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Background and Policy Directions for Decarbonizing Canadian Road Transportation

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Introduction

When Canada signed the Kyoto Protocol, the federal government committed to a 30% reduction in greenhouse gas (GHG) emissions below 2005 levels, by 2030. In November 2020, the federal government also introduced bill C-12, the *Canadian Net-Zero Emissions Accountability Act*, intended to legally bind the government to a process to achieve net-zero emissions by 2050 (Government of Canada, 2020). These are valiant goals to address climate change in Canada, but time is running out to make the necessary changes to meet these targets and, more importantly, to combat the snowballing effects of climate change. In his book *The Citizen's Guide to Climate Success*, Mark Jaccard explains there is near consensus that decarbonization can occur at a modest cost, yet there is no traction to adopt the necessary policies (Jaccard, 2020). The inertia in the global system to develop effective environmental policy means 2ºC of warming, if not more, is likely inevitable (Jaccard, 2020). In order to have a timely response to rising GHG emissions, the world needs to quickly decarbonize the electricity and transportation sectors (Jaccard, 2020).

Our interest is focused on the reduction of GHG emissions from private passenger vehicles, delivery and long-haul transportation trucks, and urban surface transit in the Canadian transportation sector. The findings and recommendations consider the implementation and effects of policies in the next 10 years. The next decade will be a critical time period for environmental policies given the urgency for a response to climate change and the impending deadlines of emission reduction commitments. The intention of this document is to relate selected studies to the issue of re-focusing support for a decarbonized transportation, while taking into consideration the current and predicted Canadian economic, political, and social context.

The development of transport-related markets and the state of the Canadian economy, as a result of the COVID-19 pandemic response, lead to three prominent themes to be considered when recommending GHG reduction policies for the next decade.

1. Transportation Markets at Different Levels of Maturity
2. Budget Challenges
3. Equity Considerations

This analysis will highlight how the effectiveness of current GHG reduction policies are affected by the realities of the transportation markets and the state of the national economy. It will also recommend adaptations to current policies that take these themes into account, in order to aid policy makers in refocusing support for reducing Canadian road transportation GHGs.

Current Canadian Policy Environment

Key policies to reduce the GHG footprint of private vehicles in Canada currently include zero-emission vehicle (ZEV) purchase subsidies, private charger purchase subsidies, support for public electric vehicle (EV) charging stations, corporate average fuel economy (CAFE) standards, a low-carbon fuel standard (LCFS), and internal combustion (IC) vehicle phaseouts. Though fuel efficiency regulations and low-carbon fuel standards are both federal measures, the other measures may be federal, provincial or even municipal, in the case of charging station subsidies. Carbon taxes, which focus solely on GHG emissions, will also make ZEVs more attractive by raising the user cost of fuel. The relative cost-effectiveness of these instruments is a matter of continuing research.

Attention has also turned to supporting purchase of non-IC buses and long-haul trucks. This also includes support for the public charging network. All levels of government support transit in many ways, including, most recently, support for the associated charging network and vehicle purchase.

1. Transportation Markets at Different Levels of Maturity

This document focuses on passenger vehicle, delivery and long-haul transportation truck, and urban surface transit markets. Though urgency is required to decarbonize each market, the decarbonization strategies will differ. Ideal policy instruments are different when ZEVs are a novelty and have limited market penetration versus having a rising market share and a well-established market. In Canada, the market for passenger ZEVs has been transitioning and is now rapidly moving toward becoming a self-sustaining market. The electric delivery and long-haul truck market is at a different level of maturity as there has not been the same broad development in electrifying truck fleets. Therefore, policies should be targeted to the given context of each transportation market in order to more efficiently reduce GHG emissions.

1.1 Passenger Vehicle Market

In the early stages of passenger ZEV production, the cost of a ZEV relative to an IC vehicle was much higher. Consumers were dissuaded by the novelty and higher price of the ZEV, resulting in low vehicle sales and limited market penetration. Purchase subsidies became a natural and straightforward policy to increase ZEV sales under the rationale that price was the most prominent purchasing barrier. However, the current market reveals the cost of a ZEV relative to an IC vehicle has been decreasing, yet ZEVs still have limited market penetration. In a model to determine the temporary and permanent impacts of these purchase subsidies, Irvine (2017) reveals subsidies cannot be validated with the logic of the form “they get the market over the hump” as the model’s equilibrium of ZEV sales over time was not impacted by the presence of subsidies. Purchase subsidies are becoming anachronistic, and this leads to questions about how effective subsidies will be at increasing ZEV market share in the coming decade, particularly as the prices of IC and ZEV vehicles are expected to converge in the near future. With the lower operating cost of EVs, existing purchase subsidies will lead to an increasing proportion of EV purchasers that are free-riders, meaning the receipt of the subsidy will not have convinced them to purchase the EV.

