PEMBINA FOUNDATION

The State of Freight

Understanding greenhouse gas emissions from goods movement in Canada

Bora Plumptre, Eli Angen, Dianne Zimmerman
June 2017

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The Pembina Foundation is working to solve today's greatest energy challenges —reducing the harmful impacts of fossil fuels while supporting the transition to an energy system that is clean, safe and sustains a high quality of life. We provide our expertise to industry and government leaders, and we advocate for a strong, science-based approach to policy, regulation, environmental protection and energy development.

About the Pembina Institute

The Pembina Institute is a national non-partisan think tank that advocates for strong, effective policies to support Canada's clean energy transition. We employ multi-faceted and highly collaborative approaches to change. Producing credible, evidence-based research and analysis, we consult directly with organizations to design and implement clean energy solutions, and convene diverse sets of stakeholders to identify and move toward common solutions.

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Contents

List of Figures

List of Tables

Executive summary

Freight, or goods movement by truck, rail, ship or plane, is a too-often overlooked source of carbon emissions. As of 2015 it accounted for 10.5% of total emissions in Canada, which is barely less than emissions from the electricity sector. Within the transportation sector — which at 24% is the second highest source of emissions in Canada — freight is the fastest growing segment. In fact, Canada's 2nd Biennial Report on Climate Change projects that freight emissions will eclipse passenger emissions around 2030. These largely unchecked emissions could prove to be a huge roadblock for Canada to meet its climate targets and live up to its Paris Agreement commitment.

At the same time, we have an interconnected and globalized economy that depends on the smooth and efficient movement of goods around the world. With annual exports and imports in 2016 valued at $521.3 billion and $547.3 billion, respectively, the Canadian economy relies on freight. The freight sector is critical to maintaining our everyday lifestyles and consumer habits.

To date, much public and policy attention has been centred on emissions from passenger vehicles, illustrated through progress in the growth of electric vehicles and expansion of rapid transit. This is of course justified, as passenger emissions represent more than half of transportation emissions. However, we believe that, due to the growing proportion of GHG emissions, equal attention need to be paid to the environmental impact of freight — not to mention the additional benefits this is likely to provide: relieving road congestion, cleaner air, more cost-efficient business practices, and more.

With this in mind, now is the time to make real progress and policy change on freight emissions that have environmental, social and economic wins. And the possibilities to do so are very much within reach. This report explores the current state of freight across Canada and outlines opportunities for how we can move forward to reduce emissions from the freight sector.

The growth of the freight sector is due to a number of factors: increasing population and economic growth, more international manufacturing and global supply chains, the increasing presence of online shopping, and the consumer expectation to receive goods quickly. However, we don't have to sacrifice economic growth to achieve deep emission cuts in the freight sector. Successful strategies for the decarbonization of goods

movement can revolve around actions to reduce the carbon intensity of freight transport, and not necessarily require decreasing the volume of goods moved.

This report identifies the following key opportunities to reduce emissions from freight:

- Climate policies that broadly impact the Canadian economy and will drive long-term reductions in GHG emissions, specifically the federal benchmark for carbon pricing and the forthcoming federal Clean Fuel Standard.
- Phase 2 heavy-duty vehicle efficiency regulations, which provide a backstop of improvement to model year 2027.
- Continued rollout and adoption of efficiency technologies.
- Build-out of fuelling infrastructure across a range of options with biofuels and natural gas in the short term, and electric and hydrogen following closely behind.
- Integrating goods movement into land use planning at the regional and municipal level.

The report is laid out as follows:

- Section 1: We look at the role freight plays in Canada's economy, and how it contributes to the country's emissions profile.
- Section 2: We explore the policy and regulatory landscapes across the country that shape the freight sector. We also develop a picture of the major companies, organizations and stakeholders who own, operate and participate in Canada's freight transport system.
- Section 3: We explore existing actions and policies to address emissions from freight, highlight promising experiences in other jurisdictions, and summarize potential challenges and opportunities for reducing emissions further in Canada.

It should also be noted that when we refer to "freight" throughout this report, we're referring to movement of goods. This encompasses many modes of transport, including road, air, marine, rail and pipelines. However, this report primarily focuses on the movement of freight by on-road heavy-duty vehicles, or trucking, as this is by far the largest segment within the sector both in terms of goods moved and emissions produced. It is anticipated that future research by the Pembina Institute will look at the other modes of goods movement.

1. Importance of freight in the climate context

With the signing of the Pan-Canadian Framework on Clean Growth and Climate Change last year, the Government of Canada and the provinces made an unprecedented commitment to coordinated action on climate change. At the same time, they agreed to collaborate on building a clean economy that positions Canada for resilience and prosperity through the challenges of the twenty-first century. In the international sphere, Canada's commitment to its 2030 greenhouse gas (GHG) emissions reductions target is formalized under the Paris Agreement concluded at COP21 (21st Conference of the Parties to the UN Framework Convention on Climate Change).[1] The 2030 target mandates a 30% reduction in GHGs compared to total national emissions in 2005, which in absolute terms means a drop from 738 megatonnes (Mt) CO_2e to 517 Mt CO_2e.[2]

As the country moves to pursue decarbonization and implement the Pan-Canadian Framework, policy-makers will be paying special attention to public and private developments related to transportation, Canada's second-largest source of emissions by economic sector.[3]

Key terms

Goods movement
Goods movement refers to the transport of physical products (e.g. clothing, food, gasoline, and furniture; finished or semi-finished) and raw materials (e.g. precious metals, lumber, fabric).

[1] Government of Canada et al., *The Pan-Canadian Framework on Clean Growth and Climate Change: Canada's Plan to Address Climate Change and Grow the Economy* (2016). https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

[2] Environment and Climate Change Canada, *Canada's Second Biennial Report on Climate Change* (2016), Annex 1. https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=02D095CB-1#BR-SecAnnex1

[3] According to ECCC's accounting methodology, Canadian transportation sector emission totals represent all emissions (including combustion, process, and refrigerant emissions) arising from the tailpipes of domestic passenger and freight/cargo transport vehicles.

