorders, such as learning and behavioural challenges, affecting our children.

Indeed, 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 the effects of diesel exhaust exposure on spatial learning and memory deficits.[20] A study of school children's exposure to TRAP 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.[21]

15 Long and Carlsten, 2022
16 Health Canada, 2016
17 Health Canada, 2016
18 Health Effects Institute. 2022
19 Health Canada, 2016
20 Health Canada, 2016
21 Sunyer,Jordi;Suades-González,Elisabet;García-Esteban,Raquel;Rivas,Ioar;Pujol,Jesús; Alvarez-Pedrerol, Mar; Forns, Joan; Querol, Xavier; Basagaña, Xavier. Traffic-related Air Pollution and Attention in Primary School Children, Epidemiology: March 2017 - Volume 28 - Issue 2 - p 181-189 doi: 10.1097/EDE.0000000000000603

ii Why Electrify Ontario School Buses?

Exposure to TRAP has been shown to negatively impact cognitive development in children and neurobehavioural function in adolescents.[22] Prenatal and early childhood exposures to TRAP are thought to contribute to neurodevelopmental disorders, such as attention-deficit/hyperactivity disorder (ADHD).[23] While the HEI's 2022 Systematic Review found a low confidence for an association between TRAP and ADHD and related behaviours, they did report a moderate to high confidence in the links between TRAP and autism spectrum disorder.[24] Researchers have found associations between TRAP and deficits in intelligence, memory, attention and behaviour, as well as symptoms of anxiety and depression.[25]

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.[26] Other epidemiological studies have linked exposure to air pollution to neurodegenerative diseases such as Alzheimer's disease and Parkinson's disease.[27]

Emerging research also links air pollution exposure to mental health concerns. A systematic review conducted in 2022 identified a link between air pollution and poor mental health, including anxiety and depression.[28] Two studies included in this review found that children and adolescents were more vulnerable to anxiety and depression following air pollution exposure. While the exact biological mechanism remains unclear, recent studies indicate that air pollutants may alter the structure and functions of regions of the brain that play a key role in stress response and emotion regulation (the hippocampus, amygdala and prefrontal cortex). Another concerning finding from this systematic review is the gap in research on "windows of susceptibility" of air pollution exposure, (in particular, early-life, childhood and adolescence exposure windows), and subsequent mental health outcomes and impacts on brain structure, function and development.

Diesel buses and other fossil fuel-powered vehicles are a significant source of noise pollution, with road traffic being the dominant source of noise in urban centres.[29] Exposure to excessive noise reduces quality of life, causes hearing loss, and is linked to cardiovascular impacts, cognitive impacts, sleep disturbance, and mental health effects.[30] Children are more vulnerable and more susceptible to the harmful effects of noise pollution.[31] Noise generated by diesel engines and other sources can adversely affect children's physical health and mental well-being, including

22 Long & Carlsten, 2022

23 Canadian Association of Physicians for the Environment 2021. Mobilizing Evidence: Activating Change on Traffic-Related Air Pollution

24 Health Effects Institute. 2022

25 Devon C. Payne-Sturges, Melanie A. Marty, Frederica Perera, Mark D. Miller, Maureen Swanson, Kristie Ellickson, Deborah A. Cory-Slechta, Beate Ritz, John Balmes, Laura Anderko, Evelyn O. Talbott, Robert Gould, and Irva Hertz-Picciotto, 2019: Healthy Air, Healthy Brains: Advancing Air Pollution Policy to Protect Children's Health American Journal of Public Health 109, 550_554,https://doi.org/10.2105/AJPH.2018.304902

26 Zhang X, Chen X, Zhang X. The impact of exposure to air pollution on cognitive performance. Proc Natl Acad Sci. 2018; 115:9193-7. https://doi.org/10.1073/pnas.1809474115

27 Long & Carlsten, 2022

28 Clara G. Zundel, Patrick Ryan, Cole Brokamp, Autumm Heeter, Yaoxian Huang, Jeffrey R. Strawn, Hilary A. Marusak. 2022. Air pollution, depressive and anxiety disorders, and brain effects: A systematic review, NeuroToxicology, Volume 93, 2022, Pages 272-300, ISSN 0161-813X, https://doi.org/10.1016/j.neuro.2022.10.011. (https://www.sciencedirect.com/science/article/pii/S0161813X22001668)

29 Ranpise, Ramesh B. and Tandel, Bhaven N.. "Urban road traffic noise monitoring, mapping, modelling, and mitigation: A thematic review" Noise Mapping, vol. 9, no. 1, 2022, pp. 48-66. https://doi.org/10.1515/noise-2022-0004

30 Toronto Public Health. How Loud is Too Loud? Health Impacts of Environmental Noise in Toronto. Technical Report. April 2017 https://www.toronto.ca/wp-content/uploads/2017/11/8f98-tph-How-Loud-is-Too-Loud-Health-Impacts-Environmental-Noise.pdf

31 Esmée Essers, Laura Pérez-Crespo, Maria Foraster, Albert Ambrós, Henning Tiemeier, Mònica Guxens,. Environmental noise exposure and emotional, aggressive, and attention-deficit/hyperactivity disorder-related symptoms in children from two European birth cohorts, Environment International,Volume 158, 2022, 106946, ISSN 0160-4120, https://doi.org/10.1016/j.envint.2021.106946. (https://www.sciencedirect.com/science/article/pii/S0160412021005717)

ii Why Electrify Ontario School Buses?

hearing impairment,[32] cognitive impairment,[33,34] and negative impacts on behaviour.[35] Recognizing the heightened sensitivity of children to noise exposure, Health Canada recommends that federal environmental assessments for resource and infrastructure projects include noise assessments to consider effects on schools and child care centres.[36]

Exposure to diesel exhaust is a social and environmental justice issue, with marginalized populations experiencing a disproportionate burden of compounding exposures and risk. Children in racialized and low-income communities are disproportionately exposed to diesel and other traffic-related pollutants in both their home and school environments. Lower socio-economic status (SES) neighbourhoods are often located closer to major roadways with higher traffic pollution than higher SES neighbourhoods, and Canadian research, including a recent Health Canada assessment, has shown that marginalized groups are disproportionately exposed to TRAP. Health Canada reports that a large proportion of schools are located near high-traffic corridors. Its assessment found that 48% of schools were located within 200 metres of high-traffic roadways and 31% were located within 100 metres of a high-traffic roadway. Health Canada defines “elevated TRAP exposure zones” as within 500 metres of a highway or 100 metres of a major urban road.[37,38,39]

3.2 Climate Change and Children’s Health

Climate change is already affecting the health and well-being of people around the globe, including Ontarians, with disproportionate impacts experienced by vulnerable populations including children and people living with inequities. Health risks will increase with increased warming. As highlighted in Health Canada’s Climate Change and Health Assessment (2022):

- “Seniors, children, racialized populations, low-income individuals, individuals with chronic health conditions, and First Nations, Inuit, and Métis peoples often experience greater health impacts of climate change.”
- “Growing climate change impacts worsen socio-economic conditions harmful to health, such as poverty, and amplify health inequities.”
- “Existing inequities, variation in geographic region, and broader socio-economic conditions influence the impact of climate change on the health of children.” [40]

Children are affected both directly and indirectly by climate change, with physical and mental health effects stemming from increasing air pollution, extreme heat and weather events, climate-related disasters, and climate anxiety.

32 Araújo Alves J, Neto Paiva F, Torres Silva L, Remoaldo P. (2020) “Low-Frequency Noise and Its Main Effects on Human Health—A Review of the Literature between 2016 and 2019.” Applied Sciences. 10(15):5205. doi: 10.3390/app10155205

33 van Kempen, E., Fischer, P., Janssen, N., Houthuijs, D., van Kamp, I., Stansfeld, S., & Cassee, F. (2012). Neurobehavioral effects of exposure to traffic-related air pollution and transportation noise in primary schoolchildren. Environmental Research, 115, 18–25.

34 Matheson, M., Clark, C., Martin, R., Van Kempen, E., Haines, M., Barrio, I. L., … Stansfeld, S. (2010). The effects of road traffic and aircraft noise exposure on children’s episodic memory: The RANCH Project. Noise and Health, 12(49), 244.

35 Hjortebjerg, D., Andersen, A. M. N., Christensen, J. S., Ketzel, M., Raaschou-Nielsen, O., Sunyer, J., … Sørensen, M. (2016). Exposure to road traffic noise and behavioral problems in 7- year-old children: a cohort study. Environmental Health Perspectives, 124(2), 228.

36 Health Canada. 2016. Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise. Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

37 Health Canada 2022

38 Canadian Institute for Health Information 2011. Urban Physical Environments and Health Inequities; Finkelstein, M. et al., Environmental Inequality and Circulatory Disease Mortality Gradients

39 Evans G.J., C. Audette, K. Badali, V. Celo, E. Dabek-Zlotorszynka, J. Debosz, L. Ding, G.N. Doerksen, R.M. Healy, D. Henderson, D. Herod, N. Hilker, C-H. Jeong, D. Johnson, K. Jones, A. Munoz, M. Noble, K. Reid, C. Schiller, U. Sofowote, Y. Su, J. Wang, L. White. “Near-Road Air Pollution Pilot Study Final Report,” Southern Ontario Centre for Atmospheric Aerosol Research, University of Toronto, 2019. https://tspace.library.utoronto.ca/bitstream/1807/96917/4/Near%20Road%20Study%20Report.pdf

40 Health Canada, 2022. Health of Canadians in a Changing Climate

ii Why Electrify Ontario School Buses?

