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Discussion paper for heavy-duty vehicles and engines in Canada: transitioning to a zero-emission future

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Glossary

The terms used in this discussion paper are defined as follows:

Canada's Strengthened Climate Plan (SCP), as described in "A Healthy Environment and a Healthy Economy: Canada's strengthened climate plan to create jobs and support people, communities and the planet."

Greenhouse gases (GHGs) are a group of gases in the atmosphere that trap heat from the sun, preventing it from escaping into space. Common GHGs include carbon dioxide, methane, nitrous oxide and fluorinated gases.

Heavy-duty vehicles (HDVs) include a diverse variety of on-road medium-duty and heavy-duty vehicles that are used across a wide range of activities and includes local delivery vehicles, garbage trucks, buses, long-haul tractor trailers, and others. In Canada, these vehicles are grouped according to their gross vehicle weight rating (GVWR), which is their maximum loaded weight, from lightest to heaviest from classes 2B through 8.

Heavy-duty zero-emission vehicles (HDZEVs) are medium-duty and heavy-duty zero-emission vehicles.

Intergovernmental Panel on Climate Change (IPCC) is an intergovernmental body of the United Nations that is dedicated to providing the world with objective, scientific information relevant to understanding the scientific basis of the risk of human-induced climate change, its natural, political, and economic impacts and risks, and possible response options.

Light-duty vehicles (LDVs) are on-road vehicles with a gross vehicle weight rating (GVWR) of not more than 8,500 pounds.

Net-zero emissions in 2050 means Canada's stated goal of having the Canadian economy achieve, in effect, no emissions of greenhouse gases by 2050 by offsetting, or capturing, our emissions by an equal amount. In realizing this goal, it is expected that some economic sectors, facilities, institutions and other sources will continue to emit at levels that, while likely lower than current rates, would be balanced by negative emissions elsewhere in the economy.

Retrofits referenced in this document is the addition of, or the replacement of an existing part with, a device or technology resulting in reduced emissions from the use of the vehicle.

Zero-emission vehicles (ZEVs) are on-road vehicles that are capable of producing zero exhaust emissions of criteria pollutants or greenhouse gases while operating. Zero-emission vehicles include plug-in hybrid, battery electric and hydrogen fuel cell vehicles.

Purpose

The purpose of this discussion paper is to begin consultations on the federal approach to further reducing Canadian emissions from medium-duty and heavy-duty vehicles (HDVs). The objective of the consultations is to identify an approach for reducing emissions from the sector in a manner that is consistent with Canada's emissions reduction targets of a 40% to 45% reduction in greenhouse gas (GHG) emissions below 2005 levels by 2030 and reaching net zero emissions by 2050.

To facilitate this conversation, the paper provides an overview of road transportation and the HDV sector and why further action is required, discusses the existing *Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations* in Canada and the need for more stringent regulatory options, and the drivers, opportunities and barriers associated with accelerating the adoption of medium-duty and heavy-duty zero-emission vehicles (HDZEVs) in Canada.

In 2020, the Government of Canada's Strengthened Climate Plan (SCP) called A Healthy Environment and a Healthy Economy, committed the government to improve the efficiency of HDVs standards post-2025 by aligning with the most stringent standards in North America – whether at the United States federal or state level.

The SCP also committed the Government to conduct stakeholder consultations on measures to increase the supply of, and demand for, HDZEVs in Canada to ensure businesses have access to the types of ZEVs that meet their needs.

More recently, the Government committed to launch consultations on developing emissions standards for heavy-duty vehicles that are aligned with the most ambitious standards in North America, and requiring that 100 percent of selected categories of medium-duty and heavy-duty vehicles be zero emission by 2040. This commitment is broadly aligned with the approach being taken by California.

In addition, the government is seeking input on how to encourage early adoption of HDZEVs and the near-term opportunities to reduce emissions from the current fleet of HDVs during this transition.

This discussion paper supports discussions on the topics mentioned above.

Introduction

The Intergovernmental Panel on Climate Change (IPCC), of which Canada is a member, has recently reported that emissions from human activities are unequivocally causing the atmosphere, ocean and land to warm, resulting in widespread and rapid changes across the climate system that are unprecedented over many centuries to many thousands of years[1].

