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Power Boost

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Chandan Bhardwaj
Donald Jantz, Priyanka Lloyd

July 2023

photo: Lion Electric

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These acknowledgements are some of the beginning steps on a journey of several generations. We share them in the spirit of truth, justice, reconciliation, and to contribute to a more equitable and inclusive future for all of society.

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Executive summary

Ontario's medium- and heavy-duty vehicle manufacturing sector, once an economic powerhouse, is now at a pivotal moment. The heavy-duty truck manufacturing industry practically collapsed in Ontario after the 2008 financial crisis. Despite signs of recovery in the past decade, Ontario's heavy-duty truck manufacturing sector is still operating at only 10% of its pre-2008 production levels as indicated by the industry's economic output. This struggling segment of the automotive sector puts at risk the survival of small- and medium-sized enterprises (SMEs) that have contributed substantially to the growth of Ontario's heavy-duty truck and bus industry.

However, with the introduction and rapid expansion of the electric vehicle sector, the truck and bus manufacturing industry is on the cusp of a major transformation. The transition to zero-emission transportation impacts all segments of the auto sector and presents a unique opportunity for growth in the production and purchase of electric school buses (ESBs) in particular.

Globally, the electric bus market is projected to reach US$3.1 billion in sales by 2030, increasing year over year at a rate of 18%. The North American electric bus market is predicted to nearly double within the next two to three years. Ontario can take advantage of such a growth driver by leveraging its well-established infrastructure and workforce in the auto sector. Investing in the production and sales of electric school buses could make a significant contribution to the revival of Ontario's commercial vehicle manufacturing industry and help reap economic benefits for the SME sector.

Our analysis shows that, of all the categories of large trucks and buses, ESBs are one of the easiest to electrify. For every dollar invested in the sector, as many or more jobs are created compared to light-duty vehicle manufacturing. If 65% of Ontario's school bus stock is electrified by 2030 (which is Quebec's target for school bus electrification), multiplier effects along the ESB supply chain (vehicle and charger manufacturing and charger installation) could cumulatively create more than 13,000 jobs and generate nearly $2 billion of economic output in Ontario by 2030. The job numbers are more meaningful when we consider that the automotive manufacturing sector offers positions that are well compensated and include professional options that do not require a level of education that is not accessible to all segments of society.

To date, Ontario has primarily invested in the supply side of the EV sector with direct financial support to mining and production facilities for metals such as nickel, cobalt

and lithium for batteries, auto parts, and battery assembly. The Ontario government has also invested in the battery and critical mineral supply chain, offered favourable corporate tax rates to mining companies, and created policies that support SMEs.

Canadian electric bus manufacturers already have a dominant market share of approximately 45% in the North American bus market. Most of the electric bus manufacturers in Canada (with more than 500 Ontario- and Quebec-based SMEs that supply auto parts to these manufacturers) are on the brink of profitability. A growing electric bus market in Ontario (and North America) naturally benefits Canadian electric bus manufacturers, including many of the Ontario-based SMEs that supply the parts.

Demand-side policies have been overlooked, however, despite evidence that demand focused policies such as purchase incentives are more effective at growing local markets than are subsidies targeting manufacturers. Incentivizing demand for electric school buses in Ontario will further support local manufacturing at a time when Canadian companies can take full advantage of heightened consumer uptake.

In addition to the business case for investing in ESBs, the electrification of school buses yields substantial climate and health benefits. There are some 16,000 school buses in Ontario, most of which run on fossil fuels. According to Health Canada, diesel exhaust is carcinogenic and particularly harmful to children, making them susceptible to asthma and lung diseases. Reducing tailpipe emissions by electrifying school buses contributes to community-wide positive health outcomes and avoided medical costs.

The Ontario government plays an active role in the procurement of school buses by virtue of provincial requirements that school boards adhere to specific fuel economy standards and because the province is a source of funding. Ontario is in a position where it can take the following steps to increase the number of ESBs produced and purchased within the province:

- **Increase awareness among operators of the economic advantages of electric school buses.** The provincial government can support programs that raise awareness of the economic benefits of electric buses compared to diesel-fueled ones. An ESB Toolkit would be a useful resource and means of disseminating information about zero-emission buses, including guidance on best practices for adoption, and consumer advice on conducting due diligence before making a purchase.

- **Encourage Ontario schools to buy electric school buses.** The province can offer grants to school districts to offset the sticker price of an ESB which is significantly higher than that of internal combustion buses. Our recommendation is that grants be designed to allow for the purchase of 500 ESBs by 2025, rising to 5,000 ESBs by 2030. This will move Ontario's stock of ESBs to 10% of the total school bus stock by 2025 and put the province on track to reach 65% of school bus stock by 2030 (similar to the targets in Quebec).
- **Build out charging infrastructure to accommodate an increase in the number of electric school buses and encourage purchases.** Ontario will need to quadruple its commitment of $91 million to build chargers and include at least five fast charging stations (>100 kW) in each of the 72 school districts by 2030. Doing so will directly benefit the SMEs that operate charging stations, and indirectly benefit manufacturing sector SMEs due to increased demand stemming from confidence that convenient charging options will be available.
- **Invest in training programs for Ontarians in ESB manufacturing, operation and maintenance.** Ontario directed $5 million to training programs targeting 500 people from underrepresented groups for jobs in the automotive sector and with SMEs. Now that this program has ended, Ontario should consider reviving the training opportunity, targeting a greater number of people in anticipation of almost certain increases in demand and a workforce that will need to fill the skills gap to transition to employment in the ESB industry.

Over the long term, Ontario will need to continue to support the integration of a North American ESB supply chain from critical mining to assembly and sales, while promoting its position as a battery hub.

In conclusion, the rapid electrification of school buses can be done cost effectively, will contribute to the revitalization of SMEs in the auto sector, will lower carbon emissions in support of national climate targets, and will make a meaningful contribution to positive community-wide health outcomes.

1. Introduction

Ontario is the epicentre of Canada's automotive sector, accounting for more than 90% of the approximately $16 billion in GDP generated by the auto industry countrywide. More than 100,000 people are employed in Canada's auto manufacturing sector, the vast majority of whom work in Ontario.

Small- and medium-sized enterprises (SMEs) constitute over 90% of the Ontario businesses employed in automotive manufacturing. The role of SMEs is even more pronounced in Ontario's heavy-duty truck manufacturing sector. A dozen or so businesses that manufacture heavy trucks (or truck bodies) are based in the province, and most employ fewer than 50 people (three SMEs have between 20 and 49 employees, and seven SMEs have fewer than 10 employees).

In the sections that follow, we analyze how growth in Ontario's electric school bus (ESB) fleets can yield direct, indirect and induced economic benefits for individual workers and for SMEs. We likewise analyze Ontario's policy landscape to identify gaps in support for increasing the number of electric school buses on the road, drawing on successful policy implementation internationally. Our analysis supports recommendations on how the province can work with school boards to increase uptake in ESBs, emphasizing demand-side supports.

As part of our efforts to explore the economic benefits and job opportunities created by investing in the ESB market in Ontario, we conducted extensive consultations with Ontario-based SMEs and with manufacturers along the ESB supply chain (including companies with business interests in vehicle assembly, battery manufacturing, school bus fleet operation, and building charging infrastructure). We also undertook modelling analysis to quantify the job and GDP benefits that would accrue to Ontarians from the uptake of ESBs.

In addition to the job creation opportunities that a strong ESB market can bring, there are clear environmental and health benefits. A single diesel-fuelled school bus emits 27 tonnes of CO_2e annually nearly all of which would be eliminated by replacing it with an electric version.

Children are especially vulnerable to the negative health impacts of diesel exhaust produced by school buses[1, 2]. A comprehensive risk assessment study on the effects of diesel exhaust — which is made up of toxic organic compounds, nitrous oxides, and particulate matter — conducted by Health Canada in 2016 concludes that diesel exhaust is carcinogenic and has been linked to increased risk of lung cancer.[3] The health impacts also impose high costs on the economy; diesel exhaust-related health costs are estimated to be about $2.3 billion annually.[4]

The province has already begun the enormous task of pivoting from conventional auto manufacturing to the electrification of the vehicle economy, which will reinvigorate the sector, drive down emissions and provide widespread health benefits. The addition of a robust ESB market can contribute to the evolution of Ontario's transition to a clean transportation sector.

Lastly, in a sector that generates more greenhouse gas emissions than any other in Canada save for oil and gas, it is increasingly urgent that Ontario, as an automotive hub, address emission reductions in the transportation sector quickly and meaningfully.

Note: Our analysis in this report is exclusive to school buses that run on electric motors and are powered by batteries that can be charged at central depots or by using public chargers.[5]

[1] Kim Perrotta, *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) (2010). https://chasecanada.org/wp-content/uploads/2011/07/cap-opha-school-bus-follow-up-report1.pdf

[2] Health Effects Institute, *Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution* (2022). https://www.healtheffects.org/publication/systematic-review-and-meta-analysis-selected-health-effects-long-term-exposure-traffic

[3] Health Canada, "Human Health Risk Assessment for Diesel Exhaust." https://www.canada.ca/en/health-canada/services/publications/healthy-living/human-health-risk-assessment-diesel-exhaust-summary.html

[4] Health Canada, "Human Health Risk Assessment for Diesel Exhaust,"

[5] The focus of this paper, and the economic modelling in this paper, is on battery-electric school buses (BEVs), as opposed to plug-in hybrid or fuel-cell electric alternatives, since nearly 100% of all zero-emission school buses in North America are BEVs. Battery electric vehicles run only on electricity using an electric motor; plug-in hybrid electric vehicles can run both on electricity (to power an electric motor), as well as on diesel/gasoline (to power an internal combustion engine); and fuel-cell electric vehicles are powered by electricity produced from hydrogen.

2. The medium- and heavy-duty vehicle industry in Ontario

2.1 Stagnating heavy-duty vehicle manufacturing

The automotive industry in Ontario produces around 2 million vehicles annually (though production has seen a precipitous decline post-COVID in 2020)[6], making it one of North America's top vehicle-producing regions. Ontario's strategic importance as an international auto manufacturing hub is amplified by the fact that five of the top global automakers (Ford, Fiat-Chrysler (Stellantis), General Motors, Honda, and Toyota) have all chosen to set up manufacturing plants in the province.[7]

However, over the last 10 years, Ontario has contributed to less than 5% of the total heavy-duty vehicle production in Canada.[8] The market size of Ontario's heavy-duty vehicle production sector is $64 million,[9] or about 2% of the $3.2 billion Canadian truck and bus manufacturing industry.[10] Ontario is home to few global heavy-duty vehicle manufacturers (e.g., BYD, Hino Motors[11]), and some have set up their manufacturing plants only recently.[12] The absence of activity in Ontario includes made-in-Canada buses. In contrast, Quebec and Manitoba dominate medium- and heavy-duty (MHDV) manufacturing, making up 90% of total economic output.[13] Further, Quebec and

[6] CEIC Data, "Canada Motor Vehicle Production." https://www.ceicdata.com/en/indicator/canada/motor-vehicle-production

[7] Invest Ontario, "Automotive." https://www.investontario.ca/automotive

[8] Statistics Canada, "Principal statistics for manufacturing industries," Table 16-10-0117-01. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1610011701&pickMembers%5B0%5D=1.8&pickMembers%5B1%5D=3.251&cubeTimeFrame.startYear=2012&cubeTimeFrame.endYear=2020&referencePeriods=20120101%2C20200101

[9] IBISWorld, "Truck & Bus Manufacturing in Ontario in Canada industry statistic" www.ibisworld.com/canada/market-research-reports/truck-bus-manufacturing-industry-ontario/

[10] IBISWorld, "Truck and Bus manufacturing in Canada." https://www.ibisworld.com/canada/market-size/truck-bus-manufacturing/

[11] Hino Motors Canada, "About Us." https://www.hinocanada.com/about-us/

[12] BYD, "BYD opens its plant in Canada," media release, June 25, 2019. https://en.byd.com/news/byd-opens-first-canadian-bus-assembly-plant/

[13] Statistics Canada, "Gross domestic product (GDP) at basic prices, by industry, provinces and territories (x 1,000,000)," Table 36-10-0402-01.

Manitoba account for 43% of Canada's MHDV production facilities and 89% of the medium and large Canadian establishments involved in MHDV manufacturing.[14] The absence of activity in Ontario includes made-in-Canada buses.

SMEs in heavy-duty vehicle production

Ontario's automotive manufacturing supply chain is made up of over 500 auto parts manufacturers.[15] SMEs that employ less than 500 workers constitute more than 90% of the Ontario businesses active in automotive parts manufacturing. Of these, some 20% employ five workers or less.[16] Collectively, Ontario-based SMEs employ about 25% of the total auto manufacturing workforce.[17] The role of SMEs is even more pronounced in Ontario's heavy-duty truck manufacturing sector with about a dozen businesses producing heavy trucks (or truck bodies). Almost all are SMEs with staff of less than 50 employees (three employ 20 to 49 people; seven employ less than 10 people).[18]

2.2 Electrification of MHDV production

While global sales of electric vehicles have grown exponentially in recent years, the auto industry in Canada and, more specifically, in Ontario, has so far failed to fully capitalize on this opportunity.