As climate change increases the number and intensity of extreme weather events, flood risks, droughts, extreme heat, wildfires and storms, there will be parallel increases in the risk of physical and mental illness, injury, and death. Worsening air pollution, damage to food systems and water resources, and increases in climate-sensitive infectious diseases (e.g., Lyme disease, West Nile virus) will also increase health risks associated with our changing climate.[41]

Climate change is expected to worsen air pollution from smog formation, wildfire smoke, pollen production, and drought, and also affect indoor air quality (e.g., infiltration of outdoor air pollutants indoors, mould from flooding). Children are at increased risk of health impacts from air pollution, as detailed in the previous section.[42] Analysis by Health Canada estimates that by 2050 a warming climate will result in an additional annual 1.9 million acute respiratory symptom days, 160,000 asthma symptom days, and 670 child acute bronchitis episodes, beyond the annual incidents of respiratory conditions from air pollution in Canada.[43]

Further, climate change disproportionately affects the mental health of children. Children are at risk of post-traumatic stress disorder (PTSD) after disasters such as severe storms, wildfires, floods, or other extreme weather events. Children and youth are at greater risk from the psychosocial impacts of climate change because they are more dependent on others to maintain their health and well-being and are less able to influence decision-making and policy (such as voting in elections).[44]

Climate anxiety is increasing among children and youth with a recent global study showing alarming results. 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.[45] Health professionals in Canada are seeing an increase in climate-related distress among children.[46]

As with all climate-related health risks, it is expected that individuals and groups experiencing other factors that make them more likely to suffer from poor health (e.g. low-income, food-insecure, and living in substandard housing, including children within these groups), will experience increased vulnerability to climate-related extreme-weather events (e.g. extreme heat, flooding) and climate-related food-borne, water-borne and insect-borne infectious disease risks.[47]

3.3 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. As highlighted in Health Canada’s 2022 Climate Change and Health Assessment, reducing GHG emissions can have substantial population health co-benefits related to improved air quality and help offset the

41 Health Canada 2022, Health of Canadians in a Changing Climate

42 Health Canada, 2022, Health of Canadians in a Changing Climate

43 Health Canada, 2022. Health of Canadians in a Changing Climate

44 Health Canada, 2022, Health of Canadians in a Changing Climate

45 Caroline Hickman, Elizabeth Marks, Panu Pihkala, Susan Clayton, R. Eric Lewandowski, Elouise E. Mayall, Britt Wray, Catriona Mellor, Lise van Susteren (2021). Young people’s voices on climate anxiety, government betrayal and moral injury: A Global Phenomenon. University of Bath, UK. Research Paper. Retrieved from: https://deliverypdf.ssrn.com/delivery.php?ID=202110105020064074016081107000125000520 86089012039042073120045043058020050089022019037053031095009084008083095073072 02400609802202300509109006404709209608500106408903001704312407609808308412511 81150140240670520130780030941151061250070220080700071151020101200001121050720 95003110124071001065&EXT=pdf&INDEX=TRUE

46 The Climate Atlas of Canada

47 Health Canada, 2022, Health of Canadians in a Changing Climate

ii Why Electrify Ontario School Buses?

costs of climate change mitigation and adaptation. As GHGs and air pollutants both primarily derived from fossil fuel combustion, strategies to address one often reduce emissions of the other. And while the climate benefits of GHG reductions may only be realized in the mid to long term, the public health benefits associated with reductions in air pollution would be realized immediately and locally where the emissions reductions are implemented.[48]

Reducing diesel emissions by switching to electric school buses has significant economic benefits as well. For example, reducing $PM_{2.5}$ and NOx by an equivalent number of tonnes to that emitted by all school buses in Ontario would provide over $7.2 million in health benefits every year.[49]

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 GHG emissions. According to the World Health Organization, children bear 88% of the burden of disease from climate change.[50] One proven solution to reducing GHG emissions is by electrifying transportation – including school buses.

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."

"Every day we're asking thousands of kids across Ontario to get on buses that they know are part of the climate change problem they learn about in school. School bus electrification represents a visible and impactful intervention that will yield multiple physical and mental health benefits for today's children and help reduce the health impacts of climate change for present and future generations."

— ERICA PHIPPS, CPCHE

Making the switch to zero-emission ESBs, 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 and school districts to model sustainable practices for students and families, thereby contributing to the societal understanding of and action on climate change. By replacing dirty diesel buses, ESBs can become a visible icon for children's health protection and a tangible example of climate action in our day-to-day lives.

48 Health Canada, 2022. Health of Canadians in a Changing Climate

49 Estimates were derived from Health Canada's Health Benefits per Tonne of Air Pollutant Emissions Reduction. Region-, Sector-, and Pollutant-Specific Estimates for two Canadian Regions. 2022 https://publications.gc.ca/collections/collection_2022/sc-hc/H144-111-2022-eng.pdf. Estimates represent the scenario assumption of PM2.5 and NOx emission reductions from the 2015 base case of on-road sources distributed throughout the Windsor-Quebec City Corridor region and where the health benefits are accrued to populations within the same region.

50 World Health Organization and United Nations Environment Programme 2010. Healthy Environments for Healthy Children: Key Messages for Action. Retrieved from: https://apps.who.int/iris/handle/10665/44381

ii Why Electrify Ontario School Buses?

4. COMBATTING CLIMATE CHANGE

A diesel school bus emits roughly 82 tonnes of carbon dioxide (CO_2) over its 12-year expected lifespan, and up to four times more CO_2 per kilometre than conventional passenger vehicles.[51] CO_2 emissions associated with gasoline-based school buses are even higher.

While GHG 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,[52] concerns remain regarding the climate change impacts of diesel and gasoline combustion. Given Ontario's low-carbon electrical grid, ESBs provide a particularly promising opportunity to address the climate change impacts associated with the emissions of fossil fuel-based school buses.

The current school bus fleet in Ontario is estimated to emit approximately 307,705 tonnes of GHGs per year. The following three scenarios, presented in Figure 2, were formulated to assess varying levels of ESB penetration in Ontario over the next 20 years based on the existing age distribution of the fleet.

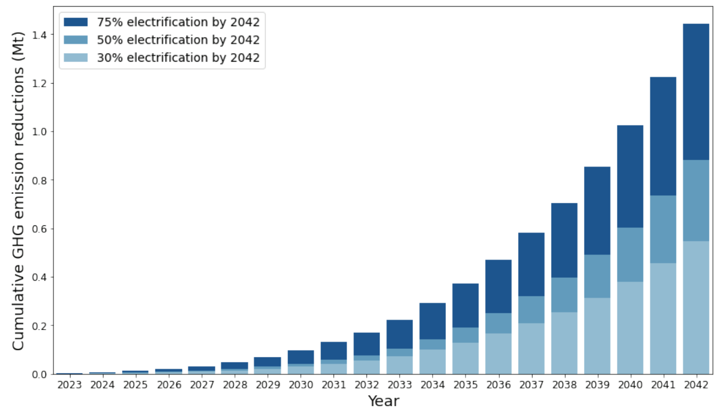


Figure 2: Ontario ESB penetration scenarios - cumulative GHG emissions reductions

30% electrification by 2042: Slow ESB penetration with the electrification of 40 buses per year between 2022-2027,[53] 150 buses per year between 2028-2032, 400 buses per year between 2033-2038 and 700 buses per year between 2039-2042. This scenario results in the electrification of 30% of the fleet by 2042, resulting in total cumulative GHG savings of 545,000 tonnes of CO_2.

50% electrification by 2042:
Mildly aggressive ESB penetration with the electrification of 60 buses per year between 2022-2027, 200 buses per year between 2028-2032, 700 buses per year between 2033-2038 and 1,200 buses per year between 2039-2042. This scenario results in the electrification of 50% of the fleet by 2042, saving an additional 335,000 tonnes of CO_2 relative to the 30% electrification scenario by 2022. The additional GHG savings are equivalent to taking 70,000 gasoline-powered vehicles off the road for a year.[54] This scenario does not include initiatives that provide direct financial subsidies for vehicle procurement but does include other initiatives that would accelerate the ESB transition. Such initiatives include pilots to prove the economic and technological viability of ESBs, educational and planning support for fleets and adequate planning by utilities for grid readiness.

75% electrification by 2042: Aggressive ESB penetration with the electrification of 120 buses per year between 2022-2027, 400 buses per year between 2028-2032, 1,000 buses per year between 2033-2038 and 1,700 buses per year between 2039-2042. This scenario results in the electrification of 75% of the fleet by 2042, saving an additional 565,000 tonnes of CO_2 relative to the 50% electrification scenario by 2022. This scenario requires provincial financial subsidies for vehicle procurement in addition to other initiatives, thereby significantly improving the economics of ESB ownership.

scenarios

51 CALSTART (2021). Electric School Buses Market Study: A Synthesis of Current Technologies, Costs, Demonstrations, and Funding. https://calstart.org/electric-school-buses-market-study/

52 Ontario Public Health Association (2010). School Buses, Air Pollution & Children's Health: Follow-up Report. https://chasecanada.org/wp-content/uploads/2011/07/cap-opha-school-bus-follow-up-report1.pdf

53 Near term penetration assumptions are based on current tentative orders by school bus operators in Ontario. Elective (2021). 200 Lion Electric school buses bound for Ontario. https://www.electrive.com/2021/12/16/200-lion-electric-school-buses-bound-for-ontario/

54 Environmental Protection Agency (2022) Greenhouse gas equivalencies calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

5. ENHANCING ECONOMIC DEVELOPMENT OPPORTUNITIES

Electrifying Ontario's school bus fleet is a transition that can build on Ontario's existing resources, expertise and infrastructure while strengthening the integration of this comparative advantage across northern and southern regions of the province. Further, the transition to ESB fleets also is expected to create jobs and aligns with the overall direction of the global automotive industry.

