5.2 **Sector:** Transportation

Extensive movement of people and goods is a defining feature of modern society. Whether one moves by car, truck, train, ship or air, transport is today almost entirely dependent on fossil fuels (gasoline, diesel, fuel oil and kerosene). Decarbonizing transportation, currently Canada's second largest source of GHG emissions, will require transformational change in technologies and practices across all modes. Here, however, the discussion focuses on two critical elements of the road transport sector: light duty vehicles and heavy trucks.

Road transport lies at the core of the current system. It also generates the bulk of transport related GHG emissions, which have risen by more than 80% over the past 30 years (see **Figure 10**).[33,63]

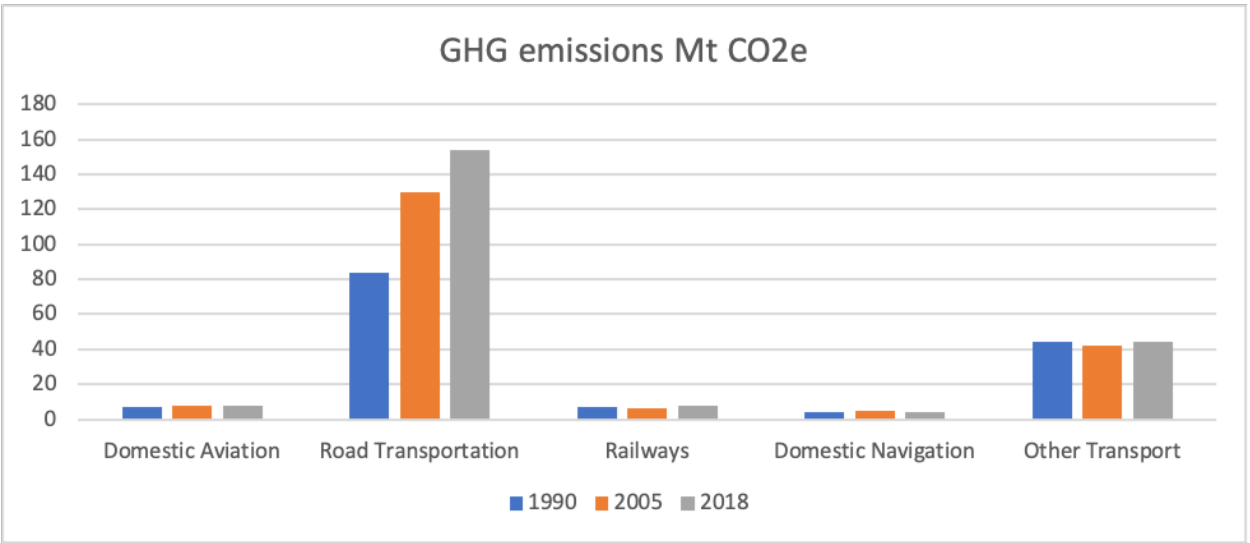

Figure 10. GHG emissions from transport (Canada), selected years.

Source: National Inventory Report 1990–2018: Greenhouse Gas Sources and Sinks in Canada, p. 36

In 2016, Canadians spent on average 70 minutes a day travelling. And those trips were made principally in light duty vehicles (see **Figures 11**). Although most Canadian cities have some form of mass transit, 80% of commuters get to work by car.[64] For three quarters of a century our cities have co-evolved with the private automobile. Land use patterns and population densities, as well as expectations about housing and lifestyle, pose significant difficulties for traditional public transit. Problems associated with the current personal mobility system include costs of car ownership, low-quality urban spaces, congestion, traffic accidents, noise, and air pollution.[65–67] Yet a series of innovations are beginning to disrupt the established internal combustion engine/private automobile based transport system, including alternative power trains (electric, hybrid electric and fuel cell vehicles), new business models (Uber, Lyft, etc.), changing attitudes towards car ownership, and the prospect of connected and autonomous vehicles.[68–71]

Mode	2017
Bus	58,987
Cars	288,392
Passenger Truck	254,934
Air-passenger	211,067
Rail-passenger	1,529

Figure 11-A. Canada passenger travel in 2017 in passenger-kilometres (millions)[196]

Main mode of commuting	2016
Car, truck, van - as a driver	11,748,095
Car, truck, van - as a passenger	868,920
Public transit	1,968,215
Walked	877,985
Bicycle	222,130
Other method	193,595

Figure 11-B. Main mode of commuting for the employed labour force aged 15 years and over in private households with a usual place of work or no fixed workplace address[197]

Approaches to transform the system and lower GHG emissions from passenger vehicles include:

