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How to Lighten the Climate Load

Technology and policy options to decarbonize B.C.'s heaviest trucks

Colton Kasteel and Maddy Ewing

November 2021

photo: Roberta Franchuk, Pembina Institute

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How to Lighten the Climate Load

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Executive summary

Heavy-duty vehicles (HDVs) are one of British Columbia's most challenging sectors to decarbonize. Class 8 HDVs encompass a wide range of vehicle types, with gross vehicle weight ratings (GVWR) between 14,968 and 63,500 kilograms. A unique and critical segment within the class 8 category are heavy-haul trucks weighing between 53,000 to 63,500 kg, which includes standard tractor-trailers and long combination vehicles. Vehicles in this segment are some of the most energy demanding of all on-road vehicles, travelling the farthest distances and consuming the most diesel fuel. In 2019, transportation contributed to 39% of B.C.'s total GHG emissions, with HDVs standing out in the emissions profile. Despite only making up 5% of the province's vehicle registrations, medium- and heavy-duty vehicles (MHDVs) are responsible for 35% of all transportation emissions. Heavy-haul tractor-trailers face some of the greatest challenges to decarbonization for several reasons including high energy demands, the prevalence of small businesses, and typically small profit margins. In this report, we assess the viability of emerging technology and fuel options as well as the provincial programs and regulations that currently support the decarbonization of B.C.'s heaviest trucks and the transportation sector more broadly.

Technologies

A range of technologies and practices, rather than any single one, are expected to contribute to the decarbonization of B.C.'s heavy-haul sector. This includes battery electric trucks, hydrogen fuel cell electric trucks, biofuels (biodiesel and renewable diesel), natural gas (including renewable natural gas), and high efficiency diesel engines. Table ES1 below presents an overview of each alternative technology's performance relative to a diesel baseline in the present timeframe. Each of these options does not currently meet all the needs of B.C.'s heavy-haul sector — each presents trade-offs in terms of life cycle GHG emissions, air pollutant emissions, cost, technological maturity, charging/fuelling infrastructure availability, and more. What remains to be determined is what the market share of each will be, and how government policy in B.C. will influence the growth, development, and adoption of these technologies in the long-term future, and the impact it will have in lightening the sector's climate load.

Table ES1. Comparison of alternative technologies for HDVs (including heavy-haul trucks) relative to a diesel baseline

	BEV	Hydrogen FCEV	CNG/LNG/ RNG	Biofuels
GHG emissions	●	●	●	●
Criteria air pollutant emissions	●	●	↔	↔
Total cost of ownership	↔	●	↔	●
Technology readiness	●	●	●	●
HDV infrastructure availability	●	●	●	●

Legend

●	Worse than diesel	●	Roughly equal to diesel
●	Better than diesel	↔	Range of results from worse to better

Policies

While B.C. has taken several steps to decarbonize HDVs and accelerate clean transportation, more needs to be done to accelerate the availability of viable, affordable near-zero and zero-emission technologies that can meet the needs of heavy-haul trucks in the weight range of 53,000 kg to 63,500 kg. We identify 16 policy actions, in five categories, that could be taken by B.C. to support this goal (Table ES2). B.C. needs to bolster its long-term strategic planning and policy framework; invest in research and development, demonstration pilots, and independent testing; invest in charging and refuelling infrastructure; enhance and create new incentives to encourage adoption; and build capacity for fleet operators with the necessary skills and know-how to make the switch.

Table ES2. Policy options to support and accelerate the deployment of near-zero and zero-emission technologies for heavy-haul trucks in B.C.

Category	Policy options
Strategic planning and regulations 	• Develop a low-carbon freight and goods-movement strategy that outlines a roadmap to 2050. • Develop of a ZEV standard for MHDVs. • Work with the Task Force on Vehicle Weights and Dimensions Policy to develop an updated Memorandum of Understanding on Heavy Truck Weight and Dimension Limits for Interprovincial Operations in Canada that includes special weight allowances for near-zero and zero-emission technologies.
Research, development and demonstration 	• Accelerate collaborative research and development into near-zero and zero-emission heavy-haul trucks by working with cross-jurisdictional partners. • Work with corporate partners that will use funding through the Go Electric Commercial Vehicle Pilots (CVP) to accelerate a stream of commercialization pilots and in-fleet demonstrations of near-zero and zero-emission heavy-haul vehicles. • Leverage the new Centre for Innovation and Clean Energy and its public-private-academic partnership structure to advance commercialization of near-zero and zero-emission HDV technology providers. • Explore the development of a new public inventory of clean technology companies contributing to the near-zero and zero-emission vehicle supply chain in the province to foster partnerships and attract global investment.
Incentives for deployment 	• Renew and update the scope of existing point-of-sale purchase incentive programs (e.g., SUVI). • Explore the effectiveness of higher incentives for the heaviest class of vehicles, to promote greater adoption of near-zero and zero-emission vehicles. • Explore waiving PST for the purchase of near-zero and zero-emission class 8 vehicles. Consider targeting this program at SMEs / owner-operators. • Investigate the potential for new, innovative financial mechanisms that can support the deployment of HDVs, such as concessional loans, reserve funds, residual value guarantees, utility bill financing or another form of lending. • Explore the feasibility of offering 'Low-Carbon Fuel Standard (LCFS) loans' as a part of B.C.'s LCFS.
Charging and fuelling infrastructure	• Develop an interprovincial/territorial working group dedicated to co-ordinating the build-out of charging and fuelling infrastructure across popular Canadian freight corridors. • Explore strengthening existing incentive programs, or developing new programs, that can accelerate the build-out of new charging and fuelling infrastructure by the private sector.

	• Explore additional co-ordinated investments with the federal government to improve the availability of charging and fuelling infrastructure that is accessible to a range of fleets.
Fleet capacity 	• Update the CleanBC Job Readiness Plan to ensure there is long-term planning and support for HDV operators to succeed in the low-carbon economy.

1. Introduction

The CleanBC plan outlines the Government of British Columbia's strategy to reduce greenhouse gas (GHG) emissions through 2050. In the two most recent CleanBC Climate Change Accountability Reports (2020 and 2021), the government recognized the critical role of transportation emissions in its provincial decarbonization pathway, with specificity on heavy-duty vehicles (HDVs).[1,2] One of the most challenging aspects of transportation decarbonization in B.C., as well as across Canada, will be addressing emissions from the most energy-demanding on-road HDVs, including heavy-duty tractor-trailers weighing up to 63,500 kg, that travel the farthest distances and consume the most diesel fuel. The CleanBC Roadmap to 2030, released October 2021, identifies actions to close the gap on B.C.'s legislated 2030 target of 40% below 2007 levels and sectoral transportation target of 27% to 32%.[3,4] The pathway beyond 2030 to meet B.C.'s 2040 (-60%) and 2050 (-80% and net-zero) targets, however, has yet to be mapped. Supporting emissions reductions among heavy-duty on-road vehicles can play a vital role in closing these gaps.

To meet this challenge, the government will need to strengthen existing transportation policies, act on a broad range of policy options in the short term, and map out strategies that consider the long-term technological transitions that will take place over the next 30 years. This report provides an overview of the current near-zero and zero-emission technologies that can contribute to decarbonizing the heaviest HDVs in B.C., and an overview of the policies and investments that currently exist to promote their adoption. It also identifies a range of policy options that can help B.C. accelerate this transition.

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[1] Government of British Columbia, *CleanBC 2020 Climate Change Accountability Report* (2020), 17. https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/2020_climate_change_accountability_report.pdf

[2] Government of British Columbia, *CleanBC 2021 Climate Change Accountability Report* (2021), 8. https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/2021_climate_change_accountability_report.pdf

[3] *CleanBC 2021 Climate Change Accountability Report,* 6, 8.

[4] Government of British Columbia, *CleanBC Roadmap to 2030* (2021). https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_to_2030.pdf

1.1 Heavy-duty vehicles in B.C.

Though definitions differ somewhat from one jurisdiction to another, HDVs are typically classified as class 7 or 8 vehicles. Typically, class 7 vehicles weigh between 11,790 kg and 14,968 kg, while class 8 represents all vehicles with a Gross Vehicle Weight Rating (GVWR) greater than 14,968 kg.[5] The maximum GVWR in B.C. is 63,500 kg. A wide range of vehicles fall under class 8, including straight trucks, tractor-trailers, buses, cement trucks, garbage trucks, and fire trucks.

Class 8 tractor-trailers and various combinations thereof are some of the heaviest trucks found on B.C.'s roads. Standard tractor-trailers — tractors that pull a single semitrailer — are commonly used in freight transport and have a maximum GVWR of 57,100 kg in B.C.[6] Long combination vehicles (LCVs), which are tractors that pull multiple trailers, are even heavier. A-trains, B-trains, and C-trains — different configurations of two trailers pulled by a single tractor — have maximum GVWRs of 53,500 kg, 63,500 kg and 60,500 kg in B.C., respectively.[7] Tractor-trailers and LCVs are sometimes referred to as heavy line haul or heavy-haul (63,500 kg +) vehicles; we will refer to these collectively as heavy-haul trucks throughout this piece.[8] On top of pulling exceptionally heavy loads, many of these heavy-haul trucks will travel hundreds of kilometres per day.

Figure 1. An example of a long combination vehicle

Heavy-haul trucks face some of the greatest challenges to decarbonization for several reasons:

[5] CALSTART, *How Zero-Emission Heavy-Duty Trucks Can Be Part of the Climate Solution* (2021) https://globaldrivetozero.org/site/wp-content/uploads/2021/05/How-Zero-Emission-Heavy-Duty-Trucks-Can-Be-Part-of-the-Climate-Solution.pdf

[6] Government of British Columbia, *Commercial Transport Regulations*, Reg. 30/1978 O.C. 27/1978. https://www.bclaws.gov.bc.ca/civix/document/id/crbc/crbc/30_78

[7] *Commercial Transport Regulations*.

[8] Transport Policy.net, "Canada: Heavy-Duty: GHG." https://www.transportpolicy.net/standard/canada-heavy-duty-ghg/

- Heavy payloads and/or long distances travelled result in high energy demands.
- The sector is dominated by small businesses with limited capital to invest in new vehicle technologies.
- Businesses typically see small profit margins (less than 5%).
- Routes can be unpredictable, and operators rely on public fuelling or charging infrastructure.
- The diversity of the sector means what works for one company may not work for another.

Given the diversity of B.C.'s on-road freight sector, it's expected that a range of technologies, rather than any single technology (e.g., battery-electric for LDVs), will be required to decarbonize HDVs in a net-zero by 2050 scenario. Known technologies include battery electric trucks, hydrogen fuel cell electric trucks, biodiesel, natural gas (including renewable natural gas), and high efficiency diesel engines. To accelerate the adoption of these technologies as part of the province's roadmap to meeting its 2030 targets,[9] we need a strategy from government with clear timelines and milestones to incent investment and accelerate affordable near-zero and zero-emission technology options for HDVs.

Any successful strategy also needs buy-in from the trucking industry, as the potential overhaul of HDV technologies has significant labour implications. In 2020, there were over 51,000 commercial HDVs licensed in B.C. (GVWR between 14,968 and 63,500)[10] across 16,000 trucking companies.[11] Of these companies, 94% operate 10 or fewer trucks (Figure 2), and only 22 companies have 100 or more employees.[12] This means a vast majority are small businesses and owner-operators who do not have financial bandwidth to explore emerging technologies while they remain in the development phase. Until new technologies and fuel options reach economies of scale and have a network of dedicated fuelling options available to drivers, the transition to near-zero and zero-emission alternatives will be stalled. Furthermore, in the context of the global economic recovery from COVID-19 lockdowns, a key challenge will delay the transition. Supply chain disruption has stalled vehicle manufacturing in an unprecedented manner,

[9] Government of British Columbia, "Transportation in 2030" https://www2.gov.bc.ca/gov/content/environment/climate-change/clean-transportation

[10] Insurance Corporation of British Columbia, "Vehicle Population Data" https://public.tableau.com/app/profile/icbc/viz/VehiclePopulationIntroPage/VehiclePopulationData

[11] Dave Earle, *De-Carbonization in Commercial Transport*, Pembina Institute Pathways for Reducing Heavy Duty Transport Emissions, webinar, June 30, 2021, 9. https://www.pembina.org/event/pathways-reducing-heavy-duty-transport-emissions

[12] *De-Carbonization in Commercial Transport,* 9, 16.

delaying purchases of new HDVs by years. This makes a supportive and informed policy environment ever more critical as the province looks to encourage the early demonstration of near-zero and zero-emission HDVs.

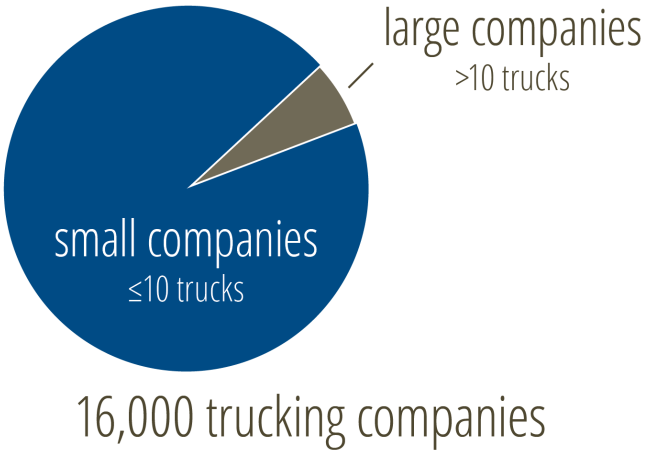

Figure 2. The vast majority of trucking companies in B.C. have 10 or fewer trucks

Data source: British Columbia Trucking Association[13,14]

1.2 Growing GHG emissions from heavy-duty vehicles

Across all of Canada, freight-related transportation emissions have been growing steadily. It is expected that emissions from freight will in fact surpass those of passenger vehicles by as early as 2030.[15] GHG emissions from heavy-duty diesel trucks, in particular, have grown significantly: since 1990, GHG emissions from the sector have risen by 280%.

B.C. is no exception to the national trend. In 2019, transportation contributed to 39% of the province's total GHG emissions,[16] with medium- and heavy-duty vehicles (MHDVs)

[13] Dave Earle, *De-Carbonization in Commercial Transport*, Pembina Institute Pathways for Reducing Heavy Duty Transport Emissions, webinar, June 30, 2021, 9. https://www.pembina.org/event/pathways-reducing-heavy-duty-transport-emissions

[14] British Columbia Trucking Association, *The British Columbia Trucking Industry*, 2. http://www.bctrucking.com/sites/default/files/52713_bcta_brochure_online.pdf

[15] Government of Canada, *Fourth Biennial Report on Climate Change* (2019), 122. https://unfccc.int/sites/default/files/resource/br4_final_en.pdf

[16] Environment and Climate Change Canada, *National Inventory Report 1990-2019: Greenhouse Gas Sources and Sinks in Canada – Part 3* (2021), 53. https://unfccc.int/documents/271493

standing out in the emissions profile. Despite only making up 5% of the province's vehicle registrations,[17] MHDVs are responsible for 35% of all transportation emissions (Figure 3).[18,19] While disaggregated data on the share of GHG emissions associated with each class of vehicle is not publicly available, heavy-haul trucks are expected to represent a disproportionate share of GHG emissions as a result of their high energy demands stemming from heavy loads and long distances travelled. And importantly, freight-related energy needs are not easily substituted, as discussed in the following section.