Heavy-duty vehicles
Vehicle weight classes and categories are defined in the Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations made under the Canadian Environmental Protection Act, 1999. Heavy-duty vehicles include all on-road vehicles with a gross vehicle weight rating of more than 3856 kg (8500 lbs), although a number of distinct vehicle types are distinguishable within this broad category.[4]

Vocational vehicles
Under the Canadian regulatory framework, this heavy-duty vehicle category includes school, transit and intercity buses; freight (heavy tandem / conventional tractor), delivery, garbage, service, and dump trucks; and cement mixers and equipment or material haulers.

1.1 Emissions from freight transport

Since 1990, GHG emissions from the transportation sector have been responsible for 20% to 24% of our total emissions. In 2015, GHG emissions from transportation were 24% (173 Mt) of total emissions (Figure 1).[5] GHGs from on-road heavy-duty vehicles (including both gasoline- and diesel-fuelled engines) totalled over 62 Mt, or nearly 9% of total national emissions.[6]

[4] Environment Canada, *Guidance Document: Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations made under CEPA, 1999* (2015). http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=71EF09D7-1

[5] Environment and Climate Change Canada, *National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada* (2017) [*NIR 2017*] Part 3, Table A10-2. http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php. The transportation sector category includes domestic aviation, road transportation, railways, marine and off-road transportation.

[6] *NIR 2017*, Part 3, Table A9-2.

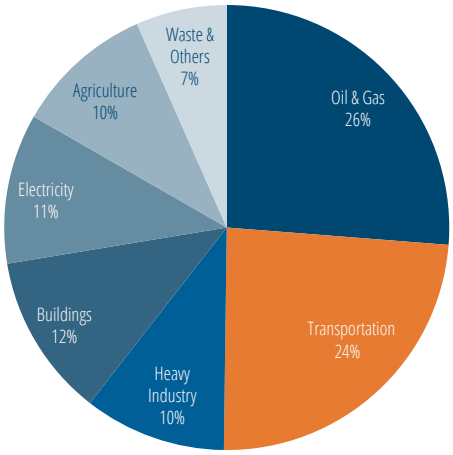

Figure 1. Canadian GHG emissions in 2015 by economic sector

Data source: Environment and Climate Change Canada[7]

While transportation-related emissions have remained relatively constant as a proportion of overall emissions, in absolute terms they have increased 42% since 1990 (Figure 2). The sector has therefore been a significant source of the continued increase in GHG emissions nationally, and without effective mitigation policies and significant action it will continue to drive emissions growth.

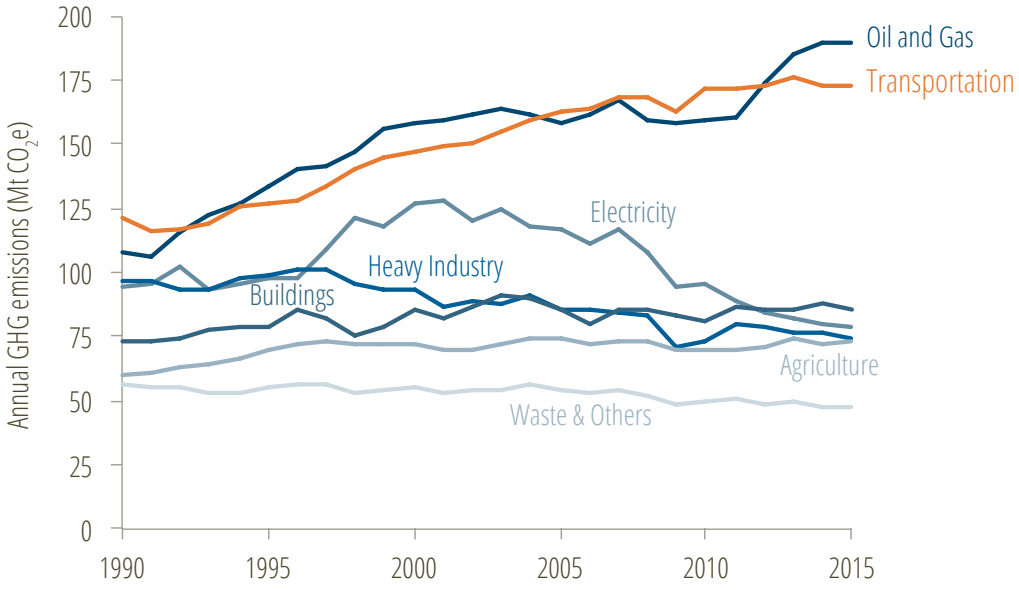

Figure 2. Change in annual GHG emissions in Canada by sector

Data source: Environment and Climate Change Canada[8]

[7] *NIR 2017*, Part 3, Table A10-2 (pg. 44).

[8] Ibid.

At the provincial level, transportation is currently the largest sectoral source of emissions in British Columbia, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, and Newfoundland and Labrador.[9] Overall, Ontario, Alberta, Quebec, and British Columbia have the highest-emitting transportation sectors (see Figure 3).

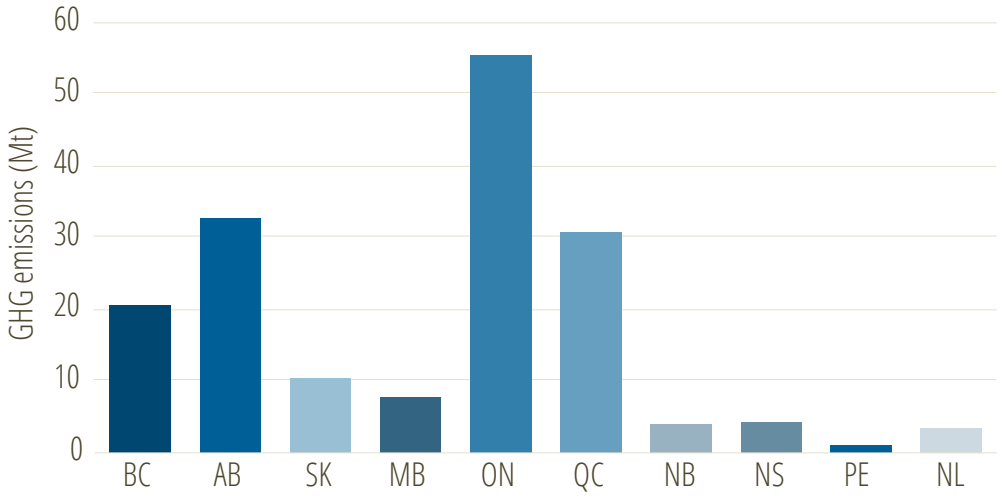

Figure 3. Transportation sector GHG emissions by province in 2015

Data source: Environment and Climate Change Canada[10]

Beyond recognizing how much impact transportation has on national emissions, effective climate and transportation policies that address freight must take into account the complexity of the sector and how emissions break down within it, as it covers a wide range of human activity. In 2015, goods movement — including trucking, domestic aviation, rail, and marine transport — accounted for approximately 44% of all transportation-related emissions.[11] Since 1990 emissions from freight, including all freight transportation modes, increased 125%, with emissions from heavy-duty freight trucks increasing by 205% (see Figure 4).[12]

[9] *NIR 2017*, Part 3, Annex 12, "Summaries of provincial GHG emissions by economic sector."