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610040201&pickMembers%5B0%5D=2.2&pickMembers%5B1%5D=3.140&cubeTimeFrame.startYear=2017&cubeTimeFrame.endYear=2021&referencePeriods=20170101%2C20210101

[14] Ben Sharpe, Nic Lutsey, Cedric Smith, Carolyn Kim, *Power Play: Canada's role in the electric vehicle transition* (ICCT, 2020), 14, https://theicct.org/sites/default/files/publications/Canada-Power-Play-ZEV-04012020.pdf

[15] Government of Ontario, *Driving Prosperity: The future of Ontario's automotive sector* (2019). https://files.ontario.ca/auto-strategy-en.pdf

[16] Statistics Canada, "Canadian Business counts with employees, December 2021," Table 33-10-0493-01, NAICS selection: Motor vehicle body and trailer manufacturing [3362]; Motor vehicle parts manufacturing [3363]. https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3310049301

[17] Brendan Sweeney, "A Profile of the Automotive Manufacturing Industry in Canada, 2012-2016", automotive-manufacturing-canada-2012-2016.pdf (automotivepolicy.ca), 7

[18] Statistics Canada, "Canadian Business Count with employees, December 2021," NAICS selection: Motor vehicle manufacturing [336120].

Canada, which typically produces about 5% of global heavy-duty vehicles,[19] contributed only 0.1% to global heavy-duty EV production in 2018.[20] Further, nearly all of the Canadian heavy-duty EV production happens outside of Ontario, in Quebec.[21]

The Ontario government has recently taken steps to transition the automotive sector to encourage production of electric vehicles domestically and is providing support for an EV supply chain that includes exploration, mining and production of critical minerals for EV batteries.[22]

Ontario-based original equipment manufacturers (OEMs) are likewise investing in the production of EVs. GM announced a $1.5 billion plan to upgrade its Ingersoll plant to produce commercial electric vans, which would be Canada's first all-electric assembly plant.[23] Stellantis announced that it would invest $3.6 billion to retool its Windsor plant for EV production.[24] Honda is investing more than a billion dollars over the next six years to upgrade its plant to produce EVs.[25]

2.3 Potential for electric school buses in Ontario

There are about 20,000 school buses and school purpose vehicles in Ontario.[26] Most run on fossil fuels, with a couple hundred ESBs expected to be on the road in the next three

[19] OICA, "2021 Production Statistics." http://www.oica.net/category/production-statistics/2021-statistics/

[20] ICCT, *Power Play: Canada's role in the electric vehicle transition*, 17.

[21] Claire Buysse, *Zero-emission bus and truck market in the United States and Canada: A 2021 update*, (ICCT, 2022), 7. https://theicct.org/wp-content/uploads/2022/09/update-ze-truck-bus-market-us-can-sept22.pdf

[22] Government of Ontario, "Driving Prosperity." http://www.ontario.ca/page/driving-prosperity-future-ontarios-automotive-sector

[23] Jamie L. LaReau, "Big GM investment will create Canada's first all-electric vehicle assembly plant," *Detroit Free Press,* April 4, 2022. https://www.freep.com/story/money/cars/general-motors/2022/04/04/gm-cami-oshawa-ev-canada-pickup/7269528001/

[24] Reuters, "Stellantis to boost EV plants with C$3.6 bln investment," May 2, 2022. https://www.reuters.com/business/autos-transportation/stellantis-boost-ev-plants-with-c36bln-investment-2022-05-02/

[25] Newswire, "Honda of Canada Mfg. to Invest more than $1.38 billion in Ontario Manufacturing Plants in Preparation for Electrified Future," March 16, 2022. https://www.newswire.ca/news-releases/honda-of-canada-mfg-to-invest-more-than-1-38-billion-in-ontario-manufacturing-plants-in-preparation-for-electrified-future-803323558.html

[26] School Bus Ontario, "School Bus Facts." https://schoolbusontario.ca/school-bus-facts/

years.[27] [28] The Ontario Ministry of Education and the Ministry of Transportation are responsible for student transportation, and work with school boards, transportation consortia, and transportation providers.[29] The Ministry of Transportation is responsible for licensing and setting standards for the safe operation of school buses in Ontario through the Highway Traffic Act and its regulations. The Ministry of Education oversees school boards and provides funding to school boards through the Student Transportation Grant.

Ontario's 72 school boards are solely responsible for transportation-related decisions, including establishing policies and eligibility criteria. Consortia of school boards are, in turn, responsible for administering policies, planning services, awarding and managing contracts with transportation providers and auditing their performance for contract compliance.[30]

Transportation providers are responsible for service delivery, including quality assurance for vehicles, drivers and driver safety training. Nearly 99% of school buses are operated by private firms on a contractual basis, and the few school boards that operate their own school buses are gradually moving towards contracting services from private firms.[31]

Because school boards set eligibility policies for transportation, boards could require transport providers to have a certain number of ESBs in their fleet to be eligible for a contract. Alternatively, school consortia, at the direction of school boards, could decide to purchase services directly from ESB operators.

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[27] Electrive, "200 Lion Electric school buses bound for Ontario," December 16, 2021. https://www.electrive.com/2021/12/16/200-lion-electric-school-buses-bound-for-ontario/

[28] Statistics Canada, "Vehicle registrations by type," Table 23-10-0308-01. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310030801&pickMembers%5B0%5D=1.7&cubeTimeFrame.startYear=2017&cubeTimeFrame.endYear=2021&referencePeriods=20170101%2C20210101

[29] Ontario Ministry of Education, *Discussion paper on a new vision for student transportation in Ontario* (2017), 8. https://files.ontario.ca/student-transportation-en.pdf

[30] A transportation consortium is an organization formed by two to five school boards operating in the same geographical area. In the 2005-06 school year, as part of the Student Transportation Reform initiative, the Ministry of Education issued policy direction for school boards to form transportation consortia, where boards in neighbouring regions were combined into a consortium to achieve efficiency in transportation services. Currently there are 33 consortia for 72 school boards. Ontario Ministry of Education, *Student Transportation Consortia Model and Operations: Discussion Guide*, (2020). https://www.opsba.org/wp-content/uploads/2021/02/StudentTransportationConsortiaDiscussionGuide.pdf

[31] Perrotta, *School Buses, Air Pollution & Children's Health,* 16.

While the uptake of electric MHDVs, including school buses, has been sluggish in Ontario, other provinces have announced plans to electrify their school bus fleet. Quebec, for example, plans to electrify 65% of its school bus fleet by 2030. Quebec's Transport Minister François Bonnardel has said that nearly 2,600 electric school buses will hit the road over the next three years in the province.[32]

[32] Olivia O'Malley, "Quebec unveils detailed plan to electrify most school buses by 2030," *Global News,* April 23, 2021. https://globalnews.ca/news/7784257/quebec-electric-school-buses-2030/

3. Economic benefits of school bus electrification

3.1 A unique opportunity

Electric school buses present a distinct opportunity among electric vehicle classes. The global electric bus market is projected to reach US$3.1 billion in sales by 2030, growing at an annual rate of 18%.[33] Growth in the Canadian electric bus market is expected to be higher still: the market is projected to nearly double within the next two to three years.[34]

Electrifying school buses yields multiple benefits. First, school buses are easier to electrify than other large vehicles. Typically, school buses have a predictable daily mileage of around 63 miles (100 km), and return to the same base regularly, making them ideal for overnight charging at home base depots.[35] Further, the fact that electric school buses do not (typically) use public chargers means that relatively low-cost Level 2 chargers (~$20,000) can be installed by private ESB fleet owners themselves. Relatedly, the Toronto Transit Commission's recent assessment of electric buses has demonstrated that the technology is market ready.[36] Moreover, studies demonstrate

[33] GlobalNewsWire, "Electric Bus Market Size is projected to reach USD 3.1 Billion by 2030, growing at a CAGR of 18%: Straits Research," July 7, 2022. https://www.globenewswire.com/en/news-release/2022/07/07/2476224/0/en/Electric-Bus-Market-Size-is-projected-to-reach-USD-3-1-Billion-by-2030-growing-at-a-CAGR-of-18-Straits-Research.html

[34] Mordor Intelligence, "North America Electric Bus Market Size and Share Analysis - Growth Trends & Forecasts Up To 2028." https://www.mordorintelligence.com/industry-reports/north-america-electric-bus-market

[35] CALSTART, *Electric School Buses Market Study: A Synthesis of Current Technologies, Costs, Demonstrations, and Funding* (2021), 4. https://calstart.org/electric-school-buses-market-study/

[36] Mobility Innovators, "Toronto Transit Commission Electric Bus Program: Head-to-Head Evaluation of Electric Buses." https://mobility-innovators.com/toronto-transit-commission-electric-bus-program-head-to-head-evaluation-of-electric-buses/

that electric buses are financially beneficial over the long term: the cost of ownership is less than that of diesel within five to six years.[37,38]

Benefits of ESBs to schools

The purchase price of electric school buses is more costly than diesel school buses due to the relatively high (although declining) cost of batteries, and the fact that electric buses are a relatively new technology, with prices around $350,000 for Type C (70-76 passengers) electric buses. (The price for diesel buses of the same size is approximately $150,000 or less). Despite these higher up-front costs, electric school buses generate cost savings over their 12-year lifetime in two main areas: fuel and maintenance. Electric buses use electricity rather than diesel fuel, saving approximately $14,000 a year. Electric buses are easier to maintain, resulting in annual savings of approximately $3,000 relative to diesel buses. Thus, with a $150,000 government rebate, the total cost of ownership of an ESB can reach parity with a diesel school bus in about 5.8 years.[39]

Another benefit to schools of owning ESBs comes from earning credits via the Clean Fuel Regulation. Under the Clean Fuel Regulation, schools could act as EV charging site operators and receive credits, amounting to earning approximately $8,600 per bus per year. With revenues from CFR included, total cost of ownership of ESBs would reach parity with diesel buses in about 4.4 years.

ESBs can also generate revenue by feeding electricity back to the grid. The El Cajon school district's pilot with Nuvve and San Diego Gas & Electric Co. is an example of a vehicle-to-grid project, where the energy stored in ESB batteries can supply power to the grid during peak demand or emergencies.[40] Such a project has twofold benefits: Schools earn extra

[37] S.D. Stone, V. Nair, G. Rogers, *Technical Review of: Medium and Heavy-Duty Electrification for MY 2027-2030*, prepared by Roush Industries, Inc. for Environmental Defense Fund (2022). https://blogs.edf.org/climate411/files/2022/02/EDF-MDHD-Electrification-v1.6_20220209.pdf

[38] Caley Johnson, Erin Nobler, Leslie Eudy, and Matthew Jeffers, *Financial Analysis of Battery Electric Transit Buses* (National Renewable Energy Laboratory, 2020), 2. https://afdc.energy.gov/files/u/publication/financial_analysis_be_transit_buses.pdf

[39] Colton Kasteel, Dunsky Energy & Climate Advisors, *Electric School Buses: The benefits to British Columbians and options for accelerating the transition* (Pembina Institute, 2022). https://www.pembina.org/reports/electric-school-bus-adoption-in-bc-rev.pdf

[40] Rob Nikolewski, "Charge by night, discharge by day: Electric school buses in El Cajon will send power to the grid," *San Diege Union-Tribune*, July 27, 2022. https://www.sandiegouniontribune.com/business/energy-green/story/2022-07-27/charge-by-night-discharge-by-day-electric-school-buses-in-el-cajon-will-send-power-to-the-grid

revenue by selling power; and contribute to grid stability by helping manage peak demand.[41]

Second, electric buses can be expected to generate new jobs. Ontario data shows that heavy-duty motor vehicle manufacturing has created on average as many (and sometimes more) jobs than light-duty motor vehicle manufacturing for every $1 million of economic output.[42] Strong job creation potential is reflected in the recent announcements by different automakers; see projects listed in Table 1. Averaging across the examples listed, electric bus and heavy-duty manufacturers claim to create about 20 new jobs for every $1 million of plant investment.

