canadian partnership for children's health & environment
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Driving Change...

The Electric School Bus

Green Teacher
Non-profit magazine, books and webinars

Instructional Materials for Secondary School

This lesson, for secondary school students in grades 8–12, aims to help learners make observations about and comparisons between fossil fuel-powered and electric school buses, with a focus on implications for human health and well-being as well as environmental sustainability. Students will gather facts and dispel misconceptions about diesel and electric school buses as well as the transition to electric vehicle transportation more generally. **They will also assess local/regional decision-making and investment in transportation and identify opportunities to encourage changes that will contribute to a healthier environment**. In response to their learning, students will have the option to design community engagement plans to educate the school and the broader community about the electrification of school bus transportation.

Overarching Inquiry Question:

What is the importance of clean air and what kinds of transportation emit little to no air pollution?

Educators can use and adapt the following framework to guide student discovery and learning:

THINK: Students will access prior knowledge and experiences as well as facts and myths about school buses and our transportation network through discussion and a 4-corners style game (see 4-corners activity description below).

LEARN: Students will examine and compare the social, health, environmental, and economic data that compares electric and diesel school buses before completing an overall impact analysis comparison that examines facts and data about diesel and electric school buses.

APPLY: With the knowledge acquired, students will investigate and compare the local provincial policies and directions regarding electrification. They can then choose to apply their learning about electric school buses and their distribution across Canada by engaging in an action connected to their learning.

Target Age Group: Grades 8–12

Curricular Competencies:

- Assess prior knowledge of different public transportation options by exploring the facts and myths associated with switching to electric vehicles.
- Perform an overall impact analysis that compares diesel and electric school buses in terms of the economic, public health, environmental, and social benefits and risks.
- Compare current implementation actions being undertaken in different provinces and territories to build electric school bus fleets.
- Educate members of the school and broader community about the overall impacts of electric and diesel school buses to enhance collective literacy about them.

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Key Vocabulary

Electric Vehicle(s) (EV): Vehicles that get their energy from the electrical grid, use an electric motor to move and store energy in a battery for use. They have zero tailpipe emissions. (Energy Education, University of Calgary)

Electric School Bus (ESB): School buses that, like EVs, use an electric motor and charge their batteries using the electric power grid.

Diesel: A hydrocarbon product that is similar to gasoline but is thicker and has a greater density. Diesel has a higher thermal efficiency than gasoline by about 20%, which means that it is also 20% more efficient than gasoline and can thus go further using a similar quantity of fuel.

Electricity grid decarbonizing: Electrical grid decarbonizing is the attempt to switch energy sources from a fossil fuel to a renewable energy source to reduce carbon emissions. (Pembina Institute, 2022)

Environmental Justice: A social movement that attempts to reduce or eliminate the impacts and causes of environmental racism (Urban Ecology, 2020)

Environmental racism: Refers to racial discrimination in the disproportionate location and increased exposure of Indigenous, Black, and other racialized communities to contamination and pollution from industry and other environmentally hazardous activities; the lack of political power these communities have to fight back against these industries in their communities; the implementation of policies that allow these harmful projects to be placed in these communities; the slow rates of cleanup of contaminants and pollutants in these communities; and the lack of representation of Black, Indigenous, and other racialized communities in mainstream environmental groups and on decision-making boards, commissions, and regulatory bodies. (The ENRICH Project, 2023)

Net-Zero emissions: Net zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance. (UN Climate Action)

Opening: Electric Vehicle Brainstormer — Fact or Opinion?

1. Give each student the handout "Statements and Questions about Electric Vehicles" **(**see Appendix A). Each student is to write 2–5 statements that explain what they know about electric or conventional (diesel or gas) vehicles and then put these statements in the statement column. You may wish to give students some of the following words as prompts for comparison: emissions, diesel, gasoline vs electric, climate change, pollution, environmental costs, health impacts, etc.

Statement	Fact (F), Myth (M), or Opinion (O)	Questions I have

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2. After a few minutes, have students share their statements with a neighbour and then the pair can attempt to determine if they think their statement is a fact, opinion, or myth.

3. Next, on a board or using the handout provided projected on a screen, collect some of the statements from the students. As a class, decide if each is a fact, opinion, or myth. Allow for questions and discussion as each statement is made, and then add in any factual information you can provide that is relevant to the discussion. *(Note: Prior to beginning this activity, we recommend you review the fact sheets and the Statements and Questions about Electric Vehicles handout (Appendix A)*

4. Afterwards, have students star a few of the statements that they are curious about and write a few follow-up questions that they hope to explore about electric or diesel vehicles in the third ("Questions I have") column. Explain that the focus of the lesson will be on school buses but that some of their questions about other vehicle types may be answered as well.