[10] Ibid.

[11] *NIR 2017*, Part 3, Table A10-2.

[12] Environment and Climate Change Canada, *Canadian Environmental Sustainability Indicators: Greenhouse Gas Emissions* (2017), 10. https://www.ec.gc.ca/indicateurs-indicators/F60DB708-6243-4A71-896B-6C7FB5CC7D01/GHGEmissions_EN.pdf

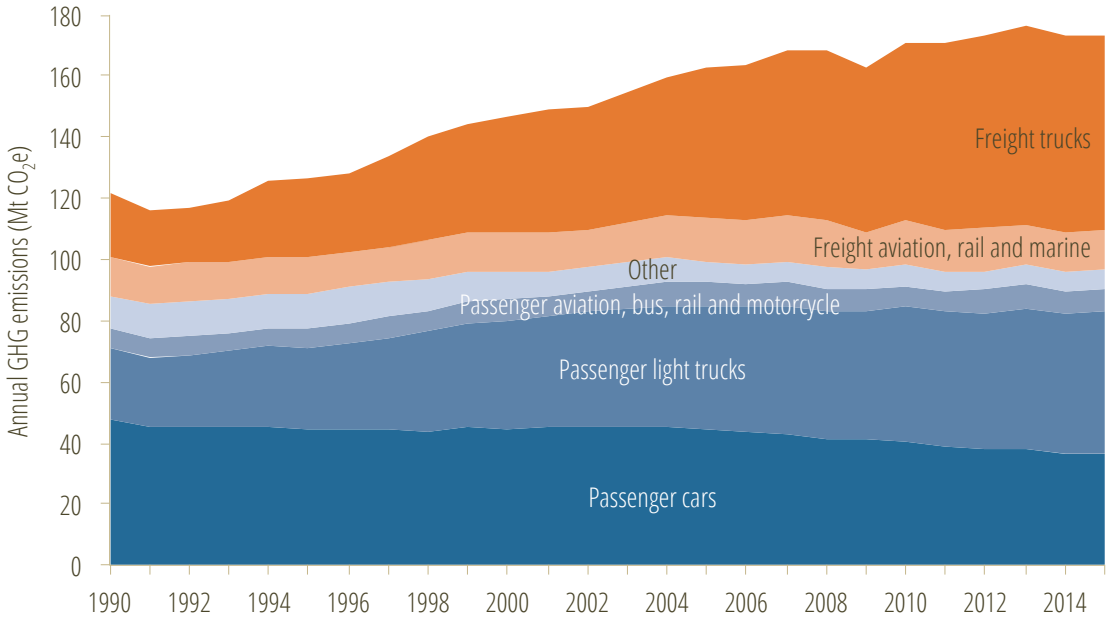

Figure 4. Canadian transportation sector GHG emissions

Data source: Environment and Climate Change Canada[13]

There are several reasons why freight trucks are the fastest-growing portion of transportation emissions. As the principal function of freight trucks in Canada is the movement of goods, emissions growth has partly followed from increasing inter-urban and interprovincial trade.[14] Emissions have also risen because trucking has a higher carbon intensity (measured in grams of CO_2e per tonne-kilometre) than most other modes of freight transport.

Other important factors include increasing population, economic growth, more international manufacturing and global supply chains, growth in online shopping, and consumer pressure to transport goods quickly. Furthermore, gains in fuel efficiency across all vehicle categories have been more than offset by the substantial increase in vehicle-kilometres travelled and by changes in the composition of the vehicle fleet, specifically the increasing number of both light-duty and heavy-duty vehicles on the road (see Figure 5).[15]

[13] ECCC, "Environmental Indicators: Greenhouse Gas Emissions by Canadian Economic Sector," (2017). https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=F60DB708-1. Data source: *NIR 2017*, Part 3, Annex 9.

[14] NRCan & L-P Tardif & Associates, Inc., *Fuel Efficiency Benchmarking in Canada's Trucking Industry* (2000). http://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/reports/7607

[15] *NIR 2017*, Part 1, 23.

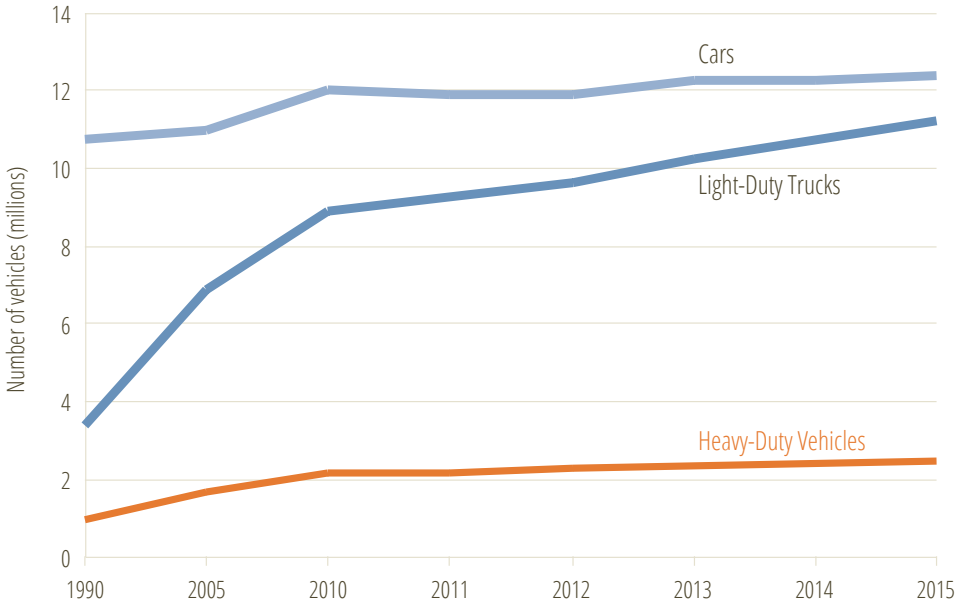

Figure 5. Trends in vehicle numbers in Canada

Data source: Environment and Climate Change Canada[16]