Table 1. Investments in manufacturing plants by ESB and battery manufacturers and related job growth expectations

Company / Plant	Investment (US$ million)	# of jobs created/expected	Plant type
Proterra[43] South Carolina	76	>200	Battery factory
Lion Electric[44] Montreal	120	280	Battery factory
Electrovaya[45]	75	250	Battery factory

[41] Tim Tyler, "Electric School Buses Could Be "Mobile Batteries" During Blackouts", *Clean Technica*, October 28, 2022. https://cleantechnica.com/2022/10/28/electric-school-buses-could-be-mobile-batteries-during-blackouts/

[42] Statistics Canada, "Input-output multipliers, provincial and territorial, detail level," Table 36-10-0595-01, Industry selection: Automobile and light-duty motor vehicle manufacturing [BS336110]; Heavy-duty truck manufacturing [BS336120]. https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3610059501

[43] Rebecca Bellan, "Proterra to build commercial EV battery factory in South Carolina, its third in US," *TechCrunch,* December 14, 2021. https://techcrunch.com/2021/12/14/proterra-to-build-commercial-ev-battery-factory-in-south-carolina-its-third-in-us/

[44] Danny Kucharsky, "Lion Electric builds $185M battery plant in Montreal," *Sustainable Biz*, September 21, 2021. https://sustainablebiz.ca/lion-electric-builds-185m-battery-plant-in-montreal

[45] Matt Glynn, "Electrovaya plans $75 million lithium-ion battery plant in Chautauqua County," *The Buffalo News*, October 3, 2022. https://buffalonews.com/business/local/electrovaya-plans-75-million-lithium-ion-battery-plant-in-chautauqua-county/article_0709402e-4345-11ed-8164-5348836f9577.html

GreenPower[46] West Virginia	25	900	HDV assembly
Lion Electric[47,48] Illinois	70	1400	HDV assembly
BYD[49] Los Angeles	50	800	HDV assembly
New Flyer[50] Kentucky	28	550	HDV assembly

Third, the domestic production of electric school buses will help revitalize Canadian auto manufacturing. The electric bus market has a greater presence of Canadian players compared to the heavy-, medium- or light-duty vehicles market. Canadian electric bus manufacturers have a dominant market share of about 45% in the North American bus market (NFI 15%, GreenPower 17%, Lion Electric 12%), with relatively lower market share of Chinese (BYD 12%) or European (Daimler-3%) firms.[51] While 99% of electric buses sold in North America were manufactured either in Canada or the U.S., 60% of the medium-duty vehicles sold in North America were produced elsewhere.[52] A growing electric bus market in North America (and elsewhere) benefits Canadian electric bus manufacturers. In comparison, the equivalent growth in the light-duty or medium-duty

[46] Ed Garsten, "New GreenPower Electric School Bus Plant Announced As Concern For Student Health Builds," *Forbes*, January 12, 2022. https://www.forbes.com/sites/edgarsten/2022/01/12/new-greenpower-electric-school-bus-plant-announced-as-concern-for-student-health-builds/?sh=3a3c8b807248

[47] Scooter Doll, "Lion Electric to construct the largest all-electric medium and heavy-duty vehicles plant in US," *Electrek*, May 7, 2021. https://electrek.co/2021/05/07/lion-electric-to-construct-the-largest-all-electric-medium-and-heavy-duty-vehicles-plant-in-us/

[48] Lion Electric, "Lion Electric Hosts Federal and State Officials, Key Stakeholders at its Upcoming Illinois Manufacturing Facility," media release, March 23, 2022. https://ir.thelionelectric.com/English/news/news-details/2022/Lion-Electric-Hosts-Federal-and-State-Officials-Key-Stakeholders-at-its-Upcoming-Illinois-Manufacturing-Facility/default.aspx

[49] BYD, "BYD continues US investment with new $5 million warehouse facility," media release, September 25, 2018. https://en.byd.com/news/press-release-byd-continues-u-s-investment-with-new-5-million-warehouse-facility/

[50] Martin Cash, "New Flyer to build $28M parts plant in Kentucky," *Winnipeg Free Press*, November 18, 2017. https://www.winnipegfreepress.com/business/2017/11/18/new-flyer-to-build-28m-parts-plant-in-kentucky

[51] Buysse, *Zero-emission bus and truck market in the United States and Canada*, 6.

[52] Buysse, *Zero-emission bus and truck market in the United States and Canada,* 7.

electric vehicle market benefits international OEMs more as Canadian manufacturers play a smaller role in those markets.

The importance of a domestic ESB market

Growing a local ESB market in Ontario can help attract more investments from OEMs. A study by Automotive Logistics discusses several examples of how market demand and regulatory environments influence where OEMs set up their production plants.[53] Among others, they cite the example of Volvo, which set up production plants in China to capture the local market there. Proximity to major markets is a key factor determining a company's decision to set up manufacturing plants; as noted in the previous section, 99% of electric buses sold in North America were manufactured in either Canada or the U.S. A study by ICCT reports, "Of the 10 million cumulative electric vehicles sold globally, 80% were produced in the same region in which they were sold."[54]

Similarly, at the provincial level, electric school bus producers in Canada are predominantly located in Quebec, including Lion Electric and Micro Bird. To date, only one auto manufacturer, BYD, is producing ESBs in Ontario. The Ontario government's Green Commercial Vehicle Program was a factor in BYD's decision to open a plant in the province, citing the potential to serve the Toronto Transit Commission.[55]

Development of the local market is also influenced by policy, including incentives.[56] In California, programs offering subsidies for purchase of electric buses sparked local demand.[57] California is home to Proterra, the leading electric bus manufacturer in North

[53] Automotive Logistics, "Plant locations: Right place, right time." https://www.automotivelogistics.media/oems/plant-locations-right-place-right-time/15754.article

[54] Anh Bui, Peter Slowik, Nic Lutsey, *Power play: Evaluating the U.S. position in the global electric vehicle transition*, Briefing (ICCT, 2021), 21. https://theicct.org/wp-content/uploads/2021/12/us-position-global-ev-jun2021-1.pdf

[55] BYD, "BYD opens 45,000 sq ft electric bus facility in Ontario", https://manufacturingdigital.com/lean-manufacturing/byd-opens-45000-sq-ft-electric-bus-facility-ontario

[56] Charlotte Yates, *How can Public Policy help Sustain a Globally Competitive Canadian Automotive Industry?* (Automotive Policy Research Center, 2015), 65. https://automotivepolicy.ca/wp-content/uploads/2018/05/aprc-public-policy-paper-yates.pdf

[57] Government of California, "Incentives for Clean Trucks and Buses." https://californiahvip.org/

America. Moreover, California has attracted international players, with Chinese BYD and Canadian GreenPower having manufacturing plants in the region.[58,59]

The need to localize auto supply chains has acquired greater urgency due to the pandemic. Historically, the vast majority of EV and lithium-ion battery manufacturing units have been concentrated in Northeast Asia and China. However, the pandemic and the resulting supply chain disruptions have highlighted the degree to which countries, including Canada, depend on China in the supply chain and the associated risks. In recognition of these supply chain risks, stakeholders are increasingly motivated to localize relevant resources and suppliers.[60]

Case Study: Stromcore and StromVolt build an industry leading battery solution in Canada

Location: Mississauga, ON Number of Employees: 35

Stromcore is a lithium battery producer that manufactures advanced lithium-ion battery solutions for forklifts. The company expects to more than triple its revenue by 2025 and is ranked as one of Americas' Fastest Growing Companies in 2022.

Stromcore demonstrates the potential for Ontario EV technology companies to prosper, delivering jobs and economic opportunity by leveraging the province's significant natural resources, talent, and R&D assets. It was working with its Taiwanese partner, Delta Electronics, to transfer IP which would give its sister company, StromVolt, the capabilities to manufacture world leading lithium-ion batteries domestically in Canada and supply these battery cells to North American bus manufacturers, such as Lion Electric, BMP, Taiga Motors, and Nova Bus. An increased demand for electric school buses in Ontario could further grow the market for StromVolt and increase demand for Ontario-supplied raw minerals.

[58] CBC, "BYD deal with Windsor ends, company opens in California," May 1, 2013. https://www.cbc.ca/news/canada/windsor/byd-deal-with-windsor-ends-company-opens-in-california-1.1334546

[59] Green Power, "Green Power announces that its manufacturing facility in California is ready for production," media release, November 30, 2018. https://greenpowermotor.com/greenpower-announces-that-its-california-manufacturing-facility-is-ready-for-production/

[60] Markets Insider, "Electric Vehicle (EV) Market Assessment 2020-2025 - Growing Interest Among Various Stakeholders for Localization/Regionalization of Supply Chains due to COVID-19 Disruptions," July 31, 2020. https://markets.businessinsider.com/news/stocks/electric-vehicle-ev-market-assessment-2020-2025-growing-interest-among-various-stakeholders-for-localization-regionalization-of-supply-chains-due-to-covid-19-disruptions-1029456854

3.2 Quantifying economic and job benefits

We used an input-output model to quantify the direct, indirect, and induced economic benefits and job creation that would result from electrifying school buses.

Direct, indirect, and induced economic impacts

Direct economic impacts: These are impacts that result from an increase in demand for an industry's output on that industry. For example, an increase in demand for automobiles may increase employment in assembly plants.

Indirect economic impacts: These are the impacts of an increase in demand for an industry's output on other industries involved in various stages of production. For example, an increase in demand for automobile manufacturers may increase employment at a tool-and-die manufacturer.

Induced economic impacts: These are the impacts of an increase in demand for an industry's output on production through increased labour income due to direct and indirect impacts. For example, an increase in demand for automobile manufacturers may increase demand for restaurants near the assembly plant and also near the associated tool-and-die manufacturers.[61]

For our modelling, we assume that 5% of all school buses in Ontario are electrified by 2025 and 65% by 2030. A similar target is set by the government of Quebec.

Based on our analysis, the direct, indirect and induced impacts of market growth in Ontario's ESB sector could cumulatively result in approximately 10,800 new jobs and $1.5 billion in GDP by 2030. The contribution from ESB charger manufacturing and installation is likely to add another 2,400 or so jobs and contribute to $0.3 billion in GDP by 2030 (Table 2).

Table 2. Cumulative jobs and economic benefits from the increased production, sales, and use of ESBs and ESB chargers in Ontario by 2030

	Jobs	Economic benefit (GDP)
ESB vehicle manufacturing	~10,800	$1.5 billion

[61] Cedric Smith, Saeed Kaddoura and Morrigan Simpson-Marran, *Taking Charge: How Ontario can create jobs and benefits in the electric vehicle economy* (Pembina Institute, 2021), 28. https://www.pembina.org/reports/taking-charge.pdf

ESB charger manufacturing	~1,200	$0.15 billion
ESB charger installation	~1,200	$0.14 billion

The job numbers are more meaningful when we consider the quality of the jobs. The automotive manufacturing sector creates jobs with twin advantages: 1) they are higher paying than most other industries; and 2) they are not exclusive to individuals with higher education degrees, which many don't have access to. On the first point, the Canadian Skills and Employment Coalition's report on wage distribution across industries compares earnings for all industries (i.e. the industrial aggregate): utilities, construction, manufacturing, motor vehicle manufacturing , and motor vehicle parts manufacturing in Canada between 2001 and 2017. On average, motor vehicle manufacturing employees earn higher hourly wages (~$40/hour) than employees in most other categories (industry average of about $25/hour).[62]

3.3 Benefits for SMEs

As noted above, nearly 90% of the over 500 companies involved in automotive assembly and parts manufacturing employ less than 500 workers, and more than 65% of those have fewer than 100 workers. Given the strong participation of SMEs in the sector, the fortunes of SMEs are strongly tied to the fortunes of the sector. A transition to electric school bus manufacturing can offer multiple opportunities for SMEs to survive and prosper.

The first opportunity comes from the restructuring of the automotive supply chain. New distribution channels will be required since new or different parts for electric vehicles are needed, creating new opportunities for SMEs. A European study examining the potential role of auto-manufacturing sector SMEs in the electric vehicle transition points out that "while the internal combustion engine (ICE) is an extremely complex system whose control depends on components and software packages in the hands of a few large organisations, the management of one or more electrical motors is much less

[62] Canadian Skills Training and Employment Coalition, *Automotive Sector Market Analysis: Wage Report*, (2019), 11. https://automotivepolicy.ca/wp-content/uploads/2019/12/Wage-Report.pdf

demanding and is accessible to many new organisations including SMEs."[63] Similarly, due to typically lower initial investment requirements, battery production allows for the entry of multiple small firms, breaking the monopolistic dominance of a few large automotive parts suppliers.[64]

This means there will be more openings in the supply chain market for smaller businesses to move into without requiring the level of investment and infrastructure that supplies for internal combustion vehicles do.

Case Study: Tube-Fab pivots to electric school buses to survive the pandemic

Location: Mississauga, ON Number of Employees: 55

Tube-Fab is a tube fabrication and manufacturing company that has been supplying the aerospace manufacturing industry with metal tubing for decades from its facilities in Mississauga, Ontario and Prince Edward Island. In 2019, when Covid-19 hit and demand from the aerospace industry plummeted, Tube-Fab was forced to pivot. The company, with deep roots in its community, retained its workforce of about 55 employees and searched for new opportunities as many of its competitors went out of business.

The result was a new partnership between Tube-Fab and a fast-growing Canadian electric school bus manufacturer to adapt its metal tubing for their needs. Tube-Fab is now set to double its manufacturing capacity and workforce and grow its revenue sevenfold over the next three to five years through supplying metal tubing to Lion's electric bus manufacturing plants in Quebec and Illinois.

Second, large OEMs may not enter certain niche business sub-segments, often due to lower profit margins or because these segments may not offer scaling up opportunities.

[63] Neil Adams, Christopher Pickering, Richard Brooks, and David Morris, "Barriers and opportunities for SMEs in EV technologies: From research to innovations," in *Electric vehicle systems architecture and standardization needs* (Springer, Cham, 2015). https://link.springer.com/chapter/10.1007/978-3-319-13656-1_2

[64] Adams, "Barriers and opportunities for SMEs in EV technologies."

Examples include battery manufacturing,[65] vehicle-to-grid demand-side management,[66] and battery recycling.

Case Study: Electrovaya develops lithium-ion batteries suited for ESBs

Location: Mississauga, ON Number of Employees: 60

Electrovaya is a leading and rapidly growing lithium battery manufacturer. The company designs, develops and manufactures proprietary lithium-ion battery solutions for clean electric transportation.

Electrovaya shows how Ontario EV technology companies can prosper, creating high-paying jobs and economic opportunity by attracting and retaining a highly skilled labour force. Electrovaya's battery pack design and management system is optimized for the heavy-duty vehicle battery systems that electric school buses require. An increase in the number of ESBs would not only be good for Electrovaya's business, it would likely encourage similar companies to locate in Ontario.

