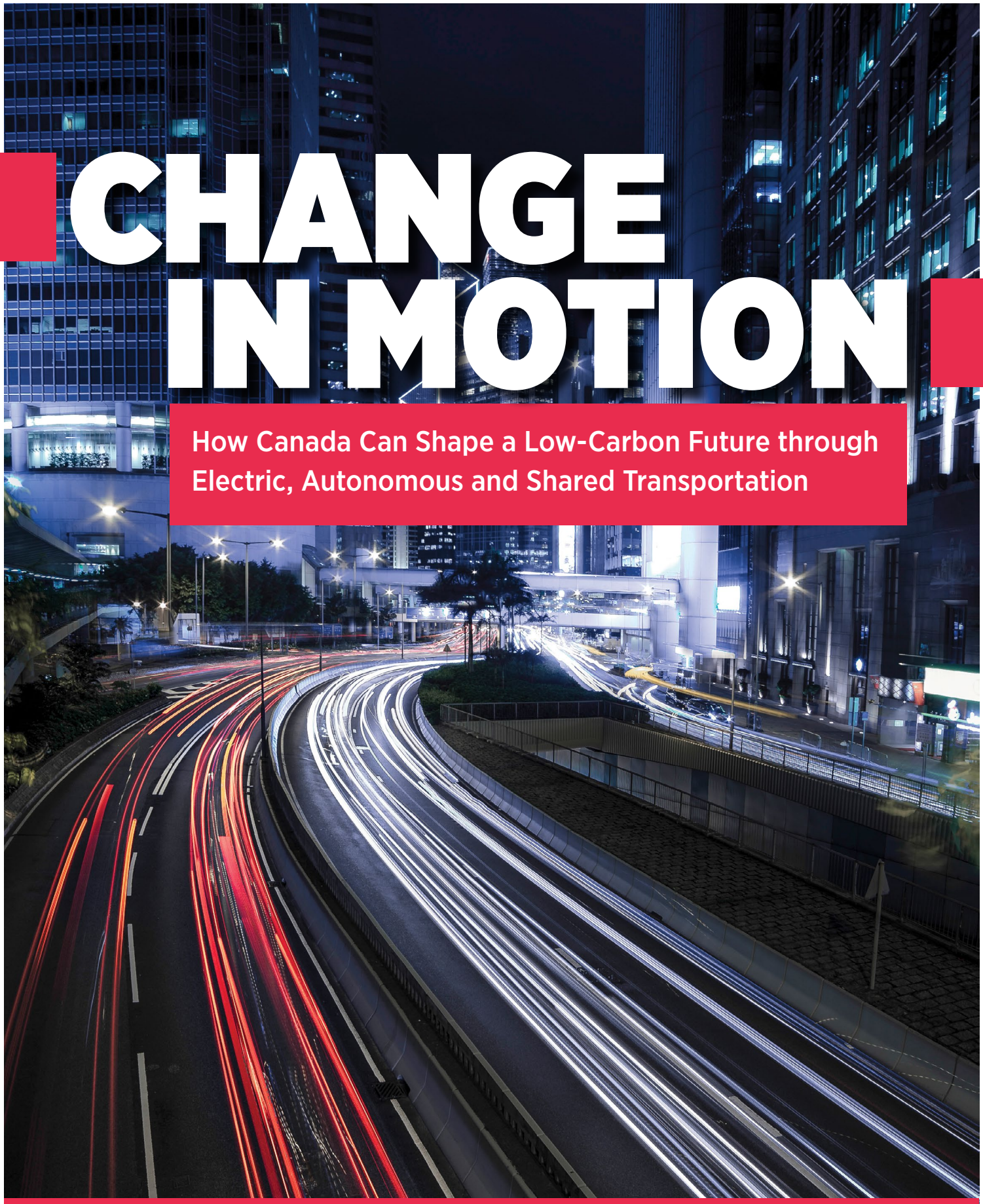

CHANGE IN MOTION

How Canada Can Shape a Low-Carbon Future through Electric, Autonomous and Shared Transportation

Your Energy Future

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Finally, this report is dedicated to the newest additions of our task force group family, whose future will be shaped by what Canada decides to do at this defining moment.

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It is 2050 – looking out over a major Canadian city, you see a gridlocked highway filled with empty cars. Everyone owns an autonomous vehicle that travels long distances for personal use or to run errands without any passengers. In some areas of the city, roads are flooded from extreme storms caused by climate change. In this grey, concrete maze, public transit is decrepit and seldom used. Where there used to be sidewalks and bike lanes, there are just more roads. Is this the world in which we want to live?

Without responsible public policy, the advent of electric, shared, and autonomous vehicles (AVs) could lead to a future we have described above. Fortunately, Canada has the resources and ingenuity to harness a brighter future for personal mobility, if supported by a national policy framework. The imperative for the federal government to act has never been clearer: sales of electric vehicles (EVs) are growing, ride-sharing services are challenging the traditional taxi business, and AVs are being tested on our roads. Even car manufacturers are moving away from a vehicle ownership model to one of mobility as a service (MaaS). What is more important, almost one-quarter of Canada's total greenhouse gas (GHG) emissions stems directly from the transportation sector. Without controlling and reducing emissions from transportation, it is conceivable Canada may never reach its GHG reduction targets and commitments made under the Paris climate agreement.

Although the pace of adoption and disruption is uncertain, it is clear that EVs, AVs and shared vehicles have the potential to transform how we live and work. Our report is primarily focused on ensuring these disruptions do not increase GHG emissions and that we maintain livable cities throughout this change. This new world is coming, but due to jurisdictional divisions and political differences, our country still operates a patchwork of policies, incentives, and regulations that could be significantly improved by a national policy framework.

Therefore, this report proposes a policy 'stack' to ensure a national policy framework led by the federal government in partnership with provinces, territories, municipalities, and Indigenous governments. It is important to note that this report focuses on urban environments – especially large cities – that are most exposed to rapid changes in personal mobility. Consequently, the policy stack recommended in this report would be implemented at different levels of jurisdiction. Although we acknowledge that the advent of EVs, AVs, and shared vehicles will have impacts on rural, remote, and Indigenous communities, this report focuses on recommendations to adapt to this transition in an urban context.

The first tier of the stack is a set of policy recommendations aimed at steering consumer behaviour. The second tier of the stack is a set of accelerating policies aimed at providing options to support consumers in changing their behaviour more rapidly or reducing the negative impacts of technology currently in use. The third tier of the stack is a set of policies aimed at protecting against undesirable consequences, such as rising GHG emissions, that could stem from emerging new technologies created for a more convenient and efficient transportation system. In our study, we propose that GHG emissions reductions can be achieved through improving one or more of three variables: fuel choice, vehicle efficiency, and user behaviour. The following policy recommendations aim to reduce at least one of these variables.

Steer Consumer Behaviour

Dynamic Mobility Pricing in Urban Areas: A federal tax on distance travelled would require road users to pay the full cost of their presence on the road.

Time-of-use Electricity Pricing: Time-of-use pricing encourages EV charging primarily at times when there is surplus power available on the grid.

Reform & Strengthen the Federal Excise Tax on High-Polluting Vehicles: Encourage consumers to purchase more fuel-efficient vehicles such as EVs by applying a progressive tax to the highest-emitting vehicles as rated by Natural Resources Canada.

Accelerate Supporting Investments

Continuous Improvement in Vehicle Fleet Efficiency Standards: Extend and strengthen Canada's existing fleet efficiency standards to generate ongoing efficiency improvements beyond 2025 and to encourage automakers to increase EV adoption.

Clean Fuel Standard: Advance policy development toward the implementation of a Clean Fuel Standard across conventional and alternative fuels.

Canada Infrastructure Bank (CIB) Investment in EV Charging: Leverage the CIB to support a massive buildout of EV charging infrastructure across Canada, including strategic investments in next-generation charging.

Protect Against Undesirable Consequences

Clear Operating Standards for AVs: All levels of government should consider the need for appropriate standards governing low-occupancy AV operation. Such standards could be based on geography or time-of-use, and could also encourage connections with existing transit systems.

Encourage Higher Vehicle Occupancy Encourage AV owners and fleet operators to make efficient use of road infrastructure and energy systems by implementing either a surcharge on low- and zero-passenger distance travelled, or by allocating a limited number of credits for each vehicle.

The policy stack outlined above was developed through literature research, impact analysis, expert stakeholder interviews, and an innovative community engagement game with Canadians that simulated these policies over time. The following report reflects what we heard during the past year and provides key policy recommendations for the Government of Canada and other levels of government.

If Canada moves quickly, our country can seize a brighter future for personal mobility. In so doing, it is not far-fetched to imagine that with a robust policy framework for EVs, AVs, and shared vehicles, Canada will be able to achieve many important outcomes: meeting our Paris agreement targets, improved personal mobility and productivity, better transportation safety, and healthier livelihoods. Ultimately, Canada has a distinct opportunity to lead and create this brighter future.

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LIST OF ACRONYMS

AV - Autonomous Vehicle
BIA - Business Improvement Area
CIB - Canada Infrastructure Bank
EV - Electric Vehicle (inclusive of hybrid, plug-in hybrid, and battery electric vehicles)
GHG - Greenhouse Gas
GTF - Gas Tax Fund
ICE - Internal Combustion Engine
MaaS - Mobility as a Service
R&D - Research and Development
SFU - Simon Fraser University
SUV - Sport Utility Vehicle
T&D - Transmission & Distribution
VDT - Vehicle Distance Travelled
ZEV - Zero-Emissions Vehicle

INTRODUCTION

Every day, Canadians depend on transportation to move goods and people within cities and across the country. As a result, transportation now represents the second largest source of greenhouse gas (GHG) emissions in Canada, accounting for 24% of total national emissions.[1] The transportation sector is at the beginning of a major transformation – electric vehicles (EVs) are decreasing in price,[2] multiple companies are investing in autonomous vehicles (AVs), and people are choosing to rent time in a vehicle rather than own one. In this report, we focus on how to ensure disruptions to personal mobility in Canada have a positive impact on GHG emissions. It is important to note that the goal of this report is not to incent the adoption of emerging technologies, but to examine their impact and suggest policy recommendations that would result in an overall reduction in GHG emissions.

While public transportation and behaviour change initiatives will be vital in the transition to a low-carbon future, three drivers of change – electrification of personal vehicles, the advent of autonomous driving vehicles, and the proliferation of shared mobility – are at the forefront of this rapid transformation in transportation. These technological changes are far-reaching and provide many opportunities and challenges. We anticipate these changes will progress without government intervention. However, without appropriate management, EVs, AVs, and shared vehicles could end up increasing GHG emissions instead of reducing them. Because of these critical uncertainties, policies are needed to ensure a smooth technological transition to reduce GHG emissions and ultimately meet our national and international targets under the Paris climate agreement.

Around the world, sales of EVs vary significantly by region and country, with an estimated global EV fleet of two million vehicles.[3,4] Although no country has made a complete transition from conventional gasoline or diesel vehicles to EVs, countries such as Norway and the Netherlands are leading the way. In the Canadian context, there are approximately 34 million total vehicle registrations, but EVs make up only 45,000 of the vehicles on the road.[5,6] Further, approximately 0.9% of new market share sales were EVs, sold mostly in Quebec, Ontario, and British Columbia, the three Canadian provinces

1 Environment and Climate Change Canada. "Greenhouse Gas Emissions" April 13, 2017.

2 Greentech Media, "Study: We're Still Underestimating Battery Cost Improvements" August 2017.

3 By comparison, there are approximately just over one billion internal combustion engine vehicles estimated on the road. See: Sousanis, John. "World Vehicle Population Tops 1 Billion Units" August 15, 2011. WardsAuto.

4 International Energy Agency. "Global EV Outlook 2017" November 2017.

5 Stevens, Matthew. "Electric Vehicle Sales in Canada, Q3" November 7, 2017. FleetCarma Telematics solutions for Fleets, Utilities, Sustainability and Research.