The case for understanding and mitigating freight sector emissions is clear. Baseline trade projections from the Organisation for Economic Co-operation and Development and the International Transport Forum show international freight transport volume, driven mostly by increased use of road transport, will triple by 2050.[17] In Canada, emissions from freight transport are projected to surpass passenger transport around 2030 (see Figure 6), with a similar progression occurring globally.[18]

[16] *NIR 2017*, Part 1, Table 2-6.

[17] Global freight volumes are measured in billions of tonne-kilometres. As the report's authors readily admit, these projections rest on a number of uncertain assumptions. Organisation for Economic Co-operation and Development and International Transport Forum, *ITF Transport Outlook 2017* (2017), 73. http://dx.doi.org/10.1787/9789282108000-5-en

[18] United States Environmental Protection Agency, "EPA and DOT Finalize Greenhouse Gas and Fuel Efficiency Standards for Heavy-Duty Trucks," news release, August 16, 2016. https://www.epa.gov/newsreleases/epa-and-dot-finalize-greenhouse-gas-and-fuel-efficiency-standards-heavy-duty-trucks-0

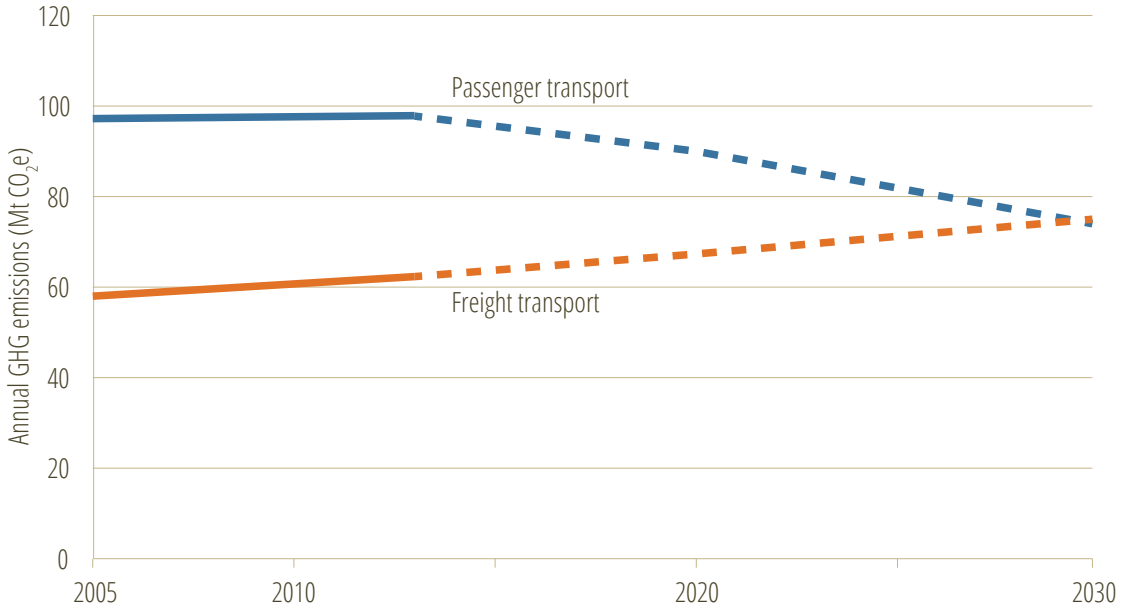

Figure 6. Emissions projections to 2030 for passenger and freight transport

Data source: Government of Canada[19]

Despite the clear growth trajectory of emissions from trucking, little public attention has so far been paid to the need to reduce emissions from commercial transport. For governments and policy-makers, goods movement now regularly enters as a planning consideration within larger studies of transportation and public policy. However, considering the significant role freight plays in the national emissions inventory, much more attention and directed policies are necessary in order to make the deep emission cuts required for Canada to meet its climate commitments and move towards a decarbonized economy.

1.2 Freight's role in the Canadian economy

Canada has a relatively balanced export and import economy with exports of $521.3 billion and imports of $547.3 billion in 2016. Freight transport is a critical enabler of this economic activity.[20]

In 2015, transportation and warehousing represented 4.3% of total gross domestic product (GDP), and the number of people employed in the sector rose to 892,000.

[19] *Canada's Second Biennial Report on Climate Change,* Table A11.

[20] Statistics Canada, "Canadian international merchandise trade: annual review, 2016" (The Daily, May 4, 2017). http://www.statcan.gc.ca/daily-quotidien/170504/dq170504c-eng.htm

Employment in commercial transport industries has accounted for roughly 5% of total employment in Canada since the mid-1990s.[21] This includes a diverse array of industries and actors including shippers, logistics providers and various kinds of carrier operators (including trucks, ships, planes, trains and pipelines).

As useful as GDP measures may be, it is important to recognize that they include only the economic activities directly related to for-hire or commercial transportation; the overall importance of freight transport services, which are embedded throughout the economy, is more difficult to capture. Any business with a supply chain depends on freight. And nearly everything we purchase as consumers has to be transported to the purchase or delivery point.

While the United States remains our largest trading partner, in recent years its share of Canadian merchandise exports has declined. Meanwhile, the value, volume, and share of Canadian exports headed to both Europe and Asia are rising.