EV manufacturers have announced approximately $16 billion in new investments in Canada, including $12.5 billion in EV and battery investments.[55] This will translate into thousands of new jobs. According to Clean Energy Canada, the clean transport industry will add over 262,000 new jobs in Canada by 2030.[56]

By volume, Ontario is the second largest vehicle-producing jurisdiction in North America and home to five major automotive original equipment manufacturers (OEMs). Paired with the $12.5 billion investment that manufacturers are making in EV and EV battery investments, the province is well positioned to use both its manufacturing capacity and mining capacity to support both EV battery and vehicle production. Additionally, existing ESB OEMs located in Quebec have seen significant growth in sales of ESBs over the past few years due in part to targets and policies being set at the provincial level to electrify transportation across Canada.

ESB manufacturing can build on the province's existing manufacturing strengths while adding skilled and sustainable jobs to the economy.

5.1 Opportunities in the Electric Vehicle Supply Chain

Ontario is well-positioned to develop its ESB manufacturing capacity. It has all of the necessary ingredients, including an abundance of the minerals required to produce batteries, growing battery manufacturing and recycling sectors, leading automotive research programs, an existing talent pool of skilled labor, and well-established distribution channels to major North American and global markets. Further, the Government of Ontario has announced investments designed to support an end-to-end EV supply chain in the province. Figure 3 outlines the key components of the EV supply chain.

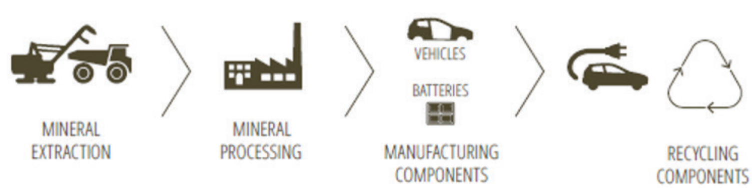


Figure 3: Electric Vehicle Manufacturing Supply Chain

55 Invest Ontario https://www.investontario.ca/automotive
56 Canada's New Economic Engine. 2022. Clean Energy Canada. https://cleanenergycanada.org/wp-content/uploads/2022/09/Canadas-New-Economic-Engine.pdf

ii Why Electrify Ontario School Buses?

5.1.1 Mineral Extraction and Processing

Ontario has an abundance of several key battery minerals. The province's mining operations account for more than 20% of Canada's cobalt production, over 25% of its copper production, and nearly 40% of its nickel production. Further, it is home to over 40% of Canadian businesses engaged in the extraction of alumina and the production and processing of aluminum.[57] Ontario's capital, Toronto, also happens to be the mining finance capital of the world, with 43% of all publicly-traded mining companies listed on either the TSX or TSXV.[58]

This abundance of key minerals has been identified as an area of opportunity for the province in Ontario's Critical Minerals Strategy. This five-year roadmap (2022 to 2027) was developed to better connect the mines in the north with the manufacturing sector in the south, and in particular to Ontario-based EV and battery manufacturing sectors. It aims to generate investment, increase competitiveness in the global market, and create jobs and opportunities in and related to the mining sector.[59]

5.1.2 Manufacturing of Vehicles and Batteries

> Vehicle Manufacturing

While primarily focused on light-duty vehicles, Ontario represents the second-largest vehicle-producing jurisdiction in North America by volume. It is home to five major automakers; and over 700 parts suppliers, including four in the top 100 global suppliers.

Vehicle manufacturing already accounts for over 100,000 jobs in the province and for $14.4 billion of provincial GDP (2019).[60] EV manufacturers have announced approximately $16 billion in new investments, including $12.5 billion in EV and EV battery investments.[61] This will translate into more than one-quarter of a million jobs by some estimates.[62]

Ontario is investing heavily in the sector through its strategy, Driving Prosperity – The Future of Ontario's Automotive Sector. This targets the production of a minimum of 400,000 EVs and hybrids by 2030 and includes commitments to spur investment in advanced manufacturing and automotive technology and to invest in training workers in the auto-sector and related supply chains.

> Battery Manufacturing

Stellantis and LG recently announced that they will build an EV battery manufacturing plant in Windsor. It will produce lithium-ion battery cells and modules and is expected to directly generate 2,500 jobs. The accompanying supply chain is expected to create tens of thousands of additional jobs. The initiative is supported by "record financial support" from all levels of government, according to Premier Doug Ford, and represents the largest auto investment in Canada's history.[63]

57 Pembina Institute (2021). Taking Charge. How Ontario can create jobs and benefits in the electric vehicle economy. Retrieved from: https://www.pembina.org/reports/taking-charge.pdf

58 Ontario Mining Association (OMA). 2022. https://oma.on.ca/en/ontario-mining/facts_figures.aspx#:~:text=Toronto%20is%20the%20mining%20finance,either%20the%20TSX%20or%20TSXV

59 Ontario Government (2022). Ontario's critical minerals strategy. Unlocking potential to driver economic recovery and prosperity. Retrieved from: https://www.ontario.ca/files/2022-03/ndmnrf-ontario-critical-minerals-strategy-2022-2027-en-2022-03-22.pdf

60 The Drive to Survive and to Grow: How Ontario can Succeed in the EV Era. Keenan, G. and Sweeney, B. Munk School of Global Affairs and Public Policy, 2022. https://trilliummfg.ca/wp-content/uploads/2022/06/Apr14_AutoSector_v1.pdf

61 Invest Ontario https://www.investontario.ca/automotive

62 Canada's New Economic Engine. 2022. Clean Energy Canada. https://cleanenergycanada.org/wp-content/uploads/2022/09/Canadas-New-Economic-Engine.pdf

63 https://windsor.ctvnews.ca/we-bagged-a-unicorn-new-ev-battery-manufacturing-plant-announced-for-windsor-1.5831034

ii Why Electrify Ontario School Buses?

Also based in Ontario are two smaller battery manufacturers: Mississauga-based Electrovaya Inc., which manufactures lithium-ion batteries and related systems and products for electric transportation and other purposes; and Stromcore, another Mississauga-based firm, which specializes in lithium-ion batteries for forklifts.[64]

To support battery manufacturing Ontario is also targeting a vertically integrated battery supply chain in the province. Belgium-based Umicore has announced that it will build an industrial-scale cathode and precursor materials manufacturing plant in Loyalist Township, near Kingston. The $1.5 billion plant will produce enough cathode materials to support battery manufacturing for one million EVs and will employ hundreds of people when it opens in 2025. Construction, which will employ another 1,000 people, begins in 2023.[65]

5.1.3 Recycling of Vehicles and Batteries

An important segment of the ESB supply chain is the recycling of vehicles and batteries to both mitigate environmental impact and keep components of the vehicles and ESB batteries in use to maximize product lifecycles. While greater capacity will likely need to be built to handle the anticipated volume of EVs and their batteries, there are existing recycling facilities in the province that can meet current recycling demands. For example, Li-Cycle, which has plants in New York, Arizona, Alabama, Ohio, and Norway, also has a plant in Kingston, Ontario. It employs 30 people and has the capacity to process 5,000 tonnes of lithium-ion batteries annually.[66]

Canadian steel company Stelco also plans to recycle end-of-life EVs and lithium-ion batteries at its facility in Nanticoke, Ontario. It will utilize proprietary technology as part of a joint venture with German and Australian metallurgical companies.[67]

64 Pembina Institute (2021). Taking Charge. How Ontario can create jobs and benefits in the electric vehicle economy. Retrieved from: https://www.pembina.org/reports/taking-charge.pdf

65 https://news.ontario.ca/en/release/1002190/eastern-ontario-joins-provinces-ev-revolution-with-game-changing-battery-materials-manufacturing-investment

66 https://li-cycle.com/our-communities/

67 https://driving.ca/auto-news/local-content/stelco-plans-to-recycle-electric-vehicle-batteries-at-its-ontario-plant

ii Why Electrify Ontario School Buses?

5.2 ESB Manufacturing Capacity

Increasing demand for ESBs is being felt by OEMs across North America. While current Canadian ESB manufacturing capacity exists only in Quebec, the case for developing increased ESB manufacturing capacity in Ontario can be made not only due to its job creation potential but also given Ontario's existing EV supply chain infrastructure from mining to production lines to distribution, as described above. The following sections will provide more detail on where current ESB manufacturing exists, the types of ESBs that are seeing increased demand, and which companies are driving the supply.

5.2.1 ESB Manufacturing

The three leading school bus OEMs in North America are Blue Bird Corporation, Thomas Built Buses (Daimler), and Traton/Navistar (IC Bus). While their primary production remains focused on diesel vehicles, these OEMs are also entering the ESB market. They are joined by EV-exclusive OEMs such as Lion Electric, Green Power Motor, and others.[68]

The increasing popularity of smaller school buses has increased investment from ESB manufacturers to develop Type A school buses with Microbird (a subsidiary of Blue Bird), Motiv Power Systems, Lion Electric, Lightning eMotors, Phoenix Motor Cars and GreenPower Motor Company offering Type A models.

Almost every major ESB manufacturer offers a Type C bus. Type D school buses are manufactured by transit bus manufacturers such as Greenpower, BYD as well as school bus-specific manufacturers such as Lion electric and Blue Bird. Transit bus manufacturers are entering the electric vehicle market due to the similar characteristics and shapes of Type D school buses and transit buses.[69] Type D buses, however, are not typically used in Ontario.

Table 3: Diesel and electric school bus OEMs in North America

OEM	DIESEL	ESB	Manufacturing facility location
Bluebird	✓	✓	Quebec Georgia
Thomas Built	✓	✓	North Carolina
IC Bus	✓	✓	Oklahoma
Collins bus	✓	✓	Kansas
Van-Con	✓		New Jersey
BYD		✓	California
GreenPower		✓	California West Virginia
Lightening eMotors		✓	Colorado
Lion Electric Company		✓	Quebec Illinois
Motiv Power Systems		✓	California
Phoenix Motorcars		✓	California
Unique Electric Solutions		✓	New York
Endera		✓	Ohio

68 Lion Electric (2021), Annual report, retrieved from https://s27.q4cdn.com/902820926/files/doc_downloads/2022/The-Lion-Electric-Company-Form-20-F_2021.pdf
69 BYD (2021). BYD TO REVOLUTIONIZE ELECTRIC SCHOOL BUSES https://en.byd.com/news/byd-to-revolutionize-electric-school-buses/

ii Why Electrify Ontario School Buses?