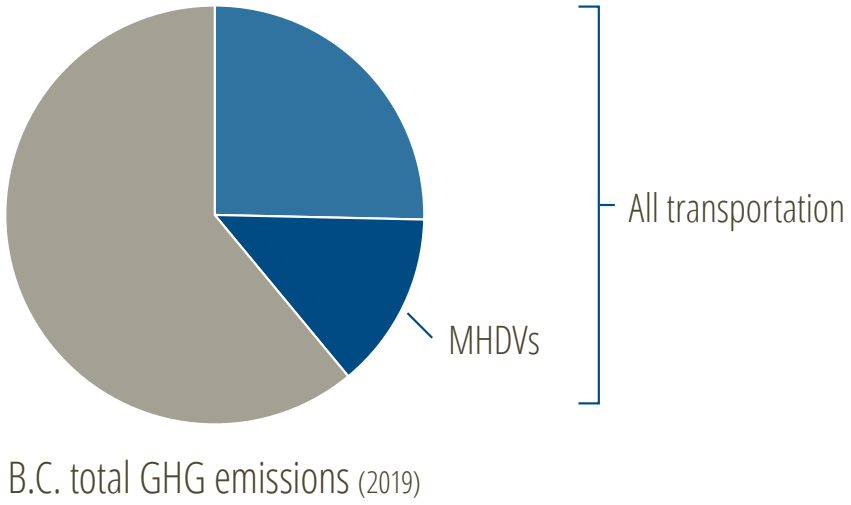

Figure 3. MHDVs are responsible for 35% of all transportation emissions in B.C.

Data source: Government of British Columbia[20]

[17] Includes vehicles weighing over 4,500 kg and buses. Statistics Canada, "Table 23-10-0067-01 Vehicle Registrations, By Type of Vehicle." https://doi.org/10.25318/2310006701-eng

[18] Includes vehicles weighing over 3,900 kg.

[19] *CleanBC 2021 Climate Change Accountability Report*, 8.

[20] *CleanBC 2021 Climate Change Accountability Report*, 8.

2. Alternative technologies for heavy-haul trucks

As a result of the diversity of B.C.'s trucking sector — which has variable needs based on geography, fleet size, payload composition and range, among other factors — it is expected that a mix of technologies will be needed to successfully and efficiently decarbonize heavy-haul trucks. While the combustion of diesel fuel is a significant source of emissions for the province, fuel is also the number one cost for conventional fleets running internal combustion engines — up to 51% of operating costs in some cases.[21] The topography of British Columbia routes, including mountainous terrain, can also lead to higher fuel consumption. For this reason, many fleets have already explored fuel efficiency measures wherever possible. The emissions reduction potential of incremental efficiency improvements, however, tends to be fairly limited,[22] and as such, it's expected that major technology shifts may be required to achieve deep decarbonization.

Battery electric vehicles (BEVs), hydrogen fuel cell electric vehicles (FCEVs), natural gas vehicles using either compressed, liquefied and/or renewable natural gas (CNG/LNG/RNG), biofuels and high efficiency diesel engines may all play a role in helping heavy-haul trucks decarbonize in line with a net-zero future. However, no technology currently meets all the needs of the sector — each presents its respective trade-offs in life cycle GHG emissions, air pollutant emissions, cost, technological maturity, charging/fuelling infrastructure availability, and more.

Table 1 presents an overview of each alternative technology's performance relative to a diesel baseline in the present timeframe. What remains to be determined is what the market share of each will be, and how government policy in B.C. will influence which technologies are successful. Results are also presented graphically in the Executive Summary.

[21] *De-Carbonization in Commercial* Transport, 10.

[22] Maddy Ewing, *Costs, Benefits and Uptake of Trailer Fuel-Saving Devices* (Pembina Institute, 2021), 25. https://www.pembina.org/pub/costs-benefits-and-uptake-trailer-fuel-saving-devices

Table 1. Comparison of future potential technologies for HDVs relative to a diesel baseline

	BEV	Hydrogen FCEV	CNG/LNG/ RNG	Biofuels
GHG emissions	●	●	●	●
Criteria air pollutant emissions	●	●	↔	↔
Total cost of ownership	↔	●	↔	●
Technology readiness	●	●	●	●
HDV infrastructure availability	●	●	●	●

Legend

●	worse than diesel	●	Roughly equal to diesel
●	better than diesel	↔	Range of results from worse to better

Sources: see Appendix A

2.1 Battery electric vehicles

2.1.1 GHG and air pollutant emissions

Battery electric vehicles (BEVs) are considered a zero-emission technology, meaning that they do not produce harmful emissions at the point of use. Because BEVs do not emit any criteria air pollutants, they can have a positive impact on local air quality.

BEVs do, however, produce emissions at other stages in their life cycle, such as during manufacturing, battery production and disposal, as well as production of electricity for charging. Nonetheless, when taking into account the full life cycle of the vehicle, BEVs still tend to offer significant GHG emission benefits over their diesel counterparts. In B.C., a class 8 battery electric truck is expected to have 92% lower life cycle GHG emissions than a conventional diesel-fueled truck.[23] In B.C., BEVs benefit from low-

[23] *GHGenius 5.01b*.

carbon grid electricity that draws from vast hydroelectric resources. However, not all jurisdictions face the same renewable resource realities, and given that 50% of B.C.'s fleets drive interprovincially,[24] they may end up with higher upstream emissions stemming from more carbon-intense electricity grids in other areas.

2.1.2 Cost

Though BEVs are expected to offer notable fuel and maintenance cost savings, their upfront capital costs are much higher than a diesel internal combustion engine (ICE) vehicle. Currently, BEVs are not generally expected to have a competitive total cost of ownership compared to their diesel counterparts.[25,26,27] Moreover, electricity rates in many jurisdictions are not currently designed with high-power fast charging of heavy-duty BEVs in mind. In particular, charging multiple HDVs in parallel over a short period of time can result in high demand charges, which are scaled according to a customer's peak power demands (in kW). To support early fleet electrification efforts, BC Hydro has developed a fleet electrification rate which, over the next six years, will not include a demand charge. BC Hydro also offers a special overnight rate to promote low-cost overnight EV charging.[28]

2.1.3 Operational considerations

Batteries in their current state are unlikely to meet the needs of the heaviest classes of HDVs or those traveling especially long distances. First, batteries are not sufficiently energy dense and therefore present operators with a trade-off between payload capacity and vehicle range. To meet the range requirements of many heavy-haul trucks, a very heavy battery would be required on board.[29] For example, to supply the 800 km range that Tesla is claiming for their Semi, researchers from the University of Waterloo estimate that a battery with 1,000 kWh capacity weighing 5,500 kg would be required

[24] *Pathways for Reducing Heavy Duty Transport Emissions.*

[25] Carlo Cunanan et al., "A Review of Heavy-Duty Vehicle Powertrain Technologies: Diesel Engine Vehicles, Battery Electric Vehicles, and Hydrogen Fuel Cell Electric Vehicles," *Clean Technologies* (2021) 3, 483. https://doi.org/10.3390/cleantechnol3020028

[26] Rick Mihelic, Kevin Otto, Jessie Lund and Mike Roeth, *Viable Class 7/8 Electric, Hybrid and Alternative Fuel Tractors* (North American Council for Freight Efficiency, 2019), 12. https://nacfe.org/emergingtechnology/electric-trucks-2/viable-class-7-8/

[27] *An Examination of Heavy-Duty Trucks Drivetrain Options to Reduce GHG Emissions in British Columbia*, 93.

[28] BC Hydro, "Fleet Electrification Rates," https://app.bchydro.com/accounts-billing/rates-energy-use/electricity-rates/fleet-electrification-rates.html

[29] *Viable Class 7/8 Electric, Hybrid and Alternative Fuel Tractors*, 48.

(15% of the vehicle's GVWR).[30] The weight of this battery, however, would cut into the payload capacity of an HDV, thus limiting the amount of goods a vehicle would be able to transport. If HDV operators are forced to transport smaller loads, this could cut into their profits, extend the payback period of the vehicle and increase the total number of trips needed to complete business-as-usual levels of shipments. To strike the right balance between payload capacity and vehicle range, many of the current or upcoming HD BEV offerings have fairly limited vehicle ranges, such as 400 km for the Freightliner eCascadia, that are well below the range of a comparable diesel engine, which is typically upwards of 2,700 km.[31]

Second, charging times may be prohibitively long. Even with an extremely high-powered direct current fast charger, such as those offering 350 kW of power,[32] it will likely take over an hour to recharge an HDV's battery. Battery technology, however, is advancing at a rapid pace, and so it is possible that future innovations could increase viability in those heavier classes and longer hauls.

Despite these shortcomings, based on horsepower ratings from original equipment manufacturers (OEMs), it is expected that BEVs will be able to provide the torque and power that some of the heaviest HDVs require in B.C. For example, the Freightliner eCascadia, which will have a GVWR of up to 37,190 kg, will supply power from 360 to 525 hp,[33] while the Tesla Semi will provide 1,000 hp.[34] These are within range or exceed current horsepower estimates for comparable semi-truck diesel engines — typically 400 to 600 hp.[35]

2.1.4 Technology readiness

The North American Council for Freight Efficiency (NACFE)'s Run on Less Electric campaign documents key learnings from the early demonstrations of electric trucks

[30] "A Review of Heavy-Duty Vehicle Powertrain Technologies," 479.

[31] *Viable Class 7/8 Electric, Hybrid and Alternative Fuel Tractors*, 111.

[32] Scooter Doll, "Electric Vehicle (EV) Charging Standards and How They Differ," *Electrek*, July 21, 2021. https://electrek.co/2021/07/21/electric-vehicle-ev-charging-standards-and-how-they-differ/

[33] Mark Vaughn, "Electric Big Rigs Are Coming — and We Drive Four of Them," *Autoweek*, May 24, 2021. https://www.autoweek.com/news/green-cars/a36506185/electric-big-rig-semi-trucks/

[34] John O'Dell, "Here's Everything We Know About the Tesla Semi," *Trucks*, September 5, 2019. https://www.trucks.com/2019/09/05/everything-we-know-about-the-tesla-semi-truck/

[35] International Used Truck Centres, "How Much Horsepower Does a Semi-Truck Have?" https://www.internationalusedtrucks.com/driver-tips/semi-truck-horsepower/

across North America, including in Canada and B.C.[36] A class 8 Lion Electric truck, BYD tractor and Freightliner eCascadia are all part of the campaign.[37]

The only BEV compliance option available to North American companies today are the modular Meritor ePowertrains, which can be mounted onto existing trucks.[38] In addition to the trucks being tested by NACFE, prominent manufacturers including Volvo[39] and Tesla Motors[40] are also launching class 8 battery electric trucks, with Volvo's VNR Electric delivering vehicles in 2021 and Tesla's Semi beginning production in 2022.

BEVs: The bottom line

Despite the fact that BEVs can result in significant GHG emission reductions and air quality benefits, it is unlikely that they will be the most suitable near-zero or zero-emission technology for heavy-haul trucks. A few key constraints persist for most of the upcoming BEV product launches: capital costs remain high compared to diesel vehicles; heavy batteries are expected to cut into the payload capacity of the vehicles; charging times may be prohibitively long; and other than the Tesla Semi, most upcoming products have a limited range.

2.2 Hydrogen fuel cell electric vehicles

2.2.1 GHG and air pollutant emissions

Like BEVs, hydrogen FCEVs are also considered a zero-emissions technology. When used in a fuel cell, hydrogen does not emit carbon or criteria air pollutant emissions, producing instead only water vapour and heat. Hence, hydrogen FCEVs can play a role in improving local air quality.

When evaluating the role FCEVs can play in HDV decarbonization, it's important to consider the production pathway of hydrogen and its associated GHG emissions. Life cycle GHG emissions for a class 8 hydrogen FCEV in B.C. are expected to be 296 g CO2e/km when the hydrogen is produced from grid electricity and 812 g CO2e/km when

[36] NACFE, "Run on Less Electric." https://runonless.com/

[37] NACFE, "Run on Less Electric Participant Profiles: Meet the Fleets." https://runonless.com/profiles/

[38] Meritor, "14Xe ePowertrains." https://www.meritor.com/products/ePowertrains/14Xe

[39] Volvo Canada, "VNR Electric", https://www.volvotrucks.ca/en-ca/trucks/vnr-electric/

[40] Tesla Motors, "Semi", https://www.tesla.com/semi

produced from natural gas without carbon capture.[41] This translates to life cycle GHG emission reductions of 81% and 47%, respectively, in comparison to a diesel baseline. In 2018, 99% of hydrogen was produced via conventional natural gas and the gasification of coal.[42] For hydrogen to play a credible role in decarbonizing class 8 HDVs, B.C. would need a substantial increase in the production and procurement of low-carbon hydrogen.

2.2.2 Cost

Hydrogen FCEVs face significant cost barriers. They have a notably higher total cost of ownership than diesel ICE vehicles as a result of high upfront vehicle costs and the high cost of hydrogen fuel. A 2017 study from the International Council on Clean Transportation (ICCT) estimated the 2020 total cost of ownership of hydrogen FCEVs to be 8% to 33% more than diesel ICE HDVs in the United States.[43] Similarly, a 2020 study from the University of California Davis suggests that the total cost of ownership of long-haul hydrogen FCEVs could be anywhere from 24% to 70% more than their diesel counterparts in the United States in the 2020-2040 timeframe, with vehicle costs alone up to 86% higher.[44] The study also notes that for hydrogen FCEVs to be cost competitive, hydrogen prices will need to fall below $5/kg.[45]

2.2.3 Operational considerations

Natural Resources Canada and the Government of B.C., along with notable organizations such as the International Energy Association and BloombergNEF, have identified heavy-duty trucking as a sector that is well suited for hydrogen fuel cell

[41] *GHGenius 5.01b*.

[42] Maddy Ewing, Benjamin Israel, Tahra Jutt, Hoda Talebian and Lucie Stepanik, *Hydrogen on the Path to Net-Zero Emissions* (Pembina Institute, 2020), 3. https://www.pembina.org/reports/hydrogen-climate-primer-2020.pdf

[43] *Transitioning to Zero-Emission Heavy-Duty Freight Vehicles*, 20.

[44] *Technology, Sustainability and Marketing of Battery Electric and Hydrogen Fuel Cell Medium-Duty Trucks and Buses in 2020-2040*, 45-46.