6 Statistics Canada. "Vehicle Registrations, 2016" June 29, 2017.

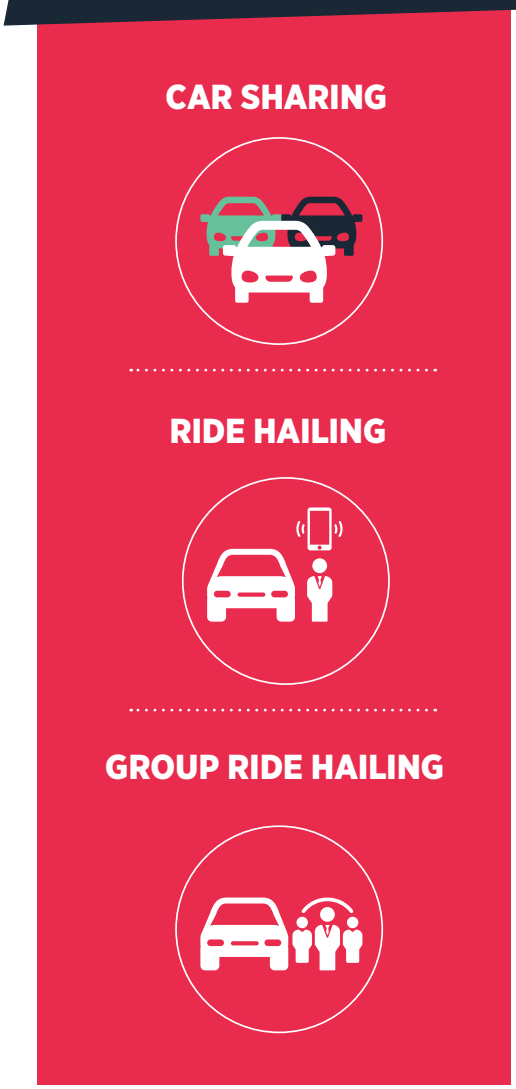
that currently offer EV subsidies.[7] It is worth noting that while subsidies contribute to EV adoption, AVs could be a driving force for the widespread adoption of EVs around the world. Indeed, AVs are more cost-efficient and user-friendly if built on EV technology. Although discussions and policies are often focused on EVs, it is likely other emerging technologies, such as hydrogen and biofuel vehicles, will be contenders for a share of the personal mobility market.

As AVs rapidly develop, the primary barriers to adoption are related to the ability of stakeholders to handle commercial and governance complexities.[8] In fact, some jurisdictions are already testing AVs on their roads.[9]

There are myriad potential societal benefits from AVs, for example, eliminating human error in driving, thereby reducing injuries and fatalities from road accidents. But there are also significant risks, such as an increase in vehicular travel, potential job losses, and increased congestion in response to new highly affordable mobility options, which could increase GHG emissions.

In addition to technological advances, we are already seeing other emerging trends in the transportation sector such as shared mobility that will continue to grow in an electrified and autonomous transportation future. Shared mobility can be divided into two types: individual-based mobility and group-based mobility.Individual-based mobility includes car-sharing[10] (e.g., Car2Go) and ride-hailing (e.g., Uber),[11] which primarily offers an alternative to private car ownership and does not necessarily lead to higher vehicle occupancy. Group-based mobility includes group ride-hailing (e.g., Uber Pool), which is a technologically enabled form of carpooling that increases vehicle occupancy.

Emerging Shared-use Mobility Modes



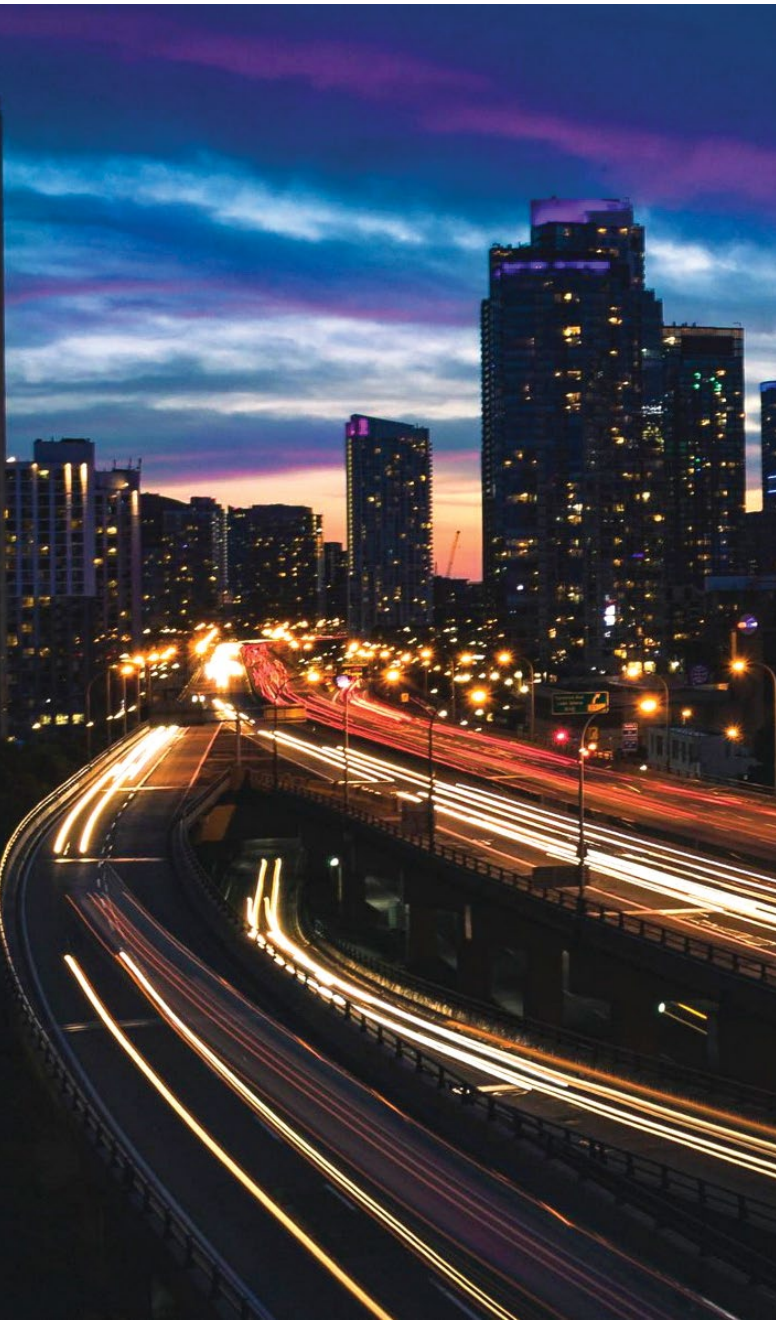
7 Stevens, Matthew.

8 Ernst & Young Global Limited. “Deploying autonomous vehicles” 2014. Accessed November 18, 2017.

9 Crawford, Alison. “Canada running to keep up with fast-moving developments in self-driving car technology” September 28, 2017. CBC News.

10 Car-sharing is a model of vehicle rental where people rent cars for short periods of time, often by the minute, offering short-term access to transportation on an as-needed basis.

11 Ride-hailing refers to transportation from an alternative taxi service.



In a future where there could be fewer gas-powered vehicles,[12] it will also be important to consider the impact on government revenues.

If gas tax revenues decrease without the introduction of a new revenue stream, the government may not be able to cover required investments in road infrastructure and other programs which provinces and municipalities depend on.

The goal of this report was to discuss, evaluate, and propose policy options for governments at all levels to reduce Canada's GHG emissions from personal mobility, while ensuring adequate financing of the required infrastructure. To that end, we investigated the future of personal mobility in 2050 by addressing two research questions:

i) What policies are needed to adapt to changes in personal vehicle systems in a manner that reduces GHG emissions?

ii) What types of public investments are necessary and how can these be financed most effectively and equitably?

Considering our research questions, we have developed three clear policy goals that serve as guiding principles for this work. First, we aim to shape consumer behaviour to reduce vehicle distance travelled (VDT) in an electric, autonomous, and shared future. This goal targets the "user behaviour" portion in Figure 1. Second, we aim to reduce GHG emissions per kilometre travelled by increasing fleet efficiency and switching to low-emission fuel sources. This goal targets the "fuel choice" and "vehicle efficiency" portions of Figure 1. Third, we aim to provide adequate funding solutions for necessary transportation infrastructure to ensure Canadians are prepared for this technology disruption.

Overall, our report provides timely policy recommendations for all levels of government to ensure Canada remains competitive, innovative, and environmentally responsible.

12 McCullough, Michael. "Car use declining in North America" August 7, 2012. Canadian Business.

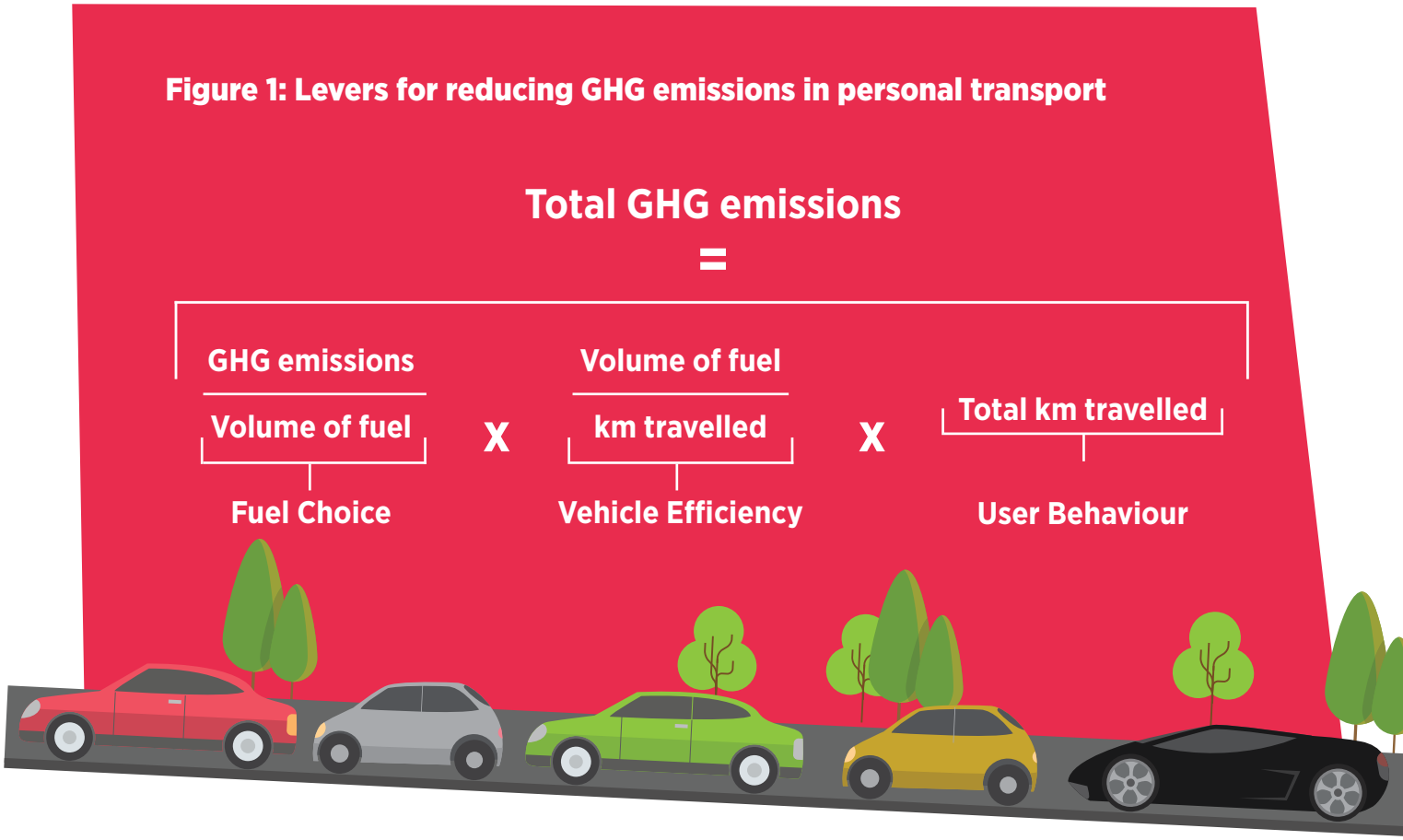
ENVIRONMENTAL SCAN

CALCULATING GHG EMISSIONS FROM TRANSPORTATION

Total GHG emissions from a particular mode of transportation can be calculated as a product of fuel choice, vehicle efficiency, and user behaviour, as highlighted by the devised framework in Figure 1. GHG emissions from transportation cannot be successfully reduced unless all three variables are managed together. For example, EVs reduce emissions per kilometre significantly, even on the highest carbon electricity grids. [13] However, current EV owners report an increase in the number of trips due to reduced operating costs,[14] potentially resulting in an increase in overall GHG emissions.

Building on the framework devised in Figure 1, our policy recommendations in this report all aim to reduce at least one of these factors while avoiding increases in the others.