Table 4 presents a comparison of available ESBs by type and manufacturer.[70]

5.2.2 Canadian Production

In Canada, two OEMs produce ESBs: US-based Blue Bird and Quebec's Lion Electric. Both are based in Quebec where the ambitious target is in place for the electrification of 65 per cent of school buses by 2030.[71] Greenpower, while headquartered in Vancouver, has its manufacturing facilities in southern California, where targets in the Advanced Clean Truck Regulation have sent a market signal via sales quotas to be met by 2035 to accelerate large scale transition of zero-emission medium and heavy-duty vehicles.[72]

Table 5 below illustrates ESB models that are manufactured in Canada.

Table 4: Bus types with ranges and North American manufacturers

Bus Type	Battery Size	Bus Range	Manufacturers
A	63 kWh – 168 kWh	110-240 km	Lightning eMotors, Lion Electric, Micro Bird, Motiv Power Systems, Phoenix Motor Cars, GreenPower Motor Company
C	126 kWh – 315 kWh	160-320 km	Blue Bird, IC Bus, Lion Electric, Thomas Built
D	126 kWh – 255 kWh	160-250 km	Blue Bird, BYD, GreenPower Motor Company, Lion Electric

Table 5: ESB models manufactured in Canada

OEM	Blue Bird			Lion		
Vehicle Model	All-American RE Electric	Micro Bird G5 Electric	Vision Electric	Lion A	Lion C	Lion D
Range (km)	193	161	193	241	250	250
Capacity (# Seats)	84	30	77	24	77	83
Energy/Battery Capacity (kWh)	155	88	155	168	210	210
First Year Available	2019	2021	2021	2021	2021	2021

70 CALSTART (2021). Zeroing in on electric school buses. The advanced technology school bus index: A U.S ESB inventory report. https://calstart.org/wp-content/uploads/2022/01/ZIO-Electric-School-Buses-2021-Edition.pdf

71 https://www.newswire.ca/news-releases/hydro-quebec-launches-a-pilot-project-with-autobus-groupe-seguin-to-support-the-electrification-of-school-buses-882315056.html

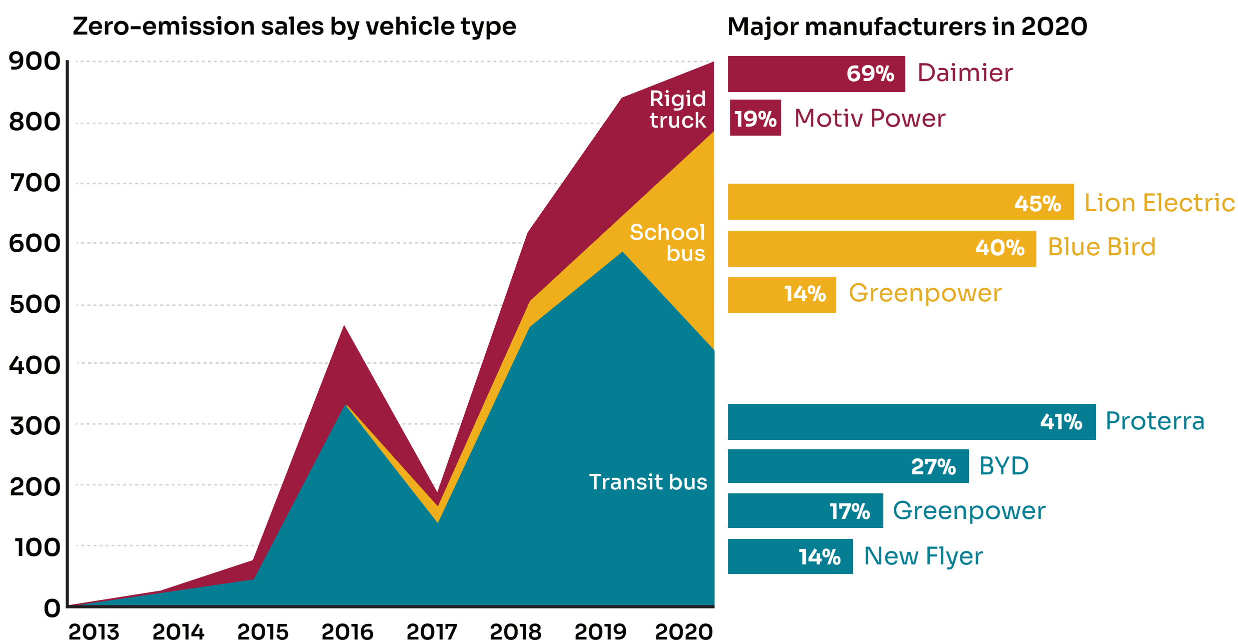
72 For manufacturers of class 2b-8 vehicles, which includes school buses, the regulation requires that 55% of their sales to be zero-emissions trucks/buses by 2035 https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-trucks-fact-sheet

ii Why Electrify Ontario School Buses?

5.2.3 A Growing ESB Market

As illustrated in Figure 4, 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).[73] Given Ontario's comparative advantages along the electric vehicle supply chain, there is a valuable opportunity for Ontario to capture a piece of the growing ESB market while mitigating fossil fuel dependence, GHG emissions, and further reinforcing the electrification of Canada's economy. In summary, electrifying Ontario's school bus fleet has the potential to create jobs while strengthening the integration of this comparative advantage founded in existing resources, expertise, and infrastructure built in manufacturing and mining across northern and southern regions of the province. The province's electric vehicle supply chain, mineral extraction and processing capacity for battery manufacturing as well as the infrastructure for recycling batteries create an environment that is ripe for the growth of an ESB manufacturing hub.

Figure 4: North American sales of zero-emissions vehicles, by vehicle type



73 CALSTART (2021). Electric School Buses Market Study: A Synthesis of Current Technologies, Costs, Demonstrations, and Funding. https://calstart.org/electric-school-buses-market-study/

How to Electrify Ontario School Buses?

To realize these opportunities, the Province requires an ESB strategy focused on funding support and key information gathering that can inform key next steps.

An ESB strategy endorsed by the Province of Ontario should contain four key components to enable and accelerate the electrification of school buses:

- Pilot programs,
- ESB supportive policy,
- Funding for ESBs and charging infrastructure, and
- Resources, including training.

Real-world data collected via ESB pilot programs, including testing of vehicle-to-everything (V2X) integration; ESB-supportive policies and funding mechanisms to offset the capital costs of ESBs and charging infrastructure are priority areas for development. This reflects and supports growth in the ESB market, better economies of scale, as well as technology improvements across battery and manufacturing capabilities.

iii How to Electrify Ontario School Buses?

6. SUPPORT ONTARIO ESB PILOTS

The typical operation of school buses, with frequent stops and starts and long periods of idling, is inefficient for diesel-burning buses, yet school districts largely rely on these vehicles. This results in higher fueling costs and emissions outputs. Conversely, school bus duty cycles are particularly conducive to electrification for three main reasons: low daily kilometres traveled on predictable routes, long downtime at depots that can be used for charging, and low speed, start-stop operations that allow for energy efficiency through the regenerative braking technology associated with electric motors.[74]

6.1 Assessing Operational Performance and Cost

Improvements in battery cost and performance over the last decade have significantly increased the range capabilities of ESBs. New ESBs on the market have an average range of 150 km in moderate temperature conditions. 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.[75] Modern ESBs can therefore accommodate the daily range requirements of most routes on a single charge in moderate temperature conditions.[76] If needed, school buses can charge between the morning and afternoon runs as well as overnight.

Concerns remain regarding battery range and performance in general, but especially in extreme weather conditions. Winter operations are one of the main cited barriers to the adoption of ESBs in Ontario.[77] Studies show that EV battery energy consumption can vary by up to 40% under winter conditions.[78] This variability is however dependent on a wide variety of factors including the battery chemistry of individual manufacturers, ambient temperatures, HVAC systems, driving style, number of starts and stops along a route, and cargo variability.

Several pilot projects to gather real-world data have been launched in the United States in recent years.[79] These studies explored the impact of weather conditions on ESB energy consumption, among other elements that have impacts on battery range and performance; however, the degree of applicability to the Canadian context has been called into question, given the prevalence of more extreme winter weather conditions.[80] Extreme cold conditions impact the operations of ESBs and have resulted in the use of diesel or propane auxiliary heaters to limit the power consumption of batteries in certain Canadian

74 CALSTART (2021). Electric School Buses Market Study: A Synthesis of Current Technologies, Costs, Demonstrations, and Funding. https://calstart.org/electric-school-buses-market-study/

75 School Bus Facts (2020). School Bus Ontario. https://schoolbusontario.ca/school-bus-facts/

76 CleanTechnica (2021). How Quickly Will Electric School Buses Scale? An Interview With Blue Bird. https://cleantechnica.com/2021/04/24/how-quickly-will-electric-school-buses-scale-an-interview-with-blue-bird/

77 Bellwether (2019). From Yellow to Green. Reducing School Transportation's Impact on the environment. https://bellwethereducation.org/publication/yellow-green-reducing-school-transportation%E2%80%99s-impact-environment

78 Effects of ambient temperature on the route planning of electric freight vehicles. Transportation Research Part D: Transport and Environment. Rastani, S., Yüksel, T., & Çatay, B., 2019, https://doi.org/10.1016/j.trd.2019.07.025

79 Texas A&M Transportation Institute (2020). Literature Review and Industry Scan of Electric School Buses. https://static.tti.tamu.edu/tti.tamu.edu/documents/0-9907-20-TM2.pdf

80 Vermont Energy Investment Corporation (2018). Electric School Bus Pilot Project Evaluation. https://www.veic.org/Media/default/documents/resources/reports/veic-ma-doer-electric-school-bus-pilot-project.pdf

regions. The use of diesel or propane auxiliary heaters in ESBs needs to be investigated further to determine the environmental, operational, and human health impacts, but also to determine what alternatives are available to supply adequate cabin heating in ESBs during Canadian winters.