Activities:

1. Think: Four Corners Fact vs Myth About Electric Buses

Suggested Materials:

- Appendix B: Four Corners Fact Cards about Electric and Diesel School Buses
- 4 pieces of paper (marked A, B, C, D) & tape

Instructions

a. On four pieces of paper, label each corner of the classroom either A, B, C, or D and create pathways so that students can move relatively freely between corners.

b. Explain that students will listen to a question and then move to the corner that corresponds to what they think the correct answer is. *(Note: If possible, put the questions on a screen one at a time so that students can read them as well).*

c. Read the first question card and the four options a couple of times and then allow students to move to the corner that they think is correct.

d. Reveal the correct answer and some of the information about why it is correct and/or why other answers are incorrect or not as correct. Allow time for any questions or debate to occur after each question.

e. Begin the next question and repeat steps a–d for as many questions as you see fit. *(Estimated time: 10 minutes)*

Note: The goal of this activity is to build on students' previous knowledge, specifically by getting them to think about and reveal facts, myths, or incorrect information that they might already have about electric vehicles versus other types of transportation. Take time with each question, particularly if it prompts other questions or discussion.

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2. Learn: What are the impacts of electric buses and vehicles compared to diesel?

Suggested Materials:

- Appendix C: Materials for Impacts Analysis of Diesel and Electric Buses
- Appendix D: About Electric and Diesel School Buses

Note: Lithium is discussed in the lesson factsheets. The batteries used in electric vehicles, including electric school buses, require lithium, which is a non-renewable resource like fossil fuels. It is important, then, for the lithium in batteries to be reused or repurposed as part of a circular economy.

Instructions

a. Hand out the diesel fact sheets and have students read them. Use the Electric vs Diesel Comparison Worksheet to compare and contrast diesel vs electric buses in terms of their impacts using the information on the fact sheet.

b. Once this is complete, come together as a class to discuss the impacts of conventional school buses (mostly diesel) versus electric school buses. *(**Note: Based on scientific analysis, there is overwhelming evidence that electric school buses have lower environmental impact and that their adoption to replace diesel-powered buses will benefit human health. They are more economical over the long term as well). See the report by Pollution Probe, The Delphi Group, and CPCHE for details**).* **This will likely be reflected on their chart by how full the Pros / benefits category will be for electric buses and how full the Cons / cost category will be for diesel buses.**

c. Together, draw some general conclusions about the benefits and risks. Have students write in their own words their own conclusions based on their findings.

3. Act: What actions is my region taking towards implementation of electric buses and what needs to be done next?

Materials

- Appendix E: Materials for Action: What actions is my region taking toward the implementation of electric buses?
- Appendix F: Electric School Buses Across Canada
- Optional: Visit CPCHE's Healthy Environment For Learning Day Website to access inspirational stories about electric school bus adoption in Canada.
- Optional Video: The Story of Change

a. Students will each be given a factsheet that examines the degree of uptake of electric school buses compared to conventional buses in each province or territory as well as current information on the policies and goals of each region (See Appendix F).

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b. After looking at the factsheet, students are to respond to the questions on the worksheet Provincial and Territorial Factsheet Comparison Questions (see Appendix E).

c. Put students into groups of ~4 to discuss what they have written on their worksheet for these questions. After they have each shared what they have written, have them brainstorm answers and transportation-related actions that the class could take that would be healthier for humans and/or the environment.

d. As a whole class, write up and share some of the thoughts and solutions that each group has developed. Show the optional Video The Story of Change, which explores the MOST impactful ways to inspire and encourage positive change.

e. What do the students feel would be the best action that they can take to support a cleaner transportation network? Can the class decide on one big idea that they want to help their region work toward?

f. Decide on an action to take either as a class or in small groups. Is there one big idea that the class is keen to work on together? A bunch of smaller ideas? Let the class and the discussions dictate which actions will take place. Some ideas include the following:

   i) Class debate about long-term transportation options at your school
   ii) Starting a school petition
   iii) An educational campaign
   iv) An art project with a message about the change needed
   v) A letter in support of changes being undertaken by your region

Closing:

After you have completed your comparison and action activities, allow time for students to reflect. Reflection helps students further process the information, make additional linkages with their experiences, and possibly formulate new, innovative ideas as next steps. This may be done through a reflection journal or a class circle. Here are some questions that you might consider using:

- What surprised you the most about what you learned about electric and diesel school buses?
- How do you feel about the action you took as a class, group, or individual?
- Is there anything you would do differently when considering the actions that you took?
- What do you still wonder about?
- Are there some next steps (as a class, individual, or region) that should be taken? If so, what are they?