1.2 Policy Recommendation

Research shows that broad demand barriers of ZEVs are high upfront costs, low consumer awareness of EV technology, limited public charging availability, and not having access for charging at home, for example residents of apartments or condominiums (Melton et al., 2020). A ZEV's battery range and charging speed are also common demand barriers for consumers. However, many of the features that drove early ZEV adoption decisions, in particular the features that persuaded consumers not to purchase a ZEV, have changed or are expected to change in the near future. Specifically, consumer pessimism about ZEV battery technology has led to new research that is exploring the effect of broadening the public charging network on ZEV market share. A robust and technologically advanced charging network could address the availability and speed of charging, as well as concerns about the vehicle's battery range. In an analysis of policies for decarbonizing transportation, expanding a public charging network was given a top ranking for "transformational signal", meaning it could effectively stimulate a market transition to ZEVs (Melton et al., 2020). Furthermore, in a comparison of a U.S. tax credit policy and subsidizing charging station deployment, researchers determined subsidizing charging station deployment required equal-sized spending, but could have been more than twice as effective in promoting EV adoption (Li et al., 2017).

Springel (2017) estimates there is a strong positive connection between ZEV purchasing and the vehicle price, but also between purchasing and charging station availability. Therefore, in the short term, utilizing public funding to expand the public charging network can be an effective policy to increase ZEV market share. Since 2016, the Canadian government has invested $226.4 million to build new recharging and refuelling infrastructure, and, to date, 433 charging and fuelling stations have been built with more than 800 are currently under construction (Government of Canada, 2020). In its 2020 Fall Economic Statement, the federal government proposes to accelerate this work by providing $150 million over 3 years to Natural Resources Canada, starting in 2021-22 (Government of Canada, 2020). This funding should be provided to provinces against a provincial performance criterion in order to efficiently distribute funds to provincial markets. Continuing to expand the public charging network should increase the attractiveness of ZEVs and create a positive feedback loop, where more ZEVs on the road utilizing the charging network will increase the profitability of the public charging network.

1.3 Delivery and Long-Haul Truck Market

In 2018, 6% of registered vehicles in the U.S. were medium-duty and heavy-duty trucks, yet these trucks accounted for 23% of transportation GHG emissions (Roberts, 2020). Freight transportation sources account for 42% of Canadian transportation and are expected to surpass passenger vehicle emissions by 2030 (Kim & Smith, 2020). This disproportionate emissions production means targeting policies to decarbonize the truck transportation sector could have a noticeable impact on reducing GHG emissions. Unlike the passenger vehicle market, the delivery and long-haul truck market is still in the early stages of electrification. The challenge of decarbonizing this market dwarfs the challenge of the passenger vehicle market. It is assumed less viable electric technology exists for long-haul freight transportation, which creates the need for targeted policy strategies in this sector (Lepitzki & Axsen, 2018). Furthermore, the COVID-19 pandemic has created a massive surge in online shopping, which has resulted in a significant increase of delivery and long-haul truck transportation (Kim & Smith, 2020). However, the current transportation policies show no plan for controlling this unprecedented growth in truck transportation, and the market transformation has been slow (Kim & Smith, 2020). Given the limited electric vehicle technology available to the truck market and the increased use of this transportation, a swift and innovative plan needs to be established.