ESB pilots are also essential for fleet operators not only to monitor ESB energy consumption but to validate maintenance cost reductions advertised by OEMs and confirm other performance reliability metrics that are essential to their operations. An example of such ESB pilots was launched in November 2022 in the City of Calgary. The project involves monitoring key performance and cost data from a single ESB as it is used in regular service over the course of a school year.[81] Preliminary results from the pilot show a reduced total range to around 85 km in winter conditions when the electrical heating system is on based on a typical 145 kWh battery bus, creating range limitations. The range limitations are particularly problematic for routes in which the driver keeps the bus without returning to the yard with access to charging in between the morning and afternoon run, as is often the case.

Consultations conducted as part of this study indicated that real-world data analyses expected to be conducted on ESBs deployed in Ontario as part of the 2017 Electric School Bus Pilot Program[82] were not completed because the program was cancelled while it was still in its early stages in 2018.

RECOMMENDATION

Increase the Ministry of Education school transportation budget to launch ESB pilot programs in Ontario through STBs. STBs can provide funding for ESB demonstrations and develop approaches to share and validate the energy consumption and maintenance cost data observed. The funding can be distributed to fleet operators via STB contractual agreements that stipulate the submission of ESB data on a yearly basis. Agreements could also require that fleet operators benefiting from additional funding to run ESBs share their operational lessons learned.

6.2 Assessing Vehicle-to-grid Integration for ESBS

Vehicle-to-everything (V2X) is a term used to describe the general concept of a vehicle connected to its surrounding environment with the ability to transfer power bi-directionally. In the context of electricity storage, Vehicle-to-Building (V2B) and Vehicle-to-Grid (V2G) represent the two most common V2X processes of transferring the electricity stored in EVs to energy-related infrastructure. Vehicle-to-Building (V2B) integration technology enables buildings to draw power from ESBs. Vehicle-to-grid (V2G) integration technology allows ESB batteries to supply power back into the electrical grid when needed. V2X provides an opportunity to offset some of the incremental costs of ESBs, however additional testing is required to support the widespread use of this technology in Ontario. Consultations conducted as part of this project highlighted that ESB V2X technology applications are gaining traction across North America and that they represent an excellent opportunity for use in Ontario.

81 Pollution Probe (2022). First-Ever Electric School Bus Pilot in Calgary. https://www.pollutionprobe.org/newsletter/e-news-fall-2022/
82 https://news.ontario.ca/en/release/45922/ontario-fighting-climate-change-with-new-electric-school-buses

iii How to Electrify Ontario School Buses?

V2X can allow for better grid management during peak hours by expanding and stabilizing the grid via surplus energy storage using the batteries of the school buses. School buses are well-suited for V2X, as they remain idle for a significant portion of the day, have extremely predictable and consistent duty cycles, and in a large majority of circumstances are parked at depots by 5 pm – when the evening period of peak electricity usage begins. In jurisdictions such as Ontario, which largely rely on emissions-free sources of baseload electricity like hydro and nuclear power, the additional electricity needed during peak periods is often provided by natural gas-fired "peaker" plants. Stationary storage in the form of vehicle batteries can supply power to the grid during peak periods and offset the need for fossil fuel-fired electricity generation.

A number of successful pilots of V2X technology with ESBs have illustrated the potential for partnerships between local utilities and school bus operators. Five Lion Electric LionC school buses in White Plains School District in New York State were piloted in a partnership between V2G technology company Nuvve, the local school district, the school bus operator, and the electrical utility Con Edison. The New York State Energy Research and Development Authority is now able to transmit energy from the school buses back into the grid. As a result of that pilot and others, Nuvve and Blue Bird Corporation have now partnered to make the V2G school bus program available across the US.[83] Lion Electric recently signed a Memorandum of Understanding (MOU) with the United States Department of Energy (DOE) to accelerate the development and deployment of V2X technologies through collaboration with stakeholders including utilities, OEMs, government agencies, industry labor organizations and the DOE.

Consultations conducted as part of this project showed that a request for expressions of interest was sent to operators by the Toronto District School Board and the Toronto Catholic District School Board in June 2022 for an initial 20 to 30-bus V2G pilot in Ontario. It is recommended that this technology be piloted more widely across the province.

RECOMMENDATION

School bus companies and transportation consortia should conduct pilots to study the provincial technological and regulatory barriers to V2X implementation with a particular emphasis on ESBs as a promising heavy-duty vehicle application.

Provincial governments, utilities, industry and other stakeholders should examine provincial utility regulatory barriers to V2X implementation to facilitate V2X pilots that could play a critical role in improving ESB economics, making the case for regulatory changes, and ultimately accelerating adoption.

This recommendation is particularly critical given ESBs could unlock the gateway for V2X implementation for other types of vehicles. As technology progresses, most EVs will be V2X eligible, and ESBs are an important stepping-stone towards enhanced economy-wide V2X integration given that their duty cycles are predictable and well-suited to V2X applications. Once a significant portion of EVs of all types are participating in V2X programs, this decentralized energy storage mechanism will serve as an extremely valuable distributed energy resource (DER). It would not only result in cost savings for bus fleets, but for utilities and their customers as well, as it would reduce electricity generation demand during daily peak periods. Further, widespread V2X would allow utilities to mitigate, defer or avoid costly generation and distribution asset upgrades and expansion.

83 Electrek (2020). New York's vehicle-to-grid e-school bus pilot program is a success. https://electrek.co/2020/12/14/new-york-vehicle-to-grid-school-bus-pilot-program-success/

iii How to Electrify Ontario School Buses?

7. DEVELOP AND ENACT ESB POLICIES

Provincial policy will play a key role in developing a conducive environment for the transition to ESBs. Several studies have identified the health impacts and associated costs of diesel school buses. These studies allow evidence-based justification for ESB transition policy through the integration of targets and costs related to impacts of diesel vehicles into provincial policies and programs. Further, research has shown that the oldest diesel school buses are predominantly responsible for most emissions associated with the school bus sector. In this context, school bus replacement policy has often primarily been targeted at older, dirtier diesel vehicles.[84]

Vehicle retirement policies have been successfully supported with scrappage programs in many global jurisdictions. These programs offer financial incentives to fleets to facilitate the replacement of older vehicles with newer vehicles that have significantly improved environmental performance. They are typically led by non-profit organizations with federal or regional government funding and oversight.

RECOMMENDATION

The Government of Ontario should:

★Incorporate ESB targets into provincial policies and programs, based on the proven health and economic benefits that would result from their increased use; and

★Enact policy, supported by a measure such as a scrappage program, to accelerate the retirement of older diesel school buses and replacement with ESBs.

Layered onto provincial policy development, changes to contractual agreements between STBs and school bus operators will be an effective mechanism to accelerate ESB uptake among fleets.

A Model Contract Template was developed by student transportation stakeholders in Ontario for use by STBs and fleet operators in the province. While the use of the template is not mandated, the Ontario Ministry of Education recommends that all STBs review the clauses and provisions which have been identified as best practices for inclusion in their own contracts with local operators.[85]

84 EPA (2022). Diesel Emissions Reduction Act. https://www.epa.gov/dera/reducing-diesel-emissions-school-buses

85 Ontario Public Health Association (2010). School buses, Air Pollution & Children's Health: Follow-Up Report. https://chasecanada.org/wp-content/uploads/2011/07/cap-opha-school-bus-follow-up-report1.pdf

iii How to Electrify Ontario School Buses?

The Model Contract Template for student transportation services includes two age-related criteria stating that fleet operators have a maximum average fleet age of 7 years and maximum bus age of 11 years for full-size buses. These age-related criteria have played a limited role in the increased turnover of buses in Ontario over the past decade. In fact, consultations with school boards conducted as part of this project revealed that best practices included in the Model Contract Template are only included in contracts as recommendations that are not mandatory to maintain competitive bidding with fleet operators.

With regard to clauses targeted at emission regulation, The Model Contract Template includes sections that require the collection of data by operators which could be used for the estimation and tracking of emissions (vehicle model, route, model year). It however does not include any information related to routing optimization or the propulsion technology of the buses used.

RECOMMENDATION

The contracts between STBs and school bus service operators can serve as a key mechanism to accelerate the transition to ESBs in Ontario. ESBs can be gradually integrated into school bus fleets by introducing a mandatory contract clause that ensures a minimal proportion of each fleet is electric. A gradual phase-in will allow school bus service operators to become familiar with the operations of ESBs and extract lessons learned. This will allow them to increase ESB adoption further as the total cost of ownership continues to approach parity with diesel school buses. The Ontario Ministry of Education should conduct a financial study to estimate an appropriate proportion for the mandatory clause based on the size of transportation contracts awarded to operators by STBs, with potential exceptions for smaller operators. The funding for school bus operations that are provided to STBs by the Ministry of Education should be increased in proportion to the incremental costs of ESB requirements.

Another important aspect of the challenge around creating a favourable business case for ESB uptake is the current length of contracts that exist with school bus companies. The contracts span only 5-years, which fails to create a favourable business model that would incentivize bus companies to consider switching their fleets to ESB. While focusing on access to funding mechanisms is an important tool, adjusting the structure and details of contracts to accommodate the capital costs of ESBs would reduce the financial risk of ESB purchases by ensuring that the operational savings of ESBs can be leveraged over a longer portion of the vehicles' lifetimes.

RECOMMENDATION

STBs should increase the duration of contracts from the current 5 years to 10 years with school bus companies who pledge to provide a portion of their services using ESBs. The longer contracts would reduce the financial risk of ESB purchases by ensuring that the operational savings of ESBs can be leveraged over a longer portion of the vehicles' lifetimes.