- Avoiding travel through 'teleworking'. Enabled by digital technologies, this option may finally have been given a decisive push by the Covid-19 crisis as employers and employees have realized daily travel to a central workplace may not be essential.[72]
- A switch to active transportation (walking and biking) that also promotes individual health, but which requires investment in alternative infrastructure (bike lanes, bike parking) and is constrained by the current urban form and (in much of Canada) by harsh winters.[73]
- Expanding and decarbonizing mass transit.[199] This would also ease road congestion, and requires infrastructure build-out, and attitudinal shifts.[74]
- Developing 'mobility as a service' models that allow users to access diverse forms of transport as their needs vary (including car sharing).[75]
- Integrated urban planning to promote denser mixed-use neighborhoods (where jobs, shops and recreation are found closer at hand) that are connected to the wider city by public transport.[76]
- Adoption of zero-emission vehicle technologies and the phase out of internal combustion engine vehicles.[77]

Connected vehicles (which communicate with each other and/or with traffic control systems), and autonomous vehicles (which could ultimately drive themselves), are currently the focus of intensive research and have the potential to transform the transport landscape.[71,78,79] These technologies could make a substantial contribution to emissions reductions, but their ultimate impacts will depend on how they are deployed.

Approaches cited above that reduce road vehicle kilometers travelled are important, even as zero emission vehicles gain market share.[198] They can promote more livable cities and improved quality of life. Until the electricity supply and auto production chains are completely decarbonized even zero-emission vehicles are associated with some GHG emissions. Moreover, the electricity system

will assume many additional loads during decarbonization (building heating, industrial processes), and this expansion of electricity provision will require significant investments in physical resources and capital. So, reversing the continuing growth in road vehicle kilometres travelled can ease the electricity supply challenge during accelerated decarbonization.

Nevertheless, the switch to zero emission vehicles and the phase out of the internal combustion engine is a critical strategic step to accelerate the transition in personal transport.

Even with the adoption of all the travel reduction and modal shift options listed above, the structure of our cities and patterns of daily life mean that millions of personal vehicles will remain on the roads for the foreseeable future. And shared, connected, or autonomous vehicles must also be zero emission if they are not to contribute to climate change. A shift to zero-emission passenger vehicles will break dependence on gasoline for mobility and alter the economic and political position of the oil industry. And the technologies that can accelerate this transformation over the coming decade are already mature.

Heavy trucks account for 40% of freight movement in Canada (as measured by ton kilometers) but generate nearly 90% of freight related GHG emissions. This is because of the comparative efficiency of moving freight by rail. Many approaches can contribute to reducing emission in the freight sector (including a modal shift towards rail), but the critical element for systems change is the adoption of zero emission vehicles and the phase out of diesel trucks.

BOX C

Decarbonising long-distance land transport

RAIL: Overhead electric, battery electric or hydrogen fuel cell locomotives could replace current diesel electric trains. Because of Canada's large distances, and especially for freight, hydrogen fuel cells look particularly promising today.

AIR: Bio-based aviation fuels, or battery electric propulsion (for shorter flights), but widespread adoption is one or more decades away. Displacing passengers from air to high speed rail for journeys up to 600 kilometers. Canada is the only developed country where freight currently has priority over passenger trains on the rail network.

5.2.1 **Sector**: Light-duty vehicles

Function	Mobility for work, shopping, social activities, recreation
GHG emissions	13% of Canadian emissions (54% of transportation emissions), plus the emissions generated in the oil and gas sector to produce this gasoline
Options for decarbonization	Electric vehicles; hydrogen fuel cell vehicles
Stage of transition	Electric vehicles: early diffusion phase; Fuel cell: emergence
Nature of the problem today	Up-front costs of zero-emission vehicles; limited charging/refuelling infrastructure; resistance by established manufacturers (supply)
Other systemic issues	Air and noise pollution, costs of ownership, traffic congestion, car-dependent land-use patterns
Opportunities and concerns	For users: reductions in fuel costs, reduced maintenance, reduced total cost of ownership, enhanced vehicle performance. For communities: reduced air pollution. Economic development: business opportunities in the EV value chain; being prepared for vehicle connectivity and automation Risks: decline in existing Canadian auto sector if sufficient investment in EV value chain fails to materialize
Priorities for action	Subsidies for EV purchases; infrastructure investment for charging; government fleet and procurement standards; zero-emission vehicle standards; gasoline/diesel phase-out date; measures to ensure charging at multi-unit residential buildings; building code adjustments. Strategic intervention to build out supply chain for zero-emission transport manufacture
Longer-term issues	Managing grid integration; complementary technologies, smart charging, vehicle to grid, advanced materials; integration with other approaches including: active mobility, public transit, mobility as a service and connected and autonomous vehicles
Indicators of progress	Percent of zero emission vehicle sales; infrastructure build out; value-added in zero emission vehicle production