Extension:

- This could lead into a possible inquiry into environmental health. What does this term mean? What can we do about it and how do electric school buses fit into its realization?

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APPENDIX A: Statements and Questions about Electric Vehicles

Statement	Fact (F), Myth (M), or Opinion (O)	Questions I have

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APPENDIX B: Four Corners Fact Cards about Electric and Diesel School Buses

How much money in operating costs will an electric school bus save or cost each year in comparison to a conventional diesel bus? A) $10,000 more/year B) $2,000 more/year C) -$4000 less/year D) -$17000 less/year	**Answer: D**. It is estimated that diesel buses cost ~$23,000 for maintenance and fuel per year. Electric buses cost on average $6,000. (Pembina Institute, 2022)
What is the largest barrier that prevents school districts from buying electric school buses? A) Lack of charging stations B) Purchase cost C) Concerns about pollution (e.g., Lithium batteries) D) Training staff to drive & maintain them	**Answer: B:** In British Columbia, purchase cost after subsidies for electric school buses is $93,000 for Type C buses and $133,000 for Type D buses (Pembina Institute, 2022). Without subsidies, the average price is around $345,000. Charging station installation also costs thousands and for each district and would be part of the cost.
Which one of the following is a benefit of electric school buses? A) Cleaner air B) Reduced noise pollution C) Reduction of greenhouse gas (GHG) emissions D) Savings in health costs related to reduced diesel pollution	**Answer: ALL of them! Everyone wins this round.** There are many benefits of electric school buses, and you can find the evidence in White Paper by Pollution Probe, The Delphi Group, & CPCHE and on the Healthy Environments for Learning Day 2023 Campaign Resources website.
In what year does PEI plan to have 100% of its school bus fleet electrified? A. 2027 B. 2031 C. 2040 D. 2052	Answer: B. 2031. PEI, as of 2023, already has electrified a good portion of its fleet. The province aims to have a full electric fleet in less than 10 years (2031).

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Is there anywhere that electric buses shouldn't run? A. In the Arctic — too cold! B. In the Tropics — buses overheat C. Everywhere — they aren't safe D. Nowhere — they are better than other buses	Answer: D. While there may be specific reasons in individual locations to not have electric buses (or any buses at all), almost all climates would be fine with them. Batteries lose some of their range capacity in cold weather, but electric buses still produce way fewer emissions in all climates. And yes, electric school buses are safer than diesel!
Which province or territory has the largest percentage of electric school buses in their fleet? A. BC B. Ontario C. Quebec D. PEI	D. PEI has electrified ~25% of their fleet as of 2023 and plans to be completely electric by ~2031.
Which country in the world has the greatest percentage of electric buses (transit, school buses, etc.)? A. The Netherlands B. France C. Israel D. China	Answer: D. China has been an early adopter of electric buses. As of January 2023, 17% of all buses in China are electric. The Netherlands is doing well, with 10% of its fleet electrified. Canada is sitting at ~0.2%.
How long, on average, might it take to recharge an electric bus on a fast charger? A. 1 hr. B. 3 hrs. C. 5 hrs. D. 7 hrs.	Answer: B. Fast chargers take around 3 hrs. to charge the average electric bus. Slower chargers can take 5–8 hrs (Pembina Factsheet).

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APPENDIX C: Materials for Impacts Analysis of Diesel and Electric Buses

Using the factsheets provided, summarize your findings about electric versus diesel buses using the following categories.

	Diesel Buses	Electric Buses
Pros		
Cons		
Overall Conclusion		

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APPENDIX E: Materials for Action: What actions is my region taking toward the implementation of electric buses?

Provincial and Territorial Factsheet Comparison Questions

1. Which regions have the greatest percentage of electric school buses? What factors do you think have led to the transition of their bus fleets?

2. Looking at the factsheet, which provinces/territories have policies and actions that suggest that they may have a fully electrified fleet by 2040?

3. How does your province or territory compare to the other regions?

4. How do you feel about how your region is doing? When examining the data on school buses, do you think there are enough policies and actions toward reducing carbon emissions and improving the health of people and the environment?