Figure 1: Levers for reducing GHG emissions in personal transport



13 Axsen, Jonn et al. "Canada's Electric Vehicle Policy Report Card" November 2016. Simon Fraser University.

14 Ibid.

How far can you drive with 10 kilowatt hours of energy?

Losses from energy production and delivery included

14KM COMBUSTION ENGINE  Nissan Versa

54KM ELECTRIC  Nissan Leaf EV

MAJOR OPPORTUNITIES RESULTING FROM DISRUPTION

Improved Efficiency

EVs are more efficient than internal combustion engine vehicles as electricity can be more readily converted to mechanical energy than energy from direct combustion. In fact, the energy conversion efficiency of electricity is nearly five times greater than that of gasoline.[15] Furthermore, regenerative braking technology recovers a portion of energy lost to heat when applying the brakes on EVs.[16] This improved efficiency results in dramatically reduced energy use. For example, a 2016 Nissan Leaf EV uses 74% less energy than a comparable Versa subcompact vehicle with an internal combustion engine.[17]

In the future, it is likely AVs will be primarily deployed as EVs as a result of better technological alignment between electric drivetrains and vehicle automation technologies, as well as the lower maintenance, energy, and insurance costs of these vehicles.[18] Therefore, further improvements in efficiency are expected to be realized through electric autonomous vehicles.

Decreased GHG intensity (changes in GHG emissions of input fuels)

In addition to improved efficiency, EVs offer the advantage of using electricity, a generally lower-emitting source of fuel in Canada. It is projected that even in provinces with the most carbon-intensive grids, EVs will reduce GHG emissions significantly.[19] This is particularly true when one considers the marginal emissions generated by each new kilowatt of demand – typically from natural gas plants rather than high-emitting coal.[20] For example, a 2015 Simon Fraser University (SFU) study estimated that adopting EVs instead of internal combustion engine (ICE) vehicles would reduce emissions per kilometre by 98% in British Columbia, 70% in Ontario, and 45% in Alberta.[21]

While GHG emissions from the production and manufacturing of EVs can be as much as 30% greater than those from conventional vehicles, the lower emissions from EV operations still results in significant GHG emissions reductions over a vehicle's typical lifetime.[22,23]

15 Natural Resources Canada. "Learn the facts: Electric-drive vehicles" December 1, 2016.

16 Ibid.

17 Office of Energy Efficiency & Renewable Energy. "Compare Side-by-Side" U.S. Department of Energy.

18 Arbib, James & Seba, Tony. "Rethinking Transportation 2020-2030" May 2017.

19 Axsen, Jonn., et al. "Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study" July 2015. Simon Fraser University.

20 Ibid.

21 Ibid.

22 Zhao, F., et al. "GHG Emissions from the Production of Lithium-Ion Batteries for Electric Vehicles in China" April 2017.

23 Ellingsen, L., et al. "The size and range effect: lifecycle greenhouse gas emissions of electric vehicles" May 2016.

MAJOR CHALLENGES AND NEGATIVE IMPACTS OF DISRUPTION

Reduced cost of transportation & economic spin-off benefits

By operating at higher efficiencies, EVs also significantly reduce the cost of fuel for transportation. For example, the Nissan Versa subcompact with an internal combustion engine is expected to cost $0.09/km for fuel, while a comparable Nissan Leaf EV is expected to cost $0.02/km.[24] In addition, EVs are expected to significantly reduce maintenance costs, given the relatively few moving parts involved in operating the vehicle.[25] However, given the higher upfront costs of new vehicles and battery replacement, full lifetime costs of EVs are only marginally lower than an internal combustion engine – estimated at $0.48/km instead of $0.50/km for an ICE.[26] It should be noted that manufacturing and battery technology advancements are expected to drive EV costs down significantly in the coming years.[27] AVs offer the most potential for cost savings and economic spin-off benefits, resulting from projections for vastly increased vehicle utilization rates by ride-hailing services that use AVs. RethinkX, a think-tank that performed a major study on disruption in the transportation sector, estimates operating costs of $0.12/km, falling to $0.08/km, for ride-hailing services that combine the use of EVs and AVs.[28] Similarly, carpooling in shared vehicles reduces these costs to as little as $0.02/km, a 95% reduction from the current cost of owning and operating an ICE vehicle.[29]

Impacts on Travel Demand

The reduced cost of AV operation combined with increased convenience, particularly for shared AVs, significantly reduces existing barriers to personal mobility. While this is a positive development in many ways, there is still a significant risk of increased VDT and GHG emissions resulting from the wide-scale deployment of shared AVs. This could happen when users send an AV home to park instead of parking at work. Another secondary impact is reduced use of public or active transportation such as biking or walking.

While it is difficult to predict exact impacts for an industry and technology still in development, one study by the University of California, Davis, (UC Davis) suggests ride-hailing services are already causing users to switch to the new service and transition away from other forms of transportation, as well as generating new trips that would not have existed otherwise. Respondents stated that 49% to 61% of all trips would not have been made at all or would have been made by public transit, walking or cycling if ride-sharing services were not available.[30] Likewise, it has been found that driving an EV has increased the number of trips for early adopters of this technology due to reduced operating costs and feeling better about driving with lower environmental impact.[31]

24 Canadian Automobile Association. "Driving Costs Calculator" Accessed November 15, 2017.

25 Idaho National Laboratory. "How Do Gasoline & Electric Vehicles Compare?" May 4, 2015.

26 Arbib, James. All CAD/USD exchange rates completed according to rates on January 31, 2018.

27 Zamorano, Alejandro. "Global EV Trends & Forecast" April 18, 2017. Bloomberg New Energy Finance.

28 Arbib, James.

29 Ibid.

30 UC Davis Institute of Transportation Studies. "Keeping Vehicle Use and Greenhouse Gas Emissions in Check in a Driverless Vehicle World" April 2017.

31 Axsen, J., et al. "Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study". July 2015. Simon Fraser University.

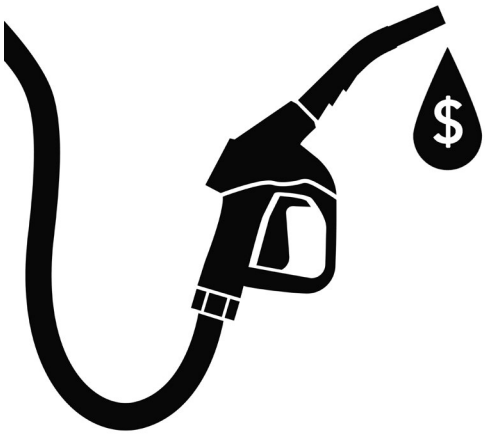
Table 1: Potential disruptions from changes in transportation

	Job Loss	Increased VDT	Decreased VDT	Decreased cost of personal mobility	Decreased demand for public transit	Increased safety	Improved productivity	Decreased GHG Emissions	Increased socialization of people	Improved air quality	Increased mining for rare minerals
EVs	✓			✓				✓		✓	✓
AVs	✓	✓		✓	✓	✓	✓				
Shared	✓		✓	✓	✓				✓		
EVs, AVs and Shared	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓

There are also economic implications from changes in driving behaviour. For example, if driving preferences shift rapidly to EVs, AVs, and shared vehicles, there could be significant impacts to the oil and gas, insurance, and taxi industries without responsive policy measures to adapt to this transition.

Impacts on Government Revenue Sources

Governments at all levels rely heavily on revenue from the taxation of vehicle fuel and other vehicle licensing fees.[32] A wide-scale deployment and adoption of EVs would result in a reduction in taxable fuel sales and a subsequent decrease in the Consolidated Revenue Fund of Canada, thereby limiting a traditional source of revenue used by the federal government for infrastructure.[33] Although the federal Gas Tax Fund (GTF) to provinces is a transfer payment legislated permanently and not influenced by the vagaries of gasoline demand, the excise and sales taxes on gas are much more responsive to such changes. For instance, the federal government alone collects more than $8 billion annually[34] in excise and sales taxes on gasoline, with some estimates across all provincial, territorial, and federal governments combined exceeding $23 billion per year.[35]



32 Department of Finance Canada. "Backgrounder – Oil and Gas Prices, Taxes and Consumers" July 2006.

33 Department of Finance Canada. "Annual Financial Report of the Government of Canada Fiscal Year 2016-2017" September, 2017.

34 Ibid.

35 Although the federal government has not recently published a breakdown of revenues, an independent report provides general estimates (See: Bowes, Jeff. "19th Annual Gas Tax Honesty Report" May 18, 2017. Canadian Taxpayers Federation.

Under Canada's current fiscal regime, EVs do not contribute an equal share to road infrastructure funding relative to other vehicle classes because they do not contribute to the excise or sales tax on gasoline.

Although impacts may be negligible in the near future, it is important that EV owners and users contribute an appropriate amount to ensure adequate resources are available to support existing and future infrastructure that relies on these revenue streams.

Impacts on Demand for Electricity

There are two general types of potential impact on grid demand resulting from more EVs:

a) **Demand occurring at off-peak times:** This type of demand limits the need for new generation, and primarily increases the electricity draw on base generation resources and transmission infrastructure. While the total electricity consumed will still increase, the impacts to the grid from this type of demand will be negligible, and would require minimal investments in transmission and distribution (T&D) infrastructure.

b) **Demand occurring at peak times:** Notably, while widespread adoption of EV charging at peak times may require some new generation and T&D capacity to be added in Canadian jurisdictions, it is estimated that total new power demand will be relatively minor. For example, applying EV grid impact assumptions from a Wood Mackenzie report[36] there would be a 3% increase in total electricity demand if half of Canada's current vehicle fleet were to be converted to EVs today, with only a fraction of this new demand occurring at peak times.[37,38] With the deployment of renewable energy and distributed energy resources such as solar arrays, additional demand from EVs may be mitigated due to the congruence of generation and charging profiles as well as proximity to the electricity load, thereby reducing negative impacts to the grid.

In addition, it may be possible for EVs to also serve as a stabilizing force in the grid, discharging power from batteries at times when there is higher demand.[39] Technologies such as smart charging, as well as policies such as time-of-use pricing, can be put in place to proactively shape EV charging demand and mitigate negative impacts on the electricity grid.

36 Wood Mackenzie. "The Rise of the Electric Car: How Will it Impact Oil, Power, and Metals" December 2017.

37 Assuming 639 TWh total Canadian grid demand (NRCan Fact Book 2016), 1.08 TWh/million vehicles (from Wood Mackenzie study), and 34 million vehicles in the Canadian fleet.

38 Natural Resources Canada. "Energy Fact Book 2016-2017" June 2016.

39 Schmidt, Eric. "The Impact of Growing Electric Vehicle Adoption on Electric Utility Grids" August 28, 2017. FleetCarma Telematics solutions for Fleets, Utilities, Sustainability and Research.

TRANSPORTATION INFRASTRUCTURE FUNDING

Current State

Every year, the federal government transfers $2 billion to provinces, territories, and Indigenous governments for local infrastructure projects through the federal GTF.[40] Although governments also collect excise and sales taxes on gasoline, the federal GTF is a unique transfer payment with the specific intent to provide reliable, predictable funding in support of municipal infrastructure that contributes to a clean environment.[41] Municipalities strongly support the GTF because it offers significant flexibility: local communities can make strategic investments immediately, bank the funds for later use, or pool the dollars with other communities for shared infrastructure projects. However, a recent report from Canada's Commissioner of the Environment and Sustainable Development found that, due to limited performance measurement accounting of the fund, the federal government could not demonstrate if the GTF achieved the intended environmental benefits.[42] As a result, some traditional models of infrastructure financing may have limited effectiveness in funding the future of personal mobility.

Impacts from Electrification

The widespread deployment of EVs and other emerging technologies also brings several challenges to the traditional transportation infrastructure funding model. Notably, EV adoption requires an effective charging network consisting of two pillars: private and public charging. Modelling by researchers from academia and industry shows the majority of EV charging will occur at homes.[43] The private charging pillar also includes installations at workplaces and other non-residential private institutions. In addition to providing incentives for the installation of EV chargers, future building codes and regulations could potentially mandate the installation of home chargers in new constructions. Nonetheless, the wide-scale deployment of public charging remains essential until such time when there is a private market to finance these types of investments. Literature does not reach a consensus on the scale or density of required charging stations, with estimates ranging from 3 to 72 chargers per 1,000 vehicles.[44] Research from SFU provides another metric to evaluate the required investments by quantifying one public charging station for every two existing gas stations.[45]

Until the business case solidifies for privately funded charging infrastructure, there is a clear need for federal support in the early years of EV adoption. Government investments are vital to spur EV infrastructure spending, but are less effective for ongoing operations and supporting technological innovations in the industry. In Budget 2017, the federal government announced its plan to invest $20.1 billion over 11 years through bilateral agreements with provinces and territories in transportation. In addition, the new Canada Infrastructure Bank will invest at least $5 billion in

40 Infrastructure Canada. "Federal Gas Tax Fund Allocation Table" December 9, 2013.

41 Dupuis, Jean. "The Gas Tax Fund: Chronology, Funding, and Agreements" September 26, 2016. Library of Parliament.

42 Office of the Auditor General of Canada. "Report 1: Federal Support for Sustainable Municipal Infrastructure" May, 2016.