Roughly 85% of Canadian households have at least one car or light duty truck (SUVs, pickups, vans) and the total number of vehicles continues to increase. Between 2008-2018 the vehicle population grew by 18% (from 19.6 million to 23.1 million), with light-duty trucks making up the fastest growing segment.[64]

Automobile production is a globalised industry dominated by a handful of large multinational companies. With its close connections to related sectors (including oil, steel, chemicals, glass and plastics), the auto industry has been a pillar of economic development for more than century and, after a house, a car is usually the largest consumer purchase.[80]

Canada has a substantial auto manufacturing sector located mainly in Southwestern Ontario. Five multinational companies (Fiat Chrysler, Ford, GM, Honda and Toyota) have vehicles assembly operations. There are also major parts manufacturers, associated machine tool and electronics firms, and testing and R&D facilities. The industry directly employs more than 125,000 workers and makes a $19 billion contribution to GDP. Canadian automotive production is fully integrated with the North American market and provides the country's second largest export (after oil and gas). Particularly since the 2008 recession vehicle production has declined and the sector has been shedding jobs. As a second-tier producer Canada has had to continuously adjust its automotive policy regime to maintain the viability of the domestic industry.

Over time the fuel efficiency (and hence GHG performance) of internal combustion engine vehicles has improved, particularly as automakers have come under regulatory pressure motivated by concerns over air pollution. But movement to net zero GHG emissions requires a fundamental shift in vehicle design. Electric propulsion, in battery electric vehicles or hydrogen fuel cell vehicles, provides the most convincing technological solution, but also promises other benefits including lower lifetime vehicle costs,[194] improved performance, reduced maintenance and elimination of conventional air pollutants (particulates, nitrogen oxides, VOCs, etc.) For an evaluation of the difficulties with alternative emissions reduction approaches — such as blending ethanol with gasoline, switching to natural gas, gasoline/electric hybrids, biofuel vehicles, or synthetic (non-fossil derived) gasoline — see the assessment table below.

NET ZERO PATHWAYS

The transition to electric mobility is already underway. Battery electric vehicles have emerged as the favored design for zero-emission light duty vehicles and have entered the diffusion phase. Vehicle functionality has improved, and producers are benefiting from improving economies of scale, infrastructure roll out, complementary innovations, and favorable regulatory and policy frameworks.[81] Hydrogen fuel cell vehicles remain at the emergence phase. Over the past decade international electric vehicle (EV) production has ramped up to pass more than 2 million a year in 2018. Battery prices have dropped by over 80%, while vehicle range has steadily improved. Globally, EVs make up about 2.5% of automobile sales but have taken a larger share in a few lead markets (Norway: 56%; Sweden 11%; China 5%). Electric vehicle figures include both battery electric (fully electric vehicles) and plug-in hybrid electric vehicles (which have an auxiliary gasoline motor that can charge the battery). The balance of sales between the two types is evolving toward the fully electric form (nearly 75% of global EV market share in 2019). Over the past few years, the major automotive producers have committed to an electric future. But while the direction of travel is clear, the pace of change remains very much in question.

The main barriers to broader EV uptake include higher purchase cost and limited range as compared to internal combustion engine vehicles, and lack of charging infrastructure. Consumers are also concerned over performance in cold weather, charging times, and the narrow range of models

available (particularly in the light truck market segment). In Canada there is increasing evidence that demand is outstripping supply with long waiting times for vehicle delivery.[193]

To date innovation has primarily been driven by outsiders (Tesla, China), while the dominant automotive producers have been resistant to shift from the internal combustion engine that has been so profitable. Incumbents have substantial physical and intellectual capital (patents, know-how) sunk in existing designs. EVs are quite different from ICE vehicles and will achieve their full potential with novel designs (rather than with the insertion of a battery and electric motor into an existing model). After many years of keeping a watching brief the major producers have now committed to electrification, but (particularly in North America) they would like to spread the transition over multiple decades.