[45] *Technology, Sustainability and Marketing of Battery Electric and Hydrogen Fuel Cell Medium-Duty Trucks and Buses in 2020-2040*, 47.

technology deployment.[46,47,48,49,50] Despite offering a lower engine efficiency than BEVs (i.e., the rate at which the engine converts the fuel or electricity into useful energy), hydrogen offers superior energy density by weight and thus can store more fuel on board with a lower weight penalty.[51] This facilitates longer ranges and heavier payloads. When a network of stations is built out, hydrogen also offers a fast and familiar fuelling process, via pump.[52]

2.2.4 Technology readiness

Despite rising demand, there are no commercial class 8 hydrogen FCEVs on the market today. In 2022, however, a 64-tonne hydrogen FCEV with real-world payloads will be piloted along the corridor between Edmonton and Calgary as a part of the Alberta Zero Emissions Truck Electrification Collaboration (AZETEC) project.[53]

An immediate alternative option for fleets is hydrogen co-combustion technology, which negates the need to purchase a new vehicle altogether. Sometimes referred to as hydrogen co-burn, this uses a mixture of hydrogen and diesel to fuel ICE vehicles. B.C. companies such as Hydra offer conversion kits and long-term fuelling contracts to provide price stability and immediate GHG reductions for drivers.[54] This can be a means

[46] Natural Resources Canada, *Hydrogen Strategy for Canada* (2020), 45. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf

[47] Government of British Columbia, *BC Hydrogen Strategy* (2021). https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/electricity/bc-hydro-review/bc_hydrogen_strategy_final.pdf

[48] Zen Clean Energy Solutions, *British Columbia Hydrogen Study* (2019), 80. https://www2.gov.bc.ca/assets/gov/government/ministries-organizations/zen-bcbn-hydrogen-study-final-v6.pdf

[49] BloombergNEF, *Hydrogen Economy Outlook* (2020), 6. https://data.bloomberglp.com/professional/sites/24/BNEF-Hydrogen-Economy-Outlook-Key-Messages-30-Mar-2020.pdf

[50] International Energy Agency, *The Future of Hydrogen* (2019), 125. https://www.iea.org/reports/the-future-of-hydrogen

[51] Michael Handwerker, Jorg Wellnitz and Hormoz Marzbani, "Comparison of Hydrogen Powertrains with the Battery Powered Electric Vehicle and Investigation of Small-Scale Local Hydrogen Production Using Renewable Energy," *Hydrogen* 2 (2021), 86. https://doi.org/10.3390/Hydrogen2010005

[52] Patrick Molloy, "Run on Less with Hydrogen Fuel Cells," *Rocky Mountain Institute*, October 2, 2019. https://rmi.org/run-on-less-with-hydrogen-fuel-cells/

[53] Kerry Banks, "Groundbreaking Edmonton-Calgary Heavy-Duty Hydrogen Truck Pilot Ready to Roll," *Electric Autonomy Canada*, June 15, 2021. https://electricautonomy.ca/2021/06/15/alberta-hydrogen-truck-pilot/

[54] "Hydra." https://hydraenergy.com/fleets

of building up demand for hydrogen and accelerating the build-out of necessary transmission and distribution networks, as well as refuelling stations. Though hydrogen co-combustion can help reduce diesel fuel use, it does not eliminate emissions at the point of use, and so selective catalytic reduction (SCR) aftertreatment technology tends to be employed to reduce nitrogen oxide (NOx) tailpipe emissions.

FCEVs: The bottom line

For the heaviest segment of class 8 HDVs, hydrogen FCEVs fit many of the needs of operators: long vehicle range, low weight penalty, and relatively short refuelling times. Moreover, hydrogen FCEVs do not produce harmful tailpipe emissions and offer potentially significant GHG emission reductions. As a result, it is likely that this technology will play a role in the decarbonization of some of the heavier and more energy demanding HDVs in B.C., such as heavy-haul trucks. However, commercially available vehicle models remain several years away from mass production, and there is a limited supply of both low-carbon hydrogen and fuelling infrastructure in the province at this time. Moreover, financial incentives will be required to make this a viable and attractive option for heavy-haul fleets, as hydrogen FCEVs face significant cost barriers resulting from high upfront vehicle costs, as well as the high cost of hydrogen fuel.

2.3 Natural gas

There are several different natural gas vehicles (NGVs) on the market today, with different fuel options. Natural gas vehicles can use either compressed natural gas (CNG) or liquefied natural gas (LNG). Renewable natural gas, meanwhile, can be blended into the natural gas stream or used at 100% to reduce the GHG intensity of fossil-based natural gas.

2.3.1 GHG and air pollutant emissions

Fossil-based NGVs are expected to present fleets with modest reductions in life cycle GHG emissions in comparison to diesel vehicles: CNG and LNG-fueled class 8 HDVs used in B.C. are expected to offer 20% and 28% reductions, respectively.[55] Uncertainty surrounding the rates of methane leakage in upstream natural gas production, however,

[55] *GHGenius 5.01b.*

brings the GHG emission reduction potential of NGVs into question[56] — although the Government of B.C. recently committed to developing stronger methane policies that could reduce methane emissions from the oil and gas sector by 75% by 2030,[57] in line with federal commitments.[58] Regardless, the emission reduction potential of fossil-based NGVs pales in comparison to those of BEVs operating in a region with a clean electricity grid or hydrogen FCEVs fueled by low-carbon hydrogen.[59] As a result, the viability of NGVs in a rapidly decarbonizing B.C. will depend on the rate of improvement in GHG capture practices and technologies, as well as the rate at which lower-GHG-intensity fuels are blended into the natural gas stream. For instance, several natural gas companies have begun blending hydrogen into the grid to reduce the GHG intensity of CNG. While ongoing research is exploring the limits of blending hydrogen into conventional pipelines, the 5-15% range appears to be safe; higher percentages of blending would require new, specially suited pipelines.[60]

Renewable natural gas (RNG) as a fuel option faces the same vehicle operability and infrastructure realities as fossil-based NGVs, but can provide more significant GHG emission reductions.[61] RNG can be sourced by capturing biogas from sources of organic waste, such as wastewater treatment plants, landfills and more. In B.C., RNG has been used as a blending option in the natural gas grid for households, but in the commercial sector can be applied as either a transportation fuel or as an energy source in industrial processes.[62] In jurisdictions such as California, where RNG represents the vast majority of gas consumed for transportation, NGVs have played a notable role in delivering GHG emission reductions for the class 8 HDV sector.[63]

In comparison to diesel vehicles, NGVs can have significant air quality benefits. In particular, they generate lower particulate matter and hydrocarbon emissions, and in

[56] Katlyn MacKay et al., "Methane Emissions from Upstream Oil and Gas Production in Canada are Underestimated," *Scientific Reports* 11, no. 8041 (2021). https://doi.org/10.1038/s41598-021-87610-3

[57] *CleanBC Roadmap to 2030*, 51.

[58] John Woodside, "Canada supports global pledge to slash oil and gas methane," *Canada's National Observer,* October 13, 2021. https://www.nationalobserver.com/2021/10/13/news/canada-supports-global-pledge-slash-oil-and-gas-methane

[59] *Transitioning to Zero-Emission Heavy-Duty Freight Vehicles*, 26.

[60] *Hydrogen on the Path to Net-Zero Emissions*, 4.

[61] United States Environmental Protection Agency, *An Overview of Renewable Natural Gas from Biogas* (2020), 11. https://www.epa.gov/sites/production/files/2020-07/documents/lmop_rng_document.pdf

[62] FortisBC, "Renewable Natural Gas", https://www.fortisbc.com/services/sustainable-energy-options/renewable-natural-gas

[63] California Natural Gas Vehicle Partnership, "Renewable Natural Gas." https://cngvp.org/renewable-natural-gas/

some cases may have near-zero NOx emissions.[64] Spark-ignited natural gas engines may, however, have slightly higher carbon monoxide emissions than an equivalent diesel vehicle.[65]

2.3.2 Cost

Some researchers, including NACFE, have concluded that NGVs have already reached cost parity with diesel HDVs.[66] The ICCT, in fact, has concluded that NGVs can offer cost savings of approximately 10% over diesel HDVs.[67] While NGVs may compete on cost, it is critical to note that to achieve significant GHG emission reductions, an increasing amount of RNG will need to be used. RNG, however, is notably more expensive than fossil-based natural gas. Pollution Probe estimates that RNG can cost anywhere from $6 to $29 per GJ, or from 100% to over 850% more than fossil-based natural gas.[68] Given that fuel costs represent over one-third of the total cost of ownership of class 8 NGVs,[69] the high cost of RNG could significantly impact their cost competitiveness.

2.3.3 Operational considerations

NGVs face similar barriers as other new and emerging fuel alternatives. High-power engine availability limits uptake of this technology among heavy-haul trucks, and particularly for those traveling through mountainous terrain, such as in B.C.[70,71]

[64] United States Department of Energy, "Natural Gas Vehicle Emissions." https://afdc.energy.gov/vehicles/natural_gas_emissions.html

[65] Andrew Burnham, *Alternative Fuel and Conventional Vehicle Air Pollutant Emissions* (Argonne National Laboratory, 2015), 26. https://cleancities.energy.gov/files/u/news_events/document/document_url/3/air-pollutant-emissions.pdf

[66] *Viable Class 7/8 Electric, Hybrid and Alternative Fuel Tractors*, 12.

[67] *Transitioning to Zero-Emission Heavy-Duty Freight Vehicles*, 20.

[68] *What Does the Future Hold for Natural Gas?* 45.

[69] *Transitioning to Zero-Emission Heavy-Duty Freight Vehicles*, 20.

[70] Natural Gas Use in Transportation Implementation Committee, *Natural Gas Use in the Medium and Heavy-Duty Vehicle Transportation Sector* (2019), 14. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/pdf/transportation/alternative-fuels/resources/pdf/NRCan_NGRoadmap_e_WEB.pdf

[71] *Viable Class 7/8 Electric, Hybrid and Alternative Tractors*, 58.

2.3.4 Technology readiness

To date, NGVs have been a popular alternative fuel option for HDVs in North America.[72] While there has been notable uptake of NGVs in select sectors (e.g., refuse collection), uptake of this technology among class 8 on-road freight vehicles in Canada is still fairly low: NGVs represent less than 1% of all class 7 and 8 vehicles sold in Canada[73] and fewer than 1,000 vehicles in B.C.[74]

Moreover, RNG as a fuel is currently produced in fairly limited quantities in Canada, and is typically more expensive than fossil-based natural gas.[75] In its 2021 long-term resource plan, FortisBC sees a possibility for renewable gas to scale-up to 20 PJ by 2030 and 114 PJ by 2050 (assuming 80% GHG emissions reductions by 2050).[76] These represent substantial increases in current levels of supply: according to the Canadian Biogas Association, there were 279 biogas projects supplying a total of 6 PJ of RNG across all of Canada in 2020.

To meet long-term supply goals, several new local sources of RNG have emerged in B.C.;[77] cross-jurisdictional supply contracts are also being used to meet the growing demand. However, in the long term towards 2040 and 2050, biogas may be vulnerable to price increases if North American demand rises as other jurisdictions begin to implement their own net-zero policies. As utilities secure long-term contracts for RNG supply, this will need to be a modelling consideration. Possible price increases could limit RNG's growth across all sectors, but particularly in a small profit-margin industry like long-haul trucking.

[72] *Viable Class 7/8 Electric, Hybrid and Alternative Tractors*, 28.

[73] *Natural Gas Use in the Medium and Heavy-Duty Vehicle Transportation Sector*, 17.

[74] Interview, BCTA.

[75] *Natural Gas Use in the Medium and Heavy-Duty Transportation Sector*, 26 and 32.

[76] FortisBC, "BC'S GHG Reduction Pathways Study — Implications For FortisBC's Long Term Resource Plans," 28. https://www.cdn.fortisbc.com/libraries/docs/default-source/about-us-documents/bcs-ghg-reduction-pathways-study-group-presentation-feb-2021.pdf

[77] FortisBC, "Meet Our Renewable Natural Gas Suppliers," https://www.fortisbc.com/services/sustainable-energy-options/renewable-natural-gas/meet-our-renewable-natural-gas-suppliers#tab-4

Natural gas: The bottom line

The air quality benefits of NGVs are significant. However, the ability of NGVs to contribute to the decarbonization of the heaviest segments of HDVs in B.C. hinges on a reduction in the life cycle GHG intensity of the natural gas stream, the availability of a sufficiently high-power engine, and the increased availability of natural gas fuelling stations.

In the near term, RNG could play a key role in reducing the GHG intensity of existing and new NGVs. However, the supply of RNG in B.C. is currently limited and would require a dramatic scale-up to be used commonly in HDVs. Moreover, the cost of RNG fuel would need to be reduced in order to make it an affordable option for heavy-haul fleets.

2.4 Biofuels

2.4.1 GHG and air pollutant emissions

Biodiesel and renewable diesel (also known as hydrogenation-derived renewable diesel or HDRD) are two promising biofuels suitable for use in B.C.'s HDV sector. These fuels are produced from a range of bio-based feedstocks, such as vegetable oils, crop residues, woody biomass or dedicated energy crops like switchgrass. It's estimated that pure (100%) biodiesel and renewable diesel in B.C. can result in GHG emission reductions of 85% and 71%, respectively, compared to diesel.[78] Meanwhile, 20% blends of biodiesel and renewable diesel (i.e., petroleum diesel blends with 20% renewable fuel content) can achieve approximately 16% and 14% reductions in life cycle GHG emissions, respectively, compared to a diesel baseline.[79] Life cycle GHG emissions from biofuels, however, depend on a multitude of factors, such as the feedstock used. In this case, we have referenced life cycle GHG emission estimates for biofuels produced from canola, a common feedstock in Canada.

Biodiesel produces slightly lower particulate matter, carbon monoxide and hydrocarbon emissions than diesel vehicles.[80] These emission benefits increase as the percentage of biodiesel increases. On the other hand, biodiesel is expected to result in higher NOx

[78] *GHGenius 5.01b*.

[79] *GHGenius 5.01b*.

[80] United States Department of Energy, "Biodiesel Vehicle Emissions." https://afdc.energy.gov/vehicles/diesels_emissions.html

emissions, which can play a role in the formation of smog and can lead to acid rain.[81] NOx emissions increase as the percentage of biodiesel increases. Renewable diesel, meanwhile, is expected to reduce NOx emissions, particularly when used in older diesel HDVs.[82]

2.4.2 Cost

In general, renewable fuels tend to be more expensive to produce than petroleum-based fuels, largely because the petroleum industry is able to achieve greater economies of scale and has lower feedstock prices.[83] In terms of renewable fuels for the diesel pool, renewable diesel tends to have higher production costs than biodiesel.[84]

Over the past few years, consulting firm Navius Research Inc. has conducted an annual review of the state of biofuels in Canada. Their most recent report estimates that the 1% renewable fuel content found in Canada's diesel pool in 2020 resulted in a marginal $206 in added fuel costs per year for a tractor-trailer, on average.[85]

2.4.3 Operational considerations

Biodiesel can present some operability issues in cold weather, as it can gel (or freeze) at a higher temperature than petroleum diesel.[86] For this reason, some HDV fleets have voiced opposition to increased levels of biodiesel being blended into Canada's diesel pool.[87] Original equipment manufacturers will typically provide warranty coverage for biodiesel blends ranging from B5 (5% biodiesel) to B20 (20% biodiesel).[88]

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[81] "Biodiesel Vehicle Emissions."