43 Lin, Zhenhong & Greene, David. "Promoting the Market for Plug-in Hybrid and Battery Electric Vehicles: Role of Recharge Availability." Transportation Research Record. 2012.

44 Cooper, Adam & Schefter, Kellen. "Plug-in Electric Vehicle Sales Forecast Through 2025 and the Charging Infrastructure Required." The Edison Foundation & Edison Electric Institute. 2017.

45 Axsen, John et al. "Canada's EV Policy Report Card" November, 2016.

public transit systems, some of which should include EV charging infrastructure.[46] Further, the federal government has committed to developing a national zero-emissions vehicle (ZEV) strategy by 2018 to increase the number of ZEVs on Canadian roads.[47] This step could encourage and spur additional investments in charging infrastructure from provincial governments as well as the private sector.

Indeed, the Government of Canada recently announced $182.5 million to expand the network of EV charging and alternative refuelling stations across the country.[48] This investment includes $30 million over four years to support demonstrations of next-generation and innovative charging projects.[49] Likewise, Ontario has already committed to investing $20 million in a network of 500 EV charging stations and there are more than 1,000 public charging stations in Québec.[50] Even at the municipal level, the City of Toronto is piloting curbside EV charging in neighbourhoods with high EV ownership,[51] a recognition that all levels of government need to take action when it comes to the future of personal transportation.

Jurisdictional Considerations

Complex jurisdictional control between municipal, provincial/territorial, Indigenous, and federal governments may make implementation of transportation infrastructure challenging. For example, provincial and municipal governments, which operate most public roads, may not have the capital for large-scale investments with the acceleration of EV and AV technology.[52] As a result, the newly created Canada Infrastructure Bank has the potential to spur larger investments where commercial finance alone would not be willing to invest.[53] Given that over the next decade Canada's federal, provincial, territorial, Indigenous, and municipal governments will spend as much as $750 billion on infrastructure,[54] a coherent national policy framework is urgently needed as outlined later in this report. EVs provide perhaps the strongest example of the extent and scale of infrastructure investments required across Canada, necessitating both major investments in electricity transmission and charging infrastructure, with even greater investments in integrated AV-public transit systems. The Senate of Canada studied policies for the regulation and deployment of AVs on the road,[55] but its findings discussed public infrastructure safety rather than the impacts of GHG emissions. Our report helps bridge this gap and provides additional recommendations for the federal government to enact the proposed national strategy outlined by the Senate in an environmentally responsible manner.

46 Infrastructure Canada. "Public Transit Infrastructure" December 21, 2017.

47 Melton, Noel et al. "Canada's ZEV Policy Handbook" December 2017. Simon Fraser University.

48 Natural Resources Canada. "Coast-to-Coast Investments Help Canadians Drive Clean" January 10, 2018.

49 Natural Resources Canada. "Clean Infrastructure programs" January 13, 2018.

50 Maloney, Tom. "Quebec is leading the charge on electric vehicles" March 24, 2017. The Globe and Mail.

51 Rider, David. "Charging stations for on-street parking get a boost in Toronto". October 18, 2017. The Toronto Star.

52 Baker, Barbara et al. Canada's Electricity Infrastructure: Building a Case for Investment. Conference Board of Canada. 2011.

53 Infrastructure Canada. "Canada Infrastructure Bank" December 14, 2017.

54 Fagan, Drew. "Canada Infrastructure Bank: bad name, good policy" May 30, 2017. The Globe and Mail.

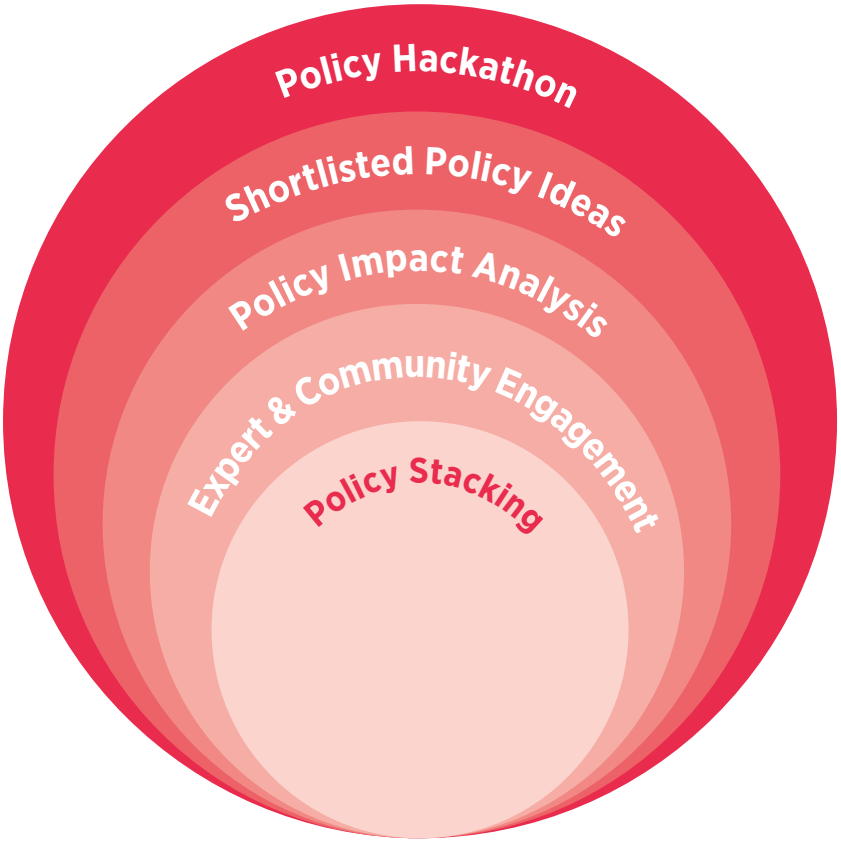
55 Senate Committee on Transport and Communications. "Driving Change: Technology and the future of the automated vehicle " January 29, 2018. Senate of Canada.

METHODOLOGY

ARRIVING AT POLICY RECOMMENDATIONS

In developing our policy recommendations, our group followed a five-step approach as highlighted by Figure 2. After a thorough review of literature and discussions with various stakeholders, a longlist of policy ideas was developed. Then, a policy hackathon exercise led to a shortlist of policies.[56] An impact analysis was then conducted to test the proposed policy recommendations for their impacts on key metrics related to our set policy goals: total distance travelled, GHG emissions, and tax revenue. Finally, input from our expert stakeholder consultations and community engagement was used to fine-tune our recommendations. The process is described in further detail in Appendix A.

Figure 2: Policy selection process



We recognize that personal mobility systems are complex and require flexible and multifaceted policies. Rather than attempting to create one policy that fulfills multiple roles, we utilized a policy stack that contains three layers – "steer", "accelerate", and "protect" policies – that will be highlighted later in this report.

56 A hackathon is an event where people come together to create new solutions to complex problems in only a few days.

IMPACT ANALYSIS

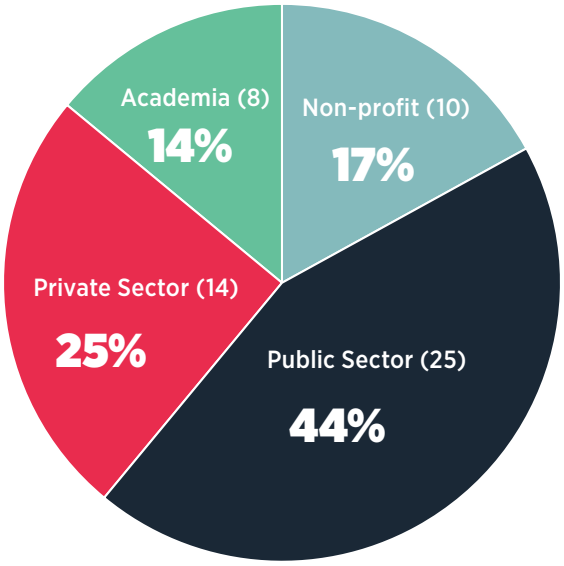
Our proposed policy recommendations were tested to assess their effect on mitigating some of the impacts associated with EV deployment and accelerating GHG emission reductions in the sector. Due to uncertainty in the deployment of EVs by 2050, a predefined reference case[57] was used for the conducted scenario analysis. The impacts of the tested policy scenarios were measured relative to this reference scenario to produce a high-level understanding of the direction and magnitude of influence each policy lever has on the metrics being evaluated.

The impact analysis used key assumptions and data from industry and academia to conduct a quantitative analysis of the impact of proposed policies. A qualitative review was then conducted to overlay policy implications and adjust for non-quantifiable impacts.

EXPERT STAKEHOLDER ENGAGEMENT

To complement our literature review, our team reached out to experts from the federal and provincial governments as well as industry and civil society, who were identified as thought leaders in our research topic. Interviews were conducted in-person, over the phone, and, in some cases, as part of our participation in the Generation Energy Forum in October 2017. Our semi-structured interviews were standardized by creating an interview guide that featured key questions. The guide did not restrict further questions, but allowed the interviewer to expand and adapt questions tailored to the expertise of the interviewee. Additionally, a standardized method for recording, transcribing, and coding key insights was employed. Input from the experts helped guide various parts of this work, ranging from supporting literature reviews to testing policy recommendations. Since our research began in June 2017, our task force interviewed 57 expert stakeholders, including 25 public sector stakeholders, 14 private sector stakeholders, 10 experts from non-profit organizations, and eight academic experts.

Figure 3: Breakdown of stakeholder interviews



COMMUNITY ENGAGEMENT

While research and analysis gave us an idea of the impact these policies could have in an ideal world, it is important to also consider the influence of human behaviour on policy implementation. To get an idea of how the complex systems involved in transportation choices could change the outcome of the policies under evaluation, we designed and facilitated an innovative simulation-style game. This activity allowed young Canadians, aged 18-35, to play the role of diverse stakeholders and make decisions in a future world. More details on the community engagement activity can be found in Appendix B.

57 In the reference scenario, it is assumed that EVs reach a 50% market share by 2050. The reference scenario assumed private vehicle ownership remains the dominant model, with negligible shared and autonomous vehicle deployment. The scenario was devised by extending projections from Bloomberg New Energy Finance (BNEF) on percentage of EV fleet by 2040 (33%) to 2050.

DISCUSSION

IMPACT ANALYSIS RESULTS

Taxes and Fees

Many policy options are available for mitigating lost gas tax revenues resulting from EV adoption, but the implementation of these policies could still have a significant social and environmental impact. The taxes and fees we investigated resulted in either a decrease in overall vehicle ownership, a decline in distance travelled, or fuel switching from ICE vehicles to EVs (or vice versa).

Policies need to strike a balance between mitigating lost revenue and maintaining the economic attractiveness of EVs. For example, a volume-of-fuel equivalent policy applied to EVs would result in fully recapturing the lost gas tax revenue, but would also result in EVs becoming less economically attractive, thus lowering adoption. In contrast, applying new funding measures to reduce incentives for driving across all vehicle types – for example, through a new charge for distance travelled – would be effective at reducing GHGs and generating new revenue without disproportionately decreasing demand for EVs.

Infrastructure Policies

The examined infrastructure policies differ in their impacts. Despite research showing the majority of EV charging will occur at home or at the workplace, the availability and perception of a public charging network is still a key driver for EV adoption. Mobilizing funds for EV charging infrastructure potentially results in higher adoption. Similarly, optimizing and reducing need for new infrastructure mitigates some of the impact on gas tax revenues.

Supporting AV infrastructure brings opportunities for vehicle efficiency as well as reducing the required vehicle fleet, but also brings about potential increases in VDT due to zero-occupancy or individual trips. This would result in an overall increase in GHG emissions, yet widespread deployment of shared AVs could lessen some of those risks.