V2G opportunities

SMEs can capture business opportunities around charging infrastructure. By combining smart chargers with V2G (or Vehicle-to-Grid) technology, energy stored in ESBs can be redistributed to the grid during peak hours.[67] As an example, a Toronto based SME, eCAMION, builds energy hubs that provide EV and eBUS charging as well as grid services for businesses.[68]

[65] Frauke Bierau et al., "Opportunities for European SMEs in global electric vehicle supply chains in Europe and beyond." In *Advanced Microsystems for Automotive Applications 2015* (Springer, Cham, 2016). https://link.springer.com/chapter/10.1007/978-3-319-20855-8_18

[66] Mostafa Rezaei Mozafar, M. Hadi Amini, and M. Hasan Moradi, "Innovative appraisement of smart grid operation considering large-scale integration of electric vehicles enabling V2G and G2V systems," *Electric Power Systems Research* 154 (2018). https://doi.org/10.1016/j.epsr.2017.08.024

[67] Byte Snap, "How SMEs contribute to the EV & EV charging sectors." https://www.bytesnap.com/news-blog/how-smes-contribute-to-the-ev-and-ev-charging-sectors/

[68] eCamion, "Home." https://www.ecamion.com

SMEs and labour productivity

SMEs can offer greater labour productivity (or economic output per hour of work) gains than larger firms. A study of the German automotive manufacturing industry, for example, finds that between 2006 and 2015, real labour productivity of SMEs increased by twice as much compared to large firms (52% in SMEs and 27% in large firms).[69] Relatedly, an Australian study found that labour productivity for manufacturing SMEs increased at a faster rate than that of large manufacturing enterprises across all industries on average between 2000 and 2005.[70]

[69] Michael Rothgang and Wolfgang Dürig, "The Changing Role of SMEs in Innovation Activities in Germany–The Example of the Automobile Value-Added Chain," in *German and Chinese Contributions to Digitalization* (Springer Gabler, Wiesbaden, 2020). https://link.springer.com/chapter/10.1007/978-3-658-29340-6_18

[70] Muhammad Mahmood, "Labour productivity and employment in Australian manufacturing SMEs." *International Entrepreneurship and Management Journal* 4, no. 1 (2008). https://link.springer.com/article/10.1007/s11365-006-0025-9

4. Policies to support vehicle electrification

4.1 EV policy support in Ontario

The Ontario government recognizes that the transition to EVs is a key opportunity to revive the auto industry.[71] To take advantage of this, Ontario must institute supportive EV policies; ones that focus on electric school buses will benefit the SMEs that play an outsize role in the province's auto sector.

Supply-side policies

Since the announcement of its Driving Prosperity strategy document, the Ontario government has supported investments by many OEMs. In March 2022, the Ontario government contributed $131.6 million to Honda Canada's $1.3 billion investment plan to upgrade its manufacturing facilities in Allison to produce new and innovative vehicle technologies.[72] In April 2022, the Ontario government announced its $259 million in grant support to General Motors of Canada Company to transform the company's Oshawa and CAMI production plants to start manufacturing EVs.[73] In May 2022, the Ontario government invested $513 million in Stellantis's Windsor and Brampton plants to support the production of EVs at those facilities.[74]

The Ontario government has also taken notable steps to strengthen the critical mineral and mining sector, which is a critical component of the EV (and ESB) supply chain, providing key minerals for battery production. The government offers favorable

[71] Michael Eatson, "Federal and provincial governments' spending shows they recognize the future of automotive is electric," *Toronto Star*, June 4, 2022. https://www.thestar.com/autos/opinion/2022/06/04/federal-and-provincial-governments-spending-shows-they-recognize-the-future-of-automotive-is-electric.html

[72] Honda News, "Honda of Canada Mfg. to Invest more than $1.38 billion in Ontario Manufacturing Plants in Preparation for Electrified Future," media release, March 16, 2022. https://hondanews.ca/en-CA/releases/release-b7c602e7f6feb65d30b129b0f62591e2-honda-of-canada-mfg-to-invest-more-than-138-billion-in-ontario-manufacturing-plants-in-preparation-for-electrified-future

[73] Government of Ontario, "Ontario Secures Another Milestone Auto Investment," media release, April 4, 2022. https://news.ontario.ca/en/release/1001941/ontario-secures-another-milestone-auto-investment

[74] Government of Ontario, "Major Investments Secure Automotive Manufacturing Futures for Windsor and Brampton," media release, May 2, 2022. https://news.ontario.ca/en/release/1002141/major-investments-secure-automotive-manufacturing-futures-for-windsor-and-brampton

corporate tax rates to mining companies.[75] The Ontario Junior Exploration Program offers funding to help junior mining companies finance early-stage exploration projects.[76] To expand the region's capacity for critical minerals processing and refining, the government has invested $300 million in Frontier Lithium's lithium extraction facility,[77] and is investing $250,000 to support Electra's battery production lines.[78] The Critical Mineral Innovation Fund, launched in November 2022 with a total outlay of $5 million over the next two years, will fund up to 50% of the project costs to support the research, development and commercialization of innovative technologies for critical minerals, including batteries for electric vehicles.[79]

Case Study: Li-Metal develops technology that will support the growth of Ontario's homegrown cleantech industry

Location: Markham, ON Number of Employees: 31

Li-Metal is a leading developer of production technologies for lithium metal and advanced battery materials. Li-Metal's technologies have the potential to dramatically reduce the cost of producing both lithium metal and lithium metal anodes used in high performance batteries, like those required for electric school buses. Their made-in-Ontario approach has the potential to reduce supply chain and geopolitical risk that the North American battery market must manage as most advanced battery materials are currently produced in Asia.

Li-Metal has chosen Ontario for its operations because of significant advantages, including proximity to large markets and electric vehicle (including bus) manufacturers, the talent ecosystem provided by outstanding public research universities, quality of life, and a reliable source of raw materials.

[75] Government of Ontario, *Ontario's Critical Minerals Strategy: Unlocking potential to drive economic recovery and prosperity 2022-2027* (2022). http://www.ontario.ca/files/2022-03/ndmnrf-ontario-critical-minerals-strategy-2022-2027-en-2022-03-22.pdf

[76] Government of Ontario, "Ontario Junior Exploration Program." https://www.ontario.ca/page/ontario-junior-exploration-program

[77] Electric Autonomy, "Ontario government invests in Frontier Lithium mining pilot." https://electricautonomy.ca/2021/05/26/frontier-lithium-ontario/

[78] Government of Ontario, "Ontario Investing in the Future of EV Batteries," media release, February 23, 2022. https://news.ontario.ca/en/release/1001642/ontario-investing-in-the-future-of-ev-batteries

[79] Government of Ontario, "Critical Minerals Innovation Fund." https://www.ontario.ca/page/critical-minerals-innovation-fund

"As a Canadian company, founded in the Greater Toronto Area, we believe that building a domestic EV supply chain in Ontario is key for our country's ability to continue to lead the global movement towards electrified transportation," says Dean Frankel (CEO Li-Metal) "Li-Metal believes that further incentives and support for electric school buses and the broader battery industry will help supercharge the growth of our domestic supply chain, facilitating the province's ability to reduce reliance on foreign supply chains for key battery materials. Li-Metal believes electric school buses are an important part of further advancing the much-needed transition to greener transportation, and fully supports measures to help produce more batteries to put more buses on the road as quickly as possible. We believe government action can be a key accelerator for Li-Metal's own growth, in addition to Ontario's EV supply, helping further position us as a reliable supplier to the battery and automotive industries in Canada."

In addition, the government is setting aside money to support and encourage R&D investments in advanced auto manufacturing. For example, as part of Budget 2021 the government committed to $400 million over four years for Invest Ontario fund.[80] Relatedly, the provincial government has granted over $50 million in the creation of an Ontario Vehicle innovation Network. This initiative's objective is to facilitate the development of new and emerging technologies such as EVs and autonomous vehicles. It has promised to contribute to the investments announced by OEMs. To help plug the gaps in skilled workers, the Ontario government has announced an investment of $5 million to train young workers for 500 new jobs in the automotive industry.[81]

Are supply-side policies enough?

The empirical evidence on the effectiveness of manufacture subsidy on the development of EV industry is limited due to lack of research and data on the topic,[82] but existing research suggests mixed results. Some academic studies suggest that government subsidies can push manufacturer behaviour towards electric vehicle production.[83]

[80] Invest Ontario, "Incentives and services." https://www.investontario.ca/incentive-programs-and-services

[81] Lauren O'Neil, "Ontario announces free education and paid training for people to work in auto industry," *blogTo*, August 3, 2022. https://www.blogto.com/city/2022/08/ontario-free-training-education-jobs-auto-industry/

[82] Xiaohua Sun, Xiaoling Liu, Yun Wang and Fang Yuan, "The effects of public subsidies on emerging industry: An agent-based model of the electric vehicle industry, " *Technological Forecasting and Social Change* 140 (2019). https://doi.org/10.1016/j.techfore.2018.12.013

[83] Shanyong Wang, Jin Fan, Dingtao Zhao and Yanrui Wu, "The impact of government subsidies or penalties for new-energy vehicles a static and evolutionary game model analysis." *Journal of Transport Economics and Policy* 49, no. 1 (2015).
https://www.ingentaconnect.com/content/lse/jtep/2015/00000049/00000001/art00006

Similarly, others find that direct government aid (in the form of subsidies or loans) increases the probability of R&D activities, as found in a study of more than 4000 firms in Spain. This study also found that the impact of R&D support programs was more effective for SMEs, rather than larger firms.[84] On the other hand, recent research finds performance differences between consumer and manufacturer subsidies. A study of the U.S. automobile market finds that consumer subsidies are more effective than manufacture subsidy in promoting the popularity and technological breakthrough in electric vehicles.[85]

To summarize, the discussion above shows that while supply-side policies (which have largely taken the form of production subsidies in Ontario) can be a useful tool for increasing EV production in Ontario, they are not a solution that can single-handedly grow EV manufacturing in Ontario. Certain gaps remain (as discussed in the Recommendations section), which may be better addressed by demand policies.

Demand-side policies

The demand side has received relatively much less attention. Ontario has the Green Vehicle License program, which grants access to high-occupancy vehicle (HOV) lanes to light-duty EVs. However, weak policies such as HOV lane access are known to have little incremental impact on EV uptake or EV production.[86]

4.2 Intergovernmental coordination

Federally, a battery of climate policies has been implemented, which in turn, support the EV market. These include most notably the carbon tax.[87] The carbon tax increases fuel costs for driving fossil-fuel based vehicles, making it more economical to drive EVs.

[84] Elena Huergo and Lourdes Moreno, "Subsidies or loans? Evaluating the impact of R&D support programmes." *Research Policy* 46, no. 7 (2017): 1206. https://www.sciencedirect.com/science/article/abs/pii/S0048733317300811

[85] Sun, "The effects of public subsidies on emerging industry."

[86] Jonn Axsen, Patrick Plötz and Michael Wolinetz, "Crafting strong, integrated policy mixes for deep CO_2 mitigation in road transport," *Nature Climate Change*, 10 (2020). https://www.nature.com/articles/s41558-020-0877-y

[87] Government of Canada, "Carbon pricing." https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/carbon-pollution-pricing-federal-benchmark-information.html

Another economy-wide policy is the Clean Fuel Regulations.[88] This policy incentivizes network operators and fuel suppliers to reduce the carbon intensity of fuel supplied. The policy acts like an implicit subsidy for electric vehicles, since operators can earn credits for building electric charging infrastructure thereby reducing the total cost of ownership of EVs. More direct demand-side policies include the purchase subsidies offered as part of the Incentives for ZEVs program. The federal government offers support for charging infrastructure via the Zero Emission Vehicle Infrastructure Program: $680 million as support for installation of Level 2 (or higher) electric vehicle chargers and hydrogen refuelling stations. The scheme also includes chargers for heavy-duty vehicles (such as electric school buses).[89] Recently, the federal government has also started to pay attention to the heavy-duty EV sector as well. The government has set up a Zero Emission Transit Fund which offers $2.75 billion for the purchase of 5000 electric school buses.[90] Complementary to this, the government mounted the Incentives for Medium and Heavy-duty ZEV program, offering purchase incentives for the purchase of medium- and heavy-duty trucks/ vehicles.[91]

4.3 International practices

Overall, from a review of international policy examples, we find that strong demand- and supply-side policies act as critical support for the development and expansion of domestic electric school bus production in a region. Demand-side policies help overcome consumer-side barriers, while supply-side policies spur manufacturing activity. The optimal mix of policies, however, varies across regions.