[1] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change[Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press.In Press

Canada is taking action across all sectors in order to meet its commitment under the Paris Agreement to reduce national GHG emissions by 40% to 45% below 2005 levels, by 2030. It is also committed to reaching net-zero emissions by 2050. Canada has made progress towards meeting our climate goals, but there is more work to do.

To meet its targets, Canada will need to significantly reduce emissions from HDVs in the medium-term with the goal of accelerating the transition of the entire fleet to ZEVs as soon as the technologies and availability of these vehicles will allow.

Some zero-emission heavy-duty vehicle types are more advanced in terms of their technology readiness level and product availability than others. As the availability of zero-emission HDV products increases, there is an opportunity to accelerate the transition to HDZEVs, as is being done in other jurisdictions in Europe and North America. There are several key considerations in addition to vehicle supply, including the integrated nature of the North American market, the deployment of charging and refuelling infrastructure, the need for education and training of fleet managers and drivers, and ensuring that HDZEVs can work reliably in Canada.

Canada's road transportation sector and heavy-duty vehicles

Class	GVWR (lb)	Vehicle Examples
2B	8 501 to 10 000	Utility van, Full-size pick-up, Step van
3	10 001 to 14 000	Walk-in, Conventional van, City delivery
4	14 001 to 16 000	Large walk-in, Conventional van, City delivery
5	16 001 to 19 500	Large walk-in, City delivery, Bucket
6	19 501 to 26 000	Beverage, Single-axle van, School bus, Rack
7	26 001 to 33 000	Furniture, City bus, Medium conventional
8	33 000 +	Dump, Cement, Heavy conventional, COE sleeper

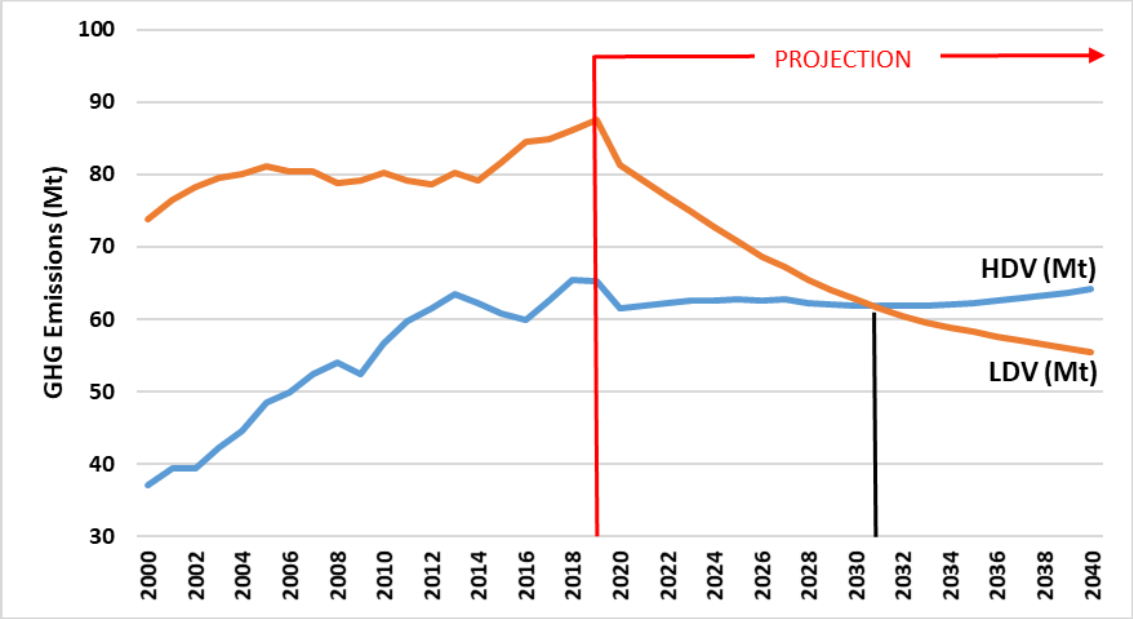
Road transportation is an integral part of Canadian society and the economy. Our personal vehicles allow us to run errands and provide us the freedom to move for work and for play. While perhaps less apparent to most, heavy-duty vehicles also touch all of our lives daily. They allow our economy to operate on a day-to-day basis by delivering the food we consume and the products that we enjoy. Light-duty vehicles (LDVs) are currently responsible for about half of Canada's transportation emissions, closely followed by HDVs. Tailpipe emissions from the transportation sector as a whole are the second largest source of GHG emissions in Canada, currently only slightly less than emissions from the oil and gas sector, and are responsible for 25% of Canada's total GHG emissions.