In 2015, for-hire trucking companies moved 64 million shipments, weighing a total 729.2 million tonnes, an average distance of 613 kilometres. Many of these shipments, and the economic activity they support, are made possible by the reach of the Trans-Canada Highway.[22] Likewise, Canada's mainline (Class 1) and regional (short line) railways continue to be a major backbone of the Canadian economy. In 2015, the Canadian railway industry moved almost 331.5 million tonnes of freight over more than 63,000 kilometres of track across the country.[23]

[21] Transport Canada, *Transportation in Canada, 2015: Overview Report*, 2. https://www.tc.gc.ca/eng/policy/anre-menu.htm

[22] Statistics Canada, “Trucking Commodity Origin and Destination Survey, 2015” (The Daily, May 12, 2017). http://www.statcan.gc.ca/daily-quotidien/170512/dq170512b-eng.htm

[23] Statistics Canada, “Rail transportation, 2015” (The Daily, March 31, 2017). http://www.statcan.gc.ca/daily-quotidien/170331/dq170331h-eng.htm

2. Canada's freight policy landscape

2.1 Federal jurisdiction

The reliance of the Canadian economy on goods movement, as well as the large distances typically involved in connecting urban centres to necessary resources and each other, mean the federal government's involvement in the governance of freight occurs at multiple points, in multiple ways. Most policies and government actions affecting goods movement are domestic in scope, though bilateral actions with the U.S. (e.g. with respect to natural gas fuelling) are ongoing.

Various federal laws, rules and policies impact the businesses and networks that collectively constitute Canada's freight transport system. The government departments most directly responsible for administering freight-related federal regulations are Environment and Climate Change Canada (ECCC) and Transport Canada. Since 2000, ECCC has introduced a range of fuel, vehicle and engine regulations, which mostly align with corresponding U.S. Environmental Protection Agency (EPA) standards. Among other aims, these standards set tailpipe requirements for air pollution prevention and GHG reduction on different classes of vehicles, limit the content of dangerous chemicals (such as sulphur, lead and benzene) in gasoline and diesel fuel, and mandate volumetric blending levels for renewable fuel content in gasoline and diesel.

Transport Canada is responsible for federal transportation policies and programs, and assumes a leadership role for ensuring that all parts of the transportation system work together effectively. The department fulfills its mandate through the pursuit of a transportation system that is efficient, clean, safe and secure. They regulate the movement of goods across Canada's air, marine and surface transport networks, as well as through the infrastructure that links these travel modes.[24]

A more comprehensive list of regulations that impact the freight sector can be found in Appendix A.1.

[24] Transport Canada, "About Transport Canada: Transition Book" (2015), 1. https://www.tc.gc.ca/eng/aboutus-668.html

2.1.1 Recent & ongoing federal policy processes

A number of recent and proposed policies have recently been announced that will have an impact on emissions from the freight sector.

Clean Fuel Standard

In November 2016, the Government of Canada announced its intent to establish a federal Clean Fuel Standard. Announced as part of the Pan-Canadian Framework on Clean Growth and Climate Change, the standard represents a central component of Canada's plan to achieve its 2030 climate commitments under the Paris Agreement. The Clean Fuel Standard, if designed and implemented as proposed, will include all fuel types (liquid, gaseous and solid) and have broad coverage over fuels used in transportation, buildings, and industrial processes. The 30 Mt of reductions that this regulation could enable would amount to nearly 15% of the total reductions needed to meet our 2030 target — more than any other individual policy. Due to its emissions potential, the Clean Fuel Standard has emerged as one of the most significant federal actions within the suite of Pan-Canadian Framework policies. As proposed, the standard would include requirements for the regulatees to reduce the life cycle GHG emissions from the fuel they supply. A public consultation is currently underway and it is expected that the standard will enter into force in 2019.[25]

Heavy-duty vehicle GHG regulations

In March 2017, the federal government published its Regulations Amending the Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations in the Canada Gazette, Part 1. These proposed amendments will establish requirements on new tractors, engines, and (for the first time) trailers. The amended requirements would be phased in for trailers beginning in 2018, followed by tractors and engines with model year 2021. They would increase in stringency every three years until 2027. The object of these regulations is, in part, to remain aligned with the regulatory program on heavy-duty vehicles established in the United States under the EPA's Phase II GHG standards. While the Canadian regulations have yet to be finalized, the Government of Canada currently

[25] Erin Flanagan, Dianne Zimmerman and Karen Tam Wu, *Submission to the federal government's discussion paper on the proposed Clean Fuel Standard* (Pembina Institute, 2017). http://www.pembina.org/pub/submission-to-federal-government-s-discussion-paper-on-proposed-clean-fuel-standard

predicts savings of 41 Mt from heavy-duty vehicles produced from 2018–2029.[26] The anticipated results of this regulatory action make it widely regarded as the most significant current federal policy to specifically target emissions reductions from freight transport. In general, the standards are supported by the trucking industry, which authored a white paper outlining its related hopes and concerns.[27]

Federal transportation strategy

After several months of consultation, in November 2016 the Minister of Transportation, Marc Garneau, announced a new federal transportation strategy called *Transportation 2030: A Strategic Plan for the Future of Transportation in Canada*. Notable themes related to freight in the strategy include:

- Trade corridors to global markets: improve performance and reliability of transportation system to get products to market more efficiently by investing $10.1 billion for transportation infrastructure to eliminate bottlenecks and enhance trade corridors; legislate reciprocal penalties in service level agreements between railway companies and their customers.
- Green and innovative transportation: working to implement the Pan-Canadian Framework to meet the 2030 climate target; investing in smart grids, electricity transmission, renewable power, and smart cities plans to support cleaner transportation technology; support regulatory framework for emerging technologies like autonomous vehicles; invest in electric vehicle charging and low-emissions fuelling stations.

Transportation Act review

In February 2016, the Transportation Act Review: *Pathways: Connecting Canada's Transportation System to the World* was tabled in the House of Commons.[28] The report is the product of a two-year review of the Canadian transportation system and the legal and regulatory frameworks that govern it, including the Canada Transportation Act.

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[26] Government of Canada, *Regulations Amending the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations and Other Regulations Made Under the Canadian Environmental Protection Act, 1999*. http://www.gazette.gc.ca/rp-pr/p1/2017/2017-03-04/html/reg1-eng.php

[27] Canadian Trucking Alliance, *White Paper on Proposed Phase II Green-House Gas Emissions & Fuel Efficiency Regulations for Heavy Trucks in Canada* (2016). http://cantruck.ca/wp-content/uploads/2016/01/CTA-GHG-SMART-whitepaper_public.pdf

[28] Canada Transportation Act Review, *Pathways: Connecting Canada's Transportation System to the World* (2016). http://www.tc.gc.ca/eng/ctareview2014/canada-transportation-act-review.html

Prior to this, the last review of the Act was conducted in 2001. The report will continue to inform the broad developments on transportation happening at the federal level.