1.4 Policy Recommendation

The delivery and long-haul truck sector faces a number of barriers to electrification, with the most prominent being the high upfront cost of electric technology for truck fleets. Cost considerations for fleet owners are not limited to the cost of a single electric truck relative to a single diesel truck (Roberts, 2020). Electrifying an entire fleet is a complicated process that involves purchasing and installing new charging infrastructure and changing operational procedures, in the face of considerable uncertainty and risk (Roberts, 2020). Given the disproportionate emission production compared to passenger vehicles, the stage of this market, and in the absence of research on the distributional effects of subsidies on trucks, one could expect targeted government investment and subsidies to be progressive for electrifying this sector. Commitment from federal or provincial government could reduce the uncertainty and risk for fleet owners and further grow the roots of this transition. Other barriers like preparation of regional electrical grids, lack of road performance data, and fleet owners having well-established supply chains for diesel engines will become less daunting as this transition accelerates and the electric truck market matures (Roberts, 2020).

As ZEV technology for the truck sector develops, including both battery electric and possibly hydrogen fuel cell vehicles, a LCFS can have a large role in decarbonizing the sector (Lepitzki & Axsen, 2018). Altering the carbon intensity of fuel already being used by truck fleets provides a strategy to reduce GHGs without having to transform an entire fleet’s technology infrastructure.

If a less carbon intense fuel can be produced in the short-term, a LCFS could be a bridge policy during the transition of electrifying truck fleets. Kim and Smith (2020) also outline a comprehensive approach to effectively transition truck fleets to electric and note that a multi-level government response with long-range planning and regulation is necessary for policies to be consistent and implemented in an accountable and transparent manner. While many policies are likely to improve uptake of ZEV technology in this sector, there is less consensus about the cost-effectiveness of alternative instruments.

2. Budget Challenges

After the response to the broad and damaging economic impacts of the COVID-19 pandemic, the Canadian government posted a large national budget deficit in 2020. Concern will soon turn to reigning in the budget deficit, which will impact how public funds are allocated in the coming decade. Specifically, the case for cash supports for private ZEV purchases seen in the past will likely be weakened by the reality of scarcer public funds. Policy makers will need compelling reason to provide additional financial support in the midst of a pandemic. Returning to the intention of this document, re-focusing any available financial support to decarbonization strategies that are less reliant on the public purse is therefore preferred.

This scarcer public funding as a result of the COVID-19 pandemic, coupled with the maturing of the passenger ZEV market and falling prices of ZEVs relative to IC vehicles, provides further evidence for subsidies being anachronistic. Jaccard (2020) explains the cost of transformation to electric transportation is lower if the country is open to the widest range of policy options. He finds regulation in the market and carbon pricing will help drive the impetus for further innovation and private R&D versus a publicly-funded moon shot (Jaccard, 2020). Policy makers need to look beyond the familiar purchase subsidy and consider more innovative approaches. Focusing on regulatory policies is an approach that requires limited public funding as change is mandated, rather than incentivized by cash supports. We focus on three regulatory policy instruments in this section:

- ZEV mandate
- corporate average fuel economy (CAFE) regulation
- low carbon fuel standards (LCFS)

The following discussion recommends adjustments to the current application of these policies and considers how an IC vehicle phaseout could be combined with these regulatory approaches in the long run. While phasing out private vehicles now seems reasonable in the medium run, in the short run, the focus should be reducing the prevalence and carbon intensity of kilometres driven by these vehicles.

2.1 Regulating Vehicle Manufacturers

ZEV mandates can increase ZEV market share without requiring reliance on public funds. By mandating that a certain percentage of new vehicle sales be ZEV, manufacturers are induced to sell more ZEVs, so as not incur loss of revenue or penalty. Likewise, overachieving manufacturers can gain revenue by selling the credits they receive from exceeding the target rates. Therefore, the burden of persuading consumers to purchase ZEVs is placed on the promotional efforts of the manufacturers, rather than the public purse. Wigle (2019) demonstrates that a ZEV mandate is relatively more costly than the economically ideal policy of a revenue neutral carbon tax. However, a ZEV mandate becomes more cost effective if consumers' pessimism about EV performance and operating cost is factored into the modeling (Wigle, 2019). This does not override the argument that a ZEV mandate is more costly, but highlights the extent to which the policy can be used effectively (Wigle, 2019). ZEV mandates are not fully cost-effective, but they are more so than other regulatory regimes that do not afford the same flexibility. One of the concerns about ZEV mandates is whether their incentives interact with those of existing CAFE regulation. There is concern that, to the extent that ZEV mandates relax the CAFE constraint, automakers can produce more high-emitting vehicles. The eventual target for a ZEV mandate is to require all personal vehicles be ZEVs. This could coincide with an IC phaseout deadline. This interaction with CAFE regulation is likely to be enhanced as both CAFE targets and ZEV mandates converge on zero IC vehicles.