The Government of Canada has implemented many transportation-related initiatives to make road transportation cleaner and more efficient. HDVs are subject to progressively more stringent regulations, but emissions from the sector have continued to rise and are projected to steadily increase in the future as the number of HDVs on the road grows to meet the increased demand for the services that they provide.

Overall the on-road HDV population has increased by about 57% since 2005[2]. Currently there are more than 2 million HDVs on Canadian roads and this number is increasing by an average of about 2% per year. HDVs are composed of a diverse variety of vehicles that are used across a wide range of activities and includes local delivery vehicles, garbage trucks, buses, long-haul tractor trailers, and others. As the HDV fleet grows, they are also travelling more total kilometres, leading to higher emissions from the sector. This is despite regulations, which have reduced emissions from each vehicle, and efforts by the trucking sector to reduce fuel consumption, switch to cleaner fuels, and adopt measures to improve efficiency. If these trends continue, the HDV sector is projected to become the largest source of GHG emissions from transportation in Canada by around 2030 (figure 1).

In addition, HDVs tend to have a long useful life. This is particularly pronounced for certain types of vehicles, such as modified specialty vehicles. This makes it difficult to reduce the GHG emissions from the HDV sector quickly, and underscores the importance of beginning the transition as soon as possible. Also, since the HDVs currently on the road will comprise a significant proportion of the on-road fleet for many years, it will be important to consider ways to reduce emissions from our existing fleet until they are replaced with HDZEVs – such as through retrofits, driver training or other measures.

Figure 1: Canada's HDV and LDV GHG emissions – real[3] and projected[4]



As seen in figure 1, transportation emissions from the LDV sector are projected to drop to significantly over the next 20 years, this is due primarily to the projected increases in fuel efficiency of on-road vehicles, which is driven by the federal GHG regulations for LDVs. Other initiatives taken by provincial and territorial governments and the Government of Canada, such as carbon pricing, also have a significant impact and is helping to drive this decrease. This will cause the existing stock of light-duty vehicles to be replaced with more efficient gasoline and

[2] Canada's official greenhouse gas inventory
[3] Canada's 2021 National Inventory Report Data 1990-2019
[4] Canada's Fourth Biennial Report on Climate Change

diesel vehicles, as well as with an increasing share of zero-emission vehicles. Unfortunately, the market penetration of HDZEVs is occurring at a much slower rate, especially in the commercial trucking sector.

Increased Ambition to 2030

Ambitious action in the transportation sector is needed to meet Canada's 2030 and 2050 targets. The HDV fleet must transition to HDZEV in order to significantly reduce emissions from the transportation sector.

National GHG trends in Canada since 2005 show that total GHG emissions from electricity and heavy industry have declined, while GHG emissions from transportation and the oil and gas sector continue to increase (figure 2). In particular, emissions from the large and intensively used fleet of HDVs have continued to rise.