[82] Jon Leonard and Patrick Couch, "The Potential — and Challenges — of Renewable Diesel Fuel for Heavy-Duty Vehicles," *Gladstein Neandross & Associates* (2017). https://www.gladstein.org/the-potential-and-challenges-of-renewable-diesel-fuel-for-heavy-duty-vehicles/

[83] Heather MacLean et al., *Evaluation of the Impact of Using Biodiesel and Renewable Diesel to Reduce Greenhouse Gas Emissions in City of Toronto's Fleet Vehicles* (University of Toronto, 2019), 80. https://www.toronto.ca/legdocs/mmis/2019/ie/bgrd/backgroundfile-130965.pdf

[84] *Evaluation of the Impact of Using Biodiesel and Renewable Diesel*, 82.

[85] Navius Research, *Biofuels in Canada 2020* (2020), 37. https://www.naviusresearch.com/wp-content/uploads/2020/10/Biofuels-in-Canada-2020-2020-10-09.pdf

[86] Government of Canada, "Biodiesel." https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/alternative-fuels/biofuels/biodiesel/3509

[87] John Smith, "Biodiesel Targets Fuel Debate in Trucking Industry," *Truck News*, February 18, 2021. https://www.trucknews.com/features/biodiesel-targets-fuel-debate-in-trucking-industry/

[88] "Biodiesel Targets Fuel Debate in Trucking Industry."

Renewable diesel, on the other hand, does not have the same cold weather operability issues as biodiesel and is considered a "drop-in" fuel, meaning that it can be used in ICE vehicles at high concentrations without engine modifications, and can be transported in existing distribution networks.[89]

2.4.4 Technology readiness

Both biodiesel and renewable diesel are already being blended into the diesel pool in B.C., as the province has mandated a 4% renewable fuel content requirement.[90] Renewable diesel is not yet being produced domestically in Canada, though Covenant Energy recently announced the construction of a renewable diesel plant in Saskatchewan.[91]

Biofuels: The bottom line

Several models, including that of the IEA, project that advanced biofuels will play a prominent role on the transportation sector's pathway to net-zero.[92] However, this assumption comes with several caveats, including a need for much improved urban organic waste collection services, rigorous evaluation standards for the opportunity cost of land use decisions associated with dedicated energy crops, efficient forestry waste residue recovery, and more. The GHG benefits associated with biofuels also rely on carbon neutrality from the feedstocks that generate their energy, as opposed to alternatives such as BEVs, which can be zero-carbon at the point of use when sourced from 100% renewable electricity.

Biofuels are likely to continue playing a role in reducing the GHG intensity of the diesel pool in B.C. To achieve deep emission reductions from these fuels, however, higher blend levels are required. And to achieve these higher blend levels, the production of sustainable, low-carbon biofuels in Canada will need to increase.

[89] "The Potential — and Challenges — of Renewable Diesel Fuel for Heavy-Duty Vehicles"

[90] Government of British Columbia, "BC-LCFS Requirements." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels/fuel-supplier-compliance-50005

[91] Covenant Energy, "Covenant Energy Prepares to Meet New Demand for Renewable Diesel," *Biomass Magazine*, March 25, 2021. http://biomassmagazine.com/articles/17827/covenant-energy-prepares-to-meet-new-demand-for-renewable-diesel

[92] IEA, *Net Zero by 2050* (2021), https://www.iea.org/reports/net-zero-by-2050

3. Current HDV policies in B.C.

This section provides an assessment of the current policy landscape in B.C. concerning the decarbonization of HDVs and identifies the gaps that are hindering further emission reductions. We outline various policy options that could be considered by B.C. to support further decarbonization of HDVs in the region.

Our policy analysis is organized into five categories, outlined in Table 2.

Table 2. Policy analysis categories

Category		Description
Strategic planning and regulations		Long-range strategic planning and regulations are critical to ensuring that policies are consistent, effective, coordinated and implemented in a manner that is accountable and transparent.
Research, development and demonstration		The foundation for deploying new technologies to meet the needs of heavy-haul trucks will be robust local research and development capacity, and effective demonstration programs. B.C. can contribute to the global effort to research new technologies and be a leading test jurisdiction when new technologies are ready to be piloted.
Incentives for deployment		The "carrot" approach has proved effective in incentivizing the movement to clean transportation. Both financial and non-financial incentives are crucial to reduce barriers and accelerate the widespread deployment of near-zero and zero-emission HDVs.
Charging and fuelling infrastructure		The operators of HDV fleets need to know their vehicles will be able to refuel or recharge at convenient times and locations. Continued investment can support the build-out of depot and private fuelling/charging infrastructure, along with spending on public infrastructure designed to support long and heavy-haul HDVs.
Fleet capacity		Fleets require accessible and easily digestible information and resources that can help them to effectively make the switch to near-zero and zero-emission technologies. Moreover, vehicle operators and maintenance workers require adequate training.

Table 3 provides an overview of the various policies and programs in place in B.C. that support the decarbonization of HDVs. These policies and programs are discussed in detail in this section.

Table 3. B.C. policies and programs in support of HDV decarbonization

Category		B.C. policies and programs
Strategic planning and regulations		• CleanBC plan and Roadmap to 2030 • Renewable and Low Carbon Fuel Requirements Regulation • Weight allowance for low-carbon commercial vehicles • Greenhouse Gas Reduction Regulation (GGRR)
Research, development and demonstration		• Go Electric Commercial Vehicle Pilots (CVP) program • Advanced Research and Commercialization (ARC) program & Commercial Vehicle Innovation Challenge • Innovative Clean Energy (ICE) fund
Incentives for deployment		• Go Electric Specialty Use Vehicle Incentive (SUVI) program • CleanBC Heavy-Duty Vehicle Efficiency (HDVE) program
Charging and fuelling infrastructure		• CleanBC Communities Fund • Hydrogen Fuelling Infrastructure program • Renewable and Low Carbon Fuel Requirements Regulation: LCFS Part 3 Agreements
Fleet capacity		• CleanBC Heavy-Duty Vehicle Efficiency (HDVE) program • Go Electric funding for EV Maintenance Training programs

3.1 Strategic planning and regulations

The province's **CleanBC Roadmap to 2030** builds on the original **CleanBC** plan, outlining new and additional actions to reduce GHG emissions and close the gap to the province's 2030 climate target.[93] The original plan included several strategies to reduce emissions from transportation, including more support for ZEVs, shifting to low-carbon fuels, and making industrial transportation cleaner.[94] This includes several programs targeted specifically at HDVs, which will be discussed in detail in subsequent sections.

[93] *CleanBC Roadmap to 2030*.

[94] Government of British Columbia, *CleanBC* (2018). https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_2018-bc-climate-strategy.pdf

The updated Roadmap builds on these actions with several new commitments. Notably, the province has committed to introducing new ZEV sales targets for MHDVs, setting targets to reduce the energy intensity of goods movement, developing a comprehensive Clean Transportation Action Plan, and working with business and industry to encourage faster fleet turnover for the oldest vehicles, among others. The details of these commitments have yet to be worked out.

On the regulatory side, B.C. has developed a few key policies that support HDV decarbonization. The **Renewable and Low Carbon Fuel Requirements Regulation** (also referred to as the Low Carbon Fuel Standard, or LCFS) has been critical to accelerating the production and availability of low-carbon fuels like biodiesel and renewable diesel. The regulation requires a minimum 4% renewable content in the diesel pool,[95] in contrast to Canada's forthcoming Clean Fuel Regulations which set a minimum renewable fuel blending rate of 2%.[96] B.C.'s LCFS also sets out annual carbon intensity targets that contribute to the decarbonization of fuels beyond the 4% blending mandate. These targets require that the average carbon intensity of B.C.'s diesel pool be reduced by 20% by 2030.[97] In the Roadmap to 2030, the Government of B.C. committed to increasing the stringency of the LCFS by exploring the possibility of raising this target to a 30% reduction in carbon intensity by 2030.[98]

To strengthen the LCFS, B.C. needed to clarify the eligibility of site hosts of EV chargers to generate credits. Electricity produced by verified fuel suppliers may generate credits if it displaces an emissions-intensive fuel. In 2019, the Ministry of Energy, Mines and Low Carbon Innovation proposed updated regulations that would expand the credit market and include entities such as fleets and charging network providers to generate credits alongside utilities and traditional suppliers.[99] In July 2021, the ministry officially

[95] Government of British Columbia, "BC-LCFS Requirements." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels/requirements

[96] Government of Canada, *Clean Fuel Regulations,* December 19, 2020, Canada Gazette, Part I. vol. 154, no. 51. https://gazette.gc.ca/rp-pr/p1/2020/2020-12-19/html/reg2-eng.html

[97] "BC-LCFS Requirements"

[98] *CleanBC Roadmap to 2030*, 28.

[99] Government of British Columbia, *B.C. Low Carbon Fuel Standard: General Amendments Discussion Paper*, July 5, 2019. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/renewable-low-carbon-fuels/general_amendments_discussion_paper.pdf

amended the LCFS regulation, with an effective date of January 1, 2022 for electric fuel suppliers.[100]

Recently, B.C. has introduced a second regulation with strong potential to contribute to the decarbonization of HDVs: a **weight allowance for low-carbon commercial vehicles**. The regulation increases gross vehicle weight limits by 1,500 kg and 1,000 kg for battery electric and hydrogen fuel cell electric vehicles, respectively, to account for the added weight of these technologies and be consistent with allowances for CNG/LNG vehicles.[101] Given the industry's tight profit margins and the importance of a full payload, the added weight allowance is an easy win for regulators to support the adoption of near-zero and zero-emission technologies while being considerate of fleet challenges related to payload capacity and revenue consequences. To date, no other jurisdiction in Canada has implemented this policy.

To promote actions by utilities that would reduce GHG emissions while covering the cost of the actions across their rate base, B.C. established the **Greenhouse Gas Reduction Regulation.** The regulation enables utilities to provide zero-interest loans or grants for natural gas MHDVs, as well as funding to construct, own and operate LNG or CNG fuelling stations.[102] This regulation has enabled utilities like FortisBC to develop their medium- and heavy-duty natural gas truck fleet incentives, which reimburse fleets up to 50% of the incremental cost of a natural gas vehicle, as well as 20% of the cost to build or fuel at a natural gas fuelling station available for third-party use.[103] Given the limited decarbonization potential of LNG and CNG, this regulation could be strengthened by giving utilities the authority to administer similar financing programs for zero-emission vehicle technologies, like BEVs or hydrogen FCEVs.

Recent amendments to the GGRR will improve the ability of natural gas utilities to supply renewable gases to customers, including by increasing the cap on renewable and synthetic gases as a share of total supply by a utility from 5% to 15%.[104] The amendment

[100] Government of British Columbia, *"Part 3 Fuel Supplier and reporting requirements for electricity, Information Bulletin RLCF-020."* https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/renewable-low-carbon-fuels/rlcf-020.pdf

[101] Government of British Columbia, "Weight Allowance Greenlit for Low-Carbon Commercial Vehicles," May 14, 2021. https://news.gov.bc.ca/releases/2021TRAN0035-000920

[102] Government of British Columbia, *Greenhouse Gas Reduction (Clean Energy) Regulation*, Reg 102/201 O.C. 295/2012. https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/102_2012

[103] FortisBC, "Medium and Heavy-Duty Natural Gas Truck Fleet Incentives." https://www.fortisbc.com/est/truck-fleets/medium-heavy-duty-natural-gas-truck-fleet-incentives

[104] Government of British Columbia, "Province Enables Increased Investments in Renewable Gas, Hydrogen" https://news.gov.bc.ca/releases/2021EMLI0046-001286

also allows for the procurement of renewable gases up to $30/GJ. This will enable greater access to supply and production of low-carbon fuel options previously discussed such as RNG, synthetic gases and hydrogen.

3.1.1 Closing the gaps

B.C. has made significant strides through policy and regulatory reforms associated with CleanBC to support the decarbonization of the HDV sector. Recent prominent updates such as initial recommendations from BC Hydro's Phase 2 Review demonstrate a shift in utility policy and growing opportunities for decarbonization in the province.[105] However, there are still a few notable gaps. For one, the province would benefit from an overarching low-carbon freight and goods-movement strategy that includes specific GHG emission reduction targets for the HDV sub-sector. This strategy should articulate clear pathways to meeting targets, such as those the province recently committed to establishing to reduce the energy intensity of goods movement.[106] Such a strategy would improve coordination across the various government agencies that overlap with this sector and help direct investments more efficiently. It could be included as a part of the Clean Transportation Action Plan that the province has recently committed to developing.[107]

The Roadmap to 2030 makes a commitment to introduce new ZEV sales targets for MHDVs,[108] in alignment with current best practices set by California, complementing the B.C. ZEV standard and federal sales targets that are in place for light-duty passenger vehicles.[109,110] The province should develop a ZEV standard for MHDVs that enforces these targets and requires that vehicle manufacturers sell or make available an increasing percentage of zero-emission vehicles (i.e., BEVs or hydrogen FCEVs) and generate a certain number of credits per year. Credits, which are proportionate to a

[105] Government of British Columbia, "BC Hydro Review Sets Path for Electrifying Economy, Supporting CleanBC," July 9, 2021. https://news.gov.bc.ca/releases/2021EMLI0049-001343

[106] *CleanBC Roadmap to 2030*, 35.

[107] *CleanBC Roadmap to 2030*, 37.

[108] *CleanBC Roadmap to 2030*, 35.