As supply-side options, most regions have chosen regulations, such as the ZEV mandate or the vehicle emission standard. China and Europe have in place stringent vehicle emission performance standards to regulate the emissions of GHGs from buses and

[88] Government of Canada, *Clean Fuel Regulations* SOR/2022-140, https://pollution-waste.canada.ca/environmental-protection-registry/regulations/view?Id=1170

[89] Government of Canada, "Zero Emission Vehicle Infrastructure Program." https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876

[90] Infrastructure Canada, "Zero Emission Transit Fund," January 27, 2022. https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/index-eng.html

[91] Transport Canada, " Incentives for medium and heavy-duty zero-emission vehicles." https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/medium-heavy-duty-zero-emission-vehicles/incentives-medium-heavy-duty-zero-emission-vehicles

trucks, which in turn promotes the sales of electric buses and trucks.[92,93] Learning from its success with light-duty vehicles, California has implemented the ZEV mandate for medium- and heavy-duty vehicles as well, called the Advanced Clean Trucks regulation.[94]

On the demand side, many jurisdictions offer a mix of purchase subsidies and incentives for supporting the deployment of electric vehicle charging infrastructure. As a key demand-side policy, the Chinese government offers up to 49,500 Chinese yuan (approximately $9,600 in 2023 Canadian dollars) per vehicle for medium- and heavy-duty battery-electric vehicles (over 12 tonnes).[95] The subsidy program for electric buses has been in place since 2009. BYD, a leading electric bus manufacturer from China, has produced more than 70,000 electric buses worldwide.[96] The firm greatly benefitted from the incentives in China.[97] The purchase incentives created local demand for electric buses, in turn spurring local innovation and manufacturing, which has contributed significantly to China being the leader in the world's electric bus manufacturing.[98,99] The California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project is

[92] Yihao Xie, Felipe Rodríguez, *Zero-emission integration in heavy-duty vehicle regulations: A global review and lessons for China* (ICCT, 2021), 7. https://theicct.org/wp-content/uploads/2021/12/china-hdv-reg-zev-review-sep21.pdf

[93] European Commission, "Reducing CO_2 emissions from heavy-duty vehicles." https://climate.ec.europa.eu/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en

[94] California Air Resources Board, "Advanced Clean Trucks." https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks

[95] Chinese Ministry of Finance, "Notice on initiating fuel-cell electric vehicle demonstration and application," September 16, 2020. http://www.gov.cn/zhengce/zhengceku/2020-10/22/content_5553246.htm

[96] Sustainable Bus, "70,000 e-buses delivered by BYD worldwide (2.5% of them in Europe). 5.5 billion km covered," January 14, 2022. https://www.sustainable-bus.com/electric-bus/byd-70000-electric-buses/

[97] Gilmar Masiero, Mario Henrique Ogasavara, Ailton Conde Jussani, and Marcelo Luiz Risso, "Electric vehicles in China: BYD strategies and government subsidies." *RAI Revista de Administração e Inovação* 13, no. 1 (2016), 8. https://www.sciencedirect.com/science/article/pii/S1809203916300018

[98] Jiuyu Du et al., "Evaluating the technological evolution of battery electric buses: China as a case." *Energy* 176 (2019), 312. https://www.sciencedirect.com/science/article/pii/S0360544219304888

[99] Xiaoling Liu, Xiaohua Sun, Hui Zheng, and Dongdong Huang. "Do policy incentives drive electric vehicle adoption? Evidence from China." *Transportation Research Part A: Policy and Practice* 150 (2021). https://www.sciencedirect.com/science/article/pii/S0965856421001415

another examples of jurisdictions offering purchase incentives.[100,101] Several European countries (e.g., Germany, France, U.K., Spain, Italy) offer some form of purchase subsidies for electric medium- and heavy-duty vehicles (including buses).[102,103,104,105] The state of New York State's Truck Voucher Incentive Program is another example of purchase subsidies offered for electric school buses,[106] while the U.S. EPA's new Clean School Bus Program provides funding worth US$5 billion over the next five years (2022-2026) to replace existing buses with zero-emission buses.[107]

To complement the subsidies, many jurisdictions have put in place policies to develop the charging infrastructure for electric buses (and other MHDVs). Luxembourg offers a grant (up to 50% of the cost) for the purchase and installation of a new electric charging station with a power output of 11 kW or higher.[108] The Swedish government, too, offers a grant that covers 50% of the costs associated with the purchasing and installation of both private and public charging stations available to companies and public entities.[109] Similarly, the Chinese government provides subsidies for charging infrastructure capital investments and operations to provincial governments.[110]

[100] California Hybrid Electric Zero Emission Truck and Bus Voucher Incentive Program, "Incentives for Clean Trucks and Buses." https://californiahvip.org

[101] California Legislative Analyst's Office, "Green School Bus Grants." https://lao.ca.gov/Publications/Report/4525

[102] Ministère de la Transition écologique, "Décret N° 2021-37 Du 19 Janvier 2021 Relatif Aux Aides à l'acquisition Ou à La Location de Véhicules Peu Polluants." 2021-37 (2021). https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000043014941

[103] Ministero delle Infrastrutture e dei Trasporti. "Decreto Ministeriale 203." Pub. L. No. 203 (2020). https://www.mit.gov.it/sites/default/files/media/documentazione/2020-07/DM%20203%20-%202020.pdf

[104] IDAE.es. "MOVES II PLAN: Impulso a la movilidad sostenible." 2020. https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/plan-moves-ii

[105] UK.gov. "Low-Emission Vehicles Eligible for a Plug-in Grant." GOV.UK, 2020. https://www.gov.uk/plug-in-car-van-grants

[106] New York State, "How to Participate in NYTVIP: Vehicle Fleets." https://www.nyserda.ny.gov/All-Programs/Truck-Voucher-Program/For-Vehicle-Fleets

[107] U.S. Environmental Protection Agency, "Clean School Bus Program." https://www.epa.gov/cleanschoolbus

[108] Government of Luxembourg, "Applying for financial aid to install a private electric-vehicle charging station." https://guichet.public.lu/en/citoyens/transports-mobilite/transports-individuels/aides-financieres-acquisition-detention-vehicule/installation-bornes-charges-privees.html

[109] Government of Sweden, "Klimatklivet – support for climate investment." https://www.naturvardsverket.se/bidrag/klimatklivet/

[110] Xie, *Zero-emission integration in heavy-duty vehicle regulations*, 14.

Further, all leading ESB manufacturing jurisdictions demonstrate good coordination between policies across different forms of governments, where higher-order policies (e.g. EU-wide ESB targets) have been complemented by local/ provincial governments (e.g. country-specific ESB targets and incentives). Insights from around the world identify gaps in Ontario's EV (and ESB) policy ecosystem, helping us arrive at a set of policy recommendations, which we discuss next. In addition, the EU has adopted the Clean Vehicles Directive in 2019, which requires a portion of all publicly procured buses to be ZEVs.[111] As a result, all member states have set targets for public procurement of zero-emission bus fleets, ranging between 35% to 65% by 2030.[112]

[111] European Commission, "Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 Amending Directive 2009/33/EC on the Promotion of Clean and Energy-Efficient Road Transport Vehicles," *Official Journal of the European Union* L 188 (2019). http://data.europa.eu/eli/dir/2019/1161/oj

[112] Eamonn Mulholland and Felipe Rodríguez, *The rapid deployment of zero-emission buses in Europe* (ICCT, 2022), 9. https://theicct.org/wp-content/uploads/2022/09/zero-emission-buses-europe-sept22.pdf

5. Recommendations

We found that strong demand- and supply-side policies act as critical support for the production and purchase of ESBs within a single region. Demand-side policies help overcome consumer-side barriers, while supply-side policies spur manufacturing activity. While supply-side policies (which have largely taken the form of production subsidies for battery and mineral suppliers in Ontario) are a useful tool to strengthen the local supply chain, they are not a silver bullet solution that can single-handedly grow EV/ESB manufacturing in Ontario. Ontario's efforts on the supply side are commendable, but certain demand-side barriers remain, which are better addressed by measures aimed at increasing ESB adoption, which we discuss next.

Barriers to the development of an EV market (and in particular ESB market) can be categorized into (but not limited to) informational barriers, financial barriers, talent barriers and network barriers.[113] Some examples of information barriers include lack of information on the advantages of electric buses, lack of operational data for electric buses, and lack of understanding of infrastructure requirements. Financial barriers include high upfront costs for electric buses, lack of financing options, and high costs for charging infrastructure. While informational, financial and network barriers are addressable via demand-side policies, talent barriers can be addressed by supply-side policies. Next, we recommend policy actions that can potentially address some of these barriers.

5.1 Build operator awareness about electric school buses

Lack of information is a barrier affecting the electric school bus market. ESBs are fast approaching total cost of ownership parity with diesel buses (Section 3.1). However, despite market readiness and availability of multiple electric bus models, uptake is slow, partially due to technology anxiety: fleet owners and drivers are hesitant to include electric buses in their fleets due to concerns about charging requirements, technical and

[113] Ryan Sclar, Camron Gorguinpour, Sebastian Castellanos, and Xiangyi Li, *Barriers to adopting electric buses* (World Resources Institute, 2019), 7. https://files.wri.org/d8/s3fs-public/barriers-to-adopting-electric-buses-executive-summary.pdf

safety issues,[114] often driven by lack of information (e.g. operational data on ESBs).[115] As an example, a recent survey conducted by NRCan revealed that 46% of Canadians are unsure of whether electric vehicles have lower repair and maintenance costs than gasoline or diesel-powered vehicles.[116] Planners, fleet managers, truck operators, engineers, mechanics and other technical workers may have less experience with new and emerging near- and zero-emission technologies. Specific to heavy-duty vehicles, a recent study in California found that fleet owners were unaware of the availability of electric vehicles, and perceived them to be functionally unsuitable.[117]

Federal and provincial governments, ENGOs and academic institutions can increase awareness and education through targeted outreach campaigns, as well as tailored support for fleets. A notable example is the Zero Emission Vehicle Awareness Initiative by Natural Resources Canada.[118] This initiative provides funding of up to 75% of the costs to support outreach, education, and capacity-building projects to increase awareness, knowledge and public confidence in zero-emission vehicles and public charging and refueling infrastructure. The Transport Ministry of Quebec is financially supporting the My Electric Bus project, which seeks to raise awareness about electric school buses among drivers and school board managers.[119] Another example is California's E-Bus and Grid Integration Project, whose aim is to demonstrate and disseminate knowledge about the potential value of ESB operator training.

Recommendation #1: To combat low operator awareness, the Ontario government should support/ fund projects that help school bus drivers, operators and managers to learn about the benefits (e.g., lower total cost of ownership, business case) of electric buses. As a first step Ontario should create an ESB Toolkit (similar to the Transit Toolkit

[114] Rebecca Thorne et al., "Facilitating adoption of electric buses through policy: Learnings from a trial in Norway," *Energy Policy* 155 (2021). https://www.sciencedirect.com/science/article/pii/S0301421521001798

[115] Moataz Mohamed, Mark Ferguson, and Pavlos Kanaroglou. "What hinders adoption of the electric bus in Canadian transit? Perspectives of transit providers." *Transportation Research Part D: Transport and Environment* 64 (2018), 146. https://www.sciencedirect.com/science/article/abs/pii/S1361920916304370

[116] Natural Resources Canada, *Canadians' Awareness, Knowledge and Attitudes Related to Zero Emission Vehicles (ZEVs)*, prepared by EKOS Research Associates (2021), 5. https://www.nrcan.gc.ca/sites/nrcan/files/057-21-NRCan_ZEVs_Final_Report_EN_accessible.pdf

[117] Bae, Youngeun, Craig R. Rindt, Suman Mitra, and Stephen G. Ritchie. "Fleet Operator Perspectives on Alternative Fuels for Heavy-Duty Vehicles." Available at SSRN 4253440. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4253440

[118] Natural Resources Canada, "Zero Emission Vehicle Awareness Initiative ", https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/electric-and-alternative-fuel-infrastructure/zero-emission-vehicle-awareness-initiative/22209

[119] Equiterre, "My Electric Bus." https://www.equiterre.org/en/resources/mon-autobus-branche

already planned by the government[120]) to spread awareness of clean bus technologies and to offer guidance on best practices for technology adoption. The government should consult and engage with advocacy groups like School Bus Ontario[121] and the Canadian Electric School Bus Alliance to disseminate knowledge on ESBs.

5.2 Help Ontario schools save on electric school bus purchases

A key financial barrier is that electric school buses have higher upfront costs relative to diesel buses. Cost for a typical electric school bus can range between $300,000 and $330,000.[122,123] In comparison, a typical diesel bus can cost $100,000 to $150,000.[124] High upfront costs are limiting demand, as also reported by bus fleet owners in a recent survey of Ontario-based SMEs.[125]

Purchase subsidies can offset high upfront costs for ESBs. This policy option has been found to be effective in increasing ZEV sales. Moreover, it typically enjoys high political acceptability among consumers and automakers.[126,127] All leading electric bus manufacturing jurisdictions (including China and Europe) offer some form of purchase subsidies to support ESB demand, as noted in Section 4.3, along with California, New York State and the U.S. EPA. In Canada, Quebec's Ecobus program offers financial assistance for the purchase of electric buses (including school buses) for a 3-year period from April 2022 to March 2025.[128]

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[120] Government of Ontario, *Driving Prosperity: Ontario's Automotive Plan Phase 2* (2021), 16. https://files.ontario.ca/medjct-driving-prosperity-ontario-automotive-plan-phase-2-en-2021-11-23.pdf

[121] School Bus Ontario, "About." http://schoolbusontario.ca/about/

[122] Plug in BC, "GreenPower Demos Its Synapse 72 Electric School Bus in Vancouver." https://pluginbc.ca/greenpower-demos-synapse-72-electric-school-bus-vancouver/

[123] Mehanaz Yakub, "Student Transportation of Canada places conditional order for 1,000 electric school buses," *Electric Autonomy*, October 28, 2021. https://electricautonomy.ca/2021/10/28/student-transportation-electric-buses/

[124] CBC, "Electric school buses hit the road in B.C.," May 9, 2021. https://www.cbc.ca/news/canada/british-columbia/electric-school-bus-bc-sooke-1.6019060

[125] Green Economy Canada, stakeholder interviews, May to July 2022.