CAFE regulations contribute to GHG reduction by also inducing manufacturers to produce and sell a higher proportion of low-emitting vehicles. Plus, this policy offers more regulatory flexibility as the calculation of a manufacturer's performance depends on the composition of its vehicle fleet between fuel-efficient and fuel guzzlers. Manufacturers have incentive to sell more vehicles with high fuel economy in order to decrease the average fuel economy of its entire fleet and avoid needing to purchase credits from manufacturers who exceed the CAFE target. Manufacturers who sell mostly zero- or low- emitting vehicles have an opportunity to either sell more high-emitting vehicles or sell CAFE credits. Tesla, which produces only ZEVs, generates significant income from its sale of CAFE credits.

Both ZEV mandates and CAFE regulation are flex-regs and are thus more cost-effective than their non-flexible equivalents.

In the U.S., Milovanoff et al. (2020) highlight that immediate and continued improvements in new vehicle fuel consumption for conventional vehicles are a keystone for ambitious climate targets in the short run. The CAFE standards contributed to decreasing the average fuel consumption of new vehicles in the U.S. from 12.3 to 9.3 litres per 100 km between 1980 and 2017 (Milovanoff et al., 2020). However, the authors note that reducing vehicle GHG emissions cannot be achieved through ZEV expansion alone (Milovanoff et al., 2020). Though these findings are from U.S. road transportation, the stark contrast between current and required ZEV market share is applicable for the Canadian market. It is here that a strict CAFE regulation can have a meaningful impact on GHG emission reductions, especially in the short run. The CAFE system currently uses a footprint-based approach, which allows larger vehicles to have lower fuel economy. This provides perverse incentives to increase or maintain the size and weight of IC vehicles (Irvine, 2017).

Besides the perverse incentives of CAFE regulation on the size and weight of IC vehicles, there is also interaction of the ZEV and CAFE regulations. ZEVs may be scaled up in the CAFE calculations (Irvine, 2017). This leads to more incentive to sell ZEVs, but, as CAFE regulations and ZEV targets tighten, what Irvine (2017) defines as the credit multiplier effect becomes more prominent. Therefore, if a ZEV mandate and CAFE policy are simultaneously implemented, manufacturers could capitalize on decreased average fleet emission from the mandated ZEV production to earn credits that could be applied to increase the sales of high-emitting vehicles. In the worst-case scenario, implementing these two regulatory policies intended to reduce GHGs will, in fact, increase GHG emissions.

2.2 Policy Recommendation

In recent years, CAFE regulation has been harmonized with California's tighter standards. Changing Canadian CAFE standards independently is challenging given the desire to rationalize vehicle production for the North American market. So, in the near term, tightening CAFE standards and ZEV mandates may be the only workable option. Nonetheless, given the cooperative attitude of the current Canadian and U.S. governments and the desire to significantly decarbonize the vehicle fleet, we would argue that ZEV targets, CAFE regulation, and IC vehicle phaseouts should be harmonized into one instrument. Our preference is to use the well-understood CAFE mechanism. An IC vehicle phaseout can be managed in a relatively cost-effective way by announcing a time path of CAFE standards that end with a zero or near zero final target in a chosen year. This would obviate the need to coordinate three measures all aimed primarily at the same target: decarbonizing the vehicle fleet. In the interim, regulation for these two policies needs to be aligned to reap the benefits of flexibility, while limiting the possibility for manufacturers to capitalize on the negative feedback loop. The policies need to be implemented in a coordinated manner where the targets from both are combined into one measure. This alignment should also reduce the administrative costs and increase the incentives for the regulation.

2.3 Decarbonizing Vehicle Fuels

A number of studies have found Canada's Clean Fuel Standard (CFS) to be an effective policy approach that does not require significant government spending. This strategy regulates fuel producers to decrease the carbon intensity of the fuel IC vehicles consume. As in the ZEV mandate and CAFE regulations, trading allows flexibility and gives all producers symmetric incentives to reduce the GHG content of their fuels. In the near term, the CFS is providing GHG reduction benefits and allowing a flexible response for refiners.