8. SUPPORT ESB UPTAKE THROUGH FUNDING

While the capital cost of ESB remains higher than that of a diesel-powered bus, efficiencies across the supply chain as well as economies of scale are helping to reduce this cost, in addition to lower operational costs.

According to a 2022 Environmental Defense Fund study, ESBs total cost of ownership (TCO) will start to compete with diesel buses by 2027.[86] This estimate will vary depending on the impact of the extensive supply chain disruptions that have resulted from the COVID pandemic.
For now, however, higher incremental capital costs are overshadowing operational cost savings. Financial incentives can help to reduce the resulting barrier to ESB adoption. It is important to note this estimate of the TOC will vary depending on the impact of the extensive supply chain disruptions that have resulted from the COVID pandemic.

The following sections outline the capital and operational cost profiles of diesel buses and ESBs, and where funding can help improve the cost profile of ESBs and incentivize their uptake across the province.

8.1 Cost Profile of ESBS

8.1.1 Capital Cost

The capital cost of an ESB is higher than that of their diesel counterparts, with an average additional price of $260,000 ($330,000 to $375,000 as compared with $100,000 for a diesel school bus).[87] As manufacturing capacity increases and achieves economies of scale, production costs will decrease, reducing the upfront investments needed for ESBs.

Battery costs are the highest contributors to the cost difference between a diesel and an electric school bus. Yet, battery costs have decreased significantly over the past decade. Battery costs have decreased from roughly $1,000/kWh in 2010 to close to $137/kWh in 2022 for the light-duty passenger sector. Costs per kWh are currently closer to $250/kWh in the heavy-duty school bus sector due to lower economies of scale and purchasing power of manufacturers, but they are expected to continue decreasing as market penetration increases.[88] Decreases of up to 65% from 2018 to 2030 are forecasted.[89]

An additional cost fleet operators must incur with ESBs are infrastructure costs. However, ESBs do not travel significant distances daily and therefore do not require expensive direct current (DC) fast charging infrastructure. Level 2 (AC) charging stations at depots are sufficient for charging in between shifts and during the overnight off-peak period. Level 2 charging stations cost between $3,000-5,000 to purchase and a comparable amount to install. They generally do not require additional electric capacity upgrades at depots and provide electricity at a rate that is not likely to increase electricity demand charges at depots or the residences of drivers. Fleet operators that choose to install higher power DC fast chargers (DCFC) would however incur significantly higher purchase and installation costs that can reach up to $150,000. [90]

86 Medium and Heavy-Duty Electrification Costs for MY 2027- 2030, Roush Industries, Inc, 2022, http://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6_20220209.pdf

87 See: https://atlaspolicy.com/wp-content/uploads/2019/07/Electric-Buses-and-Trucks-Overview.pdf

88 CALSTART (2022). Zeroing in on zero-emission trucks. The advanced technology truck index: A U.S ZET inventory report. https://calstart.org/wp-content/uploads/2022/02/ZIO-ZETs-Report_Updated-Final-II.pdf

89 A Behind the Scenes Take on Lithium-ion Battery Prices, Bloomberg, 2019. https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

90 World Resources Institute (2022). Electric School Bus U.S Market Study and Buyers' Guide: A Resource for School Bus Operators Pursuing Fleet Electrification. https://www.wri.org/research/electric-school-bus-us-market-study-and-buyers-guide-resource-school-bus-operators

iii How to Electrify Ontario School Buses?

8.1.2 Operational Costs

While capital costs of ESBs remain higher than their diesel counterparts, a total cost of ownership (TCO) analysis reveals significant savings in operational costs including both maintenance and fuel for electric buses. ESBs have significantly fewer moving parts than diesel powertrain technology, which reduces the maintenance needs of the vehicles. Diesel school buses also require regular fluid changes, oil changes, and brake replacements due to the stop-and-go operations of school buses. On the other hand, electric school buses benefit from stop-and-go operations through regenerative braking technology, which allows the bus to generate energy in these conditions while reducing brake wear by up to five times relative to diesel buses.

With the increasing costs of petroleum fuels, vehicle charging costs are significantly lower than diesel fuel costs. Further, electricity is less prone to extreme fluctuations in price relative to petroleum-based fuels, therefore allowing more reliable budget estimates for fleet operators.

8.1.3 Vehicle-to-Everything Integration

Vehicle-to-Everything (V2X) integration presents an opportunity to offset some of the incremental costs of ESBs by enabling school bus companies to sell power from ESB batteries back to the grid.

School bus operators can sell stored electricity in the batteries back to the grid during outages or periods of low energy supply or high energy demand. As an incentive for providing power to the grid when it is most needed, electrical utilities will typically pay a significant premium relative to the cost of off-peak electricity (which occurs overnight when buses would do the bulk of their charging). Preliminary estimates show a compensation rate of $0.40-0.50/kwh for power drawn by utilities accounting for potential battery degradation. Given electricity prices in ON, that would represent revenues for fleets of up to 8,000$ per ESB on a yearly basis, depending on local electricity prices, the size of bus batteries, and the agreements struck with local utility companies.

V2X studies are being piloted across multiple jurisdictions. The technology gives utilities a bigger role to play in the school bus electrification transition. School bus fleet operators often do not have access to the required upfront capital cost to purchase ESBs. One model first proposed by Dominion Energy in Virginia, United States aims to capitalize on the potential savings achieved by V2X by offering “pay as you save” or tariffed on bill financing models for fleet operators.[91] In these financing models, the utility covers the initial extra cost of electric powertrain technology, and as the customer saves on their energy costs, the customer repays the utility company on a monthly basis over the lifetime of the bus. This approach particularly lowers the cost barrier of fleet operators with tight budgets.[92]

V2X integration offers another tool that could be leveraged to offset the cost of ESB while supply chain efficiencies and economies scale gradually close the gap between ESBs and diesel buses. The success of this pathway has been demonstrated in the US via partnerships between local utilities and school bus operators. Based on these

91 US PIRG (2022). Electric School Buses and the Grid Unlocking the power of school transportation to build resilience and a clean energy future. https://environmentamerica.org/reports/amc/electric-school-buses-and-grid#:~:text=Vehicle%2Dto%2Dgrid%20(V2G,providing%20these%20and%20other%20services

92 US PIRG (2021). Accelerating the transition to electric school buses. How schools, lawmakers and utilities can work together to speed the transition to zero emissions electric buses https://uspirg.org/reports/usp/accelerating-transition-electric-school-buses

iii How to Electrify Ontario School Buses?

outcomes, the next step for Ontario will be to encourage and facilitate similar types of partnerships while working with utilities to better understand the regulatory barriers and policy solutions available.

8.2 Funding

In the absence of financial incentives, the total cost of ownership (TCO) of ESBs is still higher than that of diesel powertrain technology as of 2022, as illustrated in Figure 5.

There is federal funding available to offset the incremental costs of ESBs. In 2021, the Government of Canada launched the Zero Emission Transit Fund (ZETF), investing $2.75 billion over five years to support public transit and school bus operators to transition to zero-emission vehicles.[94] The ZETF provides subsidies that cover up to 50% of the cost associated with the purchase of ESBs and charging infrastructure. With no provincial programs available, ESB purchases in Ontario rely entirely on funding from the ZETF.

Several provinces have also targeted increased adoption of ESBs as part of broader climate change strategies.

Figure 5: TCO of diesel vs electric school bus over a 12-year lifespan, with and without a purchase incentive of 50% [93]

91 US PIRG (2022). Electric School Buses and the Grid Unlocking the power of school transportation to build resilience and a clean energy future. https://environmentamerica.org/reports/amc/electric-school-buses-and-grid#:~:text=Vehicle%2Dto%2Dgrid%20(V2G,providing%20these%20and%20other%20services

92 US PIRG (2021). Accelerating the transition to electric school buses. How schools, lawmakers and utilities can work together to speed the transition to zero emissions electric buses https://uspirg.org/reports/usp/accelerating-transition-electric-school-buses

93 CALSTART (2021). Electric School Buses Market Study: A Synthesis of Current Technologies, Costs, Demonstrations, and Funding. https://calstart.org/electric-school-buses-market-study/

94 Government of Canada (2022). Zero Emission Transit Fund. https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/index-eng.html

iii How to Electrify Ontario School Buses?

> In BC, 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 the capital costs of each electric bus. Adding to those incentives, provincial funding is also available for charging infrastructure to support CleanBC's target to reduce GHG emissions by 40% by 2030.[95]

> 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.[96] Province-wide, a total of $250 million will be provided to purchase new ESBs, putting a total of $300,000 toward the cost per bus.[97]

> In late 2021, Prince Edward Island announced a purchase of 35 new ESBs from Lion Electric to replace diesel vehicles, increasing its e-fleet to 47 ESBs, representing 15% of PEI's total school bus fleet.[98]

While federal funding represents an important investment that will help to catalyse the ESB market in Canada, stackable provincial funding would support Ontario school bus companies and school boards in setting and meeting more aggressive fleet electrification targets, targets that would improve air quality, reduce child health risks, and position Ontario as a leader in the EV economy. A provincial funding strategy should incorporate equity considerations and include a focus on accelerating ESB procurement in socio-economically marginalized communities and those facing a disproportionate burden of air pollution.

95 Government of British Columbia (2021). Fleet of the future: electric school buses coming soon. https://news.gov.bc.ca/releases/2021EDUC0031-000848

96 CTV News (2022). Quebec plugs $18 million into electric school bus subsidies. https://montreal.ctvnews.ca/quebec-plugs-18-million-into-electric-school-bus-subsidies-1.5800773

97 https://electricautonomy.ca/2021/04/28/quebec-electric-school-buses-2030/

98 Government of Prince Edward Island (2021). Electric School Buses. https://www.princeedwardisland.ca/en/information/education-and-lifelong-learning/electric-school-buses

iii How to Electrify Ontario School Buses?