[109] Government of Canada, "Building a Green Economy: Government of Canada to Require 100% of Car and Passenger Truck Sales be Zero-Emission by 2035 in Canada", June 29, 2021. https://www.canada.ca/en/transport-canada/news/2021/06/building-a-green-economy-government-of-canada-to-require-100-of-car-and-passenger-truck-sales-be-zero-emission-by-2035-in-canada.html

[110] Government of British Columbia, "Zero Emission Vehicles Act." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/zero-emission-vehicles-act

particular vehicle's range, are generated whenever a vehicle manufacturer brings an eligible ZEV to market.[111] The province should consider furthering its leadership on this policy by working with and supporting the federal government to implement national sales targets for zero-emission commercial MHDVs; similar to carbon pricing, jurisdictional policies have a limited impact when firms can relocate operations to the province next-door. This proposition is not without precedent — Canada is one of eight nations that have called for a global MOU "to accelerate the manufacturing and adoption of zero-emission medium- and heavy-duty vehicles (ZE-MHDVs)" with the intention to achieve 100% ZEV sales sometime between 2040 and 2050.[112] Although not a domestic policy commitment, this is an important starting point. Most importantly, however, ZEV sales targets would be misplaced without appropriate financial incentives to help mitigate the higher upfront costs of ZEVs in the near term and ensure undue burden for the transition isn't placed solely on SMEs. Given some of the uncertainty around the ability of BEVs and hydrogen FCEVs to meet the operational requirements of heavy-haul trucks in the near term, consideration will also need to be given to near-zero-emission vehicles, such as those operating on high blend levels of biofuels or RNG, that can bridge the gap between ICE vehicles and ZEVs, at least in the short term.

Lastly, while B.C. has led the way in increasing the weight allowance for battery electric and hydrogen fuel cell trucks, it is critical that this allowance be coordinated across other provinces and territories. Given the high proportion of HDVs that travel interprovincially, an effective implementation strategy would require B.C. to work with neighbouring jurisdictions to increase commercial vehicle weight limits across Canada. The Government of B.C. should work with members of the federal-provincial-territorial Task Force on Vehicle Weights and Dimensions Policy to update the Memorandum of Understanding on Heavy Truck Weight and Dimension Limits for Interprovincial Operations in Canada.[113]

[111] Clean Energy Canada, "Media Brief: What is a 'Zero-Emission Vehicle Standard' and Why Does Canada Need One," September 22, 2020. https://cleanenergycanada.org/media-brief-what-is-a-zero-emission-vehicle-standard-and-why-does-canada-need-one/

[112] Global Commercial Vehicle Drive to Zero, "Austria, Canada, Chile, Germany, Greece, Netherlands, Norway, Sweden Call on Leading Nations to Jointly Pursue Global Agreement on Zero-Emission Trucks and Meeting Paris Climate Goals," May 31, 2021. https://globaldrivetozero.org/2021/05/31/cem12announcement-5-31-21/

[113] Task Force on Vehicle Weights and Dimensions Policy, *Heavy Truck Weight and Dimension Limits for Interprovincial Operations in Canada* (2019). https://comt.ca/english/programs/trucking/MOU%202019.pdf

Policy options

- Develop a low-carbon freight and goods-movement strategy that outlines a roadmap to net-zero by 2050.
- Work with the Government of Canada to develop a national ZEV standard for MHDVs that requires manufacturers to sell or make available an increasing percentage of zero-emission vehicles over time. This standard should:
  - Outline the ZEV credit requirements for manufacturers by year.
  - Include interim sales targets across vehicle classes that reach 100% ZEV sales by 2040 and 2050.
  - Be paired with financial incentives to mitigate the higher upfront cost of ZEVs in the near term.
- Work with the Task Force on Vehicle Weights and Dimensions Policy to develop an updated Memorandum of Understanding on Heavy Truck Weight and Dimension Limits for Interprovincial Operations in Canada that includes special weight allowances for near-zero and zero-emission technologies.

3.2 Research, development and demonstration

To advance the development of near-zero and zero-emission vehicle technologies that can meet the needs of heavy-haul trucks, it is critical that the B.C. government enhance and expand its support for research, development and demonstration. This effort should recognize the technological advancements already made in the U.S. and Europe, including early demonstrations of battery electric trucks,[114] in order to identify lessons that can be learned on how to make similar advancements in B.C. Current supports for research, development and demonstration can be accessed through the Go Electric Commercial Vehicle Pilots program, the Advanced Research and Commercialization program, the Innovative Clean Energy (ICE) fund and the ICE fund – Sustainable Development Technology Canada funding stream.

The Go Electric **Commercial Vehicles Pilots (CVP)** program supports early-stage clean technology pilots, with specific relevance to HDVs. The CVP program provides financial support for businesses looking to deploy commercial BEVs or hydrogen FCEVs, including on-road MHDVs and their supporting infrastructure.[115] While the program

[114] Jon Porter, "Germany Tests Overhead Wires to Charge Hybrid Trucks on Highways," *The Verge*, May 9, 2019. https://www.theverge.com/2019/5/9/18538030/germany-ehighway-siemens-vw-group-electrified-cables-wires-overhead-electric-hybrid-trucks

[115] CleanBC Go Electric, "Commercial Vehicle Pilots Program." https://cvpbc.ca/

requires a minimum vehicle deployment number for classes 3 to 6, there is no minimum for class 7 and 8. Up to 33% of vehicle and charging costs are eligible for rebate, up to a maximum of $100,000.

The **Advanced Research and Commercialization (ARC)** program, the funding stream for which is currently closed, provided funding for eligible companies in the ZEV supply chain to support research, development and demonstration of B.C.-based technologies.[116] This funding can contribute to advancing the market-readiness of near-zero and zero-emission technologies for the HDV sector and its supporting infrastructure, as well as local economic development in B.C. Through the province's economic recovery plan, $30 million was allocated for a targeted initiative under ARC, the **Commercial Vehicle Innovation Challenge**. The challenge will engage ZEV technology suppliers of all kinds in an effort to spur the ongoing research and development activities in B.C. associated with decarbonizing HDVs.

B.C.'s **ICE Fund,** which is funded through a levy on certain energy sales, aims to support a range of pre-commercial clean energy projects and technologies, including low-carbon energy solutions for transportation.[117] The **ICE fund – SDTC funding stream** is the result of a 2017 partnership that the B.C. government formed with Sustainable Development Technology Canada to support similar pre-commercial clean energy solutions.[118] These types of programs are critical to reducing some of the risk and uncertainty associated with ZEVs prior to large scale deployments.

3.2.1 Closing the gaps

The commercialization of near-zero and zero-emission vehicles for HDVs is considerably further behind than for MDVs and LDVs, and this gap is further exacerbated by supply chain disruption induced by the COVID-19 pandemic, which is delaying manufacturing of conventional heavy-haul diesel trucks. It is therefore important that the B.C. government dedicate new and additional efforts to support the testing and demonstration of potentially viable technologies, with consideration of the short-term economic realities we face. The development stage is essential to de-risk

[116] CleanBC Go Electric, "ARC." https://arcbc.ca/

[117] Government of British Columbia, "Innovative Clean Energy (ICE) Fund." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/innovative-clean-energy-solutions/innovative-clean-energy-ice-fund

[118] Government of British Columbia, "ICE Fund and SDTC Joint Call Funding Partnership." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/innovative-clean-energy-solutions/bc-sdtc-partnership-in-clean-energy-technology

future investments and uncover the reliability of these technologies, how their costs will compare to a conventional internal combustion engine vehicle, and any other operational considerations.

Canada is home to hundreds of companies that are a part of the clean vehicle supply chain, such as B.C. innovators Ballard and HTEC. However, a clear and accessible inventory of the companies operating within the sector across the country is lacking. Given the abundance of relevant companies operating within B.C., the province should map out the key local players within the clean vehicle supply chain in order to increase transparency, facilitate the creation of new partnerships and foster collaboration. This would also provide B.C. with the opportunity to easily showcase local expertise to other international stakeholders.

While funding provided through programs such as B.C.'s Commercial Vehicles Pilot program can benefit other MHDV segments, it will be difficult for heavy-haul fleets to take advantage of these programs in the near term given the lack of market-ready battery electric and hydrogen fuel cell electric heavy-haul trucks. To support decarbonization efforts within fleets in the near term, funding support for pilot programs could be expanded to include additional decarbonization efforts, such as testing higher concentrations of renewable diesel and biodiesel in existing ICE vehicles.

Policy options

- Accelerate collaborative research and development into near-zero and zero-emission heavy-haul trucks, by working with cross-jurisdictional partners, including the federal government, provinces, the trucking industry, manufacturers, and leading U.S. states.
- Work with corporate partners that will use funding through the CVP to accelerate a stream of commercialization pilots and in-fleet demonstrations of near-zero and zero-emission heavy-haul vehicles weighing more than 53,000 kg, when they are market-ready.
- Leverage the new Centre for Innovation and Clean Energy and its public–private–academic partnership structure to advance commercialization of near-zero and zero-emission HDV technology providers.
- Explore the development of a new public inventory of clean technology companies contributing to the near-zero and zero-emission vehicle supply chain in the province to foster partnerships and attract global investment.

3.3 Incentives for deployment

Financial incentives will be critical to addressing the higher upfront capital costs of near-zero and zero-emission HDVs. ZE MHDVs that are currently on the market, including BEVs and hydrogen FCEVs, can cost three times as much as an equivalent fossil-fueled vehicle.[119] Strong financial incentives are one of the most effective demand-side policies to promote ZEV uptake.[120]

B.C. is one of only two jurisdictions in Canada that offers vehicle purchase incentives for zero-emission MHDVs. These incentives are administered through the province's **Go Electric Specialty Use Vehicle Incentive (SUVI)** program, which provides rebates for 33% to 66% of the manufacturer's suggested retail price, up to a maximum of $100,000 for eligible MDVs, HDVs, and other specialty vehicles.[121] The province had originally committed $2.5 million in funding for the program in 2017, which was topped up with an additional $2 million in August 2020.[122]

Beyond vehicle purchase incentives, the province's **CleanBC Heavy-Duty Vehicle Efficiency (HDVE)** program provides incentives for fuel-saving devices, which can contribute to GHG emission reductions from diesel HDVs that are on the road today and will be for several years to come. Fleets that complete a one-day training course on fuel efficiency measures are eligible for rebates on the purchase and installation of certain fuel-saving devices, up to $10,000 per vehicle or $100,000 per fleet.[123] Given that viable near-zero and zero-emission alternatives are not yet commercially available for every segment of the HDV sector, this program is contributing to emissions reductions in the interim. As a part of their Roadmap to 2030, the Government of B.C. has committed to identifying how the HDVE program could be enhanced to drive further improvements in vehicle efficiency.[124]

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[119] ICF, *Comparison of Medium- and Heavy-duty Technologies in California: Part 2: Total Cost of Ownership Technology Analysis*, prepared for California Electric Transportation Coalition and Natural Resources Defence Council (2019), 4. https://caletc.com/assets/files/ICF-Truck-Report_Final_December-2019.pdf

[120] SFU Sustainable Transportation Action Research Team (START), *Canada's ZEV Policy Handbook* (2017), 30. https://sfustart.files.wordpress.com/2017/12/zev-policy-handbook_web.pdf

[121] PlugIn BC, "Specialty Use Vehicle Incentive." http://pluginbc.ca/suvi/

[122] Truck News, "B.C. Adds $2 Million to Electric Vehicle Rebates," August 6, 2020, https://www.trucknews.com/transportation/b-c-adds-2-million-to-electric-vehicle-rebates/1003143275/

[123] B.C. Trucking Association, "New! CleanBC Heavy-duty Vehicle Efficiency Program." https://www.bctrucking.com/content/new-cleanbc-heavy-duty-vehicle-efficiency-program

[124] *CleanBC Roadmap to 2030*, 37.

FortisBC offers **medium- and heavy-duty natural gas truck fleet incentives**, which can be used for purchase of NGVs and the construction and maintenance of natural gas fuelling stations. These can be paired with the HDVE program and federal Green Freight Assessment (more details in the appendix) to further reduce costs.[125,126]

3.3.1 Closing the gaps

Overall, B.C. is doing better than most jurisdictions in Canada at providing financial incentives for fleets to transition to near-zero and zero-emission ZEVs. However, to ensure that the HDV sector can effectively plan its transition to net-zero, more transparency and certainty is needed on the long-term renewal of these programs. Heavy-haul trucks are still at an early stage in their commercialization curve and purchasers will need higher levels of financial support in the long term to support B.C.'s sectoral transportation GHG target and complement possible regulatory policies such as a ZEV standard.

The provincial and federal governments could look to California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) as an example. HVIP, funded by the state's cap-and-trade policy, has delivered US$230 million in point-of-sale purchase incentives valued up to US$120,000 each (approximately C$150,000[127]) to over 3,900 vehicles weighing 15 tonnes or more since the program's inception in 2009. US$35.18 million of this was for class 8 trucks. For B.C. to reach its emissions targets, similar levels of point-of-sale purchase incentives may be needed as new vehicles come to market.[128] A University of Waterloo cites the current cost of new class 7 and 8 battery electric and hydrogen fuel cell HDVs to range between $169,000 and $731,000, whereas new diesel trucks can cost $149,000 to $167,000.[129,130] Class 8 BEVs currently available for purchase in B.C. and eligible for the SUVI program have a suggested retail price

[125] Government of Canada, "Green Freight Assessment." https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/greening-freight-programs/green-freight-assessment-program/green-freight-assessment/21935

[126] Fortis BC, "Medium and Heavy-Duty Natural Gas Truck Fleet Incentives." https://www.fortisbc.com/est/truck-fleets/medium-heavy-duty-natural-gas-truck-fleet-incentives

[127] Based on an exchange rate of C$0.80/US$1, as of September 2, 2021.

[128] California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), "Voucher Data." https://californiahvip.org/impact/

[129] Carlo Cunanan et al., "A Review of Heavy-Duty Vehicle Powertrain Technologies: Diesel Engine Vehicles, Battery Electric Vehicles, and Hydrogen Fuel Cell Electric Vehicles." *Clean Technologies* 3, no 2. (2021), 483. https://doi.org/10.3390/cleantechnol3020028

[130] Based on an exchange rate of C$0.80/US$1, as of September 2, 2021.

ranging from $450,000 to $637,000.[131] Recent data from the U.S. shows used class 8 trucks ranging from roughly $71,000[132] to $57,000,[133] on average, over the past year and a half.[134]

In addition to time-limited financial subsidies, there are opportunities for government to use innovative financing tools that can catalyze private sector resources to support the build out of near-zero and zero-emission vehicles and infrastructure. Innovative financing for deployment can come in many forms. A best practice toolkit is the "Total Cost of Electrification" developed by Environmental Defense Fund, M.J. Bradley & Associates and Vivid Economics, which maps a variety of financial and non-financial solutions to support fleet electrification.[135] For heavy-haul trucks in B.C., when upfront costs remain prohibitive, examples of innovative financial solutions include:

- **Concessional loans** with preferential terms (e.g., below-market or zero interest rates, longer maturity, flexible eligibility requirements, first-loss guarantees) for vehicles with relatively lower life cycle GHG emissions could provide fleets with the financial flexibility needed in the short term to allow for quick adoption while providing a flexible payback period.
- **First loss funds** could be set up by government to de-risk and incentivize concessional debt provided by the private sector. A fund of this nature could act as a liquid cash reserve that would allow businesses to access capital with preferential market terms.
- **Residual value guarantees** can provide purchasers with guaranteed minimum resale values in the case where resale values for fleets and owner-operators may be uncertain in the short term.
- **Public extended performance guarantees** (e.g., for new battery technologies) could go beyond manufacturer warranties to further fleet confidence in pilots.
- **Utility bill financing models** also offer a mechanism to set preferential loan terms and shift costs for purchasers over time. Both BC Hydro, when directed by government (for electricity), and FortisBC (for renewable gases, hydrogen and CNG/LNG) can provide on-bill lending services. Outreach efforts coordinated

[131] Government of British Columbia, *Specialty-Use Vehicle Incentive Program Eligible Vehicle List July 7th, 2021*. https://pluginbc.ca/wp/wp-content/uploads/2020/12/SUVI_MHD_26_08_2021.pdf

[132] For May 2021, using an average monthly exchange rate of C$0.82/US$1.