Mandates and Supporting Policies

Mandates and supporting policies also have diverse impacts. However, they generally exhibit a trend of reducing GHG emissions and gas tax revenues. Full bans on ICE vehicles, as well as higher energy and carbon performance standards for vehicles, have the potential to significantly reduce GHG emissions, but are controversial and may not have adequate political support in the Canadian context, despite growing popularity across Europe. Stronger policy support for EV and shared vehicle adoption, combined with ZEV mandates, can also have a similar influence. Overall, the challenge with mandates and supporting policies examined is their effect in depleting gas tax revenue funds, underscoring the need for policymakers to consider the indirect and secondary impacts of policies that aim to reduce GHG emissions.

> *Once consumers buy electric vehicles, they don't go back to internal combustion engines"*
>
> — Pierre-Olivier DesMarchais, Researcher, Policy Horizons Canada

INPUT FROM EXPERTS AND STAKEHOLDERS

In consultation with experts and stakeholders it became clear that there were diverse views regarding the future of personal mobility. In fact, many stakeholders emphasized that, irrespective of EV adoption, public mass transit will likely be the backbone of urban transportation for the next decade, citing large government infrastructure spending as an indication of the future of mass transit. The shift to smart cities could also spur a need for innovative transportation systems. We envision a future where electrification, automation, and ride-sharing are prioritized alongside a suite of public policies that encourage decarbonization and promote urban planning that keeps in mind the greatest social benefits.

Government actions at the provincial level have been key to EV adoption, especially rebate incentives. However, many barriers to EVs still exist, most notably costs, lack of understanding and awareness, infrastructure, and availability of supply and choices. At a consumer level, many people who are not aware of government incentives still think EVs are too expensive. Meanwhile, dealerships rarely advertise such incentives. Although not included in our final recommendations, there should be thoughtful supply-side policy, such as a ZEV target that sets a minimum percentage of vehicles sold as ZEV. As one government stakeholder emphasized, "Once consumers buy electric vehicles, they don't go back to internal combustion engines".

INPUT FROM COMMUNITY ENGAGEMENT

Our community engagement was conducted using an innovative simulation-style game. This approach allowed us to test our policy recommendations as well as provide an avenue for participants to engage in enriching discussions on Canada's energy and transportation future.

Each round of the community engagement game had a different focus. First, we started by considering policies aimed directly at reducing GHGs through consumer-focused taxes. Second, we considered incentives for corporations to invest in improved vehicle technologies and infrastructure. Finally, we looked at AV-specific regulations. At each round, players had the option to advocate for or against any of the three policies under consideration and take other actions based on the policies that had been implemented. The input received from the community engagement informed our policy proposals and provided helpful guidance for implementation plans.

Implications for Policy Proposals

Multifaceted approach: In the first round of the game, when players saw only user-focused GHG taxes under consideration, participants focused on the need for policies that would support better infrastructure. This shows that our approach must be multifaceted to ensure corporations are investing in innovation and infrastructure that will allow citizens to be able to change their behaviour and benefit from GHG taxes.

Encourage cross-industry cooperation: The most innovative approaches in responding to policy changes involved cooperation among different players, such as private and public organizations. This indicates that policies should be sector-agnostic to encourage more collaboration. Cooperation should also be encouraged to reduce redundancies and overlap between ride-sharing, ride-hailing, and public transportation modalities. Using each modality to complement the other, rather than compete, will reduce overall GHG emissions. For example, Alphabet Inc. has launched a mobility services startup, Coord, which plans to integrate navigation tools and urban infrastructure data into one platform.[58]

58 Marshall, Aarian. "Sidewalk Labs Launches a Platform for Making the City of Tomorrow" February 2, 2018. WIRED.

Significant potential from Canada Infrastructure Bank: The need for investment in infrastructure for EVs was highlighted both by consumer players and ride-sharing/ride-hailing companies. Although infrastructure pilots were considered without policy supports in the game, investment in charging stations at scale required support from the government. Investment in large-scale battery storage infrastructure was also enabled by CIB loans.

Implications for Policy Implementation

Transparency of impact: Consumers often do not understand the full implication of policies under consideration and how these policies will impact vehicle purchase and operational costs. The most creative and high-potential solutions proposed by the players came when they fully understood the mechanics of the game. It will be important to ensure that the final impact of policy on industry and consumers is clear.

Predictable and progressive increases: Policies that involved immediate impact were highly scrutinized by consumers and corporations alike. Even where policies have aggressive goals to meet the GHG reduction goal, it will be important to implement those policies in a gradual way, with clear annual targets and real incentives/penalties. It should be noted that players were generally one step ahead of the federal government in advocating for policies that the government was going to implement at each round of the game.

Political accessibility: In the simulation, consumers and corporations had equal access to the government. Even in this idealistic scenario, corporate interests had more influence. Rarely did a consumer approach the government to advocate for or against an idea without encouragement from or participation of a corporation, and the feedback provided was highly influenced by previous discussions with the corporation. The government must invest in seeking out honest, unbiased input from consumers on the proposed policies. One way to do this is by conducting similar simulation-style games across the country that can actively engage citizens.

OTHER CONSIDERATIONS

Implications for Rural and Indigenous Populations

As of 2017, one in five Canadians lived in a rural area.[59] Although this report focuses on urban centres, our recommendations may have disproportionate impacts in rural communities. For example, there is a different mobility behaviour in more remote areas due to high affinity for Sport Utility Vehicles (SUVs) and trucks. At the same time, there are generally fewer types of mobility services available in these regions. Some municipalities, however, are developing creative solutions to this challenge – Innisfil, Ontario, recently replaced its public bus system with Uber drivers.[60] The results of this pilot partnership with Uber have not yet been evaluated, but it is clear that policy options for personal mobility will vary depending on regional context.

Indigenous populations are also becoming increasingly urbanized and represent the fastest growing population in Canada, especially among younger demographics.[61] Indigenous communities, particularly First Nations living on reserves, could likely be further disadvantaged due to systemic lack of federal funding for infrastructure that could prevent prioritising EV/AV infrastructure investments in these communities.[62] There is also a unique challenge for Indigenous people living in urban areas who could be unfairly charged by driving to their community to practice their constitutionally protected Indigenous rights, such as hunting, fishing, and other cultural practices. As a result of all of these challenges, unique policy recommendations would be required beyond the scope of this report to address these equity concerns, such as possible exemptions from certain policies. To that end, it is vital for Canada to respect and honour the unique nation-to-nation relationship with Indigenous peoples in order to continue down the road of reconciliation.

Autonomous Vehicle Implications

We recognize it is likely that Canada, or specific jurisdictions within the country, will open up roads to AVs in the near future. In that case, there will be a need for a policy framework supporting and shaping AV deployment in a manner that is constructive toward other policy goals, such as reduced GHG emissions. Indeed, the Senate of Canada released its report[63] to the Minister of Transportation with recommendations on how to prepare for the future of AVs, but failed to highlight the potential environmental impacts of this future.

We expect the majority of AVs will be deployed as shared-use vehicles, operating a model similar to today's ride-sharing service but without a driver. This model is often called Mobility as a Service (MaaS) and is actively being pursued by both ride-sharing operators and conventional car manufacturers[64] as their strategic business opportunity of the future.[65] There are a number of potential benefits of the MaaS business model, such as reduced need for parking, fleet size, and ownership rates, all potentially achieved through higher utilization rates of shared AV vehicles.

59 Although more than 80% of Canada's population is considered urbanized, this statistic is based on the definition of a "population centre" or city as an area with more than 1,000 people and a density of 400 or more people per square kilometre. See: Statistics Canada. "Canada goes urban" March 3, 2017.

60 Pelley, Lauren. "Innisfil, Ont., partners with Uber to create substitute for public transit" May 15, 2017. CBC News.

61 Statistics Canada. "Aboriginal peoples in Canada: Key results from the 2016 Census" October 25, 2017.

62 Indigenous and Northern Affairs Canada. "Evaluation of the First Nation Infrastructure Fund" April, 2014.

63 Senate Committee on Transport and Communications. "Driving Change: Technology and the future of the automated vehicle " January 29, 2018. Senate of Canada.

64 Davies, Alex. "GM Will Launch Robocars Without Steering Wheels Next Year" January 12, 2018. WIRED.

65 General Motors. "GM Launches Personal Mobility Brand: Maven" January 21, 2016.

Nevertheless, we also anticipate significant risks with AV deployment and MaaS that may jeopardize GHG emission reductions from other positive developments in personal mobility. Since AVs allow a vehicle to operate with zero passengers, and are expected to operate at a significantly lower cost than today's vehicles, there is a likelihood these vehicles will spend a significant portion of their time on the road without any passengers, taking up valuable road space and energy as well as contributing to GHG emissions in the process. Furthermore, evidence has shown that the convenience and affordability of ride-sharing is already increasing the number of trips that people take by car, both by generating new trips and causing people to switch from public transit or active transportation.[66]

> *"Canada needs a national strategy that is comprehensive but not necessarily uniform"*
>
> — Niall O'Dea, Director General of Electricity Resources, Natural Resources Canada

We see a critical role for the federal government to lead policy development in advance of widespread AV deployment. We believe there are a number of options available for the federal government to proactively manage AV occupancy for constructive GHG and economic outcomes. Further, our community engagement session found that government policies helped shape and encourage cross-sector and public-private collaborations in sustainable AV development. Our recommended policies presented later in the report are premised on a connected-vehicle world, where vehicle use and occupancy data are actively tracked and available to local governments as part of dynamic road pricing schemes. Given the pace of innovation and the challenges with changing established behaviour patterns, we believe it is in the national interest for the federal government to be proactive in preparing policy options for implementation simultaneously with AV deployment in Canadian jurisdictions.

Political Considerations

Effective policy transcends partisan lines. Since many of the recommendations in this report require constructive collaboration across jurisdictions and diverse political perspectives, it is necessary to acknowledge that managing these relationships will not always be easy, especially with varying electoral timelines and mandates. Across the federation, however, it is clear that national platforms, such as the first ministers' meeting and meeting with national Indigenous leaders, are able to convene discussions and debates on relevant policies outlined in this report. Progress has been made in recent years through this inter-jurisdictional dialogue, most notably the adoption of the Pan-Canadian Framework on Clean Growth and Climate Change. This political forum could be used again to facilitate decisions regarding some of the recommendations outlined in this report.

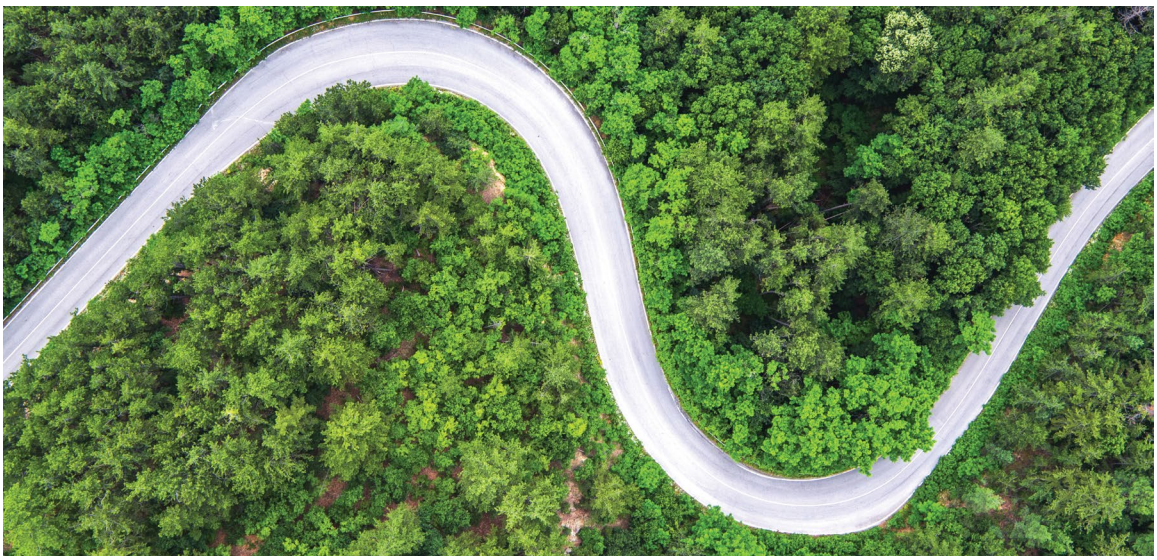
66 UC Davis Institute of Transportation Studies. "Keeping Vehicle Use and Greenhouse Gas Emissions in Check in a Driverless Vehicle World" April 2017.

To develop a shared vision of a path forward, it will be important to implement our proposed policy stack in a time-sensitive manner that takes into account the common, but differentiated, responsibilities of provinces, territories, and Indigenous governments.