[126] Global Automakers of Canada, "Public Policy Positions." https://globalautomakers.ca/resources/policies/

[127] Zoe Long, Shelby Kitt, and Jonn Axsen, "Who supports which low-carbon transport policies? Characterizing heterogeneity among Canadian citizens," *Energy Policy* 155 (2021). https://www.sciencedirect.com/science/article/abs/pii/S0301421521001713

[128] Quebec Ministry of Transport, "Ecobus Financial Assistance Program." https://www.transports.gouv.qc.ca/fr/aide-finan/electrification/ecobus/Pages/ecobus.aspx

However, purchase subsidies also have some critiques. Most importantly, poorly designed purchase subsidies can be costly for governments, especially if there is free ridership — buyers who receive subsidies for electric vehicles they would have bought even without the rebate.[129,130] For example, some large fleet owners are buying ESBs even in the absence of Ontario-specific subsidies.[131,132,133] Creditably, the Ontario government is cognizant of this shortcoming of rebates.[134]

Recommendation 2: Ontario should offer targeted, carefully designed grants directly to school districts (rather than uniform subsidies where exclusion of free-riders is difficult) for purchase of 500 ESBs by 2025, rising to 5000 ESBs by 2030.

5.3 Ensure Ontario's infrastructure is ready for electric school buses

The need for chargers is another critical barrier to electrification. ESBs require Level 2 chargers or higher. As noted earlier, ESBs are unique in that they require little or no public charging; however, chargers will be required at the buses' home depots, and will incur installations costs of about $20,000 or higher.

Many jurisdictions provide support for the purchase of chargers by ESB operators. B.C.'s Go Electric School Bus program reimburses the purchase and installation costs of eligible new Level 2 charging equipment at 75% of installed costs, including electrical modifications required for the charging stations, up to a maximum of $6,000 per

[129] Ambarish Chandra, Sumeet Gulati, and Milind Kandlikar, "Green drivers or free riders? An analysis of tax rebates for hybrid vehicles," *Journal of Environmental Economics and Management* 60, no. 2 (2010). https://www.sciencedirect.com/science/article/abs/pii/S0095069610000598

[130] Ian Irvine, "Electric vehicle subsidies in the era of attribute-based regulations." *Canadian Public Policy* 43, no. 1 (2017). https://www.utpjournals.press/doi/full/10.3138/cpp.2016-010

[131] Electric Autonomy, "Student Transportation of Canada places conditional order for 1,000 electric school buses."

[132] Electrive, "200 Lion Electric school buses bound for Ontario."

[133] Huntsville Doppler, "Local bus operator aims to reduce emissions with 10 new electric buses," August 25, 2022. https://doppleronline.ca/huntsville/local-bus-operator-aims-to-reduce-emissions-with-10-new-electric-buses/

[134] Lisa Xing, "Doug Ford says he won't give Ontarians rebates to buy electric vehicles, even though sales are lagging," *CBC*, November 11, 2021. https://www.cbc.ca/news/canada/toronto/doug-ford-electric-vehicle-rebate-ev-sales-ontario-1.6244947

station.[135] The Canada Infrastructure Bank is providing loans to bus operators for the purchase of electric buses and installation of the necessary charging infrastructure.[136] The California Energy Commission has allocated US$75 million to replace California's oldest diesel school buses with electric buses, where a part of the funding is dedicated for installing school bus chargers.[137] Germany's 300 million euros On-Site Infrastructure program is dedicated specially for SMEs and local governments and offers up to 80% of the total costs of charger purchase and installation.[138] Spain's MOVES III 2021 program funds up to 55% of costs for small companies, and 45% of costs for medium companies, for charging infrastructure greater than 50 kW.[139] Ontario's recent commitment to invest $91 million on EV infrastructure is a notable step, though it focuses more on public chargers for light-duty vehicles and hence does not directly benefit ESBs.[140]

Recommendation 3: To increase widespread availability of ESB-charging infrastructure, Ontario should quadruple its recently made commitment of $91 million spending on chargers, to include at least five fast charging stations (>100 kW) in each of the 72 school districts by 2030.

[135] The Association of School Transportation Services of BC, "Go Electric School Bus Program." https://astsbc.org/go-electric-school-bus-program/

[136] Mehanaz Yakub, "Canada Infrastructure Bank to fund 4,000 electric school buses in Quebec," *Electric Autonomy,* November 24, 2021. https://electricautonomy.ca/2021/11/24/cib-4000-electric-school-buses-quebec/

[137] California Energy Commission, "CEC Funded School Bus Chargers." https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/cec-funded-school-0

[138] Government of Germany, "On-Site Infrastructure Program", https://www.bav.bund.de/DE/4_Foerderprogramme/6_Ladeinfrastruktur_fuer_Elektrofahrzeuge/6_1_Ladeinfrastruktur_vor_Ort/Ladeinfrastruktur_vor_Ort_node.html

[139] LRP Energy, "MOVES III Plan: What the subsidy is for and who can benefit from it?" January 25, 2023. https://lrpenergy.com/moves-iii-plan-what-the-subsidy-is-for-and-who-can-benefit-from-it-2/

[140] CTV News, "Ontario putting $91M toward electric vehicle chargers at rest stops, parks," March 23, 2022. https://toronto.ctvnews.ca/ontario-putting-91m-toward-electric-vehicle-chargers-at-rest-stops-parks-1.5830735

5.4 Help train Ontarians for ESB manufacturing, operation and maintenance

Growth in EV (and ESB) auto and battery manufacturing is being impacted by the lack of highly skilled manpower.[141,142] Globally, battery manufacturing giants like LG Energy Solution and Samsung SDI Co that supply to automakers like Tesla, Volkswagen and Ford are grappling with a shortage of research and engineering specialists even as demand for electric vehicles continues to rise.[143] Canadian firms are also facing a talent crunch. Despite rising demand, the Canadian battery industry is struggling to scale up production due to a shortage of skilled workforce.[144] This finding was corroborated in our interviews, where multiple Ontario-based battery manufacturing SMEs highlighted the lack of skilled workforce in the industry.[145]

The workforce shortage is not only affecting the battery manufacturing industry, but in fact is a concern across the entire automotive supply chain. Labour shortage is reported to be the primary concern among auto suppliers in Ontario.[146] Relatedly, there is lack of trained technicians to provide repair and maintenance support to electric vehicles. Approximately 70,000 new repair technicians will be needed between 2022 and 2025.[147] The mining sector is no different. In an interview with Electric Autonomy Canada, Stella

[141] Jamilah Lim, "Korea's EV battery manufacturers wringing hands over talent crunch," *Tech Wire Asia*, November 1, 2021. https://techwireasia.com/2021/11/koreas-ev-battery-manufacturers-wringing-hands-over-talent-crunch-2/

[142] Jack Hunsley, "Talent shortage poses EV battery manufacturing questions," *Automotive World*, May 9, 2022. https://www.automotiveworld.com/articles/talent-shortage-poses-ev-battery-manufacturing-questions/

[143] Heekyong Yang, "Battery giants face skills gap that could jam electric highway," *Yahoo Finance*, October 4, 2021. https://ca.finance.yahoo.com/news/battery-giants-face-skills-gap-230435502.html

[144] Anita Balakrishnan, "As cash floods into the battery business, companies face a battle for talent," The Logic, May 10, 2022. https://thelogic.co/news/as-cash-floods-into-the-battery-business-companies-face-a-battle-for-talent/

[145] Green Economy Canada, Stakeholder interviews, May to July 2022.

[146] Grace Macaluso, "Labour shortage top concern for Canadian auto suppliers," *Automotive News Canada*, October 20, 2022 .https://canada.autonews.com/suppliers/labour-shortage-top-concern-canadian-auto-suppliers

[147] Alyssa DiSabatino, "How supply chain is leading to repair challenges for electric vehicles," *Canadian Underwriter,* November 3, 2022. https://www.canadianunderwriter.ca/brokers/how-supply-chain-is-leading-to-repair-challenges-for-electric-vehicles-1004227151/

Holloway, general manager at Ontario-based MacLean Engineering, acknowledged that "we are in a skilled labour shortage."[148]

Many regions have funded skills training programs related to ESB manufacturing, operation and/or maintenance. For example, Quebec's EV Competencies program is the first of its kind in Canada that trains auto industry workers to design, manufacture and repair electric and hybrid vehicles (including heavy-duty vehicles and buses).[149] Since 2020, in partnership with Proterra and Christ College, the Los Angeles County Department of Workforce Development, Aging, and Community Services has been running the Electric Bus Manufacturing Technology training program to train students for manufacturing jobs in the industry.[150]

The California Energy Commission awarded US$1 million to California Community Colleges to provide electric school bus technician training to community college faculty and fleet technicians employed by high school districts statewide.[151]

Notably, the Ontario government too is taking important steps to address the workforce constraints facing the electric vehicle (and bus) industry. The government is setting up an EV maintenance skills training program in partnership with St. Lawrence College in Kingston to train tradespeople to work on EVs.[152] Moreover, recently Ontario announced that it is spending $5 million to train 500 people from underrepresented groups to train them for automotive jobs and place them in SMEs.[153] Ontario has also recently expanded Specialist High Skills Major program, with additional funding of $39.6 million, to help students gain job-ready skills in the skilled trades.[154]

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[148] Emma Jarratt, "There's a skills shortage maintaining electric mining vehicles. One training program is trying to fix that," *Electric Autonomy Canada*, August 25, 2021. https://electricautonomy.ca/2021/08/25/mining-ev-maintenance-workforce-training/

[149] Programme Competencies, "EV Skills." https://competencesve.ca/en/

[150] Zachary Shahan, "Electric Bus Manufacturing Workforce Training Launched In Los Angeles," *Clean Technica*, October 7, 2020. https://cleantechnica.com/2020/10/07/electric-bus-manufacturing-workforce-training-launched-in-los-angeles/

[151] California Community Colleges, "The Electric School Bus Training Project." https://atleducation.org/cec/the-electric-school-bus-training-project/

[152] Adam Malik, "AIA, Ontario team up on EV training," *Auto Service World*, May 5, 2022. https://www.autoserviceworld.com/aia-ontario-team-up-on-ev-training/

[153] Canadian Manufacturing, "Ontario announces new program to train more workers for careers in automotive manufacturing," August 3, 2022. https://www.canadianmanufacturing.com/manufacturing/ontario-announces-new-program-to-train-more-workers-for-careers-in-automotive-manufacturing-284009/

[154] Ontario, *Driving Prosperity: Ontario's Automotive Plan Phase 2*, 18.

Recommendation #4: The government should continue the good work on workforce development initiated so far, expanding the geographical scope (by including other colleges and universities) and the monetary allocation of the multiple training programs already in operation in the province. The province should ensure ESB-specific training is included in its programs.

"Made in Canada" considerations

The supply chain shortages due to the COVID-19 crisis and the Ukraine-Russia war have highlighted the perils of over-dependence on international supply chains. Recognizing this, an increasing number of leading auto manufacturing countries are now taking steps to protect and grow their domestic automotive industries. The recently announced U.S. Inflation Reduction Act requires that to qualify for a $7,500 tax credit, an electric vehicle and its battery must be assembled in North America.[155] French Finance Minister Bruno Le Maire said the European Union should consider applying electric-vehicle subsidies to cars built in the bloc, after the U.S. limited its support to North American-made vehicles.[156] Germany's car industry has called for a European industrial policy to counter the U.S. green subsidy regime in order to safeguard the competitiveness of European industry.[157] The Global Automakers of Canada recommends that the government protect Canadian-based manufacturers against "Buy American" policies.[158] Unifor, Canada's largest private-sector union, is urging the government to support domestic industries and establish a "made-in-Canada guidance for government fleet vehicle purchasing," where the government prioritizes procurement of Canadian-made vehicles.[159] Most of the SMEs interviewed as part of this study echoed the call for "Made in Canada" supportive policies. Ontario, recognizing the demands by the SMEs and workers' unions, must consider avenues to safeguard the interests of domestic auto industry. As part of the upcoming 2023 Budget, the Ontario government's proposed legislation (Ontario Made Manufacturing Investment Tax Credit) to create a new 10% refundable corporate income

[155] Dan Mihalascu, "Inflation Reduction Act Disrupts EV Market, Says Kia Of America COO," *Inside EVs,* November 29, 2022. https://insideevs.com/news/624061/inflation-reduction-act-disrupts-ev-market-says-kia-of-america-coo/

[156] Automotive News Europe, "Europe should copy U.S. EV subsidies, France says," September 27, 2022. https://europe.autonews.com/automakers/europe-should-copy-us-electric-car-subsidies-france-says

[157] Financial Times, "German car industry calls for European policy to counter US subsidies," January 11, 2023. https://www.ft.com/content/4024a766-3578-403b-93be-5f5efbfd93f5

[158] Global Automakers of Canada, "Public Policy Positions."

[159] Mehanaz Yakub, "Unifor calls for national auto policy after landmark vote to elect Lana Payne as first female president," *Electric Autonomy*, August 12, 2022. https://electricautonomy.ca/2022/08/12/unifor-auto-policy-report-lana-payne/

tax credit for Canadian-controlled private corporations making investments in the province is a notable first step in this direction.