[133] For May 2020, using an average monthly exchange rate of C$0.71/US$1.

[134] Roger Gilroy, "Average Used Class 8 in May Brings All-Time High Price," *Transport Topics*, June 29, 2021. https://www.ttnews.com/articles/average-used-class-8-may-brings-all-time-high-price

[135] Environmental Defense Fund, *Financing the Transition: Unlocking Capital to Electrify Truck and Bus Fleets* (2020). https://www.edf.org/energy/financing-transition-electric-truck-and-bus-fleets

with industry and supported by the province (e.g., Plugin BC) can help popularize understanding of the total cost of ownership for new vehicles after alternative financing support is taken into account.

Additionally, recent changes to the LCFS in B.C., which will be discussed in more detail in the following section, allow fleets to generate monetizable credits and thus have opened the opportunity for a new source of revenue. An innovative approach building on California's pre-existing allowance for fleets to generate credits is CALSTART's "LCFS loan" proposition, which would allow credits normally generated by fleets over the vehicle's lifetime to be monetized upfront for the vehicle purchase.[136] This could be an alternative source of financing supported either publicly or privately.

Policy options

- Renew and update the scope of existing point-of-sale purchase incentive programs (e.g., SUVI) or create new programs that meet the emerging needs of fleets and owner-operators to transition to near-zero and zero-emission HDVs. Incentive programs should reflect the class and weight differences of HDVs.
- Explore the effectiveness of higher incentives for the heaviest class of vehicles, to promote greater adoption of near-zero and zero-emission vehicles. This may mean a need for incentives greater than SUVI's $100,000 for class 8 vehicles, particularly heavy-haul trucks.
- Similar to provincial policy for cargo e-bikes, the province could explore waiving PST for the purchase of near-zero and zero-emission class 8 vehicles. This could complement the accelerated capital cost allowance (CCA),[137] to incent adoption. For SMEs or owner-operators that may not generate enough taxable revenue to benefit from the CCA, investing in lower total purchase prices may be more prudent. A program of this nature could also be targeted solely to SMEs/owner-operators to ensure the incentive goes to businesses that need savings the most.
- Investigate the potential for new, innovative financial mechanisms that can support the deployment of HDVs, such as concessional loans, reserve funds, residual value guarantees, utility bill financing or another medium of lending.

[136] Robert Gurman, *Taking Commercial Fleet Electrification to Scale: Financing Barriers and Solutions* (Calstart, 2021), 52. https://globaldrivetozero.org/site/wp-content/uploads/2021/03/Taking-Commercial-Fleet-Electrification-to-Scale-White-Paper.pdf

[137] Government of Canada, "Zero-Emission Vehicles." https://www.canada.ca/en/revenue-agency/services/tax/individuals/topics/about-your-tax-return/tax-return/completing-a-tax-return/deductions-credits-expenses/line-22900-other-employment-expenses/capital-cost-allowance/classes-depreciable-properties/zero-emission-vehicles.html

- Explore the feasibility of offering LCFS loans as a part of B.C.'s Low-Carbon Fuel Standard.

3.4 Charging and fuelling infrastructure

The operators of alternatively fueled HDV fleets need to know their vehicles will be able to refuel or recharge at convenient times and locations. B.C. currently has four programs in place that support the build-out of charging and fuelling infrastructure for alternative vehicle technologies: the CleanBC Communities Fund, the Hydrogen Fuelling Infrastructure Program, the Greenhouse Gas Reduction Regulation and the LCFS.

The **CleanBC Communities Fund** provides funding for clean energy infrastructure projects such as charging or fuelling stations.[138] The **Hydrogen Fuelling Infrastructure Program**, meanwhile, specifically seeks to build out B.C.'s network of publicly available hydrogen fuelling stations.[139] Most recently, as a part of the Roadmap to 2030, the Government of B.C. announced a commitment to establish a target of 10,000 public EV charging stations by 2030. It is unclear whether any of these commitments or program streams will provide support or infrastructure specifically for HDV fleets.[140]

In addition to increasing production of low-carbon fuels in B.C., recent changes to the **LCFS** that allow new suppliers to generate market credits have unlocked the potential for public charging networks to expand.[141] This is particularly notable for fleets and companies providing both public charging networks and charging-as-a-service (CaaS). Public charging infrastructure that is owned, operated and maintained by a separate company, in a format similar to traditional gasoline and diesel fuel stations, is essential to provide confidence to fleets and owner-operators transitioning to new technologies. B.C.'s **LCFS Part 3 Agreements** have also been offering credits directly to fuel suppliers

[138] Government of British Columbia, "Investing in Canada Infrastructure Program – British Columbia – CleanBC Communities Fund." https://www2.gov.bc.ca/gov/content/transportation/funding-engagement-permits/funding-grants/investing-in-canada-infrastructure-program/greeninfrastructure/cleanbc-communities-fund

[139] Government of British Columbia, "Go Electric Hydrogen Fuelling Infrastructure." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program/dcfc-program/hydrogen-fuelling

[140] *CleanBC Roadmap to 2030*, 36.

[141] Government of British Columbia, "Renewable and Low Carbon Fuel Requirements Regulation." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels

for project proposals that invest in the development of low-carbon fuels, including alternative fuelling infrastructure. The fuels industry in B.C. has received more than $450 million of LCFS credits for low-carbon projects since 2019.[142]

Relevant projects funded in 2021 through Part 3 Agreements include $1.9 million in credits for Hydra Energy to build a hydrogen refuelling station for HDVs in Northern B.C.,[143] and $5.6 million in credits for a next generation "Renewable Energy Hub" at the University of British Columbia, which includes a hydrogen refuelling station for light and heavy-duty vehicles.[144] In 2020, Hydrogen Technology and Energy Corporation, which operates the largest network of retail hydrogen refuelling stations in Canada (four in total, three of which are located in B.C.), invested in a North Vancouver hydrogen refuelling station with support from the LCFS.[145,146,147]

In 2020, B.C. separately invested $20 million for the construction and operation of 10 hydrogen fuelling stations and three years of support for Hydrogen BC. It is not yet clear however when those stations will be built and if they will have public access.[148] The province also invested $2 million to support the build-out of new public fast-charging and hydrogen fuelling stations. In 2019, B.C. allocated $5 million towards the construction of battery electric vehicle charging stations at highway rest areas and buildings owned by the province. However, it is unclear whether any of this funding will support infrastructure specifically for HDVs.

According to Natural Resources Canada's Electric Charging and Alternative Fuelling Stations Locator, there are 21 CNG and four LNG fuelling stations that are accessible to

[142] Government of British Columbia, *BC Hydrogen Strategy*, July 6, 2021. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/electricity/bc-hydro-review/bc_hydrogen_strategy_final.pdf

[143] Government of British Columbia, "Heavy-duty Hydrogen Fuelling Station Powers Clean Energy Transition", June 28, 2021. https://news.gov.bc.ca/releases/2021EMLI0044-001213

[144] Government of British Columbia, "UBC Renewable Energy Hub Fuels B.C.'s Low-Carbon Future", May 5, 2021. https://news.gov.bc.ca/releases/2021EMLI0034-000843

[145] Government of British Columbia, "Province Supports New Fuelling Stations for Hydrogen Vehicles", June 25, 2020. https://news.gov.bc.ca/releases/2020EMPR0024-001161

[146] Hydrogen Technology & Energy Corporation, "HTEC and 7-Eleven Canada to Open Retail Hydrogen Refueling Stations in BC", March 19, 2019. https://www.htec.ca/htec-and-7-eleven-canada-to-open-retail-hydrogen-refueling-stations-in-bc/

[147] Hydrogen Technology & Energy Corporation, "HTEC and Shell Partner to Open Canada's First Retail Hydrogen Fueling Station in Vancouver Later This Year", March 15, 2018. https://www.htec.ca/htec-and-shell-partner-to-open-canadas-first-retail-hydrogen-fueling-station-in-vancouver-later-this-year/

[148] Government of British Columbia, "Province Invests in Hydrogen to Help Transition to Cleaner Energy," September 10, 2020. https://news.gov.bc.ca/releases/2020EMPR0046-001696

class 6-8 HDVs in B.C. (11 and three of which accept fleet fuelling cards, respectively).[149] There are also three biodiesel stations offering biodiesel blends of B20 and above, four hydrogen fuelling stations and over 1,100 public EV charging stations. It is unclear how many of these are accessible to heavy-haul trucks. It is not expected that B.C.'s existing EV charging stations would supply sufficient power to meet the needs of these HDVs.

3.4.1 Closing the gaps

Overall, policies, programs and funding in support of the build-out of publicly accessible charging and fuelling infrastructure for near-zero and zero-emission HDVs in B.C. is limited. While the province's Part 3 Agreements in the LCFS have increased the number of commercial hydrogen fuelling stations and changes to the LCFS offer prospects to finance new stations, they currently remain few and far between. To get B.C. to a point where the adoption of near-zero and zero-emission heavy-haul trucks begins to accelerate, both private and public sector investments, along with interprovincial coordination, are needed.

For private sector services, there are several options. Infrastructure-as-a-service, which has been a historically successful business model in the digital services sector, has been adopted by charging network companies. For return-to-base vehicles and customers with predictable routes, Hydra's 'hydrogen as a service' and Chargepoint's fleet services[150] already provide complete refuelling and infrastructure services. However, long-haul trucks are more reliant on publicly available fuelling and charging stations.

The province should explore funding programs that build out class 8-specific publicly accessible fuelling and charging infrastructure. The Hydrogen Fuelling Infrastructure Program could be expanded to create new fuelling opportunities for heavy-haul trucks. Existing programs for BEVs, such as the Go Electric Public Charger program, appear to be targeted primarily at passenger vehicles. The CVP provides funding for charging and fuelling infrastructure, but the stations built are designed for the use-case of the pilots rather than sectoral needs. The province should consider making a portion of the 10,000 public charging stations committed to in the 2030 Roadmap accessible to commercial HDV fleets; while BEVs do not currently meet the needs of the heavy-haul sector, this may change in the future.

[149] Government of Canada, "Electric Charging and Alternative Fuelling Stations Locator." https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/electric-charging-alternative-fuelling-stationslocator-map/20487#/find/nearest

[150] ChargePoint, "The Most Comprehensive Fleet Charging Portfolio." https://www.chargepoint.com/en-ca/businesses/fleet/

Additionally, HDV activity frequently crosses provincial and international borders. Half of the BC Trucking Association (BCTA)'s membership drives interprovincially.[151] It is critical that the B.C. government work with neighboring provinces (and potentially states, too) to coordinate the build-out of publicly accessible charging infrastructure along popular freight corridors. This could take the shape of an interprovincial working group.

Policy options

- Develop an interprovincial-territorial working group that is dedicated to coordinating the build-out of charging and fuelling infrastructure across popular Canadian freight corridors.
- Explore strengthening existing incentive programs, or developing new programs, that can accelerate the build-out of new charging and fuelling infrastructure by the private sector.
- Explore additional coordinated investments with the federal government, as done for LDVs, to improve the availability of charging and fuelling infrastructure that is accessible to a range of fleets. New stations for HDVs need to be:
    - Optimized according to HDV volumes.
    - Sufficient in quantity. If BEVs become a viable technology for the heaviest classes of HDVs, there need to be several fast-charge stations at key truck stops to meet demand.

3.5 Fleet capacity

To help with the transition to low- and zero-emission technologies, fleet operators would benefit from having access to easily digestible information, resources and training programs to help make the switch to alternative HDV technologies. The B.C. government currently offers support in this regard through Plug In BC, the Heavy-Duty Vehicle Efficiency Program, and EV maintenance training programs.

Fraser Basin Council, in collaboration with the B.C. government and other key stakeholders, developed **Plug In BC**, a central source of information on EV-supportive programs and initiatives.[152] The website provides dedicated resources for HDV fleets, including information on relevant programs and incentives, as well as a fleet procurement analysis tool. The **West Coast Electric Fleets** initiative also provides

[151] *De-Carbonization in Commercial Transport*, 9.

[152] "Plug In BC." https://pluginbc.ca/

public resources for light, medium and heavy-duty fleets in B.C. and the western U.S., and already has a plethora of collaborators and fleet partners involved.[153]

The CleanBC **Heavy-Duty Vehicle Efficiency Program** provides HDV fleet operators with training on various fuel efficiency initiatives.[154] As a part of this program, the B.C. Trucking Association administers a one-day course that educates fleets on how to implement fuel efficiency measures like fuel management programs or fuel-efficient driving techniques. This program helps save fuel, reduce costs, and support GHG emission reductions from diesel vehicles on the road today.[155]

In addition to these programs, the Government of B.C. also recently provided $440,000 in funding through the CleanBC Go Electric stream to support the expansion of **EV maintenance training** programs at B.C. colleges.[156] It is essential that automotive technicians are equipped with the skills required to support the next generation of vehicles.

3.5.1 Closing the gaps

The province should continue to play a role promoting existing ZEV education and awareness initiatives by working with the administrators of these programs to ensure that resources pertaining to MHDVs, including heavy-haul vehicles, are included. Much of the readily available information in B.C. pertains to BEVs, and HDV operators may benefit from information on other near-zero and zero-emission technologies like hydrogen FCEVs, biofuels or RNG.

New EV maintenance training programs developed using funding from the CleanBC Go Electric stream will begin to roll out at B.C. colleges in Fall 2021. To ensure that these programs are successful and adequately prepare automotive technicians to work on EV technologies, the province should monitor their progress to identify any blind spots in the programs. In particular, the province should consider developing training programs for other key industry stakeholders, such as drivers, engineers, electricians and fleet

[153] "West Coast Electric Fleets." http://www.westcoastelectricfleets.com/

[154] BC Trucking Association, "New! CleanBC Heavy-duty Vehicle Efficiency Program." https://www.bctrucking.com/content/new-cleanbc-heavy-dutyvehicle-efficiency-program

[155] BC Trucking Association, "CleanBC Heavy-duty Vehicle Efficiency Program Course" https://www.bctrucking.com/training/cleanbc-heavy-duty-vehicle-efficiency-program-course

[156] Government of British Columbia, "EV Skills Training Now Available at Three Additional Colleges," March 29, 2021. https://news.gov.bc.ca/releases/2021EMLI0028-000568

managers, who will all play a role in the transition to near-zero and zero-emission HDVs.