GHGs from locomotives

The Locomotive Emissions Regulations currently do not cover carbon dioxide and other greenhouse gases. However, Canada is working with the United States on approaches to reduce GHGs from locomotives through the Canada-U.S. Regulatory Cooperation Council, which is in the process of finalizing a voluntary action plan.[29]

2.1.2 Federal departments and programs

Natural Resources Canada (NRCan) and Transport Canada are responsible for administering programs targeting the movement of commercial goods.

FleetSmart

FleetSmart's purpose is to introduce heavy-duty truck fleets to best practices for reducing fuel consumption and the GHG emissions associated with fuel use. FleetSmart offers free information and training on how energy efficiency technologies and business practices can cut fleet operating costs while reducing harmful vehicle emissions. In doing so, it provides a practical toolkit to help companies improve their productivity and increase their competitiveness.[30]

FleetSmart's SmartDriver training provides opportunities for trucking fleets to comprehensively understand issues of energy management across their operations, including through choice of vehicle, vehicle maintenance, and driving techniques to promote fuel efficiency.

SmartWay

The SmartWay Transport Partnership is a collaboration between government and industry designed to help businesses reduce fuel costs while transporting goods in the cleanest, most efficient way possible. SmartWay works with freight shippers, truck carriers, barge carriers, multi-modal carriers, and logistics companies who are committed to benchmarking their operations, tracking their fuel consumption and

[29] Transport Canada, "Regulatory area to be addressed: Locomotive Emissions." http://www.tc.gc.ca/eng/acts-regulations/tc-usepa-860.html

[30] Natural Resources Canada, "FleetSmart." http://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/fleetsmart/16930

improving their annual performance. The program provides tools to monitor and measure operations and benchmark performance. It processes carrier data into company-specific emissions performance metrics (in Canada, grams per kilometre and grams per tonne-kilometre). Shipper companies that purchase freight transportation services (manufacturers, retailers, wholesalers) can also participate.

Originally launched in 2004 by the EPA (in partnership with 50 companies and organizations), SmartWay expanded to Canada in 2012 under a letter of agreement establishing joint administration of the program by NRCan.[31] One of the oldest and largest "green freight" programs in the world, SmartWay covers multiple modes and is well known and respected by its diverse set of partners and affiliates. According to NRCan's most recent report to Parliament under the Energy Efficiency Act, SmartWay fleets are estimated to save on average over 5000 litres of fuel per truck per year, representing over $180 million in annual fuel cost savings.[32] Figure 7 below shows the average decline in CO_2 and particulate matter ($PM_{2.5}$) emissions per tonne-kilometre over partner companies' first five years of participation in SmartWay. Over the period from 2008-2015, carriers reduced their CO_2 emissions by an average of 12.1% and their $PM_{2.5}$ emissions by an average of 59.5%.

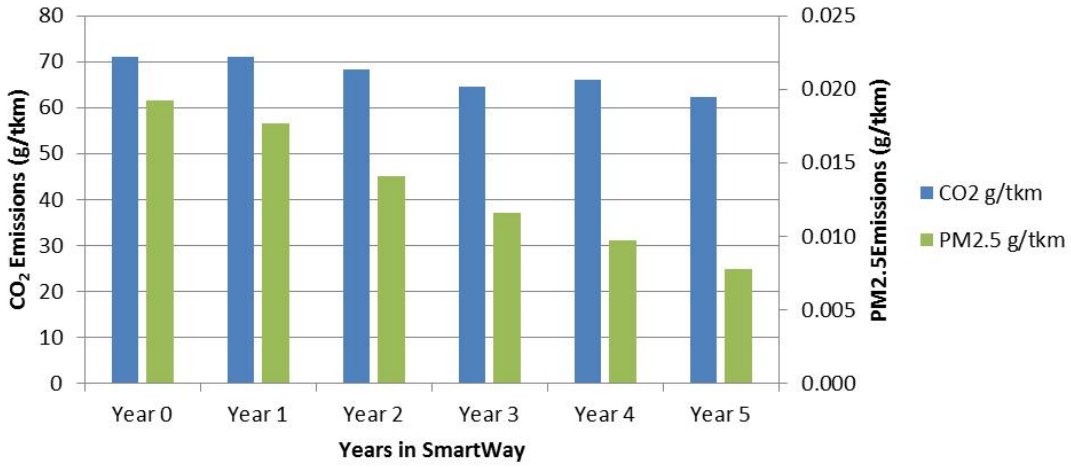

Figure 7. Emissions reductions from participation in SmartWay

[31] Natural Resources Canada, "SmartWay: About." https://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/smartway/15541

[32] Natural Resources Canada, *Improving Energy Performance in Canada: Report to Parliament Under the Energy Efficiency Act 2013-2015* (2016) 21. http://oee.nrcan.gc.ca/publications/statistics/parliament10-11/index.cfm

Source: Natural Resources Canada[33]

More than 3,500 North American companies, over 400 of which are Canadian, have become registered affiliates to the SmartWay Transport Partnership. Carriers can use SmartWay to market themselves to shippers that are concerned about emissions, and benchmark themselves against industry peers.[34] Shippers can use SmartWay to compare the environmental performance of carriers and calculate their freight carbon footprint.

Shippers' and logistics companies' use of publicly available carrier performance rankings provides an important incentive for the participation and performance improvement of carriers.[35] Many SmartWay shippers, including multinational companies, prefer or require SmartWay carriers—whether for corporate sustainability reporting, stockholder reports, or media and customer relations. SmartWay also provides awards and recognition for its top-performing partners.

Under their agreement of joint administration, NRCan and EPA have harmonized their data collection, emissions calculation, and database functionality for data-sharing and comparison purposes. Though certain technology-verification and research components of the program are housed within the EPA, the program uses the same partner recognition and logo qualification requirements in Canada and the United States.[36] In both countries, stakeholders credit the SmartWay brand with helping to accelerate the availability and uptake of fuel-saving technologies and operational practices.