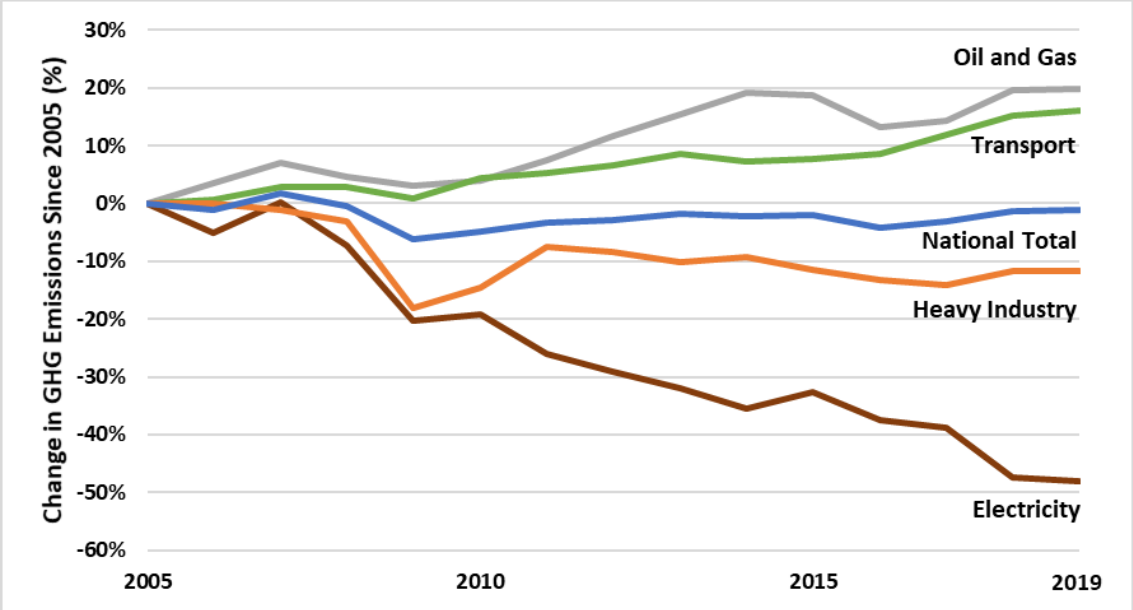
In addition to contributing to the fight against climate change, reducing GHG emissions from HDVs and transitioning to HDZEVs will have air quality benefits. Cleaner air is important for all Canadians, but this shift will be particularly beneficial to those who live or work in or near areas where HDVs are intensively used, such as adjacent to busy highways, ports and shipping hubs[5]. These residents currently suffer higher rates of asthma and have increased cancer risks as a result of their current exposure to diesel exhaust from HDVs. Transitioning the fleet to HDZEVs is expected to be of most benefit to those communities.

Owners of HDZEVs will also benefit from reduced operation and maintenance costs and drivers would benefit from improved driver comfort resulting from the powerful, quiet and clean operating characteristics of these vehicles. Their green and clean profile may even help fleets that adopt HDZEVs to attract and recruit drivers, an important consideration given the current acute driver shortage.

However, challenges to the widespread adoption of these vehicles remain, including their high initial capital cost. For long distance transport vehicles, there are range constraints relative to traditional diesel or gasoline-powered vehicles, and a lack of a widespread battery charging and hydrogen refuelling infrastructure. And as previously mentioned, currently, the supply of HDZEVs available for purchase is limited.

[5] Daniel Sperling, Lew Fulton & Vicki Arroyo, Accelerating Deep Decarbonization in the U.S. Transportation Sector, in Zero Carbon Action Plan 188 (New York: Sustainable Development Solutions Network 2020).

Figure 2: National GHG trends in Canada 2005-2019 by sector[6]



Regulatory options for heavy-duty vehicles

Greenhouse gas emissions from heavy-duty vehicles in Canada are currently regulated by the *Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations* made under the *Canadian Environmental Protection Act, 1999* (CEPA)[7]. These regulations are aligned with those of the United States Environmental Protection Agency (U.S. EPA), which has historically been the case for all transportation emission regulations in Canada. Aligning Canada's emissions regulations with those of the United States has provided efficiencies for industry and supported the competitiveness of Canadian manufacturers, given the integrated nature of manufacturing and distribution of vehicles in North America. In February 2021, President Biden and Prime Minister Trudeau agreed to take aligned and accelerated policy actions to achieve a zero-emission vehicle future.

In its SCP, Canada committed to "further improve the efficiency of heavy-duty vehicles standards for post-2025 by aligning with the most stringent standards in North America – whether at the United States federal or state level."