Policy options

- Update the CleanBC Job Readiness Plan to ensure there is long-term planning and support for HDV operators to succeed in the low-carbon economy. The Job Readiness Plan needs to:
    - Identify actions by the relevant ministries (Ministry of Jobs, Economic Recovery and Innovation, Ministry of Labour, and the Ministry of Advanced Education and Skills Training) that act on the skills training needs and labour market shifts to come as a result of the adoption of near-zero and zero-emission HDV technologies.
    - Explore whether additional provincial support is needed to create new grants and bursaries that support enrollment in skills training programs for alternative vehicle technologies at post-secondary and vocational institutions. The province may want to consider offering additional measures that support specific programming for other key industry stakeholders.

4. Conclusion

Since CleanBC was announced, B.C. has invested approximately $150 million into clean transportation policies and programs that overlap with MHDV decarbonization (see Appendix B Table 13). New regulatory updates, strategic planning changes and policy announcements, such as amendments to the GGRR, the Commercial Vehicle Innovation Challenge and ongoing LCFS Part 3 Agreements are helpful actions that advance B.C.'s goals to decarbonize HDVs and accelerate clean transportation more broadly. Nonetheless, a substantial gap in viable, cost-effective near-zero and zero-emission technologies remains for all HDV fleets, with very limited options for vehicles in the weight range of 53,000 kg to 63,500+ kg. Simultaneously, HDV fleets face rising costs for carbon-intensive fuels.[157]

Improvements to the efficiency of ICE vehicles and increases to the renewable fuel content of the diesel pool will continue to play a role in the incremental decarbonization of HDVs in B.C. as clean technology solutions remain limited. However, research shows that the GHG emission potential of these actions will be marginal and should not distract from the urgent need to move to new technologies that offer opportunities for deeper decarbonization.

Given this urgency, the province of B.C. will need to examine pathways to consider new and bold ways to support fleet owners to transition to near-zero and zero-emission alternatives when it may not yet be cost-effective for them to do so. B.C.'s modest combination of incentives for ZEVs and their associated infrastructure are a starting point, but a more comprehensive toolkit is needed in this climate crisis. This could include ongoing support of demonstration projects, larger purchase subsidies (building on the capacity and deployment incentives made through the SUVI, CVP and GGRR), financing mechanisms that can tap into new markets (e.g., LCFS loans), preferential fuel prices (e.g., the model of the Clean Industry and Innovation Rate), and more, depending on how key hydrogen FCEVs and BEVs mature in the coming years. Manufacturer technology developments will determine the sector's capacity to meet its share of emissions reductions in the race to net-zero. Affordable options for emerging fuels such as hydrogen and RNG, which have yet to reach scaled use in B.C., will be just as important to plan for as the technology itself. While large fleets may have some

[157] Ontario Trucking Association, "CTA Provides Comments to Feds n Carbon Pricing Cost and Feedback on Clean Fuel Regs," March 17, 2021. https://ontruck.org/cta-provides-comments-to-feds-on-carbon-pricing-cost-and-feedback-on-clean-fuel-regs/

purchasing power to transition to alternative technologies in the near-future, small fleets and owner-operators will remain limited in their options so long as transition costs remain high.

Experiences among transit, urban delivery, drayage, regional haul fleets, and others that are well-suited to early deployments of near-zero and zero-emission vehicles, will offer best practices and insights into how to smooth the transition. Throughout this transition, government should remain flexible and focused on emissions reductions, rather than any specific technology. As domestic and international market mechanisms push the cost of fossil fuels up, clean technology compliance options will mature and generate market share based on their respective best use cases.

Appendix A. Comparison of alternative technologies

Table 4. Life cycle GHG emissions relative to a diesel baseline

Technology	Life Cycle GHG Emission Reductions Relative to a Diesel Baseline	Notes[158]	Source
BEV	92%	Charged using B.C.'s electricity grid	GHGenius[159]
Hydrogen FCEV	47%	Hydrogen produced through SMR using natural gas	GHGenius
Hydrogen FCEV	81%	Hydrogen produced through electrolysis using B.C.'s grid electricity	GHGenius
CNG	20%		GHGenius
LNG	28%		GHGenius
RNG blend (CNG)	70%	RNG blend	GHGenius
RNG blend (LNG)	69%	RNG blend	GHGenius
100% Renewable Diesel	71%	Canola oil feedstock	GHGenius
20% Renewable Diesel Blend	14%	Canola oil feedstock	GHGenius
100% Biodiesel	85%	Canola oil feedstock	GHGenius
20% Biodiesel Blend	16%	Canola oil feedstock	GHGenius

[158] Used model defaults for a class 8 truck operating in B.C. in 2021.

[159] (S&T) Squared Consultants Inc., *GHGenius 5.01b*. https://www.ghgenius.ca/index.php/downloads/57-ghgenius-5-01b

Table 5. Criteria air pollutant emissions relative to a diesel baseline

Technology	Tailpipe Emissions Relative to a Diesel Baseline	Source(s)
BEV	No tailpipe emissions	U.S. DOE Alternative Fuels Data Center[160]
Hydrogen FCEV	No harmful tailpipe emissions	U.S. DOE Alternative Fuels Data Center[161]
CNG/LNG/RNG	Lower PM, NOx and HC tailpipe emissions Potentially higher CO emissions[162]	U.S. DOE Alternative Fuels Data Center[163] Argonne National Laboratory[164]
Biodiesel	Lower PM, CO and HC emissions Slightly higher NOx emissions	U.S. DOE Alternative Fuels Data Center[165]
Renewable Diesel	Lower PM and NOx emissions	Gladstein, Neandross & Associates[166]

[160] U.S. Department of Energy, "Electric Vehicle Benefits and Considerations." https://afdc.energy.gov/fuels/electricity_benefits.html

[161] U.S. Department of Energy, "Fuel Cell Electric Vehicles." https://afdc.energy.gov/vehicles/fuel_cell.html

[162] For natural gas spark-ignited engines

[163] U.S. Department of Energy, "Natural Gas Vehicle Emissions." https://afdc.energy.gov/vehicles/natural_gas_emissions.html

[164] Andrew Burnham, *Alternative Fuel and Conventional Vehicle Air Pollutant Emissions* (Argonne National Laboratory), Clean Cities Webinar, January 28, 2015, 26. https://cleancities.energy.gov/files/u/news_events/document/document_url/3/air-pollutant-emissions.pdf

[165] U.S. Department of Energy, "Biodiesel Vehicle Emissions." https://afdc.energy.gov/vehicles/diesels_emissions.html

[166] Jon Leonard and Patrick Couch, "The Potential – and Challenges – of Renewable Diesel for Heavy-Duty Vehicles," 2017. https://www.gladstein.org/the-potential-and-challenges-of-renewable-diesel-fuel-for-heavy-duty-vehicles/

Table 6. Total cost of ownership (TCO) relative to a diesel baseline

Technology	Change in TCO Relative to a Diesel Baseline	Sources
BEV	80% to 85% increase 9% decrease to 158% increase 111% increase 8% to 14% decrease Worse	Mojtaba Lajevardi[167] UC Davis[168] NREL[169] ICCT[170] NACFE[171]
Hydrogen FCEV	50% to 115% increase 24% to 69% increase 37% increase 8 to 33% increase Worse	Mojtaba Lajevardi University of California Davis NREL ICCT NACFE
CNG/LNG/RNG	0% to 40% increase[172] 11% increase[173] 8% to 11% increase[174] Parity	Mojtaba Lajevardi NREL ICCT NACFE

[167] S. Mojtaba Lajevardi, *An Examination of Heavy-Duty Trucks Drivetrain Options to Reduce GHG Emissions in British Columbia,* doctoral dissertation, University of Victoria (2019), 93. http://hdl.handle.net/1828/11446; values represent range of high and low carbon pricing scenarios.

[168] Andrew Burke and Anish Kumar Sinha, *Technology, Sustainability and Marketing of Battery Electric and Hydrogen Fuel Cell Medium-Duty Trucks and Buses in 2020-2040* (University of California Davis, 2020), 45-46. https://doi.org/10.7922/G2H993FJ

[169] Chad Hunter, Michael Penev and Evan Reznicek, *Market Segmentation Analysis of Medium and Heavy Duty Trucks with a Fuel Cell Emphasis* (National Renewable Energy Laboratory, 2020) 17. https://www.hydrogen.energy.gov/pdfs/review20/sa169_hunter_2020_o.pdf

[170] Marissa Moultak, Nic Lutsey and Dale Hall, *Transitioning to Zero-Emission Heavy-Duty Freight Vehicles* (The International Council on Clean Transportation, 2017), 20. https://theicct.org/sites/default/files/publications/Zero-emission-freight-trucks_ICCT-white-paper_26092017_vF.pdf; scenario: United States, 2020.

[171] Rick Mihelic, Kevin Otto, Jessie Lund and Mike Roeth, *Viable Class 7/8 Electric, Hybrid and Alternative Fuel Tractors* (North American Council for Freight Efficiency, 2019). https://nacfe.org/emerging-technology/electric-trucks-2/viable-class-7-8/

[172] For CNG

[173] For CNG

[174] For LNG and CNG

	0% to 867% increase[175]	Pollution Probe[176]
Biofuels	1% Parity	Navius[177] NACFE

Table 7. Technology readiness relative to a diesel baseline

Technology	Technology Readiness Relative to a Diesel Baseline	Source
BEV	Low	NACFE[178]
Hydrogen FCEV	Low	NACFE
CNG/LNG/RNG	Parity	NACFE
Biofuels	Parity	NACFE

Table 8. HDV infrastructure availability in B.C.

Technology	Number of HDV Stations in B.C.	Source
BEV	Unknown[179]	Government of Canada[180]
Hydrogen FCEV	4	Government of Canada
CNG/LNG/RNG	21[181]	Government of Canada
Biofuels[182]	3	Government of Canada

[175] For CNG and RNG, respectively

[176] Pollution Probe, *What Does the Future Hold for Natural Gas?* (2019), 45. https://www.pollutionprobe.org/wp-content/uploads/Future-of-Natural-Gas-November-2019.pdf

[177] Navius Research, *Biofuels in Canada 2020* (2020), 37. https://www.naviusresearch.com/wp-content/uploads/2020/10/Biofuels-in-Canada-2020-2020-10-09.pdf

[178] *Viable Class 7/8 Electric, Hybrid and Alternative Fuel Tractors*

[179] 1000 public EV charging stations, but assumed that the majority do not accommodate HDVs

[180] Government of Canada, "Electric Charging and Alternative Fuelling Stations Locator." https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/electric-charging-alternative-fuelling-stationslocator-map/20487#/find/nearest?country=CA

[181] Number of RNG stations is unknown

[182] 20% renewable fuel blend levels or higher

Appendix B. Overview of B.C. policies, programs and funding

Table 9. Current policies, programs, incentives and actions in direct support of HDV decarbonization in B.C.

Policy	Category	Description
CleanBC Communities Fund	Charging/fuelling infrastructure	The CleanBC Communities Fund supports the development of clean energy infrastructure projects in communities across B.C. through cost sharing. $47 million has been allocated to this fund.[183] Projects that increase access to clean energy transportation, such as the deployment of public charging infrastructure or hydrogen fuelling infrastructure, would be eligible for funding.[184] It is unclear whether or not this project supports the building out of supporting infrastructure for HDVs.
CleanBC Go Electric Programs		
Advanced Research and Commercialization (ARC) Program	Research, development and demonstration	The Go Electric Advanced Research and Commercialization program aims to support and promote the ZEV sector in B.C. The program provides funding for eligible companies in the ZEV supply chain to support research, development and demonstration of B.C.-based technologies.[185] The funding call is currently closed.
Commercial Vehicle Pilots (CVP) Program	Research, development and demonstration	The Go Electric Commercial Vehicle Pilots (CVP) program supports businesses looking to deploy commercial ZEVs, including on-road MHDVs (class 3 and above), as well as the

[183] Government of British Columbia, "Investing in Canada Infrastructure Program – British Columbia – CleanBC Communities Fund." https://www2.gov.bc.ca/gov/content/transportation/funding-engagement-permits/funding-grants/investing-in-canada-infrastructure-program/green-infrastructure/cleanbc-communities-fund

[184] Government of British Columbia, *CleanBC Communities Fund – Program Guide* (2020), 11. https://www2.gov.bc.ca/assets/gov/driving-and-transportation/funding-engagement-permits/grants-funding/investing-in-canada/icip-clean-communities-fund-program-guide.pdf

[185] CleanBC Go Electric, "ARC." https://arcbc.ca/

		supporting infrastructure.[186] There is a total of $11 million in funding and applicants are eligible to receive funding support for up to one-third of the total cost of their ZEV deployments and infrastructure projects.[187]
Specialty Use Vehicle Incentive (SUVI) Program	Incentives for deployment	The Go Electric Specialty Use Vehicle Incentive program provides up to $100,000 towards the cost of eligible on-road MHDVs, including low-speed utility trucks, heavy duty transport trucks, and motorcycles.[188]
Hydrogen Fuelling Infrastructure Program	Charging/fuelling infrastructure	The Go Electric Hydrogen Fuelling Infrastructure Program seeks to expand the B.C. hydrogen fuelling network, providing funding for station upgrades and construction.[189] The program is administered in partnership with the Canadian Hydrogen and Fuel Cell Association. The maximum amount of funding available per project was $500,000; however, the funding call is currently closed.[190]
Innovative Clean Energy (ICE) Fund	Research, development and demonstration; Incentives for deployment; Charging/fuelling infrastructure	The Innovative Clean Energy (ICE) Fund in B.C. aims to support the development of pre-commercial technologies, projects and research and development related to clean energy, clean vehicles, and energy efficiency. The program is funded through a levy on certain energy sales, and since 2008, has provided a total of $110 million in funding.[191] Between 2011 and 2017, the ICE Fund provided portion of the funding for the province's Clean Energy Vehicle (CEV) program, which established funding for point-of-sales incentives for clean

[186] CleanBC Go Electric, "Commercial Vehicle Pilots Program." https://cvpbc.ca/

[187] Government of British Columbia, "Go Electric Commercial Vehicle Pilots Program." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program/commercial-vehicles/17208-53529

[188] PlugIn BC, "Specialty Use Vehicle Incentive." http://pluginbc.ca/suvi/

[189] Government of British Columbia, "Go Electric Hydrogen Fuelling Infrastructure." https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program/dcfc-program/hydrogen-fuelling?bcgovtm=AgriServiceBCWebinarandprogramannouncement1

[190] Canadian Hydrogen and Fuel Cell Association, *Request for Proposals: Go Electric BC Hydrogen Fuelling Infrastructure Program* (2019), 8. http://www.chfca.ca/wp-content/uploads/2019/12/CA20191128-BC-CEV-Hydrogen-Fuelling-Program-FINAL-Nov-28.pdf