2.4 Policy Recommendation

ZEV mandates, CAFE regulations, and LCFS regulations are each operational and have had a record of reducing GHG emissions of vehicles. In analysis modeling the abatement cost for specific combinations of GHG reduction policy instruments, Rivers and Wigle (2018b) find a policy package with LCFS regulation and a relatively weak ZEV mandate is an appropriate strategy for Canada in the near term. The modeling revealed that when these instruments are combined in a policy package, the marginal abatement cost (MAC) curve drops below the MAC curve of each policy if implemented alone (Rivers & Wigle, 2018b). In the longer term, as ZEV and CAFE targets tighten, the CFS will become progressively less relevant and crucial as the demand for the volume of liquid fuels falls.

3. Equity Considerations

ZEV purchase subsidies have been commonly used to increase ZEV market share. However, if this policy instrument continues to be pursued, not only will it be increasingly difficult to justify the public spending, it will also perpetuate economic and social inequity. An analysis of the U.S. federal income tax credits reveals that “clean energy” tax credits are unevenly distributed across low and high-income households (Borenstein & Davis, 2015). The bottom 3 quintiles received approximately 10% of the credits, while the top quintile received approximately 60% of the credits (Borenstein & Davis, 2015). This discrepancy was most extreme for tax credits aimed at electric vehicles, as the top quintile received 90% of the credits (Borenstein & Davis, 2015). The authors note there may be political considerations that favour a tax credit system, but the approach comes at a real cost, both in terms if efficiency and equity (Borenstein & Davis, 2015). Irvine (2017) notes, from an equity standpoint, subsidies essentially require taxpayers-at-large to “bribe” polluters to change their behaviours or purchase decisions, in contrast to user-pay policies like a carbon tax that directly put the onus on the polluters. In the early stages of increasing ZEV market share, higher income households were the most likely to adopt ZEVs, so it was reasonable to focus support where it would be the most effective. However, purchase subsidies will be increasingly expensive if low-income households are progressively targeted for ZEV purchases. Since purchase subsidies will come under increased scrutiny due to national budget pressures, the added concern about the distribution of their benefits should raise concern.

If any subsidies are to be provided, we argue that private vehicle purchase seems the lowest priority. Alternative approaches targeting earlier stage technologies that also generate wider benefits, like better access to, and reduced cost of, public transit, should move up in priority. Providing public support for public transit can generate more equitable benefits, as opposed to allocating public funds to subsidize private ZEV purchases.

3.1 The Potential of Electric Buses

GHG emissions per passenger-km from public buses is only moderately less than that of a private passenger vehicle. Buses operate on diesel fuel, which is more carbon intense than petroleum, and buses are not constantly at capacity, which decreases the emissions efficiency of this mode of transport. Therefore, given the carbon intense fuel and potential emissions inefficiency, fostering the transition to electric bus fleets can be an effective strategy to long-term reduction in GHG emissions. The Toronto Transit Commission (TTC) estimates electric buses could reduce fuel usage by 70% - 80% and save $50 - $70 million in fuel annually, while reducing 150 tonnes of GHG emissions per bus per year (Chung et al., 2020). Furthermore, Milovanoff et al. (2020) make it clear that electrification of light-duty vehicles is not a silver bullet for meeting emissions budgets. A combination of mitigation policies is required that could include moving from technology-oriented to activity-oriented policies to provide better alternatives for private passenger vehicles, such as deployment of new public transport options and subsidies for public transportation (Milovanoff et al., 2020).

Improved public transportation systems are also economically and socially equitable. Unlike the ownership costs of private vehicles, public transportation is an affordable commuting option that can be accessed by households in any income range. The 2016 Canadian Census also revealed that New Canadians are overrepresented as users of public transit as "immigrants accounted for 24% of all commuters, but 40% of commuters using public transit" (Government of Canada, 2020). In a gender comparison, the data revealed women were more likely to use public transit than men, as immigrant women represented 60% of all immigrant public transit users, but only 48% of immigrant commuters, and non-immigrant women are also more likely to use public transportation than non-immigrant men (Government of Canada, 2020). The findings from this census demonstrate the equity of public transportation services goes beyond just household income. Implementing policies to support electrifying bus fleets and bolstering their service will have meaningful benefits for socio-economic groups that are over-represented and typically marginalized.