Other initiatives

As of February 2017, Transport Canada continues to administer several freight-related "clean transportation" programs under its environment and innovation policy/programming baskets, including:

- EcoTechnology for Vehicles program: This program tests the safety, environmental, and driving performance of new technologies for passenger

[33] Natural Resources Canada, "2008-2015: Carbon dioxide (CO_2) and particulate matter ($PM_{2.5}$) emissions of Canadian class 8b truck carriers," in "Archived SmartWay Trends and Statistics." http://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/smartway/about/15689

[34] Natural Resources Canada, "SmartWay: Join." http://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/smartway/15543

[35] Rick Baker et al., Eastern Research Group, *Global Green Freight Action Plan — Technical Background: Final Report*, prepared for U.S. Environmental Protection Agency (April 2, 2015). http://globalgreenfreight.org/sites/default/files/downloads/Green%20Freight%20Technical%20Background%20Report.pdf

[36] Ibid., 40.

vehicles and heavy-duty trucks. Test results are subsequently used in the development of codes, standards, and regulations covering Canada's road transport sector. Tested technologies include advanced engines and transmissions, renewable fuels, hybrid and electric vehicles, fuel-cell vehicles, and autonomous vehicles. The program works with both ECCC and the U.S. EPA.

- Shore Power Technology for Ports: Provides cost-shared funding to deploy shore power technology at Canadian ports that enables docked ships to connect to the local electrical grid. The program helps reduce fuel consumption and emissions from the auxiliary diesel engines ships typically use for power while at port.
- Clean Transportation Initiative on Port-Related Trucking:[37] Establishes $7.5 million contribution program to encourage deployment/development of truck reservation technologies at major container ports. The program aims to improve the movement of trucks at ports and terminals through improved scheduling, timing, and directions to appropriate access and loading points.
- Sustainable Development Technologies Canada: This is an independent, arm's-length cleantech funding agency supported by the Government of Canada. It has funded a number of projects related to cleaner freight transport.[38]

Additional freight-related activity at the federal level occurs under the National Research Council, whose Automotive and Surface Transportation R&D group pursues several research programs, including:[39]

- Fleet Forward 2020, which works to commercialize technologies to improve the operational efficiency of Canadian ground vehicle fleets[40]
- Lightweighting of ground transportation vehicles
- Rail vehicle and track optimization
- Vehicle propulsion technologies

2.1.3 Strategic gateways and trade corridors

Transport Canada serves as the lead department for the implementation of the federal government's National Policy Framework for Strategic Gateways and Trade Corridors.

[37] Transport Canada, "Grants and Contributions to Support Clean Transportation Initiatives." https://www.tc.gc.ca/eng/corporate-services/planning-rpp-2015-2016-1237.html

[38] Sustainable Development Technology Canada, "Projects (Transportation)," May 2017. http://bit.ly/2qkzSpG

[39] National Research Council Canada, "Automotive and surface transportation." http://www.nrc-cnrc.gc.ca/eng/rd/ast/

[40] National Research Council Canada, "Fleet Forward 2020 program." http://www.nrc-cnrc.gc.ca/eng/solutions/collaborative/ff2020.htm

Approved in June 2007 as part of the Building Canada plan, this framework was accompanied by $2.1 billion in funding through the Gateways and Border Crossings Fund, as well as $1 billion for the Asia-Pacific Gateway and Corridor Initiative. These programs fund transportation infrastructure projects (on a cost-shared basis) and related initiatives to develop Canada's "strategic gateways, trade corridors, and border crossings ... supporting international trade and efficient and integrated supply chains."[41]

2.1.4 Summary of federal policy landscape

The fragmented federal policy landscape with respect to freight reflects the underlying diversity of the transport modes involved in goods movement, the shared jurisdiction of different federal departments, and the different policy lenses — from economic efficiency and environmental benefits to security and safety — that are rightly discussed around Canada's transportation system. In the next section, we explore how some Canadian provinces and municipalities have demonstrated climate leadership by highlighting the role of freight within their broader transportation planning processes.

2.2 Provincial and municipal jurisdiction

Canadian provinces and several cities have worked individually and collectively to pursue energy and cost efficiencies in freight transportation, although with varying degrees of commitment.

Management of the complex freight sector often spans multiple provincial ministries, including transportation, infrastructure, environment, and economic development. Similarly, freight involves municipal authorities across bureaucratic jurisdictions. Municipal councils may, for example, set bylaws regulating heavy-duty truck traffic movement. Municipal departments of the environment will view freight as an air quality and pollution concern; transportation and city planning services will view it as an element of traffic and congestion management; and local or regional economic development departments or agencies will attempt to increase access or reduce barriers to freight services and help shippers and customers save on transportation costs.

[41] Transport Canada, "Evaluation of Gateways and Borders Crossing Fund," Executive Summary. https://www.tc.gc.ca/eng/corporate-services/des-reports-1158.html#toc4

The following sections provide snapshots of current policy frameworks governing freight in the provinces with the highest-emitting transportation sectors: British Columbia, Alberta, Ontario, and Quebec. The snapshots provide a representative, non-comprehensive account of the provinces' planning context and efforts to reduce emissions from the commercial movement of goods.

2.2.1 British Columbia

In 2015, transportation emissions in British Columbia amounted to nearly 23 Mt, or 37% of total provincial emissions. Within the transportation sector, freight transport accounted for roughly half, with trucks accounting for the majority of freight emissions.[42]

British Columbia's transport system is a key hub for domestic and international patterns of trade through Canada, the United States, and the Asia-Pacific region. The roads, railways, waterways, airports and seaports of Vancouver, in particular, play a fundamental role in supporting the economies of British Columbia and Western Canada. As Canada's busiest and largest deepwater port (and the third-largest in North America), Port Metro Vancouver's 27 marine cargo terminals handled 138 million tonnes of cargo worth $200 billion in 2015. With three Class I railways and a regional short line railway, the Port facilitates trade with more than 170 global economies; nearly 95% of its total volume serves Canadian import and export markets.[43] Meanwhile, the Vancouver International Airport (YVR) moved over 281,000 tonnes of air cargo in 2016.[44] To the north is the Port of Prince Rupert, the country's deepest natural harbour and Asia's closet port of entry to the western coast of the Americas, which further enhances British Columbia's strategic position within world trading networks.