The federal government can help build consensus across jurisdictions by showing leadership in reducing its own emissions. Indeed, the Government of Canada recently announced its Greening Government Strategy,[67] which goes beyond Canada's international GHG reduction targets and demonstrates how the federal government is greening procurement of its vehicle fleets and real property assets. At the same time, it will be important to ensure green infrastructure projects are not solely selected on the merit of being quick to complete, as is the tendency for some governments closer to election years. The recommendation to leverage the CIB, outlined later in the report, could be a first step to maintaining non-partisan investment in green infrastructure over the long-term.

It is also important to recognize that shifts in the transportation sector will have other socio-economic impacts. Shifts to EVs will impact Canadian oil and gas demand, and a shift to AVs will impact taxi and delivery demand as well as insurance companies. In each case, if support is not provided to retrain the workforce or encourage diversification, the economic impacts may have political ramifications, especially if policies are viewed as speeding up the transition.

Finally, in order for a dramatic decrease in GHG emissions, there needs to be international alignment of policies related to personal transportation. If Canada views itself as a global leader in reducing GHG emissions, then the federal government should also ensure that Canada is not importing fuels with high GHG emissions from other countries. Moreover, international environmental harmonization – such as a standard of allowable GHG emissions – would ensure economic competitiveness for Canada's energy industry so that domestic reductions in emissions do not create an unfair disadvantage to Canada's products in international markets. Nonetheless, we recognize the difficulty of harmonizing international standards through trade and realize there are considerable political barriers beyond the remit of the federal government to achieve such outcomes.



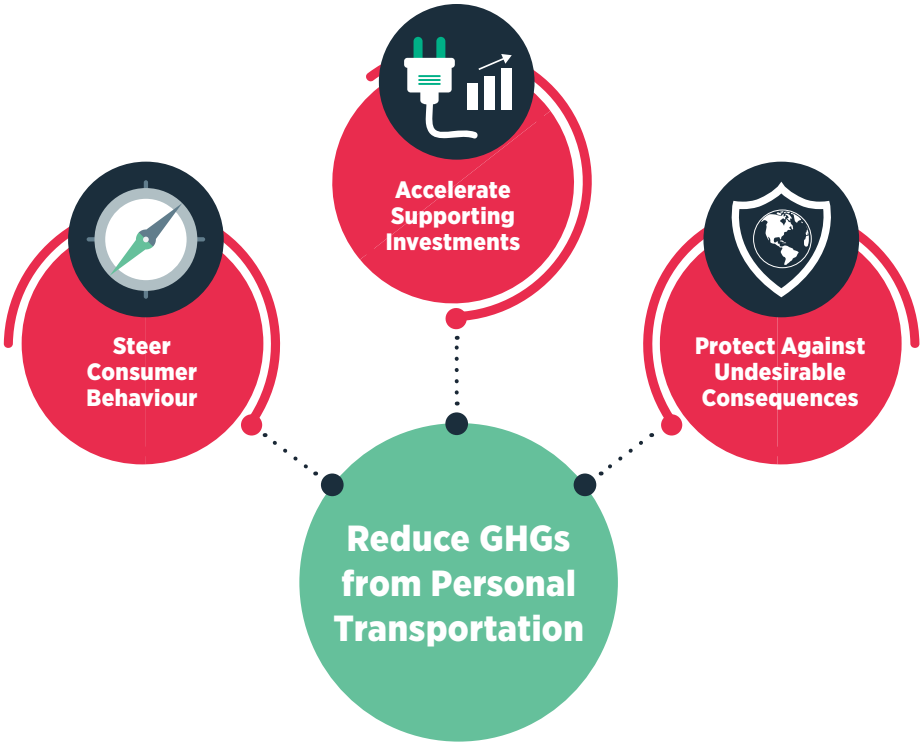
67 Treasury Board of Canada Secretariat. "Greening Government Strategy" December 29, 2017.

POLICY RECOMMENDATIONS

National Framework

As highlighted earlier in the report, three policy goals were identified: reducing vehicle distance travelled, reducing GHG emissions, and replacing lost revenues for transportation infrastructure funds.

When examining potential policies and their role in achieving the set policy goals, it became clear that no 'silver-bullet' solution exists to address all these challenges. In addition, there are multiple initiatives already in progress at different levels of government that impact the transportation sector, so a framework approach must be taken to engage multiple levels of government. Therefore, we propose a national framework that combines a policy stack with strong inter-governmental relations. **The policy stack consists of three levels**:



At each level, cooperation between national, provincial/territorial, municipal and Indigenous governments will be required. A consistent standard across the country will be necessary to make it easier for corporations and individuals to adapt. However, each jurisdiction must also be able to adapt to the unique challenges and opportunities facing its own population. As indicated by the outcomes of our community engagement, policies must be transparent, predictable, and progressive over time. Given the limited nature of our engagement session, we would also recommend the Government of Canada conduct additional community game simulations across Canada to verify our findings and identify regional modifications.

Based on the results of our research, analysis, and engagement, we recommend the following policy stack, and associated levers, to implement a national framework. The federal government can have the greatest impact where levers are national in scope, either by implementing those within federal jurisdiction, or by supporting coordination and alignment across provincial, territorial, and municipal governments.

Steer Consumer Behaviour

The first level of policies should address the principal goal of reducing GHG emissions. These policies ideally provide an ongoing incentive to reduce emissions and meet other transportation policy goals without being prescriptive as to how this is achieved. Additionally, steering policies are important to ensure the government is maintaining a level of revenue that will cover required infrastructure investments. Currently, multiple provincial and national policies exist, but these may benefit from national coordination.

Accelerate Supporting Investments

Consumers can only change behaviour in response to steering policies if there are other options available to them. The second level of policies should encourage investment in improving infrastructure or transportation options to support consumers in changing their behaviour more rapidly or reducing the negative impacts of technology in use. Currently, isolated province-led policies exist as well as sector-agnostic national programs.

Protect Against Undesirable Consequences

There are several trends that could disrupt transportation systems beyond what the other policies were designed to accomplish. Protection policies are intended to provide a safeguard on the potential increase of GHG emissions. Similar to the emissions cap in climate agreements, these policies are more stringent, but less likely to be triggered in the near term. Currently, few to no protection policies are in place.

STEER CONSUMER BEHAVIOUR

Policy Lever 1: Dynamic Mobility Pricing in Urban Areas

We recommend that the federal government set guidelines on dynamic mobility pricing to tackle congestion by applying a new variable cost component to distance travelled. The real costs of congestion (i.e. GHG emissions and infrastructure) would be built into this price, and pricing would be adjusted depending on routing and time of use. With recent technology advancements, it is now possible to adjust road pricing based on time of day, road congestion, speed, occupancy, and even fuel efficiency and carbon emissions.[68] This type of charging scheme could shape demand to encourage the behaviour that leads to the lowest economic and social costs in Canadian cities. Notably, the specific instrument of pricing is not as important as ensuring a dynamic and appropriate price can be applied.[69]

According to Canada's Ecofiscal Commission, pricing traffic congestion is an essential piece of smart transportation policy that is missing from Canada's cities.[70] Without this policy in place, the economic cost of congestion continues to rise across Canada. In the Greater Toronto Area alone, this figure is estimated to grow to $15 billion annually by 2031 without further action.[71]

Similar to congestion charges that have been implemented successfully around the world in jurisdictions such as London, Singapore, Hong Kong, Stockholm, and California,[72] the goal of this policy is to require road users to pay the full cost to society for their time on the road. Metro Vancouver is currently undertaking a consultation and research process with an independent commission to explore options for mobility pricing in that region.

Anticipated Risks & Challenges

While dynamic pricing will require widespread adoption of connected vehicle technology, it can be noted that many of these technologies are already available.[73] Regardless, it would be possible to implement a flat price for distance travelled immediately in addition to an annual payment as a part of vehicle licensing fees.[74]

This policy is primarily relevant to metropolitan areas where congestion is a significant issue and where these risks are exacerbated by increasingly convenient and affordable mobility options. We support the recommendation from Canada's Ecofiscal Commission to focus initially on the four largest Canadian cities: Toronto, Montreal, Vancouver, and Calgary.[75]

In addition, demand for transportation is also highly connected to socio-economic status, with lower housing costs often located at greater distances from employment and commercial centres. For this reason, any mobility pricing policy must be designed in a progressive manner to ensure that lower-income Canadians are not unfairly burdened with the costs of this initiative.

68 Deloitte. "Trends: Dynamic pricing" 2017. Accessed January 4, 2018.

69 Srivastava, Lorie & Burda, Cherise. "Analysing the Benefits of Traffic Pricing in Toronto and the GTA" May 2016.

70 Canada's Ecofiscal Commission. "We Can't Get There from Here: Why Pricing Traffic Congestion is Critical to Beating It" November 2015.

71 Ibid.

72 International Council on Clean Transportation. "Congestion Charging: Challenges and Opportunities" 2010.

73 Ibid.

74 Saidla, Karl. "Encouraging Sustainable Transportation : The Promise of Congestion Charging" May 2016.

75 Canada's Ecofiscal Commission. "Why Pricing Traffic Congestion is Critical to Beating It" November 2015.

Policy Lever 2: Time-of-use Electricity Pricing

We recommend that provincial/territorial governments implement time-of-use pricing that promotes EV charging primarily when there is surplus power available on the grid or in accordance with an optimal grid GHG intensity profile. Recognizing that there is some potential for new demand on Canada's power grid as a result of transportation electrification, it will be key to ensure that charging demand occurs at off-peak times to avoid significant new investments in electricity generation, transmission, and distribution infrastructure.

Anticipated Risks & Challenges:

Widespread adoption of smart charging technology would significantly improve the results of time-of-use pricing. Instead of requiring people to plug in their vehicles only at low-cost times to take advantage of lower prices, smart chargers can be programmed to delay charging until lower prices are in effect. Implementation of this policy lever would fall under provincial/territorial jurisdiction, and consequently should be customized by each province to align with the mix of demand they anticipate.

Policy Lever 3: Reform and Strengthen the Federal Excise Tax on High-Polluting Vehicles

We recommend that the federal government reform the current excise tax on fuel-inefficient vehicles to increase its effectiveness, with a progressive tax on the vehicles with the highest GHG emissions. One of the significant barriers to electrification of personal mobility in Canada is the price difference between EVs and ICE vehicles at the retail level.[76] At the same time, ICE vehicles with high emissions are consistently making up a greater portion of Canadian vehicle sales: 60% of the top 30 vehicles in Canada are now pickup trucks, SUVs, or vans.[77]

Anticipated Risks & Challenges:

It can be argued that taxes on new vehicles may encourage people to hold on to their older, high-polluting vehicles for longer. In response to this concern, the government could reduce or waive this excise tax on people who trade in their older vehicles for higher-efficiency vehicles.[78]

If implemented in conjunction with a policy that increases the cost of high-carbon fuels, a GHG- based excise tax may end up being overly punitive for ICE trucks, SUVs, or vans. Any reform to the excise tax should take into account lifecycle cost of ownership with all new taxes or fees included as well as rules to clearly communicate these changes at the dealership level.

We also recognize that new taxes are often politically challenging to implement. However, in direct contrast to programs offering a subsidy for EV purchase, this approach to bridging the gap in costs for EVs provides additional government revenue instead of requiring additional government spending.

76 Bérubé, Annie & Samson, Rachel. "Carbon Pollution and Car Buying Decisions" July 2017.

77 Ibid.

78 Ibid.

ACCELERATE SUPPORTING INVESTMENTS

Policy Lever 1: Continuous Improvement in Vehicle Fleet Efficiency Standards

We recommend that the federal government establish progressively more stringent average GHG emission standards for passenger vehicle fleets for the 2018 to 2025 model years.[79] As a fleet average standard, this regulation provides flexibility to meet the standard by either selling more lower-emission vehicles or by increasing the efficiency of individual vehicles across their fleet. As a result, this standard positively rewards automakers that can successfully increase the share of ZEVs (such as EVs) that are sold in their fleet.

From our community engagement feedback, it was clear that longer timelines and predictable goals are important to ensure investments in fleet efficiency. Recognizing that ICE vehicles will continue to represent the majority of the personal vehicle market in the near future, we recommend the federal government continue to target average fleet-wide efficiency with increasingly stringent efficiency standards beyond 2025, and that these standards continue to provide flexibility for automakers to meet the target through introduction of both ZEVs and higher-efficiency ICE vehicles.