Electricity rates and ESG considerations

High electricity rates have hurt SMEs in the auto sector.[160] A survey of auto SMEs reveals that high electricity prices are a key challenge affecting firms.[161] This has led some automakers to suggest that it is getting difficult to do business in Ontario.[162] Electricity rates in Toronto are almost twice those of Montreal.[163]

In response to high rates, the government introduced the Ontario Electricity Rebate program. In April 2022, Ontario announced its plan to work on a new ultra-low overnight electricity rate[164] and adopted it in late October 2022.[165] Furthermore, the Ontario Energy Board recently announced lowering of electricity prices for SMEs.[166] As per the Ontario Electricity Rebate program, eligible consumers (including SMEs) will receive a further 11.7% rebate from the province on the subtotal of their electricity bill, starting November 1, 2022.[167] While such measures are welcome as they offer temporary relief, Ontario will

[160] Financial Post, "Ontario's job killer: Business sounds alarm over soaring electricity prices," July 10, 2015. https://financialpost.com/opinion/ontarios-job-killer-business-sounds-alarm-over-soaring-electricity-prices

[161] John Holmes, Tod Rutherford and Jeffrey Carey, "Challenges confronting the Canadian automotive parts industry: What role for public policy?" *Canadian Public Policy* 43, no. S1 (2017). https://utpjournals.press/doi/10.3138/cpp.2016-030

[162] Gabriel Friedman, "Ontario risks losing its auto crown as cheap, green power gives Quebec the EV edge," *Financial Post,* March 11, 2022. https://financialpost.com/commodities/energy/electric-vehicles/ontario-risks-losing-its-auto-crown-as-cheap-green-power-gives-quebec-the-ev-edge

[163] Hydro Quebec, *2022 Comparison of Electricity Prices in Major North American Cities* (2022), 6, https://www.hydroquebec.com/data/documents-donnees/pdf/comparison-electricity-prices.pdf

[164] Government of Ontario, "Ontario Advances Work on New Ultra-Low Overnight Electricity Rate," media release, April 12, 2022. https://news.ontario.ca/en/release/1002018/ontario-advances-work-on-new-ultra-low-overnight-electricity-rate

[165] Government of Ontario, "Proposed Implementation of an Ultra-Low Overnight Electricity Price Plan for Regulated Price Plan Consumers," October 31, 2022. https://ero.ontario.ca/notice/019-5849

[166] Ontario Energy Board, "Ontario Energy Board announces changes to electricity prices for households and small businesses." https://www.oeb.ca/newsroom/2022/ontario-energy-board-announces-changes-electricity-prices-households-and-small

[167] Government of Ontario, "Manage energy costs for your home." https://www.ontario.ca/page/manage-energy-costs-your-home

need to resort to other structural measures (e.g., electricity grid modernization) to achieve lower electricity prices over the long term.

Ontario must also consider environmental, social and governance (ESG) concerns in its electricity solutions. Increasingly, firms are laying greater emphasis on ESG factors in their investment decisions,[168,169] and choosing to invest in regions with clean electricity. GM chose to set up its battery manufacturing plant in Quebec. The vice-president of corporate and environmental affairs at GM Canada noted that "Quebec's low greenhouse gas (GHG), low-cost electricity is important," in deciding to set up the plant in Quebec.[170] Stromcore, an Ontario-based SME, is planning to set up its battery manufacturing plant in Quebec, "where cheap clean electricity is plentiful, and the provincial government is keen to foster a battery and zero-emission economy."[171] With rapidly declining prices of wind and solar[172] and historic leadership in developing clean energy sources, Ontario should consider investing further in clean electricity generation and in grid modernization, which will help present itself as an attractive investment destination which scores high on ESG criteria. Modernizing the electrical grid also brings direct benefits to users like enabling resilience and saving bill costs through energy efficiency and demand management.[173]

[168] Swetha Venkataramani, "The ESG Imperative: 7 Factors for Finance Leaders to Consider," *Gartner*, June 10, 2021. https://www.gartner.com/smarterwithgartner/the-esg-imperative-7-factors-for-finance-leaders-to-consider

[169] PwC, "Companies failing to act on ESG issues risk losing investors, finds new PwC survey," November 3, 2021. https://www.pwc.com/lt/en/about/press-room/pwc-global-investor-esg-survey.html

[170] CBC, "GM and POSCO to build plant in Quebec to produce battery material," March 7, 2022. https://www.cbc.ca/news/canada/montreal/gm-posco-plant-quebec-battery-material-1.6375759

[171] Gabriel Friedman, "Canada could see its first lithium-ion battery cell factory open soon — on the back of the humble forklift," *Financial Post*, October 20, 2021. https://financialpost.com/commodities/energy/electric-vehicles/canada-could-see-its-first-lithium-ion-battery-cell-factory-open-soon-on-the-back-of-the-humble-forklift

[172] Rupert Way, Matthew C. Ives, Penny Mealy and J. Doyne Farmer, "Empirically grounded technology forecasts and the energy transition," *Joule* 6, no. 9 (2022). https://doi.org/10.1016/j.joule.2022.08.009

[173] Binnu Jeyakumar, *Achieving a Net-Zero Canadian Electricity Grid by 2035* (Pembina Institute, 2022). https://www.pembina.org/reports/achieving-a-net-zero-canadian-power-grid-by-2035.pdf

6. Conclusion

With a thorough analysis of the electric school bus industry and related policies and regulations both in Canada and internationally, this report shows that investing in the ESB market will help revive Ontario's automotive sector (particularly the MHDV sub-sector), increase Ontario's automotive GDP, create well-paid, secure, job opportunities, lower carbon emissions, and generate community-wide health benefits.

Of the different categories of large trucks and buses, electric school buses are comparatively easy to electrify. Introducing demand-side policies that will increase uptake will, in turn, incentivize manufacturers to produce ESBs. We estimate that the ESB supply chain (vehicle and charger manufacturing and charger installation) could create some 13,200 jobs and generate nearly $2 billion in economic output in Ontario by 2030.

SMEs, in particular, can benefit by capitalizing on the multiple new opportunities created by a transition from diesel-fuelled school buses to electric ones. Those opportunities include:

- expanding the supply chain to respond to the need for new components such as batteries); numerous battery manufacturing start-ups in Ontario have experienced rapid growth in the past few years;
- creating new business models such as smart vehicle-to-grid charging services. SMEs are well suited to switching to an electric vehicle marketplace due to their lean size, ability to change business models quickly, and high labour productivity. These operations can leverage their size and entrepreneurial approach to pivot to new but related service offerings and alternative means of marketing and generating revenue.

Despite steps taken by the Ontario government, much more needs to be done to expand into the ESB market. A combination of demand- and supply-side policies need to be implemented to address institutional barriers, the absence of adequate information, financial needs, network insufficiencies and skills training.

We recommend the following:

- Build awareness among operators about the benefits of electric school buses
- Provide Ontario schools with the supports needed to purchase electric school buses

- Build out charging infrastructure that is adequate for the anticipated number and location of electric school buses
- Offer skills training for Ontarians so that they can be employed in ESB manufacturing, operation and maintenance.

Ontario can regain its position as an automotive hub that meets country-wide consumer demand, and it can demonstrate leadership in the clean energy transition at the same time. Electric school buses are a key part of the new economy that will fuel environmental and economic sustainability.

Appendix A. Methodological notes

A.1 Forecasting electric school bus (ESB) units

A.1.1 Forecasting school bus units

Ontario's current (2019) and historical (200-2019) stock of electric school buses is taken from Table 31: Bus Explanatory Variables for the Transportation Sector – Ontario summary tables of the National Energy Use Database.[174]

Past values were used to create a linear forecast of total school bus stock to 2030. We assume the total school bus stock increases from about 16,000 in 2019 to nearly 18,000 in 2030.

A.1.2 Forecasting electric school bus units

In our high-growth scenario, we assume Ontario hits a target of 65% of its school bus fleet being electric as of 2030. We assume Ontario hits an interim target of 5% as of 2025. As a result, we see the electric school bus stock increase to about 11,500 as of 2030.

These 5% by 2025 and 65% by 2030 stock targets are similar to those in other regions:

- Quebec has a stock target of 25% by 2025[175] and 65% by 2030.[176, 177]

[174] Government of Canada, "National Energy Use Database." https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=tran&juris=on&rn=31&page=0

[175] Quebec has not specified a fixed target, but it has announced plans to have 2600 buses in the next two or three years. 2600 buses would account for roughly 25% of the about 10,000 school buses in Quebec.

[176] Jasmin Legatos, "Quebec unveils funding to electrify 65 per cent of all school buses by 2030," *Electric Autonomy,* April 28, 2021. https://electricautonomy.ca/2021/04/28/quebec-electric-school-buses-2030/

[177] Government of Quebec, "Reduce GHG in transportation." https://www.quebec.ca/en/government/policies-orientations/plan-green-economy/initiatives-fight-climate-change/reduce-ghg-transportation

- U.S. has a stock target of 2% of its 500,000 school bus fleet by 2027,[178] though more than 12,000 ESBs are already in the commitment stage (i.e either delivered or ordered).[179]
- New York state has a stock target of 100% by 2035.[180]
- In terms of sales targets, 17 North American states have targets to electrify 30% of new school buses in their jurisdictions by 2030.[181]

A.1.3 Electric school bus type split

We assume all electric school buses in Ontario are battery-electric, as opposed to plug-in hybrid electric and/or fuel-cell electric. While we do this for the sake of simplicity, this is also reflective of the current battery-electric /other split in the global electric school bus stock (almost 100%) and the split in Ontario's electric bus stock (100%).[182,183]

A.2 Forecasting electric school bus manufacturing benefits

A.2.1 Electric school bus cost and useful life

We assume the cost of an electric school bus to be $300,000 in 2022, increasing linearly to $316,000 in 2030. We assume 100% of electric school buses sold in Ontario are manufactured in Ontario. We convert electric school bus stock values to electric school bus sales values through net stock additions and an assumption that the average electric school bus has a useful life of twelve years.[184]

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[178] This is not a binding target but indicates the announcement made by the U.S. government. Alejandro de la Garza, "U.S. School Buses May Never Be The Same Thanks to Biden's Infrastructure Plan," *Time*, November 15, 2021. https://www.yahoo.com/now/u-school-buses-may-never-120050013.html

[179] CNBC, "The race to Electrify America's School Buses", https://www.youtube.com/watch?v=6QKfqt2IRTA&t=185s

[180] Michelle Lewis, "New York State commits to 100% electric school buses by 2035," *Electrek*, April 8 2022. https://electrek.co/2022/04/08/new-york-state-governor-100-electric-school-buses-2035/

[181] Stephen Edelstein, "17 states stand by plan to electrify 30% of buses and trucks by 2030," *Green Car Reports*, July 28, 2022. https://www.greencarreports.com/news/1136645_17-states-stand-by-plan-electrify-30-trucks-buses-by-2030

[182] ICCT , *The rapid deployment of zero-emission buses in Europe*, 2.

[183] Buysse, *Zero-emission bus and truck market in the United States and Canada*, 3.

[184] CALSTART, *Electric School Buses Market Study,* 11.

A.2.2 Determining economic benefits

We multiply electric school bus sales by electric school bus costs to determine electric school bus sales revenue.

We then apply direct, indirect and induced jobs and GDP multipliers sourced from Statistics Canada Table 36-10-0595-01.[185] These multipliers are for 2018, for the Geography "Ontario", with the geographical coverage "Within province" and for the industry "Heavy-duty truck manufacturing [BS336120]," which is defined as:

> "This industry comprises establishments primarily engaged in manufacturing heavy-duty vehicles and heavy-duty vehicle chassis, for highway use."[186]

We sum benefits from 2022-2030 to arrive at cumulative economic and jobs benefits of manufacturing electric buses in Ontario. Table 3, below, summarizes.

Table 3. Economic and jobs benefits of electric school bus manufacturing (2022-2030)

Benefit	Revenues (2022-2030)	Multiplier	Benefit (2022-2030)
Jobs	$3.6 billion	3.02 jobs per $1 million output	10,800 jobs
Gross domestic product		$0.41 per $1 output	$1.5 billion GDP

A.3 Forecasting ESB charger manufacturing and installation benefits

A.3.1 Manufacturing and installation costs

We assume the manufacturing cost of a level 2 charger is $10,000 in 2022, declining linearly to $9,000 in 2030.[187] We assume the installation cost of a level 2 charger is

[185] Statistics Canada, "Input-output multipliers, provincial and territorial, detail level," Table 36-10-0595-01.

[186] Innovation, Science and Economic Development Canada, "Heavy-duty truck manufacturing – 33612." https://www.ic.gc.ca/app/scr/app/cis/summary-sommaire/33612

[187] Sam Pournazeri, "How much does electric vehicle charging infrastructure actually cost?" *ICF*, January 25, 2022. https://www.icf.com/insights/transportation/electric-vehicle-charging-infrastructure-costs

$6,000 in 2022, remaining constant to 2030.[188] We assume the manufacturing cost of a DC charger is $60,000 in 2022, declining linearly to $50,000 in 2030, and the installation cost of a DC charger is $30,000 in 2022, remaining constant to 2030.[189]

A.3.2 Ratios of chargers to electric school buses

We assume that electric school buses return to base and do not require public charging, so our modelling assumes all chargers are depot chargers.