[191] "Innovative Clean Energy Fund."

		vehicles, the deployment of charging and fuelling infrastructure and fleet support, among other things.[192]
Innovative Clean Energy (ICE) Fund – Sustainable Development Technology Canada (SDTC) Funding Stream	Research, development and demonstration	The B.C. and federal governments formed a partnership in 2017 to develop the ICE-SDTC program to support prototype deployment, testing and commercial-scale demonstration projects of clean energy projects and technologies that can contribute to GHG emission reductions. The program provided a total of $40 million in funding over 2017-2020.[193]
Low-Carbon Fuel Standard (LCFS)	Strategic planning and regulations; Incentives for deployment; Charging/fuelling infrastructure	British Columbia's Low-Carbon Fuel Standard (LCFS) requires fuel suppliers to meet established carbon intensity reductions.[194] Fuel suppliers can generate credits by supplying fuels that fall below the set carbon intensity threshold. These credits can then be invested in clean fuels and vehicles, such as ZEVs and their supporting charging or refuelling infrastructure. In 2019, the ministry proposed updated regulations that would expand the credit market and include entities such as fleets, charging network providers and owners to generate credits alongside utilities and traditional suppliers. The LCFS regulation was officially amended in July 2021, with an effective start date of January 1, 2022 for suppliers.
CleanBC Heavy-Duty Vehicle Efficiency Program	Fleet capacity	The B.C. Government has partnered with the British Columbia Trucking Association to develop the Heavy-Duty Vehicle Efficiency Program. The program includes a one-day course that covers various fuel efficiency measures, including how to develop a fuel management program, fuel-efficient driving techniques, an improved vehicle maintenance program, as well as installing fuel-saving devices. Once companies have participated in the course, they are eligible for a

[192] Government of British Columbia, *Innovative Clean Energy (ICE) Fund: 2016-2017 Performance Report*. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/ice-fund/2016_ice_fund_performance_report.pdf

[193] Government of British Columbia and Sustainable Development Technology Canada, *Call for Applications for the Development of Pre-Commercial Clean-Energy Projects and Technologies*, 7. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/ice-fund/phase_1_applicant_program_guide.pdf

[194] Government of British Columbia, "Renewable and Low Carbon Fuel Requirements Regulation." https://www2.gov.bc.ca/gov/content/industry/electricityalternative-energy/transportation-energies/renewable-low-carbon-fuels

		rebate on the purchase and installation of certain fuel-saving devices, up to $10,000 per vehicle or $100,000 per fleet.[195]
Greenhouse Gas Reduction Regulation (GGRR)	Strategic planning and regulations	The Greenhouse Gas Reduction Regulation was designed to develop the domestic market for natural gas in transportation.[196] The regulation allows public utilities in B.C. to make investments in transportation and infrastructure that supports GHG emissions reductions, including administering grants or zero-interest loans for natural gas MHDVs, as well as funding to construct, own and operate LNG or CNG fuelling stations.[197] Among other changes, 2021 Amendments to the GGRR expanded the cap on renewable gases (e.g. RNG, hydrogen) as a share of gas for utilities to supply, from 5-15%. Overall, the amendments support substantial expansion of renewable gases in the province and provide more flexibility to utilities to make procurement and development decisions.
Weight Allowance for Low-Carbon Commercial Vehicles	Charging/fuelling infrastructure	B.C. is increasing maximum gross vehicle weight of full-size commercial battery electric vehicles and hydrogen fuel cell electric vehicles in order to offset the additional weight of batteries and hydrogen tanks. The province is increasing gross vehicle weight limits by 1,500 kg for battery electric, full-sized commercial vehicles and by 1,000 kg for hydrogen-powered vehicles (i.e., maximum weights of 65,000 kg and 64,500 kg, respectively).[198]
FortisBC: Medium and heavy-duty natural gas truck fleet incentives[199]	Incentives for deployment; Charging/fuelling infrastructure	To incent companies operating MDVs (GVWR 5,360 kg to 11,793 kg) and HDVs (11,793 kg or more) to switch from diesel to natural gas vehicles, FortisBC offers:

[195] BC Trucking Association, "New! CleanBC Heavy-duty Vehicle Efficiency Program." https://www.bctrucking.com/content/new-cleanbc-heavy-duty-vehicle-efficiency-program

[196] Government of British Columbia, "Increasing the Market for LNG and Renewable Natural Gas," March 22, 2017. https://news.gov.bc.ca/releases/2017MEM0011-000790

[197] Government of British Columbia, *Greenhouse Gas Reduction (Clean Energy) Regulation*, Reg 102/201 O.C. 295/2012. https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/102_2012

[198] Government of British Columbia, "Weight Allowance Greenlit for Low-Carbon Commercial Vehicles," May 14, 2021. https://news.gov.bc.ca/releases/2021TRAN0035-000920

[199] FortisBC, "Medium and Heavy-Duty Natural Gas Truck Fleet Incentives." https://www.fortisbc.com/est/truck-fleets/medium-heavy-duty-natural-gas-truck-fleet-incentives

		1. An incentive of up to 50% of the additional purchase price (at least 30% for early adopters in their market segment): additional to what the vehicle operator would be otherwise paying for an equivalent diesel vehicle. 2. A 20% incentive (additional to #1) to build a new fuelling station, or re-fuel at an existing FortisBC fuelling station. 3. For non-early adopters building new fuelling stations, a 20% incentive (additional to #2) for each truck re-fuelling at the station. This program can be paired with the Province's *Heavy-Duty Vehicle Efficiency Program* to reduce purchase costs even further.
FortisBC: Maintenance facility incentive program[200]	Incentives for deployment; Fleet capacity	As a complementary program to the *Medium and heavy-duty natural gas truck fleet incentives*, FortisBC offers an incentive of up to 100% of the engineering, and 50% of the labour and material costs for the construction of, or improvements to, a natural gas vehicle maintenance facility.
Centre for Innovation and Clean Energy	Strategic planning and regulations; Research, development and demonstration	New strategic planning funding came in StrongerBC in the form of $35 million for a Centre for Innovation and Clean Energy. B.C. later announced a partnership investment of $35 million from Shell Canada and $35 million from Natural Resources Canada.[201] The Centre will bring together government, industry and academia to grow the clean technology sector in B.C.

Table 10. Plans and strategies in B.C. relevant to HDV decarbonization

Policy	Description
CleanBC Job Readiness Plan	The prospect of a "Job/Labour/Workforce Readiness Plan"[202] was introduced in CleanBC to address the future skills and occupations required to meet the transition to a low-carbon economy. Public consultation ran in November

[200] FortisBC, "Maintenance Facility Incentive Program." https://www.fortisbc.com/est/truck-fleets/maintenance-facility-services

[201] Government of British Columbia, "Clean Energy Centre to Invest in Low-Carbon Innovation, Drive Emissions Reduction." https://news.gov.bc.ca/releases/2021EMLI0050-001381

[202] Several titles have been attributed to the plan as it undergoes development.

	2019, and featured discussions on green jobs, opportunities and challenges, upskilling, and driving business growth in the transition.[203] The plan remains in development and a release date has yet to be announced. The importance of a just transition for B.C.'s workforce cannot be overstated, and the long-haul trucking sector is no exception. Policies will need to be carefully crafted to avoid pricing-out small and medium-sized trucking companies as the requirements for new technologies grow, and where possible, the job readiness plan will need to address any estimated reductions in the trucking labour force, whether that be due to automation, innovation, rise in nominal prices, or other factors.
B.C. Hydrogen Strategy	The B.C. Hydrogen Strategy was released July 2021 and contains 63 actions detailing the province's short-, medium- and long-term actions to grow the low-carbon hydrogen market from 2020 to 2050.[204] Prior to the updated strategy, the last major analysis completed on hydrogen for the province was by Zen Clean Energy Solutions in 2019.[205] This analysis, along with the federal hydrogen strategy, were used as key sources in the strategy.[206]
B.C. Bioenergy Strategy[207]	The last bioenergy strategy for the province was completed in 2008. CleanBC commitments included the renewal and update of the strategy in 2021.[208] However, the province has yet to announce any plans for release.
B.C. On The Move	B.C. has a 10-year transportation master plan, B.C. On the Move. Strategies included in this plan that are relevant to the HDV sector are centred primarily around infrastructure and safety updates to support popular freight corridors. The only strategy in support of HDV decarbonization is to promote the use of low-carbon fuels, such as natural gas for heavy-duty commercial fleets. No details, however, are provided on how this will occur.

[203] Government of British Columbia, "CleanBC Job Readiness." https://engage.gov.bc.ca/jobreadiness/

[204] Government of British Columbia, *B.C. Hydrogen Strategy* (2021). https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/electricity/bc-hydro-review/bc_hydrogen_strategy_final.pdf

[205] Zen and the Art of Clean Energy Solution, *British Columbia Hydrogen Study: Executive Summary* (2019). https://www2.gov.bc.ca/assets/gov/government/ministries-organizations/ministries/zen-bcbn-hydrogen-study-final-v5_executivesummary.pdf

[206] Government of Canada, *Hydrogen Strategy for Canada* (2020). https://www.nrcan.gc.ca/climate-change/the-hydrogen-strategy/23080

[207] Government of British Columbia, *BC Bioenergy Strategy* (2008). https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/bc_bioenergy_strategy.pdf

[208] Government of British Columbia, "Clean Economy." https://www2.gov.bc.ca/gov/content/environment/climate-change/clean-economy

Table 11. Additional processes and partnerships relevant to HDV decarbonization in B.C.

Program	Description
Clean Power 2040: BC Hydro Integrated Resource Plan	The British Columbia Utilities Commission (BCUC) requires utilities to undergo long term resource planning. B.C. Hydro's current Integrated Resource Plan process began in March 2020 and has run three concurrent consultations processes: one for the general public, one with Indigenous nations in B.C., and another via its Technical Advisory committee (of which the Pembina Institute is a member). The last Integrated Resource Plan was completed in 2013, and this updated process was launched to update B.C. hydro's load forecasting to align with B.C.'s updated emissions reduction goals and consequent projected increases in electricity demand.
BC Hydro Phase 2 Review	Initial recommendations from BC Hydro's Phase 2 review are complete, with future recommendations to be announced at a later date.[209] Current and future recommendations will have significant impacts on fuel options and the regulatory environment available to foster the growth of B.C.'s long-term decarbonization needs for HDVs.
FortisBC Resource Planning: *Long-Term Electric Resource Plan (LTERP)* & *Long-Term Gas Resource Plan (LTGRP)*	FortisBC undertakes updated planning processes for both the LTERP[210] and the LTGRP[211] as required by the BCUC. The last LTGRP and LTERP were completed in 2017 and 2016, respectively. The BCUC requires the upcoming LTERP to be submitted by December 1, 2021 and the next LTGRP by March 31, 2022.
Drive to Zero	B.C. is a pledge partner to CALSTART's Global Commercial Vehicle Drive to Zero program. The pledge requires partners to recognize the importance of reducing GHG emissions in medium- and heavy-duty vehicles, recognize the importance of focusing on 'beachhead' applications in which zero-emission medium- and heavy-duty vehicles

[209] Government of British Columbia, "BC Hydro Review Sets Path for Electrifying Economy, Supporting CleanBC." https://news.gov.bc.ca/releases/2021EMLI0049-001343

[210] FortisBC, "Electricity Resource Planning." https://www.fortisbc.com/about-us/projects-planning/electricity-projects-planning/electricity-resource-planning

[211] FortisBC, "Natural Gas Resource Planning." https://www.fortisbc.com/about-us/projects-planning/natural-gas-projects-planning/natural-gas-resource-planning

	have the most immediate potential, and commit to actions including information sharing, identifying best practices, and co-ordinating globally.[212]
International ZEV Alliance	B.C. is a member of the International ZEV Alliance, a group of jurisdictions seeking to collaborate to increase the international ZEV market and increase policy cooperation.[213]

[212] Global Commercial Vehicle Drive to Zero, "The Pledge." https://globaldrivetozero.org/about/pledge/

[213] International ZEV Alliance, "Members." http://www.zevalliance.org/members/

Table 12. Total B.C. budget provisions to CleanBC

Budget Allocations	Amount
StrongerBC Economic Recovery Plan	$190 million
Budget 2021	$506 million[214]
Budget 2020	$419 million over three years[215]
Budget 2019	$902 million over three years[216,217]

Table 13. B.C. investments (direct and indirect) supporting HDV decarbonization (2019-2021)

Year	Program	Amount
2021	**Total**	**$78.5 million**
2021	SUVI program	$31 million
2021	Further investigation of clean fuels and hydrogen	$10 million
2021	Commercial Vehicle Innovation Challenge	$30 million
2021	LCFS Part 3 Agreement Credits	$7.5 million
2020[218]	**Total**	**$42 million**
2020	Construction and operation of 10 hydrogen fuelling stations, and three years of support for Hydrogen BC[219]	$10 million
2020	Go Electric program	$20 million
2020	Home and workplace charging stations	$5 million

[214] Government of British Columbia, *Budget and Fiscal Plan 2021/22 to 2023/24* (April 2021). https://www.bcbudget.gov.bc.ca/2021/pdf/2021_Budget%20and%20Fiscal%20Plan.pdf

[215] Pembina Institute, "B.C. Budget 2020 Builds on Clean Economy Investments," February 18, 2020. https://www.pembina.org/media-release/bc-budget-2020

[216] Pembina Institute, "After Promising Start, CleanBC Still a Long Way from Finish Line." https://www.pembina.org/op-ed/cleanbc-progress

[217] Government of British Columbia, *Budget and Fiscal Plan 2019/20 to 2021/22* (February 2019). https://www.bcbudget.gov.bc.ca/2019/pdf/2019_budget_and_fiscal_plan.pdf

[218] Government of British Columbia, *Budget and Fiscal Plan 2020/21 to 2022/23* (February 2020). https://www.bcbudget.gov.bc.ca/2020/pdf/2020_budget_and_fiscal_plan.pdf

[219] Government of British Columbia, "Province Invests in Hydrogen to Help Transition to Cleaner Energy," September 10, 2020. https://news.gov.bc.ca/releases/2020EMPR0046-001696

2020	Charging stations for zero-emission buses and heavy-duty vehicles	$5 million
2020	New public fast-charging and hydrogen fuelling stations	$2 million
2019	**Total**	**$29 million**
2019	Incentives for medium- and heavy-duty vehicles, including trucking, port and airport ground equipment, buses, and marine vessels	$10 million
2019	Supporting training programs for automotive technicians and electricians, as well as research and commercialization, in the zero-emission vehicle sector	$6 million
2019	Incentives for the installation of home and workplace charging stations	$5 million
2019	Battery electric vehicle charging stations at highway rest areas and buildings owned by the Province	$5 million
2019	Heavy-duty vehicle efficiency program	$3 million over three years