At the federal level, the U.S. EPA has announced its Clean Trucks Plan[8] to reduce GHG emissions and other harmful air pollutants from heavy-duty trucks through 2 rulemakings over the next 3 years. A first rule, to be finalized by the end of 2022, will apply to HDVs beginning in 2027 and will set new standards for criteria pollutants as well as targeted updates to GHG emissions standards for certain segments of the HDV sector. A

[6] *National Inventory Report 1990 – 2018*
[7] Canadian Environmental Protection Act, 1999
[8] U.S. Environmental Protection Agency Clean Trucks Plan

second rule, to be finalized by July 2024, would set more stringent GHG emission standards for new HDVs for the 2030 model year and beyond. Canada will continue to work with all of our American partners and consider how to implement the more ambitious of the U.S. EPA or California Air Resources Board (CARB) standards to help meet Canada's GHG targets.

Currently the most stringent GHG HDV regulation in North America is California's Advanced Clean Trucks (ACT) regulation[9]. This was adopted at the state level by the CARB and complements their GHG regulations that align with the U.S. EPA federal regulations. The ACT regulation, which is the first of its kind in the world, will require manufacturers to sell between 5-9% of HDZEVs beginning in 2024 depending on the class of HDV, and up to between 30-50% by 2030. For 2035 and beyond, ZEVs as a percentage of annual sales must be a minimum of 40 to 75%. This regulation is the latest in a series of rules by California that aim to reduce air pollution and GHGs by 40% below 1990 levels by 2030 and is intended to support Governor Newsom's 2020 Executive Order N-79-20, to develop and propose strategies to achieve 100% ZEV short-haul and drayage trucks by 2035 and a full transition to ZEV buses and heavy-duty long-haul trucks by 2045, where feasible[10].

Among other considerations, new strengthened regulations must meet the objective of significantly reducing GHG emissions from the sector in a manner that is aligned with Canada's 2030 emissions reduction target, while providing benefits to all Canadians, including to businesses that operate in Canada. The department will examine flexibilities that could be incorporated in future regulations. For example, the department will consider how these more stringent performance-based emission standards and sales requirements would apply to small volume manufacturers, the use of a credit and deficit system to provide compliance flexibility for manufacturers, and allowing credits for low-emission vehicles. There may also be opportunities to allow for early action credits for future compliance obligations and recognition for early adopters and manufacturers that are making the transition to HDZEVs now, in advance of any regulations.

The process that produces these regulations will be transparent and collaborative. The regulations will provide certainty for investors and be implemented according to timelines that allow vehicle manufacturers to make business decisions with respect to production so they can provide these vehicles to the market.

Transitioning the HDV fleet in Canada towards a net-zero future

This paper is focused on measures underway and others needed to decarbonize the HDV sector in a manner that is aligned with Canada's 2030 and 2050 emissions reduction targets by accelerating the adoption of HDZEVs. The Government recognizes that actions are needed in addition to regulations, such as investments, testing and setting standards. The Government of Canada welcomes input on any measures that enable this transition.

To incentivize greater ZEV adoption by businesses, the federal budget in 2019 provided for a 100% write-off for zero-emission vehicles. Under this program, eligible ZEVs for the tax write-off include a motor vehicle that is a plug-in hybrid, with a battery capacity of at least 7 kWh, or vehicles that are fully electric or fully powered by hydrogen, including light-duty, medium-duty and heavy-duty vehicles purchased by a business. On March 2,

[9] California Air Resources Board Advanced Clean Trucks regulation
[10] https://ww2.arb.ca.gov/resources/documents/zero-emission-road-medium-and-heavy-duty-strategies

2020, the Government also expanded a 100 per cent tax write-off for business investments in eligible ZEVs to include a wider array of eligible automotive equipment and vehicles.

In addition, Canada is a signatory to the International Drive to Zero pledge[11], which defines a "Beachhead Strategy" to the medium-duty and heavy-duty vehicle transition. Over the next five years, the project and its participants will focus on sharing information, identifying best practices, eliminating barriers, and coordinating among stakeholders to ensure success of the beachhead markets in China, India, Mexico, South America, Canada, the European Union and the United States[12]. This strategy, which recognizes different rates of adoption expected in various vehicle classes, will inform the Government's approach as we accelerate the adoption of HDZEVs.

The HDZEVs models that are currently on the market represent many common vehicle types and include large pick-ups and vans, delivery trucks, drayage and short-haul tractors, school and transit buses. Some classes of HDV, such as transit buses, are rapidly electrifying with some of these vehicles on the road now and many more anticipated. Near-term regulatory and non-regulatory measures will be initially stronger for these segments of the HDV sector. For example, the Government of Canada is already investing to electrify transit and school buses.