5. What do you think your region and school district should do next?

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About Electric School Buses

Economics

- Electric school buses cost more than diesel to buy. ~$220 000 more than diesel without subsidies, add $15 000 for a charging station.
- In BC, the Pembina Institute estimates that a school district will save $17 000 per bus annually compared to a diesel bus due to lower fuel cost (electricity) and lower maintenance costs. After 4-5 years, when some subsidies are included, the electric bus outperforms the diesel bus. Over 12 years that is ~$165 000 in savings!

Environmental Impacts

- Lithium-ion batteries need to be replaced every 8-15 years. Lithium is mined and there is an environmental impact to mining (see example of impacts from the Thacker Pass Lithium Mine Project in Nevada).
- It is a 'critical mineral' (essential to our technological world yet may be in short supply). There is a lot of research in Canada and in the world going into finding solutions for recycling lithium from batteries.

Safety & Performance

- There is evidence that because electric school buses do not have a heavy engine on board, they have a more equal distribution of weight. This allows for better performance on icy and snowy conditions.
- Batteries operate at lower range when temperatures are below zero (~55-58% of normal). Also, battery & bus technology geared for colder conditions is improving.
- Fueling time can take 3hrs (fast charge) or between 5-8hrs (slow charge).

Greenhouse Gas (GHG) Emissions and Climate Change

- Electric buses, sourced by a clean energy grid, reduce operational GHG emissions, over an average bus lifetime of 12 years, by 92% compared to diesel school buses.
- Overall GHG emissions depends on the manufacturing process of electric school buses and the electrical grid (i.e. coal powered vs hydroelectric powered).

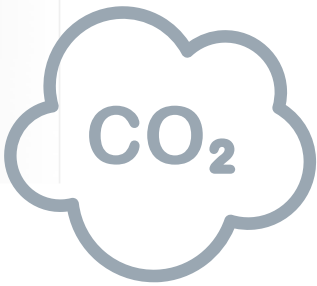
Health Benefits

- Switching to electric school buses improves local air quality and related health outcomes.
- There are multiple physical and mental health benefits from improved air quality in the short term, and the reduction in GHG emissions will help reduce the health impacts of climate change for children today and future generations.

Social Impacts

Electric school buses allow, if implemented well, opportunities to provide environmental justice to communities suffering from the effects of diesel emissions. Reports from both The World Resources Institute & CleanTechnica suggest embedding equity into the rollout of electric school buses programs. One example would be to make sure that lower income neighbourhoods receive electric bus service first.

About Diesel School Buses



Economics

- Diesel buses cost $125 000 for a new vehicle.
- Maintenance and fuel costs are high-- around $23 000 per bus per year. (Pembina Institute)

Greenhouse Gas Emissions:

- A diesel school bus creates around 82 tonnes of CO2 over 12 years. Gasoline buses have even higher emissions.

Environmental Impacts

- Diesel exhaust is a key human-made source of outdoor air pollution.
- Smog is a mixture of air pollutants (ground-level ozone and particulate matter) which is linked to many harmful effects on health and the environment.
- Smog can block out sunlight which affects plant growth and ground level ozone can damage plant cell membranes.

Health Impacts

There are numerous health impacts from diesel exhaust. These include:

- Increased risk of asthma development in children
- Contributes to asthma suffering (estimated 170,000 asthma symptom days each year in Canada)
- Diesel exhaust is a known carcinogen that is linked to causing lung cancer.
- Traffic-related air pollution, which includes diesel, is linked to adverse effects on brain development including deficits in memory and attention.
- One study demonstrated that students exposed to higher levels of traffic pollution had lower attention processes.

Safety & Performance

- Like all school buses, they are generally 72 times safer than traveling by car to school.
- In intense cold, 25-30% of a diesel bus fleet may not work..
- Quick refueling (~7 minutes) as infrastructure and transportation networks for diesel already exist.

Social Impacts

- Air pollution is an environmental justice issue. This means that low-income and marginalized people suffer the greater health and environmental burden. Racialized peoples and those affected by poverty often bear the burden of disproportionately high levels of TRAP and associated health outcomes.

Electric School Buses Across Canada

*ESB = Electric School Bus

Overall

As of 2022, Canada has electrified only 0.2% of its school bus fleet. Many more have been ordered and almost every province is either piloting or considering purchasing some. Some provinces, like BC & PEI, are early adopters. The territories are regions which are more challenging for electrification in general. There is mounting evidence that even in regions with fossil fuel energy grids, electric buses still provide large benefits to both the climate and our own health. And yes, ESB buses still work well in cold climates! Find below how each region compares on their adoption of ESBs and the policies and plans each has in place so far.