3.2 Barriers to Electric Buses

Like delivery and long-haul truck fleets, the most prominent barrier to transitioning bus fleets to electric technology is the high upfront costs. A single electric bus can cost between $200,000 - $500,000 more than a diesel powered bus (Chung et al., 2020). Bus fleet owners would need to purchase entire fleets of these expensive electric buses, while also establishing the expensive charging infrastructure that has the capacity to meet the heavy usage demands (Chung et al., 2020). The TTC received $140 million from the Public Transit Infrastructure Fund that resulted in bringing 60 electric buses online, but $70 million of the funding was used for buying and installing the charging infrastructure (Chung et al., 2020). These costs will be offset over time as electricity costs are cheaper, electric buses have fewer parts resulting in maintenance that is approximately 25% cheaper, and, "as with many new technologies, the cost of electric buses is also falling over time" (Chung et al., 2020). However, when fleet owners are faced with such a stark and intimidating difference in upfront cost, it is reasonable to assume these offsetting future costs will be discounted.

Even if fleet owners are in a financial position to make the transition, there is still an element of uncertainty and risk with electric buses. Canada has yet to have an electric bus in service for the typical 12-year lifespan, and the TTC also finds there are only 3 suitable manufacturers for long-range bus that would be required for a city the size of Toronto (Chung et al., 2020). With only a small number of electric buses on the road over a short period of time, there is limited data on how this alternative technology holds up over time. With only 3 viable manufacturers, fleet owners may find the available technology does not fit the needs of the organization and delay purchasing to when there are more options available. Ultimately, both cases stall the transition to electric buses. A report by Clean Energy Canada also acknowledges staff capacity and expertise, working relationship with local utility provider, flexibility to adapt to rapidly changing technology, and universality and interoperability of the new technology are potential barriers to bus electrification (Clean Energy Canada, 2020). This suggests not only are there financial and information barriers, but also operational barriers resulting from changes at multiple points along the supply chain.

A February 2021 Clean Energy Canada note welcomes recently announced federal funding for transit. Such funding could be expanded and/or focused even further on the operational investment necessary to increase staffing capacity and train service personnel or for developing a strategy for the increased electrical grid capacity with utility providers. Kim and Smith (2020) explain that increased transparency and certainty on the long-term renewal of government financial incentives would increase the ability for truck fleet owners to plan their transition to electric technology. The same rationale can be applied to bus fleets, where transparency, certainty, and long-term support from the federal and provincial governments allow fleet owners to plan the necessary transition steps. The transparency and long-term investment in either sector could also offer valuable R&D spillover and increase the speed of technology development. Clean Energy Canada defined the universality and interoperability of electric vehicle technology as a prominent barrier because "the lack of standardization in the technology risks locking transit agencies into a specific manufacturer or supplier or requiring further investment in the future if they decide to change" (Clean Energy Canada, 2020). With more resources being applied to R&D in both sectors, it may be possible to increase electric vehicle technology standardization and foster more confidence in fleet owners to invest in transitioning their fleets, thereby contributing to the widespread transition to electric technology.

3.3 Policy Recommendation

Given the upfront costs, limited information, and broad system changes required to accommodate electric buses, it is understandable why fleet owners would be dissuaded from transitioning to electric bus technology. However, this should not dissuade policy makers from continuing to implement strategies necessary to make this transition. The barriers of electric bus fleets will prevail unless stakeholders of this transition are willing to coordinate their efforts to reduce costs, share information, and support organizational partners. The federal government needs to continue investing in electric bus projects by providing funding to support fleet owners and public transit agencies overcome these barriers. This recommendation does echo the argument made for purchase subsidies for passenger ZEVs in that government spending should get the electric bus market “over the hump”. However, in the case of bus fleets, the government spending could be utilized in multiple avenues, not just purchase subsidies. Government funding would be employed to establish the entire electric bus system. The CEO of the Canadian Urban Transit Research and Innovation Consortium outlines potential government funding will not only be for incentives to motivate transit systems to make the switch, but also for feasibility studies, technology to collect and share data on performance, and “incentives to encourage Canadian procurement to build the industry in Canada” (Chung et al., 2020). The funding would have more reach and impact by catalyzing an improved public transportation system that has reduced GHG emissions and that broadly benefits Canadians at all socio-economic levels.

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