We assume the ratio of Level 2 depot chargers per electric school bus is 1:1 in 2022 and remains constant to 2030. We assume the ratio of DC depot chargers per electric school bus is 0.25 in 2022 and also remains constant to 2030.[190]

A.3.3 Determining economic benefits

We multiply the net addition of ESBs to Ontario's roads in a year by the ratio of chargers to ESBs to determine the number of new Level 2 and DC depot chargers added to Ontario's network in that year.

We multiply the number of new Level 2 and DC depot chargers added to Ontario's network in a year by their respective manufacturing and installation costs to determine the total charger manufacturing and installation revenues for that year.

We make the simplifying assumption that 100% of Level 2 and DC depot chargers installed in Ontario are installed by Ontario firms and manufactured by Ontario firms.

We source multipliers for installation and manufacturing of ESB chargers from Statistics Canada Table 36-10-0595-01.[191] We source direct, indirect and induced multipliers for GDP and jobs for the year 2018, for the geography "Ontario" and for the geographical coverage "Within province".

For the manufacturing of chargers, the industry "Other electrical equipment and component manufacturing [BS335900]" is used, defined as:

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[188] Ray Minjares, Felipe Rodríguez, Arijit Sen and Caleb Braun, *Infrastructure to support a 100% zero-emission tractor-trailer fleet in the United States by 2040* (ICCT, 2021). https://theicct.org/wp-content/uploads/2021/12/ze-tractor-trailer-fleet-us-hdvs-sept21.pdf

[189] ICF, "How much does electric vehicle charging infrastructure actually cost?"

[190] Caley Johnson, Erin Nobler, Leslie Eudy and Matthew Jeffers, *Financial Analysis of Battery Electric Transit Buses* (National Renewable Energy Laboratory, 2020). https://www.nrel.gov/docs/fy20osti/74832.pdf

[191] Statistics Canada, "Input-output multipliers, provincial and territorial, detail level," Table 36-10-0595-01.

> "This industry group comprises establishments, not classified to any other industry group, primarily engaged in manufacturing electrical power storage and transmission devices, and accessories for carrying current."[192]

For the installation of chargers, the industry "Engineering construction [BS23C]"is used.

For the manufacturing of chargers, the aforementioned multipliers are applied to the charger manufacturing revenues to derive GDP and jobs benefits. Table 4, below, summarizes.

Table 4. Economic and jobs benefits of ESB charger manufacturing (2022-2030)

Benefit	Revenues (2022-2030)	Multiplier	Benefit (2022-2030)
Jobs	$259 million	4.7 jobs per $1 million output	1,230 jobs
Gross domestic product		$0.6 GDP per $1 output	$147 million GDP

For the installation of chargers, the aforementioned multipliers are applied to the charger installation revenues to derive GDP and jobs benefits. Table 5, below, summarizes:

Table 5. Economic and jobs benefits of ESB charger installation (2022-2030)

Benefit	Revenues (2022-2030)	Multiplier	Benefit (2022-2030)
Jobs	$155 million	7.55 jobs per $1 million output	$1,170 jobs
Gross domestic product		$0.9 GDP per $1 output	$140 million GDP

A.4 Determining policy cost estimates

Although the following policy costs were estimated, we did not explore them further in this work.

[192] Innovation, Science and Economic Development Canada, "Other electrical equipment and component manufacturing – 3359." https://www.ic.gc.ca/app/scr/app/cis/summary-sommaire/3359

A.4.1 Electric school bus subsidy program

To determine the policy cost for the electric school bus subsidy program, we took the difference between the projected cost of an ESB and the projected cost for a diesel bus in 2023 and 2024.

We multiplied this difference (nearly $200,000 for each year) by the number of new electric school buses needed in Ontario in 2023 and 2024 to hit our projected trajectory to a 65% electric school bus fleet as of 2030.

We made the assumption that 100% of the new electric school buses would be subsidized by the Ontario government. In reality, we expect that the Ontario government would not subsidize electric school buses that school boards were already expecting to purchase, thereby overcoming the free-ridership issue mentioned above.[193] Should the Ontario government effectively overcome this free-ridership issue, actual costs will be lower than those estimated here.

We estimate that this subsidy program would cost about **$110 million** over the 2023-24 period.

A.4.2 Electric school bus infrastructure program

To determine the policy cost for the electric school bus infrastructure program, we assumed the Ontario government would subsidize 100% of the cost of new AC and DC ESB chargers (including manufacturing cost and installation cost). We also assumed that 100% of these chargers would be subsidized by the Ontario government.

As such, we multiplied the cost of new AC and DC chargers by the number of new chargers needed in 2023 and 2024 to stay on track with our projected trajectory towards 65% of school buses being ESBs as of 2030.

As with the ESB subsidy program, this does not take into account the fact that the Ontario government will seek to limit free ridership. Should the Ontario government effectively limit free ridership, policy costs for this program will be less than those estimated here.

We estimate that the infrastructure program will cost the Ontario government about **$20 million** between 2023 and 2024.

[193] It is expected that at least 200 ESBs will be on Ontario roads in the next two or three years. Electrive, "200 Lion Electric school buses bound for Ontario."

Appendix B. SMEs interviewed

The following members of Ontario's electric school bus and electric MHDV ecosystem, many SMEs in the ESB value chain, were interviewed to provide input into the above policy recommendations. Some are also profiled in textboxes in this paper.

Li-Metal is an Ontario-based manufacturer of lithium anode, a key ingredient used in new generation solid-state lithium batteries. The firm employs about 22 workers in its 14,000-square foot manufacturing facility in Markham (with another pilot and commercialization plant in Rochester, NY). Its key clients include Samsung, Blue Solutions (which in turn is a supplier of batteries to Mercedes Benz), and British Volt. According to the firm's CEO, solid-state batteries are expected to be about 10% of all EV batteries by 2030.[194] The firm, which will start commercial production by 2025, expects to be a key player in the solid-state batteries market, expecting to grow exponentially in this decade, and thereafter.[195]

Tube-Fab is a 50-year-old company based in Mississauga.[196] The company manufactures titanium, aluminum and steel rigid tubes for use in aviation and freight vehicles. Since 2019, Tube-Fab provides high-quality fabrication and assembly services to a leading Canadian electric school bus manufacturer, and employs 65 workers in Ontario.

eLeapPower manufactures smart inverters and wireless chargers, a technology that can be used in different categories of electric vehicles (including electric school buses).[197] The company was founded by University of Toronto engineering graduate student in 2016, and is based in the city. The firm employs about 25 workers. ELeapPower's products are at prototyping stage but expect to begin commercial scale production in 2023.[198] The company expects to grow by three to four times if all of Ontario's 18,000 school buses started using smart inverters (as produced by eLeapPower).

[194] Li-Metal, "Videos & Media." https://li-metal.com/news/

[195] Li-Metal, "Presentations & Events." https://li-metal.com/investor/

[196] Tube-Fab, "Home", www.tube-fab.com

[197] eLeapPower, "Home" https://www.eleappower.com

[198] eLeapPower, "Investors." https://www.eleappower.com/company/investors

Stromcore is a Mississauga-based company that assembles lithium batteries for forklifts.[199] This six-year-old start-up has been rated as one of the fastest growing companies by Forbes,[200] growing its revenue by two to three times annually for the last few years. StromVolt, a subsidiary of Stromcore, has partnered with Taiwan-based Delta Electronics to build the first large-scale lithium-ion cell factory in Canada.[201] StromVolt will be the first North American firm to fully own such a facility along with the rights to develop and scale up this critical technology.[202] The company expects to start production by 2024.

Electrovaya develops and manufactures proprietary lithium-ion batteries, battery systems, and battery-related products for energy storage, clean electric transportation and other specialized applications. The company is headquartered in Mississauga, Ontario, and has about 64 employees.[203] It has two production capacities in Canada, and is further expanding by setting up a plant in New York, where it plans to add 250 jobs by completion of the project.[204]

Southland Transportation operates school, charter, commuter, as well as specialized transportation buses in Alberta, Nova Scotia, Ontario, and Saskatchewan,[205] with about 250 employees.[206] They manage 2200 vehicles.

Toronto Student Transportation Group is a Toronto-based school bus fleet operator.[207] The company is a consortium between the Toronto Catholic District School Board and the Toronto District School Board, and provides transportation services to approximately 50,000 students in more than 800 schools and centres throughout the

[199] Stromcore, "Home", https://www.stromcore.com

[200] Stromcore, "Jonathon Dos Santos Inducted Into Forbes 30 Under 30," media release, December 1, 2020. https://www.stromcore.com/post/jonathon-dos-santos-inducted-into-forbes-30-under-30

[201] Financial Post, "Canada could see its first lithium-ion battery cell factory open soon."

[202] StromVolt, "StromVolt to build Canada's first lithium-ion cell factory with cutting-edge technology from delta," media release, October 5, 2021 https://www.stromvolt.com/post/stromvolt-to-build-canads-first-lithium-ion-cell-factory

[203] Zoom Info, "Electrovaya." https://www.zoominfo.com/c/electrovaya/39932216

[204] Buffalo News, "Electrovaya plans $75 million lithium-ion battery plant in Chautauqua County."

[205] Southland Transportation, "About us." https://www.southland.ca/about-us/

[206] Zoominfo, "Southland Transportation." https://www.zoominfo.com/c/southland-transportation-ltd/109429185

[207] Toronto Student Transportation Group, "Home", https://www.torontoschoolbus.org/bus/school-bus-policies/policy-faq/

City of Toronto. The organization has a staff of about 30 individuals responsible for the operation, planning, technology, and safety of transported students.[208]

Highland Fleets is a U.S.-based SME with about 50 employees headquartered in Massachusetts.[209] The firm is a key player in vehicle electrification-as-a-service, focusing on school, municipal and other government agency fleets.[210] The company is in the process of signing agreements to provide services to school boards in Ontario and Alberta.

SWTCH is an EV network operator that provides end-to-end EV charging and energy management solutions.[211] The firm employs less than 25 workers.[212] This Ontario based firm had already installed more than 300 chargers across the country, with more than 60 in Ontario.[213] With more than $1 million in investor funding, the company hopes to expand rapidly, with plans to install 1,200 chargers in the next 18-24 months.[214]

Electric Autonomy Canada is an independent news platform reporting on Canada's transition to electric vehicles, autonomous transportation and new mobility services.[215] The organization is based in Toronto and employs about 11 staff.[216]

School Bus Ontario is a non-profit association providing advocacy, education and legislative consultation services to the owners of school bus fleets, school boards/transportation consortia and supplier/manufacturer/distributor companies across Ontario for over 60 years.[217] Its members include bus operators and suppliers (e.g., Girandin Blue Bird, Cummins Canada).

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[208] Toronto Student Transportation Group, *Annual Report 2018-2019* (2019). https://tcdsbpublishing.escribemeetings.com/filestream.ashx?DocumentId=20670

[209] Signal Hire, "Highland Electric Fleets Overview." https://www.signalhire.com/companies/highland-electric-transportation-inc

[210] Highland Fleets, "About us." https://highlandfleets.com/about

[211] SWTCH, "About SWTCH." https://swtchenergy.com/about-us

[212] Zoom Info, "Switch Energy." https://www.zoominfo.com/c/switch-energy/449529949

[213] Maryam Farag, "Switch Energy to install EV chargers in Ontario and Quebec," *MRO*, April 19, 2021. https://www.mromagazine.com/2021/04/19/switch-energy-to-install-ev-chargers-in-ontario-and-quebec/

[214] Luke Sarabia, "Canadian EV charging networks post double-digit growth since start of pandemic," *Electric Autonomy,* February 4, 2021. https://electricautonomy.ca/2021/02/04/canadas-ev-charging-networks-2021/

[215] Electric Autonomy, "About." https://electricautonomy.ca/about/

[216] Electric Autonomy, "Team." https://electricautonomy.ca/team/

[217] School Bus Ontario, "Home." https://schoolbusontario.ca

Appendix C. Summary of recommendations

Recommendation	Description	ESB barrier addressed	Estimated cost (2023-2025)
Recommendation #1: Build operator awareness about electric school buses	Ontario should support/ fund projects that help school bus drivers, operators and managers to learn about the benefits (e.g., lower total cost of ownership, business case) of electric buses.	Addresses *informational barriers:* lack of knowledge about ESBs among fleet operators	NA
Recommendation #2: Help Ontario schools save on electric school bus purchases	Ontario should offer targeted, carefully designed grants to school districts for purchase of 500 ESBs by 2025, rising to 5000 ESBs by 2030.	Addresses *financial barriers:* the high upfront costs of ESBs	$25 million (2023) $40 million (2024) $50 million (2025) $1 billion cumulative (2026-2030)
Recommendation #3: Ensure Ontario's infrastructure is ready for electric school buses	Ontario should quadruple its recently made commitment of $91 million spending on chargers, to include at least five fast charging stations (>100 kW) in each of the 72 school districts by 2030	Addresses *network and infrastructure barriers:* the lack of charging infrastructure for ESBs	$5 million (2023) $10 million (2024) $15 million (2025) $320 million cumulative (2026-2030)
Recommendation #4: Help train Ontarians for ESB manufacturing, operation and maintenance	Ontario should continue to expand the monetary allocation of the skills training programs already in operation in the province.	Address *talent barriers:* the skills gap in Ontario workforce for ESB manufacturing	$10 million by 2025