Alberta <1% ESB

There are electric school buses running in Alberta. St. Albert has a half dozen or so and there are other regions with a few.

Alberta is focusing on transitioning the electrical grid to 30% renewable energy by 2030 and as of 2023 has shifted from 10% in 2017 to 18%.

BC 4% ESB

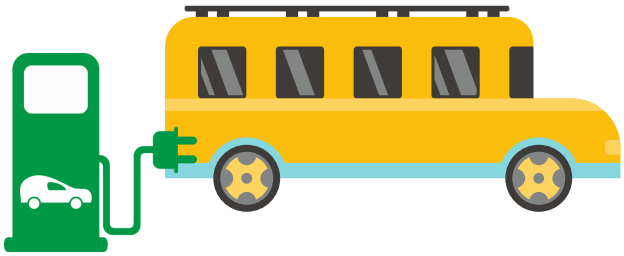
BC's CleanBC Roadmap to 2030 encourages electric school bus adoption and provides provincial funding. With the Federal Zero Emission Transit Fund ~100% of the electric bus purchasing costs are now covered. The Pembina institute recommends BC sets a specific ESB target for 100% of its new purchases of public sector school buses to be electric by 2030 (currently BC only has overall emissions target that are not specific to ESBs).

Saskatchewan 1 ESB

The first ESB in Saskatchewan hit the road in March 2023 in the Rivers School Division.

Manitoba 0 ESB

As of March 2023, there were no electric school buses running in Manitoba. Seine River District had applied for funding for one but discovered later that they must first encourage the province to hire an expert to research the costs/benefits and safety standards before proceeding.



New Brunswick 2 ESB

In 2017 New Brunswick (NB) purchased two ESBs to do a pilot study. Currently, NB is considering electrifying their school bus fleets and is conducting feasibility studies.

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PEI 25% electric

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The Provincial Government put in place a policy in 2021 that all future school bus purchases would be electric.

As of January 2023, 25% of the bus fleet was electric, which totals 82 buses. It is likely that 100% of the school bus fleet will be electric by around 2031.

Newfoundland 0 ESB

Newfoundland and Labrador do not have any electric school buses but are currently considering them.

Yukon 0 ESB

The Yukon is working on a plan to build and support electric vehicle infrastructure in the territory. The Our Clean Future Plan has targets for electric vehicle (EV) adoption.

There are no specific targets for adoption of electric school buses.

Nova Scotia 0 ESB

Like NB & Newfoundland, Nova Scotia is currently in the piloting and studying phase and does not have any ESBs on the road yet.

Quebec 1% ESB*

* This data is from 2022 and with the rapid purchase of new buses may be out of date.

Quebec is electrifying its ESB fleet though most of the buses are ordered but not yet running. Currently there are around 130 ESB running in the province out of ~10 000. The Provincial Government's 2030 Plan for a Green Economy is the legislation driving this initiative.

The Provincial Government has committed to electrifying 65% of school buses by 2030. Some Quebec school bus companies such as Transdev have a goal of 100% electrification by 2025. Quebec's Lion Electric is a company that is making and selling ESBs all over the world.

Ontario 0.1% ESB

Ontario has around 20 000 buses. 93% of them are diesel, 5% run on gasoline and 2% other sources. As of February 2023, there are currently 20 ESB or 0.1% of the fleet.

Ontario has on order more than 200 ESB that are set to be delivered between 2022-2026. Once the order has been filled, this will then represent ~1% of the fleet.

NWT 0 ESB

Both the NWT and Nunavut face a larger number of barriers to the adoption of electric vehicles. Remote, northerly locations and small communities means the import and purchase of the vehicles is more costly. Some communities do not have a reliable energy grid (many remote communities still run off of diesel generators). Building charging stations is equally challenging.

Feasibility studies for electric vehicles for both territories are being undertaken. The current focus is overcoming the funding barriers. In the NWT, there is currently a funding program to install some public charging stations.

According to PlugShare, only 5 charging stations exist in the NWT, with a couple more planned.

Nunavut 0 ESB

Similar to the NWT, Nunavut faces a number of challenges.
Feasibility studies for electric vehicles are being undertaken.

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According to Plugshare, there are currently no charging stations in Nunavut or data on the number of electric vehicles.