ZEV models for certain vehicle types, such as for walk-in step vans and some specialty applications such as refuse trucks, are still in early production and testing. ZEV options for vehicle types that must travel long distances between charging or refuelling, such as long-distance intercity buses and long-haul tractors, are being developed and are not currently available in significant quantities. Given the unique technical challenges for these types of vehicles, they may be slower to make the transition to ZEV over the next few years.

In sectors where there is limited deployment of HDZEVs in Canada[13], the Government intends to consult with partners, conduct research and gather data to ensure that they are fit for purpose and will work across Canada's diverse climate and geography before requiring that they be adopted through regulation. Ensuring that these vehicles are safe and reliable is crucial, particularly in applications where there are long distances between destinations with limited access to repair facilities. Demonstrating the abilities of these vehicles will remove a barrier to their adoption.

Most current HDV manufacturers are working to expand their capabilities to produce HDZEVs or related technologies, and this is expected to double the number of available models in North America in the next few years. Organizations such as Canada's Smart Prosperity Institute have identified HDV manufacturing as one of the major strategic innovation opportunities for Canada. Canada's $8 billion Strategic Innovation Fund/ Net Zero Accelerator Initiative is already investing in several innovative manufacturing plants.

As the number of available HDZEV models and the quantity of units for purchase increases, so should their adoption. Future more stringent HDV regulations in Canada will take into account the technological readiness of HDZEV solutions for each class and application of HDV. And Canada will support HDZEV supply and provide manufacturers with a predictable long-term path to meet the requirements and the needs of the market.

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[11] Global commercial vehicle drive to zero
[12] https://globaldrivetozero.org/about/pledge/
[13] ICCT Report – RACE TO ZERO How manufacturers are positioned for zero emission commercial trucks and buses in North America

The U.S. Argonne National Laboratory recently projected the total cost of ownership (TCO) for vehicles with different powertrains for model years 2020 and 2025.[14] It considered the costs of finance, fuel, insurance, maintenance and repair, taxes and fees, and payload in addition to the capital cost. Generally, it projects that future retail vehicle prices for HDZEVs will be higher than their diesel-powered equivalent vehicles, but also that the fuel, maintenance and repair costs would be lower for HDZEVs than for diesel HDVs.

The same study analyzed the average 10-year per-mile cost of driving for traditional diesel-fuelled vehicles compared to hybrid electric, plug-in hybrid, fuel-cell electric vehicles and battery electric vehicles for model year 2025. It found that for a class 4 delivery truck, a battery electric truck was the lowest-cost option at $1.01/mile with a diesel delivery truck costing about $1.15/mile. When comparing a tractor with a sleeper cab, a hybrid electric vehicle was found to have the lowest cost to operate, followed closely by a diesel-powered tractor. However, other studies have found that a class 8 electric truck operated 300 miles per day when compared to a diesel truck has a TCO that is about 13% lower[15]. It is expected that some HDZEVs will have a TCO that is less than that of diesel-fuelled vehicles, but depending on how the vehicle is used and a host of other factors this may not immediately apply to all segments of the HDV sector. As battery prices decline and energy densities improve the TCO of HDZEVs will be further reduced.

Charging and fuelling infrastructure is also an important consideration and is one of the key barriers to ZEV adoption, and the Government is committed to facilitating the development of a widespread network of charging and refuelling infrastructure. Funded through Budget 2019 and the 2020 Fall Economic Statement, the Zero Emission Vehicle Infrastructure Program (ZEVIP) is a 5-year $280 million program to address the lack of charging and refuelling stations in Canada. Among other things, the program supports infrastructure deployment for on-road and off-road commercial and public fleets.

HDZEVs will include both electric and hydrogen-powered vehicles and the creation of adequate charging and refuelling points for both of these will address a major barrier to their broad adoption.

As demand for electricity from these vehicles accelerates, it will be necessary to ensure that the grid is ready to supply and distribute significantly more clean electricity. Likewise, expanding clean hydrogen production capabilities will also be required. Canada is a world leader in zero-carbon power, and can use this clean power advantage to drive our economy when providing Canadian-made clean electricity and hydrogen to refuel these vehicles.