A number of funding mechanisms have successfully supported the accelerated uptake of ESBs in other jurisdictions. For example, the introduction of school bus rebate programs such as that offered by the US EPA through its Diesel Emissions Reduction Act (DERA), which offers up to $65,000 per bus, would result in a reduction of the number of years for ESB to reach cost parity with diesel buses by around 2 years. The advantages and disadvantages of the most common options are outlined below.[99]

RECOMMENDATION

Provide provincial government funding under the following areas:

- ★ **Eliminate PST for the purchase of new ESBs.**
- ★ **Grant funding for ESB procurement that is stackable to federal ZETF funding targeted at small to medium-size fleet operators and prioritizing support for ESB acquisition in marginalized communities and those facing high burden of TRAP exposure. This could be phased out by 2030 as ESBs approach price parity with diesel school buses.**
- ★ **Low-interest financing is targeted at fleet operators irrespective of size.**

Table 6: Types of funding mechanisms available to the Government of Ontario

Type	Definition	Advantages	Disadvantages
Grant	**An award made to qualifying applicants, for a specific purpose or use case, deemed the worthiest based on set criteria.**	Generally direct aid to priority districts; often cover planning and project management costs.	Applications can sometimes be time-intensive and onerous.
Rebate	**A reimbursement after certain eligible purchases of pre-approved equipment.**	Limited paperwork. A pre-approved equipment list reduces the burden on applicants and simplifies purchase decisions.	Requires the recipient to pay full price at the time of purchase; lower-resourced districts may not be able to cover these initial costs.
Voucher	**A credit applied "on the hood" immediately at purchase lowers the price paid by the recipient.**	Least amount of paperwork. Eliminates the burden of delayed reimbursement.	Programs risk inducing unintended consequences like inflated prices.
Financing	**An arrangement that provides capital for cost today to be paid back over a future period, often with a small premium (interest).**	Enables districts to make cost-effective investments.	Districts with poor credit or lacking the capacity to issue public bonds might face higher interest rates.

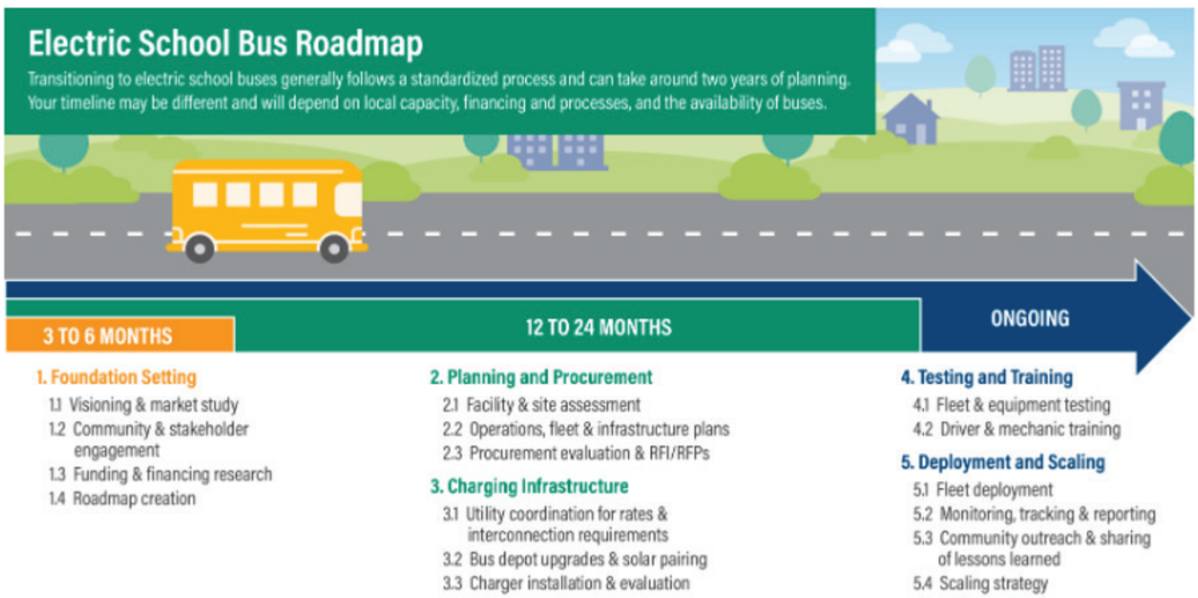
99 https://cleantechnica.com/2022/02/02/the-real-cost-of-electric-school-buses-is-lower-than-you-think/

iii How to Electrify Ontario School Buses?

9. SUPPORT THE TRANSITION WITH RESOURCES

According to the World Resources Institute's (WRI's) Electric School Bus Initiative, it may take upwards of two years for a school bus operator to plan for, purchase and deploy ESBs.[100]

Figure 6: Electric School Bus Roadmap



9.1 Guides and Toolkits

With the decision to adopt ESBs into their fleets, school boards and school bus operators may face a steep learning curve. Resources such as guides, best practices and toolkits could remove uncertainty and support an easier transition. Resources could address considerations including:

- Stakeholder engagement
- Fleet electrification strategy development
- Needs assessment
- Identification of funding mechanisms
- Vehicle procurement
- Coordination with utilities for charging requirements
- Charging plan, including a selection of charging infrastructure
- V2X options
- Installation of charging infrastructure
- Employee training options
- Prioritizing disadvantaged communities/riders
- Regional charging collaboration options for field trips/ sporting events
- Test drive programs for fleets and/or drivers

100 https://www.wri.org/initiatives/electric-school-bus-initiative

iii How to Electrify Ontario School Buses?

For example, a guide similar to WRI's Electric School Bus U.S. Market Study and Buyer's Guide: A Resource for School Bus Operators Pursuing Fleet Electrification[101] could be commissioned in a Canadian context. Also, Propulsion Quebec has produced a similar guide for the province. This valuable resource, which was produced by the World Resources Institute, covers current model availability and market growth, charging infrastructure requirements and case studies in a variety of use case scenarios. It is accompanied by How to Help Your Community Fund Electric School Buses in the US[102], which addresses funding options to address the barrier of high upfront costs of buses and charging infrastructure.

RECOMMENDATION

The Government of Ontario and school boards should collaborate to commission the development of guides and toolkits to support the transition to ESBs.

9.2 Training

Training of bus operators and mechanics is an essential piece for the ESB transition. As noted by the World Resources Institute (WRI) in its guiding report "How to Enable Electric Bus Adoption in Cities Worldwide", training bus operators is one of the key recommendations for the mass adoption of large-scale electric bus projects.[103]

Despite the difference in the technology (i.e., regenerative braking systems), driving ESBs is not particularly distinct from driving their diesel counterparts. The main focus on retraining drivers, therefore, is first to augment acceptance of this new technology, especially during the project's initial phase and, secondly, to reinforce good driving habits to improve battery performance and reduce operating costs.

Retraining maintenance staff is also crucial for the transition. As more ESBs are introduced, a skilled workforce will be needed to repair and maintain the new generation of electric bus fleet. Recent research indicates that when introducing electric buses into public transit systems, most cities contracted bus manufacturers to provide maintenance services. [104] This indicates that maintenance staff are not well prepared for electric powertrain technologies. This highlights a need for training and/or certification programs for existing heavy-duty diesel mechanics to ensure their skills are retooled to apply to ESB fleets. This type of training and certification can also be beneficial in building trust in the technology and creating champions among fleet depots to ease any sense of threat or resistance to the transition to ESBs.

For instance, there are currently no training programs for motive power technicians focused on HDZEVs at Ontario colleges. Instead, initiatives come from the private sector. These are largely based in the US – only a few OEMs provide specific training for maintenance tradespeople and drivers in Canada. For example, Lion Electric offers a series of training programs for mechanics, drivers, and school district staff as part of its Learning Academy service.

101 WRI, Electric School Bus U.S. Market Study and Buyer's Guide: A Resource for School Bus Operators. https://www.wri.org/research/electric-school-bus-us-market-study-and-buyers-guide-resource-school-bus-operators

102 WRI, How to Help Your Community Fund Electric School Buses in the US, https://www.wri.org/insights/how-help-your-community-fund-electric-school-buses-us

103 WRI (n.d.), How to Enable Electric Bus Adoption in Cities Worldwide. https://files.wri.org/d8/s3fs-public/how-to-enable-electric-bus-adoption-cities-worldwide.pdf

104 WRI (n.d.), How to Enable Electric Bus Adoption in Cities Worldwide. https://files.wri.org/d8/s3fs-public/how-to-enable-electric-bus-adoption-cities-worldwide.pdf

iii How to Electrify Ontario School Buses?

Blue Bird provides free online training for technicians – the Blue Bird Tech's Book - along with technician certification, technical training events and on-site training through Blue Bird Academy offered to Blue Bird dealers.[105]

Other training initiatives come from the electric transit bus or light-duty vehicle maintenance sector which are not specific to the ESB market but can relate to it as the technology is similar.

For example, Proterra prepares mechanics for the e-transition with onsite training, combining theoretical content and hands-on activities through its Technical Training Department.[106] In BC, the provincial government, in partnership with colleges and universities, is offering the first-of-its-kind EV Maintenance Training program to support the transition to EVs.[107] Quebec also provides support and funding to fleet operators through the Ministry of Education and Ministry of Environment. Another comprehensive EV initiative is offered by the Electric Vehicle Training Program (EVTP) which trains and certifies technicians for the installation of EV charging infrastructure in North America.[108]

The US has been leading the ESB transition both in terms of technology development and training opportunities. In California, the Energy Commission provided $1 million in funds to the Advanced Transportation and Logistics (ATL) Sector of the California Community Colleges for the ESB technician training program tailored to college faculty and fleet technicians. To further develop the ESB training sector, ATL plans to create multiple courses to meet OEMs' and experts' recommendations. Initially, community college faculty will be trained to troubleshoot, diagnose and repair battery electric transit vehicles. After the completion of the program, a full six-course series will be available to the general public in California.[109]
The US Department of Energy provides a series of educational webinars and handouts about ESBs. Part 7 of the series gives a training overview.[110]

Provincially subsidized training for existing fleet technician staff to ensure a just transition. There are currently post-secondary schools that offer training programs for electric MHDVs. By giving the current workforce better access to these training programs through subsidies, the risk of workers being left behind is reduced and mitigates potential labour gaps as more bus operators electrify their fleets.