Anticipated Risks & Challenges:

We recognize there may be political challenges related to implementing increasingly stringent efficiency standards fleet-wide beyond 2025. However, when considered against other policy options for encouraging ZEV adoption, we believe this option provides automakers with the greatest flexibility at a significantly reduced cost or complexity when compared to alternatives such as subsidy programs for EVs or ZEV mandates. In fact, a recent policy report card issued by the Sustainable Transportation Action Research Team (START) found that strengthened and extended fleet efficiency standards would be one of the most effective policies for encouraging ZEV adoption, with a relatively low cost to government.[80]

Canada's fleet efficiency standards are currently harmonized with the United States' Corporate Average Fuel Economy (CAFE) standards set by the previous administration in 2014. While the current U.S. administration has announced plans to reduce these standards, California and other U.S. states representing one-third of the vehicle market in that country plan to uphold them.[81] Canada will have to decide whether to harmonize our efficiency standards with the higher efficiency requirements of California and other states that are upholding current levels, or to adopt revised lower U.S. standards. Clearly, the former would lead to better outcomes for higher EV adoption rates and reduced GHG emissions in Canada.

79 Environment and Climate Change Canada. "Regulations Amending the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations" March 17, 2017.

80 Simon Fraser University Sustainable Transportation Action Research Team. "Canada's ZEV Policy Handbook" December 2017.

81 Tabuchi, Hiroko. "California Upholds Auto Emissions Standards, Setting Up Face-off with Trump" March 24, 2017. The New York Times.

Policy Lever 2: Clean Fuel Standard

We recommend that the federal government continue to advance policy development toward the implementation of a clean fuel standard across conventional and alternative fuels. At current rates of replacement, even if Canadians are encouraged to purchase electric or efficient ICE vehicles, it may take several decades to transition to low-emission transportation through vehicle change alone. These standards would require suppliers of gasoline, diesel, biofuels, electricity, or hydrogen for transportation to meet average GHG intensity standards, either through supplying low-GHG-emission fuels or through purchasing credits.[82] GHG intensity would be measured on a lifecycle basis to encourage upstream GHG reductions across all fuel types, supporting the creation of expanded markets for low-carbon-intensity conventional fuels or biofuels in addition to the adoption of EVs and other low-carbon vehicle technologies.

As of the end of 2017, British Columbia was the only province to have a clean fuel standard (requiring a 10% reduction in average carbon intensity from 2010 to 2020).[83] Standards confined to a single province may not be sufficient to drive a business case for large fuel suppliers to invest in low-carbon fuel extraction or sourcing. Therefore, our recommendation is to continue developing a national framework for a clean fuel standard, inclusive of conventional and emerging transportation fuels, that is aligned across the provinces with specific, long-term, and transparent targets set by each province for every five-year interval, supported by a national credit system.

Anticipated Risks & Challenges:

This policy is complex as it requires coordination among a number of government agencies as well as extensive monitoring to ensure compliance.[84] If the lifecycle GHG impact is calculated to include transportation of fuels, rural and Northern communities may be unfairly impacted, so appropriate exemptions should be included after consultation with these communities and their fuel suppliers. Additionally, if provinces decide to customize targets or credit calculations, there may be opportunities for arbitrage in the credits system that reduces the overall efficiency of the policy.

Ideally, other jurisdictions outside Canada would also implement a similar fuel standard to ensure that GHG emissions are not increasing globally despite emission reductions domestically. The international alignment of fuel standards would also ensure that provinces within Canada that are producing more intensive fuels remain economically competitive in the world market. However, encouraging and developing an international standard would be challenging due to varying national comparative advantages and the ability of the fuel standard to be enforced.

It is possible this policy may also have adverse social impacts, such as affecting food prices to the extent that crops are directed toward renewable fuel development instead of the food system. To mitigate these impacts, this policy could include requirements that only non-food and waste sources could be used for biofuel production. If development of low-carbon conventional fuel sources falls behind the timelines set by the provinces, or if adoption of EVs reduces fuel demand, this could also impact jobs and royalty revenues from the oil and gas sector. Another report from the Your Energy Future program will discuss potential policy levers to support this labour disruption and workforce transition.

82 Clean Energy Canada. “What a Clean Fuel Standard Can Do for Canada: A road to cleaner fuels, more jobs and less carbon pollution” November 2017.

83 Simon Fraser University Sustainable Transportation Action Research Team. “Canada’s ZEV Policy Handbook” December 2017.

84 Ibid.

Policy Lever 3: Canada Infrastructure Bank Investment in EV Charging

We recommend that the federal government leverage the CIB, including its $5-billion commitment to green infrastructure projects,[85] to support a massive buildout of EV charging infrastructure across Canada. Projects could include public EV parking and charging stalls, smart chargers, and new charging research and development (R&D) such as wireless charging.

In order to remain competitive and ensure EV technology continues to develop, Canada must keep abreast of next-generation charging technologies, most notably wireless charging. This advancement in wireless charging would allow EVs to be continually charged while driving, alleviating fears of range anxiety. Google is already testing wireless inductive charging,[86] currently used in smartphones and other consumer electronics, and this trend could be accelerated through CIB investment. Because private sponsors are likely to pitch projects for static EV charging technology already available, the CIB should consider creating investment streams targeted at next-generation technology themes such as wireless charging. These themes could be selected annually depending on emerging areas of R&D investment that are most salient.

In addition, the unique nature of the CIB would be well-suited to play a role in building EV charging stations where there is an insufficient business case for sole private investment. Because the CIB incentivizes such private investment, it also forces the government to think more innovatively about what Canadian roads could look like in 20 to 30 years and how remote communities can benefit from this personal mobility future. It should be noted that project sponsors could include not only private enterprises, but also municipal and provincial governments and their publicly owned utilities.

Anticipated Risks & Challenges:

The CIB approach will be most relevant to projects with a demonstrable business case having returns below commercial rates. Although some EV/AV infrastructure could be built through the CIB, other funding streams, such as the federal GTF, will still likely be required for conventional charging infrastructure and networks for AV. In particular, the GTF will remain an important funding tool for EV charging in rural areas since the CIB is likely to focus on more profitable projects in urban areas.

Another challenge with the CIB investing in long-term R&D infrastructure projects is the uncertainty over which technologies will emerge. For example, projections suggest that wireless charging technology is still more than 10 years away from early adoption.[87] Nevertheless, initial investment in innovative, yet flexible, infrastructure through the CIB could help Canada leverage this technology and circumvent investments in static charging stations that are not currently compatible with all vehicles. The CIB is intended to invest in public projects – such as road tolls and public transit – which people are used to paying for. As with any new technology, there may not be an established behaviour or proven demand to make a business case for certain next-generation infrastructure.

Finally, one of the biggest risks is that the mandate of the CIB is still rather large and misunderstood, making it a frequent target of infrastructure projects that could be out of the scope of the bank or do not leverage public investment to its greatest effect.

85 Infrastructure Canada. “Canada Infrastructure Bank” December 14, 2017.

86 Oreskovic, Alexei. “Google is testing a clever trick to charge self-driving car batteries without ever plugging into a wall” February 7, 2016. Business Insider.

87 McDonald, Zach. “When Can We Expect Wireless Charging for Electric Vehicles?” August 2, 2017. FleetCarma Telematics solutions for Fleets, Utilities, Sustainability and Research.

PROTECT AGAINST UNDESIRABLE CONSEQUENCES

Policy Lever 1: Clear Operating Standards for AVs

We recommend that all levels of government develop standards regulating AV usage to mitigate the risk of increased VDT and congestion. Depending on the local context, these standards could include:

- Requirements to integrate routing with major public transit lines to support, rather than displace, transit use;
- Geographic restrictions on lower-occupancy use in high-traffic areas to reduce congestion in major thoroughfares;
- Time-of-use restrictions to reduce congestion, such as occupancy minimums at rush hour.

In addition to the locally implemented standards, national standards should be established for highway systems to manage congestion and encourage efficient use of our inter-urban transportation infrastructure. The Standing Senate Committee on Transport and Communications published the findings from their study on the regulatory and technical issues related to the deployment of AVs, but these recommendations focused primarily on road safety and the balance between regulation and innovation in AV development without acknowledging the environmental impacts.[88]

Anticipated Risks & Challenges:

Any restrictions to location of AV use or number of occupants may also present technological challenges or privacy concerns regarding data sharing with enforcement agencies. We support the Senate's recommendation to strengthen the Office of the Privacy Commissioner of Canada to proactively investigate and enforce industry compliance with related privacy legislation.[89]

In addition, depending on the exact policy mechanism selected, clear operating standards for AVs may be challenging to implement technologically and/or politically. For example, the City of Toronto approved a plan to toll major thoroughfares in the city, but its plan was denied by the Government of Ontario.[90] The province's decision to reject the city's plan was based on the unavailability of other reliable and affordable public transit options. In the advent of AVs, there will likely be even more jurisdictional and political complexity in decision-making, underscoring the value of national leadership.

88 Senate Committee on Transport and Communications. "Driving Change: Technology and the future of the automated vehicle " January 29, 2018. Senate of Canada.

89 Ibid, p. 57.

90 Benzie, Robert. "Kathleen Wynne stopping John Tory's plan for tolls on DVP, Gardiner" January 26, 2017. The Toronto Star.

Policy Lever 2: Encourage Higher Vehicle Occupancy

We recommend two market-driven options for specifically encouraging higher vehicle occupancy in an automated vehicle world. While effective road pricing will provide some incentive for increased occupancy in AVs, we believe both individual AV owners and MaaS ride-sharing operators should be encouraged to operate their fleets at higher occupancy to make the most efficient use of available road space and energy. We see similarities between this policy challenge and that of pricing carbon emissions across sectors. We also believe the policy instruments offering solutions to higher vehicle occupancy may be similar to instruments addressing climate change, and we see clear alignment with carbon pricing mechanisms outlined as follows:

OPTION A: *Similar to a carbon tax, the federal government or local governments could apply an additional distance-based levy to vehicles traveling with zero or few occupants for more than an agreed-upon acceptable portion of their distance travelled. This additional cost would provide a direct incentive for people to share rides and for MaaS operators to design and price their services attractively for higher-occupancy use to connect travellers on similar routing (i.e., Uber Pool). This policy option could be applied more easily be applied across the vehicle fleet, and could be the more appropriate mechanism for targeting individual AV owners. Revenues from this tax could directly to services designed to reduce congestion and GHG emissions, such as public transit or active transportation infrastructure.*

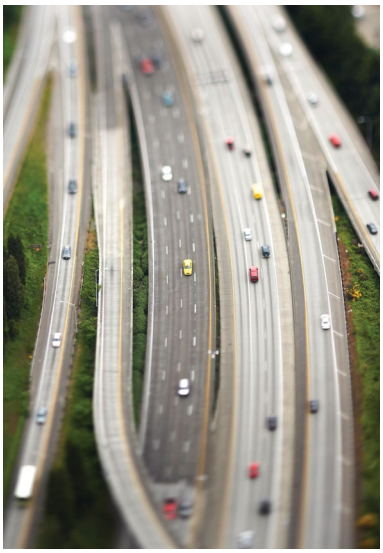
OPTION B: *Similar to a cap and trade system, fleet operators in the MaaS model could be required to purchase a set amount of credits for low-occupancy travel in their fleet. These credits could be auctioned to MaaS operators, with the amount of credits available adjusted annually to meet fleet efficiency and congestion targets. Again, revenues from this tax could be used to support public transit or other critical transportation infrastructure. This policy option is likely most practically applicable to MaaS AV fleet operators rather than individual AV owners.*

Either of these options above would significantly incentivize carpooling and micro-transit AV business models, and deter single-occupancy or no-occupancy AV rides. Rather than specifically restricting undesired behaviour, we suggest that providing financial incentives for improved performance is the most effective method to achieve such policy goals.

Anticipated Risks & Challenges:

Current technology would not likely enable such a sophisticated system of occupancy tracking. Indeed, connected vehicle technology would be necessary to support the enforcement of these standards – the advent of smart cities, however, suggests that this development is on the horizon.[91]

There may be privacy concerns with providing government access to occupancy data at the individual vehicle level. If it is not possible to track this data, a system of restrictions with police enforcement would be necessary to achieve the same goals. Protection and enforcement of privacy data will likely be the greatest challenge in implementing these policy options, especially as a safeguard against potential cybersecurity issues.



91 Policy Horizons Canada. "Canada 2030 Infrastructure: What if self-driving vehicles were the new mass transit solution for cities?" April, 2017.