Building the EV value chain in Canada is essential both to accelerate the market penetration of electric vehicles and to secure economic opportunities in a net zero future. Automobile production in Ontario is today based almost entirely around internal combustion engine vehicles as international automakers have preferred to concentrate EV innovation in their home territories or in major markets such as China. Policy makers in Canada have been hesitant to drive EV uptake if it is seen as hastening the decline of an established industry. As the global transition in this sector gathers pace, existing manufacturing jobs are subsisting on borrowed time. For economic and political reasons building EV market share and expanding domestic industrial capacity go hand in hand. If there is to be a vibrant Canadian auto industry in the future, policy must embrace both goals.

While its domestic market is small, Canada potentially enjoys advantages in the race to build production capacity for electrified transport. These include mineral resources, the mining, processing, and electro chemical capacity required for battery manufacture, as well as strengths in vehicle assembly, a skilled workforce, and R&D capacity. Pioneering research on the development of lithium-ion batteries and electric drive chains took place in Canada, as well as ongoing research on vehicle connectivity and autonomy. Portions of the value chain are already growing, particularly in the manufacture of busses, medium duty trucks and specialized industrial and off-road vehicles.

Canada cannot expect to be a first rank player in the global automotive industry (like Germany, China or the United States), but even a second-tier position with a strong presence in particular niches, could yield annual markets worth tens of billions of dollars. Attracting foreign partners can speed up development. It is not clear that incumbent auto makers will dominate EV production in the future. New entrants are joining the sector, and battery and drive chain technologies are still at the beginning of their development curves. If Canada is to have a place in this future, governments must take an active role to chart a path forward, build capacity, attract capital, and support training and R&D. So far, the Quebec government has taken several important initiatives, but despite some recent announcements, the Ontario and Federal governments still appear to lack focus, have been discouraged by existing incumbents, and hampered by a reflex of 'letting markets decide' or (since Biden's election) waiting for the US to take the lead.

SHORT AND LONG TERM PRIORITIES

Federal and provincial governments have offered incentives to encourage EV purchase, and initial investments have been made in vehicle charging networks. Quebec and British Columbia have had the most active policy supports with 8.3% and 5.9% of new vehicle sales in 2019 respectively. [82] As production volumes have gone up prices are falling, but purchase supports will be required for some time. Experience from other countries suggest a basket of measures are most effective to accelerate sustainability transitions. For EVs these can include subsidies for individual and fleet purchases, public procurement policies that favor EVs, investment in charging infrastructure, and public education around the benefits. Zero emissions vehicle standards (that compel suppliers to meet a target percentage of emission free vehicles in their annual sales) can be effective. Strengthened emissions standards for gasoline and diesel engine cars can also help by raising the price of traditional vehicles. Announcement of a phase out date for GHG emitting vehicles sales sends a powerful signal to producers and consumers.[83–85]

Over the next few years battery prices are expected to continue to fall, and vehicle range will grow. A wide variety of SUVs, vans and pick up trucks will enter the market, although prices for these will be relatively high. Improved charging infrastructure is critical to widen EV appeal. Public investment is important but so is development of business models to encourage private investment. Catering to adopters living in multi-unit dwellings is particularly challenging,[86] as 'range anxiety' has now been replaced by concerns over 'charging deserts' for urban dwellers.[87] So building codes, regulations and condo rules for multi unit dwellings must be updated to be 'EV ready'.

Measures to encourage vehicle uptake should be coupled with strategic intervention to build the EV supply chain, so that the positive economic and political synergies between EV market penetration and EV-related economic activity can be achieved. This can also strengthen Canada's presence in connected and autonomous vehicle development. Time is short to take maximum advantage of potential comparative advantages.

Longer-term issues include: ensuring sufficient grid capacity, as an increasing share of the transport load is assumed by electricity; managing charging demand and possible 'vehicle to grid' energy storage applications; 'second life' battery applications and battery recycling;[191,192] complementary transportation demand management, especially expansion of public transit and transit-integrated land use planning; and integrating electrification with approaches related to mobility as a service, connectivity and automatous vehicles.

Continued fossil energy presence on the electricity grid, and the GHG footprint of EV manufacturing and end-of- life vehicle disposal, are sometimes advanced as reasons not to accelerate EV adoption. But the Canadian grid is already largely decarbonized, and research suggests that even in provinces with higher GHG intensity of electricity supply EVs will bring short term emissions reductions. But the real issue is not short-term emissions but tipping the transport system away from dependence on fossil fuels. Driving up EV market share accelerates this process, and in the decade or two that it will take to electrify the light vehicle fleet, full decarbonization of electricity supply will proceed.

Similarly, it will be by decarbonizing the grid, and addressing energy and process emissions in the mining industry, steel, chemical and plastics production, and in battery production and recycling that GHG emissions embodied in vehicles can progressively be addressed.