RECOMMENDATION

The Government of Ontario should offer a subsidized/free ESB maintenance certification program for existing heavy-duty diesel (HDD) mechanics.

105 Blue Bird (2022), Blue Bird Academy. https://vantage.blue-bird.com/Portal/academy-home.aspx
106 Proterra (2022), Training. https://www.proterra.com/customer-support/training/
107 Government of British Columbia (2022), EV skills training expands to three more schools in B.C. https://news.gov.bc.ca/releases/2022EMLI0011-000347#:~:text=The%20British%20Columbia%20Institute%20of,New%20Caledonia%20and%20Camosun%20College
108 Electric Vehicle Training Program (2022), Training. https://evitp.org/training/
109 California Community Colleges (2022), The Electric School Bus Training Project. https://atleducation.org/cec/the-electric-school-bus-training-project/
110 U.S. Department of Energy (2022), Electric School Bus Education. https://afdc.energy.gov/vehicles/electric_school_buses.html#driver-training

iii How to Electrify Ontario School Buses?

9.3 Public Messaging

An opportunity that should not be overlooked is communication and education on the health and climate benefits of ESB both through public campaigns and in the classroom.[111] These benefits include cleaner air, improved physical and mental health, and health equity, for children and local communities, more sustainable jobs, reduced dependency on fossil fuels, lower carbon emissions, and less noise. The transition to ESBs represents visible, tangible climate change action, particularly for youth. ESBs provide an example of what a transition away from fossil fuels looks like and how it improves the day-to-day lives of Ontarians. The government of Quebec funds the My Electric Bus campaign, which seeks to raise awareness about electric school buses among stakeholders within the school transportation sector and currently offers a variety of educational and promotional resources for electric school buses. Green Teacher, a CPCHE partner organization is currently developing a school curriculum module on ESBs including the health and climate benefits.

RECOMMENDATIONS

The non-profit sector, with support from the Government of Ontario, should develop public education and awareness resources on the health benefits of ESBs.

9.4 Zero Emission Transit Fund Support

The Infrastructure Canada Zero Emission Transit Fund (ZETF) provides subsidies that cover up to 50% of the costs associated with the purchase and installation of ESBs and charging infrastructure. Prior to being awarded grants for the procurement of vehicles and infrastructure, the ZETF requires applicants to conduct a planning study to ensure they have planned and allocated sufficient resources for the successful integration of ESBs into fleets. The ZETF covers up to 80% of the costs associated with the planning stage.

The ZETF is applicable to both fund both ESBs and transit buses. The majority of funds are currently being disbursed to transit agencies. Transit agencies are being supported in the ZETF application process by the Canadian Urban Transit Research & Innovation Consortium (CUTRIC), which streamlines the process and facilitates enhanced access to funding relative to school bus fleets. Many school bus operators are concerned ZETF funding may be exhausted before they can access it.

Technical assistance should be provided to school bus fleets in Ontario to facilitate access to federal ZETF funding. This is primarily due to the fact that the process is onerous and existing fleets typically lack the in-house expertise to navigate the novel processes which must be articulated in ZETF applications. This role could be undertaken by an independent third party such as an industry association or NGO. For example, both Quebec and BC offer these services through the Fédération des transporteurs par autobus and The Association of School Transportation Services of B.C., respectively.

111 CPCHE partner organization Green Teacher is developing a curriculum module on ESBs for schools. Release date TBD.

iii How to Electrify Ontario School Buses?

RECOMMENDATIONS

The Government of Canada should allocate a fixed portion of total ZETF funding to school bus fleets, to prevent the lion's share of funding from going to public transit agencies.

An appropriate third-party organization should offer technical assistance to school bus fleets in Ontario to facilitate access to federal ZETF funding.

9.5 Charging Infrastructure Support

Natural Resources Canada's (NRCan's) Zero Emission Vehicle Infrastructure Program (ZEVIP)[113] is a $680 million initiative ending in 2027, which aims to increase the number of charging stations available for both light- and heavy-duty vehicles in Canada to address one of the key barriers to ZEV adoption – a lack of adequate charging infrastructure. It delivers funding through cost-sharing contribution agreements for eligible projects that will help meet the growing charging and refuelling demand nationally.

ZEVIP is ideally designed to support school bus fleets in deploying charging infrastructure but in most cases would require a third-party delivery organization to secure and administer the funding. Such third-party organizations are allocated lump sums of ZEVIP funding from NRCan to redistribute to ultimate recipients (end users who own the charging infrastructure) to support eligible projects. Depending on the status of each ultimate recipient (i.e., public vs private sector) ZEVIP funding is stackable with ZETF funding up to a certain portion of total eligible project costs.

RECOMMENDATION

Stakeholders in Ontario should select an appropriate not-for-profit organization to apply for Natural Resources Canada's ZEVIP funding to establish a third-party delivery organization funding stream explicitly aimed at supporting the purchase and installation costs of EV charging infrastructure for Ontario school bus operators.

113 Natural Resources Canada. 2022. Zero Emission Vehicle Infrastructure Program. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876

Matrix of Actions

iv

The proven benefits of electrifying student transportation in Ontario include reduced GHG and air emissions, health benefits for children who ride school buses and communities as a whole, and enhanced economic development opportunities across the province.

Given the decentralized nature of school bus service in the province, however, a number of stakeholders will be required to act together to accelerate this transition. In establishing a strategy to electrify school buses, the Government of Ontario will play a vital role in coordinating all actors to achieve this beneficial transition in a just and equitable manner.

School bus service in Ontario is provided by about 150 private companies that operate under contract to the school boards. These range from small, family-run operations to multi-national companies. Unlike some other Canadian provinces and the United States, Ontario does not have a strategy in place to accelerate the ESB transition. As such, without significant education, coordination, and support to bus companies to the scope and procure both buses and charging infrastructure, the shift to ESBs is unlikely to occur in a timely manner. ESBs currently costs about three times more than their diesel counterparts, and contracts with school boards are typically too short (under five years) to create a favourable business model for bus companies to consider switching.

The reality is that overcoming the barriers and achieving the successful electrification of school bus fleets in Ontario will require concerted action. There is no single action or organization, that alone will electrify

iv Matrix of Actions

Ontario's school bus fleet. Multiple coordinated, concurrent and consecutive actions are required by a range of stakeholders including federal and provincial policy-makers and regulators, boards of education, school bus fleet owners, OEMs and their EV supply chain partners, utilities, local advocacy organizations, and community members. Many of these actions will require partnerships and/or coordinated effort, with overarching provincial leadership as a pivotal and catalyzing force. This Matrix of Actions identifies the actions that should be taken to achieve the electrification of school bus fleets in Ontario. It is presented as the proposed foundation for a Provincial School Bus Electrification Strategy.

RECOMMENDATION

The Government of Ontario should adopt this Matrix of Actions as the foundation for a Provincial School Bus Electrification Strategy.

iv Matrix of Actions

PILOTS	POLICY	FUNDING	RESOURCES
Undertake large and small scale ESB pilot programs designed to gather real world technical data in the Ontario context	Incorporate targets and costs related to health benefits into provincial policies and programs	Increase contract funding for all fleets based on % integration of ESBs in their fleets	Establish a program to school bus fleets in Ontario to provide technical assistance to access to federal ZETF funding
Incentive collection and sharing of pilot project data from both urban and rural areas	Enact policy to accelerate the retirement of older diesel school buses and replacement with ESBs	Implement provincial lows interest financing for ESBs for operators irrespective of size	Develop utility programs that facilitate deployment of ESB charging infrastructure at fleet depots
Pilot V2X technology for ESBs	Develop a scrappage program to support retirement of older diesel	Introduce grants and/or rebate programs for small school bus fleet operators	Commission the development of guides and toolkits to support the transition to ESBs
Prioritize marginalized	Conduct a financial study to determine the recommended proportion of ESBs now and in the future years	Eliminate PST for ESBs	Offer a subsidized/ free ESB maintenance certification program for existing HDD mechanics
	Introduce a mandatory gradual phase in of ESBs in school bus operator fleets through contracts between School Boards and Bus Companies	Establish a 3rd-party delivery ZEVIP program to fund installation of ESB charging stations in Ontario	Create an ESB/ EV module for secondary schools with automotive programs
	Support ESB purchase through revised contracting	Install EVSE at schools and popular field trip destinations with free access for buses	Develop public education and awareness resources on health benefits of ESBs
			Create an award/ recognition program for fleets leading the ESB transition

LEGEND

- Government of Ontario
- School Boards
- School bus companies/ Transportation Consortia
- Utilities
- Non-profit sector

For more information, please contact:

Steve McCauley | SENIOR DIRECTOR
smccauley@pollutionprobe.org

Cara LaRochelle | DIRECTOR OF SUSTAINABLE MOBILITY
clarochelle@delphi.ca

Erica Phipps | EXECUTIVE DIRECTOR
erica@healthyenvironmentforkids.ca

Helen Doyle | CPCHE COORDINATING COMMITTEE CHAIR
ONTARIO PUBLIC HEALTH ASSOCIATION REP
helen@healthyenvironmentforkids.ca

Pollution Probe | canadian partnership for children's health & environment / partenariat canadien pour la santé des enfants et l'environnement | DELPHI