CONCLUSION

It is 2050 – you are sharing a self-driving car with three other passengers on a road that is free from traffic congestion. As you look out the window, you notice people in other vehicles are either working, sleeping, or talking with friends. The impacts of climate change, while not negligible, are less extreme thanks to lower GHG emissions from the transportation sector. When you arrive at work, each office building has solar panels to charge electric and autonomous vehicle fleets. Energy demand from the transportation sector has significantly decreased as people are driving less and most road lanes are reserved for carpooling. Although you do not own your own vehicle, you are safely connected to a network of publicly owned AVs integrated with your city's thriving, mass public transit system. As a result, you have more time for your family, your work, and your life. This possible future is within Canada's reach.

To realize this vision, our report set out a policy stack to ensure a comprehensive and responsible national framework that reduces GHG emissions from personal vehicle transportation. Although there are significant policy reforms needed to enable a low-carbon future, Canada is fortunately in a position to harness this transition. Now, we have a chance to travel on a road where autonomous, electric, and shared mobility is more effective and environmentally sustainable than ever before.

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APPENDIX A: ARRIVING AT POLICY RECOMMENDATIONS

Step 1: Policy Hackathon Exercise: After thorough review of literature and discussions with various stakeholders, a longlist of policy ideas was developed. A hackathon exercise enabled task force members to contribute innovative ideas without setting any constraints on method, applicability, effectiveness or social acceptance of the proposed idea.

Step 2: Shortlisted Policy Ideas: Starting with the identified longlist of policies, we grouped policy ideas into categories, with key factors that influence each policy taken into consideration. This exercise resulted in shortlisted policy ideas, presented in Table 3, that the team deemed relevant for consideration and further analysis. The team further narrowed the list of recommendations by level of government. Given the federal lens of our report, the focus of our analysis was on federal policies. However, some levers where provincial and municipal government intervention may be possible were also considered.

Step 3: Policy Impact Analysis: Using the impact analysis methodology described earlier, including feedback from the community engagement, our proposed policy recommendations were tested for their impacts on key metrics related to our set policy goals: total distance travelled, GHG emissions, and gas tax revenue. Table 4 highlights the output of the impact analysis and the projected direction and magnitude of each proposed policy.

Step 4: Expert and Community Engagement: Policy ideas were tested and refined by using input from the expert stakeholder interviews as well as the community engagement activity. The engagement exercise also provided an avenue for participants to engage in enriching discussions on Canada's energy and transportation future while considering the influence of human behaviour on policy implementation.

Step 5: Policy Stacking: Recognizing that personal mobility systems are complex and rapidly evolving, the policies recommended must be flexible and multifaceted. Rather than attempting to create one policy that fulfills multiple roles, we proposed a policy stack that contains three categories: "Steer", "Accelerate" and "Protect".

Table 2: Final policy recommendations

Policy Type	Policy	Goals Achieved
Steer	Dynamic Mobility Pricing in Urban Areas	Reduce VDT Increase Revenue
	Time-of-use Electricity Pricing	Reduce GHG Intensity
	Reform and Strengthen the Federal Excise Tax on High-Polluting Vehicles	
Accelerate	Continuous Improvement of Vehicle Fleet Efficiency Standards	Reduce GHG Intensity
	Clean Fuel Standard	
	Canada Infrastructure Bank Investment	
Protect	Clear Operating Standards for AVs	Reduce VDT
	Encourage Higher Vehicle Occupancy	

Table 3. Shortlisted policies

Policy Name	Policy Description	Jurisdictional Level
Taxes/Fees		
Tax on volume of fuel	EV users pay gas tax equivalent at charging station	Federal/provincial
Miles travelled fee	Users (both EV and ICE) pay taxes or a fee based on distance travelled; fees may be differentiated by vehicle class	Provincial
Vehicle fee	Users are charged a fixed (annual) fee for either owning or using a vehicle; fees may be differentiated by vehicle class.	Provincial
Road tolls	Public or private roadway for which a fee (or toll) is charged for usage	Provincial/municipal
Carbon pricing mechanism	Direct carbon pricing mechanisms appied to end-users (as a levy on fuel and electricity)	Federal/provincial
Import fees	Higher imports fees on higher carbon emission vehicles	Federal
Parking fees	Parking fees that reflect the real cost of the parking space	Municipal
Pay as you drive insurance	Insurance rates that are charged at a 'per-kilometer' rate	Provincial
Congestion charges	Users pay a fee for using the road in a highly congested area (i.e. downtown core)	Provincial
	Infrastructure	
Canada Infrastructure Bank	Leveraging public money to attract private investments in transportation infrastructure required to support electric and autonomous vehicles	Federal
Canadian regulations/ framework for autonomous vehicles	A federal policy that allows, supports, and encourages the safe and sustainable deployment of autonomous vehicles	Federal
Federal Gas Tax Fund	Modernize and reform the federal GTF to implement performance-based EV targets for provinces and municipalities and increase awareness of the fund	Federal/provincial/municipal
Right-size existing infrastructure	Optimization of road infrastructure for the future of personal mobility, accounting for the potential reduction in number of vehicles arising from the wide deployment of autonomous and shared vehicle fleets	Federal/provincial/municipal
	Mandates and Supporting Policies	
ICE vehicle ban	Ban the purchase and use of all ICE vehicles	Federal
Zero-emissions vehicle mandate	Set minimum requirements for EV and ZEV sales for auto manufacturers	Provincial
Subsidies for EVs	Provide subsidies and support policies for incenting the deployment of EVs	Federal/ Provincial
Canadian efficient vehicle standards	Set minimum fuel efficiency standard for sold and used ICE vehicles	Federal
Subsidies for shared vehicles	Subsidies and support policies for incenting the deployment of shared vehicles	Provincial/ Municipal
Renewable energy portfolio standards	Minimum requirements for production of electricity from renewable energy sources	Provincial
Carbon Intensity Performance Standard	Minimum carbon emission standards for sold and used vehicles	Federal
Time-of-Use Electricity Pricing	Varying electricity rates by time and by date for EV charging (e.g. peak and off-peak)	Provincial

Table 4. Policy impact analysis

	Policy	Reduce VDT	Reduce GHGs	Reduce Lost Revenue
Taxes / Fees	Tax on volume of fuel			
	Miles travelled fee			
	Vehicle fee			
	Road tolls			
	Carbon pricing mechanism			
	Import fees			
	Parking fees			
	Pay as you drive insurance			
	Congestion charges			
Infrastructure	Canada Infrastructure Bank			
	Federal Gas Tax Fund			
	Canadian regulations/ framework for Avs			
	Right-size existing infrastructure			
Mandates and Supporting Policies	Personal vehicle ban/ICE ban			
	Zero-emissions vehicle mandate			
	Subsidies for EVs			
	Canadian efficient vehicle standards			
	Subsidies for shared vehicles			
	Renewable energy portfolio standards			
	Carbon intensity performance standard			
	Time-of-use electricity pricing			

MAGNITUDE OF IMPACT

Least Desirable **Most Desirable**

Table 5. Policies tested in community engagement activity

Round	Policies considered (Bold = selected in simulation	Description	Feedback from players
1	**VDT Fees**	To better reflect the impact of vehicles on infrastructure and the environment, we are considering moving from a gas tax to a tax based on Vehicle Distance Travelled (VDT). Tax rates will vary by vehicle type, with a higher tax rate on heavy and gas/diesel vehicles	• Ask for government to mandate charging infrastructure • Provincial governments advocates for joint policy project (VDT and carbon pricing at the pumps) • EV manufacturer advocates for gas tax (and proposes EV user rebate)
	Carbon pricing at the pump	Based on the GHG intensity, all gasoline, diesel, and electricity used to fuel personal vehicles will be taxed	• Oil and gas industry advocates for energy fuel content tax • Significant push for infastructure and R&D funding from car companies
	Gasoline vehicle ban	In 10 years, pure gasoline vehicles will no longer be allowed to be sold and in 15 years, the vehicle license fee for ICE vehicles will be 5 times the current price	
2	Low-carbon intensity standard for fuels	All fuels for vehicles (including electricity) will be held to an increased lifecycle carbon intensity standard starting in 2 years (taxes applied to vehicle manufacturers and fuel providers)	• Ask for comprehensive plan for incentive to make switch to EV • Ride-hailing company decides to stop contributing $1 million annually to the governing political party because of its disagreement with the decision to impose VDT fee • Increase R&D investment advocated by car manufacturer • Utility company advocates for large-scale battery storage infrastructure centre in Ontario to create jobs and stabilize the grid
	Canada Infrastructure Bank loans	Significant matching funding available for infrastructure projects that support the transition to low-carbon transportation (e.g. charging stations, public transportation, carbon capture & storage in congested areas)	• Business Improvement Areas (BIA), ride-sharing company, and auto manufacturer worked together on EV charging pilot – indicated need for infrastructure bank funding to make large scale roll-out financially feasible • Significant push from OEM for AV supports
	Increased R&D credits	Investments in improved fuel intensity for ICE vehicles or range improvements for electric vehicles will be qualified for increased R&D tax credits	
3	Restricted zero-passenger miles	Any use of AVs with no passengers will be highly taxed	• Oil and gas industry and ride-hailing service team up to advocate against zero-passenger miles (“buses are empty too, why should we be unfairly taxed?”). Equity issue raised that this fee means that only rich people can own and operate AVs • Comprehensive regulatory framework advocated by multiple parties including car manufacturer, EV manufacturer, and provincial government
	Ban on personal AVs	Significant fees for any personal ownership of AVs although fleets of shared AVs (ride-sharing and car-sharing) are allowed	
	Canadian regulations & framework for AVs	A federal policy that allows, supports, and regulates deployment of personal and public AVs	

APPENDIX B: PUBLIC ENGAGEMENT PROCESS

While modelling gives us an idea of the impact our proposed policies could have in an ideal world, it is also important to consider the influence of human behaviour on policy implementation. To understand how complex systems involved in transportation choices could change the outcome of the policies under evaluation, we used a simulation-style game. This approach was inspired by similar games, including Newtonian Shift (Fresh Forces), Poverty Simulation (United Way) and California Water Crisis (Alfred). An immersive simulation is effective for not only testing ideas in a way that mimics the chaos of real life, but also to improve empathy among participants.

Within the simulated system, each of the players had different goals and options available, which would help or hurt their individual score. The game took place over three rounds of play, representing 1-year, 5-year, and 10-year intervals. In each round, participants were given information about the system and the federal policies under consideration. Then, they had a limited amount of time to negotiate with other players and decide on their course of action. While the game provided some options for potential actions at each stage, players were free to devise their own course of action as well. This gave us unique insight into potential undesirable impacts of the policies we were considering, as well as where there could be public or corporate opposition.

In this game, participants were given transportation-related roles in a simplified municipal system, including:

- **Municipal and provincial governments**
- **Original equipment manufacturers**
- **A regional power utility**
- **Power generators**
- **Consumers**
- **Advocacy groups**
- **An oil and gas company**
- **Car-sharing service providers**

Our task force acted as the Government of Canada in the simulation to provide detail on policies under consideration. Players were requested to provide input regarding the suitability of the policy approach under consideration, feedback on timelines, as well potential exclusions from the policies in Table 5.

In the game, which took place December 3, 2017, at the EV Discovery Centre in Toronto, we had 18 participants between 18-35 years of age, from a variety of backgrounds, including:

- **Consumer advocacy**
- **Public policy**
- **Urban and regional planning**
- **Sustainability advocacy**
- **Transportation business transformation**
- **Health care and disease prevention**

LIMITATIONS

The system simulated in the public engagement was simple by design to enable participants to quickly understand the game and fully participate. However, this means the simulation is missing some nuance and does not accurately reflect the myriad perspectives in the real world. While this bias could be reduced with further research and development, it will never fully reflect the actual personal mobility system in Canada. Therefore, the simulation was used for feedback rather than as an integral part of the recommendation process.

Due to time and cost constraints, we held only one event in Toronto. This resulted in less diversity of perspectives from fewer regional backgrounds. Further research on our recommendations should engage rural and Indigenous communities, as well as youth voices from other provinces.

During each round of game-play, participants considered several actions which included investment decisions, partnership proposals, marketing to customers, or anything else the players could imagine. If an action had not already been pre-assessed for points (points could be money-based, environment-based, or reputation-based), our team members assessed the proposals to assign point values that were fair and reflected the relative monetary, environmental, or reputational impact of the action. Because of the subjective nature of these point values, some of the results from the community engagement session could be limited. Further game simulations should be conducted across the country to determine how our recommended policies are interpreted regionally and with participants in other age demographics.

Your Energy Future

Votre Avenir Énergétique