Supply and demand for HDZEVs will both need to grow in Canada. Working with partners, stakeholders and operators, the Government of Canada intends to identify measures to support the transition to HDZEVs.

As the transition to HDZEVs occurs, we will also need to address the emissions from the fleet that is on the road today and that will continue to be used for many years. Lower carbon fuels, driver training and supporting the adoption of technologies that reduce fuel consumption are concrete measures to reduce emissions from the on-road fleet. An example of a program that has done this is the Green Freight Assessment Program (GFAP).

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[14] Argonne National Laboratory. Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains. 2021. https://publications.anl.gov/anlpubs/2021/05/167399.pdf Pages 112 - 115.

[15] International Energy Analysis Department - Energy Analysis and Environmental Impacts Division, Lawrence Berkeley National Laboratory, *Why Regional and Long-Haul Trucks are Primed for Electrification Now*, A. Phadke, A. Khandekar, N. Abhyankar, D. Wooley, D. Rajagopal, March 2021.

Launched in 2018, the Government of Canada has invested $3.4M over 4 years to help companies make data-driven investment decisions to reduce their emissions and fuel costs.

Conclusion

Canada's Strengthened Climate Plan shows that the Government of Canada is committed to building a clean economy and attaining our climate goals. This includes meeting or exceeding our 2030 GHG reduction commitments, and achieving net-zero emissions in 2050. The strategy to accomplish this will include new measures to reduce GHGs from HDVs and make a successful transition to a zero-emission future. Some key considerations in this regard are that new measures be implemented in a timeframe that achieves Canada's GHG objectives, while continuing to grow the economy, and that businesses continue to have access to workable options for meeting their transportation needs.

The Government of Canada is committed to working with the provincial and territorial governments, Indigenous Peoples, industry, non-governmental organizations and all interested or affected Canadians as we define the best path forward to reduce GHG emissions from the HDV sector in Canada and meet our commitments for HDVs.

Questions and considerations

The Government of Canada would like to receive input from all interested and affected parties to inform decision-making. While all input is welcome, the department has identified several key questions it would like to receive feedback on. For each of the below considerations, we seek input that advances the objective of meeting Canada's 2030 target of reducing greenhouse gas emissions from 40% to 45% below 2005 levels by 2030 and ensuring net-zero emissions by 2050. The results of these consultations will give more detailed insight on how best to reduce emissions from heavy-duty vehicles to address Canada's climate commitments.

If you are responding to these questions, please provide a rationale for your views and supporting evidence. As on-road medium-duty and heavy-duty vehicles are used across a wide range of activities, when possible, please specify the vehicle class or intended use on which you are providing input. You are invited to provide written comments to infovehiculeetmoteur-vehicleandengineinfo@ec.gc.ca. We request that all written input be sent prior to January 21, 2022, so that it may be considered and form the basis of future consultations. If you would like to receive future correspondence from the department related to this topic please also indicate this in your written response.

Regulatory approach:

1. Canada has historically aligned its heavy-duty vehicle GHG regulations with those of the U.S. EPA. What will be the challenges and the benefits of also aligning with the sales targets in the California ACT?
2. What classes and uses of HDV are now technically ready, or close to being ready, for adoption and an HDZEV-specific sales requirement? What criteria should go into that assessment of readiness? What is the lead time that would be appropriate for those classes? What other elements or measures are required to enable a swift transition to HDZEVs over the coming decades and meet our climate change commitments? What regulatory flexibilities would ease the transition?
3. What challenges and opportunities do you foresee for your organization as Canada accelerates the transition to HDZEVs? Please provide suggestions to ease the transition and capture the benefits.
4. What issues impede adoption of ZEVs in Northern and remote communities?

5. If you are a First Nation, Inuit or Métis individual, organization or government, what are your suggestions or concerns regarding the transition to HDZEVs and the issues raised in this paper?

Supply and demand:

6. How should the requirements factor in anticipated growth in supply? What lead times should be considered when targets are being set?
7. What are the key near-term measures that should be adopted to increase the Canadian supply of HDZEVs? If your organization produces or uses HDZEVs, address the types of vehicles that your organization produces or uses.
8. What level of certainty is required to support investments in production capacity?
9. What are the key near-term measures that should be adopted to increase the Canadian demand for HDZEVs? If your organization produces or uses HDZEVs, address the types of vehicles that your organization will produce or use.
10. What measures could increase Canadian production of HDZEVs? What are the roles of the public sector in increasing production?
11. In the next five to ten years, how do you see HDZEV products and technologies evolving and the commercial readiness of the HDZEVs? If your organization uses HDZEVs, address the types of vehicles that your organization will use.

Costs and Benefits and Barriers:

12. Generally, what are the key hurdles you see to transitioning the fleet to HDZEVs in the coming decades, and how can these be overcome? What are the key opportunities and how can these be captured?
13. What do you project for the expected total costs of operation of HDZEVs, in particular in comparison to an equivalent diesel powered vehicles? The work done by the Argonne National Laboratory, or equivalent Canadian analysis, may provide a framework for your response.
14. Is the prospect of building charging/refuelling infrastructure for your operations a deterrent to adoption?
15. Is the lack of public charging/refuelling infrastructure a barrier to the adoption of HDZEVs in your community or business? How can that be addressed?
16. How do you foresee those costs changing over the coming decade?
17. What type of financing would allow you to adopt HDZEVs by covering the higher upfront costs of HDZEV vehicles and charging infrastructure? For example, would you use loans paid back from reduced operating and maintenance costs?
18. What benefits to you see to implementing HDZEVs, such as cleaner air and better working conditions?
19. What particular concerns do you have regarding the suitability of HDZEVs in Canada given our climate, geography, provincial and territorial weight and dimension requirements, or other Canada unique factors? Please specify according to class and intended use, if possible.
20. Are there gaps in technical standards, for example for fuelling equipment?
21. What types of demonstrations would be useful to address technical or operational uncertainties, both right away and in the longer term? Specify according to vehicle class and intended use if possible.
22. What types of education and awareness programs, or activities for fleet owners and drivers, would be most effective in providing information and building confidence in these types of vehicles?

Research and information:

23. What technologies and research gaps regarding vehicle and fuelling infrastructure do you see as a priority?
24. If you have or will gain experience operating HDZEVs, or information on operating and maintenance costs, would you be willing and able to share information and data, especially on costs and operation in Canadian conditions?
25. If you have or will gain information on charging/fuelling infrastructure, would you be willing and able to share it?

Non-regulatory measures:

26. What are the roles of the private sector, research institutions, electrical utilities and the public sector play in advancing HDZEVs? Who should coordinate their efforts?
27. What additional measures other than regulations and demonstration projects could be implemented in the immediate term between now and 2030 to support decarbonizing the existing fleet and transitioning to a zero-emission future? For such non-regulatory measures, please indicate to whom it would be beneficial and most effective (e.g. provinces and territories, municipalities, manufacturers, fleet owners), and indicate which type of HDVs should be targeted first and in which timeframe. For example, should "proof of concept" pilot projects to reduce HDV emissions or advance ZEV deployment in urban centres be supported, or regional projects such as the hydrogen pilot in Alberta.

Retrofitting the on-road fleet:

28. For the current on-road fleet, what role can aftermarket retrofits play to support and complement the broader effort towards decarbonizing on-road transportation? Ideally, how would such a program be designed?
29. How can the Government work with industry to encourage the adoption of retrofits for the fleet of today without diverting investment decisions to HDZEV alternatives?

Next steps

After the comment period for this discussion paper has ended, the feedback received will be consolidated into a report summarizing what we heard and will be published.

The Government of Canada has commenced a series of virtual engagement sessions with stakeholders related to some of the issues raised in this paper. The Government is interested in gathering perspectives to inform a comprehensive federal strategy with the goal of addressing the challenges and opportunities associated with advancing and accelerating HDZEV deployment in Canada.

These engagement sessions will be followed by ongoing consultations on strengthening Canada's HDV regulations and other non-regulatory measures needed to make the transition to HDZEV.

If you would like to participate in future consultations, please indicate this in your correspondence with us, while also indicating your area of interest, if applicable, as well as your preference regarding how you would like to be consulted.