The expectation of steady growth in commerce between Asia and North America has been a major strategic focus for transportation planning in British Columbia. Over the past decade, the need to promote expanded and more efficient goods movement has received significant attention from provincial and municipal policy-makers, as well as substantial federal support through the Asia-Pacific Gateway and Corridor Initiative. Today, governments across Canada continue to recognize the importance of the British

[42] *NIR 2017*, Part 3, Table A12-11.

[43] Port of Vancouver, "About Us." http://www.portvancouver.com/about-us/.

[44] Vancouver International Airport (YVR), *Facts and Stats: YVR Cargo* (2017). http://www.yvr.ca/en/about-yvr/facts-and-stats

Columbia gateway to maintaining and developing Canadian and North American connections to Asian and global markets.

Within British Columbia, the Pacific Gateway Transportation Strategy outlines the provincial government's vision for B.C. as North America's "gateway of choice for Asia Pacific trade."[45] The plan focuses mainly on increasing the capacity of B.C.'s goods movement networks: highways, rural resource roads, rail, bulk terminals, container terminals, and air cargo. This strategy intersects with the Ministry of Transportation and Infrastructure's 10-year planning document for the province's transportation system, *B.C. on the Move*. Released in 2015, this plan sets out several priorities, two of which have particular relevance for efforts to reduce emissions from freight:

- Delivering a provincial trucking strategy: This includes commitments to upgrade and replace structures such as bridges and overpasses (so they can accommodate the increasingly heavy and large loads that industry needs to transport); to expand the number of highway corridors approved for transport of 85–125 metric-tonne loads; and to build new truck pullouts.
- Enabling efficient ports and rail: This includes a commitment to invest in infrastructure that enhances access to ports and increases port bulk, break bulk, and container capacity and the efficiency of goods movement by rail.[46]

The provincial government has released a report card describing the first year of progress made in pursuit of specific action items under these (and other) priorities established in *B.C. on the Move*.[47]

The two strategy documents discussed above are notable in that they frame provincial spending plans for trade and transport over the medium term (up to 2020–2025), yet contain relatively little direct discussion of the environmental implications of increased freight activity.

At the regional level, TransLink (Metro Vancouver's regional transportation authority) has been active in recent years in trying to understand and develop plans for more

[45] Government of British Columbia, *Building Markets, Growing Jobs: The Pacific Gateway Transportation Strategy 2012-2020* (2012). http://www.pacificgateway.gov.bc.ca/documents/120402_Gateway_Strategy.pdf

[46] Government of British Columbia, *B.C. on the Move: A 10-Year Transportation Plan* (2015). http://www2.gov.bc.ca/gov/content/transportation/transportation-reports-and-reference/reports-studies/planning-strategic-economic/bc-on-the-move

[47] British Columbia Ministry of Transportation, *B.C. on the Move — Year One Report Card 2015/16* (2016). http://www2.gov.bc.ca/assets/gov/government/about-the-bc-government/transportation/bconthemove-reportcard-1.pdf

efficient goods movement. This effort is visible in two detailed 2013 goods movement studies,[48] and in a recent set of draft consultation documents. These include:

- a draft primer on regional goods movement in Metro Vancouver[49]
- a backgrounder summarizing TransLink's research findings on moving goods and services[50]
- a draft regional goods movement strategy, entitled *Moving the Economy*, that attempts to address the "inadequate attention" given to coordinated planning for goods movement, compared to personal and passenger travel.[51]

It is worth mentioning that all of British Columbia's major transportation planning and processes will also interact with existing municipal policy statements and regulations regarding the movement of trucks and goods within their boundaries. For instance, the City of Vancouver has developed its own comprehensive transportation strategy, *Transportation 2040*, which details long-term plans and policy orientations (e.g. paid loading zones, late-night delivery, "hub-and-spoke" delivery models using freight consolidation centres, and low-impact procurement) that simultaneously support more efficient and less-polluting urban goods movement.[52]

Within the complicated nexus of freight-related planning in British Columbia, the provincial government has introduced a number of specific policies (including regulations and incentives) that either explicitly or implicitly target emissions from freight, including:

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[48] TransLink, *Moving Goods,* RTS Working Paper (2013). http://www.translink.ca/-/media/Documents/plans_and_projects/regional_transportation_strategy/Research/Moving_Goods.pdf

[49] TransLink, *Primer: Regional Goods Movement in Metro Vancouver,* draft consultation document (2016). http://www.translink.ca/-/media/Documents/plans_and_projects/roads_bridges/2016_06_primer_goods_movement_for_consultation.pdf

[50] TransLink, *Moving Goods and Services,* RTS Backgrounder #6 (2016). http://www.translink.ca/-/media/Documents/plans_and_projects/regional_transportation_strategy/Backgrounders/Moving_Goods_and_Services.pdf

[51] TransLink, *Moving the Economy: A Regional Goods Movement Strategy for Metro Vancouver*, draft consultation document (2016). http://www.translink.ca/-/media/Documents/plans_and_projects/roads_bridges/2016_06_rgms_draft_strategy_for_consultation.pdf

[52] City of Vancouver, *Transportation 2040* (2012), 51-54. http://vancouver.ca/files/cov/Transportation_2040_Plan_as_adopted_by_Council.pdf. See also the Condensed version of the Plan, 45-49: http://vancouver.ca/files/cov/transportation-2040-plan.pdf

- support for alternative fuels, including a renewable fuel standard (i.e. biofuel blending mandate) and a low-carbon fuel standard (the Renewable & Low Carbon Fuel Requirements Regulation)[53]
- Long Combination Vehicle Program and inter-jurisdictional efforts to harmonize regulatory weights and dimensions requirements
- heavy-duty diesel vehicle emission-control technology retrofit requirements
- anti-tampering legislation for emission-control technology on commercial vehicles
- a scrappage program (BC SCRAP-IT) providing rebates to retire commercial trucks[54]
- other fuel efficiency programs, such as dedicated roadway lanes, driver training, anti-idling, and greener road paving techniques.

Similar initiatives have been implemented in other provinces, although B.C. is the only province with a low-carbon fuel life cycle requirement (see "Fuel carbon intensity" box in Section 3.1). It should also be noted that British Columbia's carbon tax also applies to transportation fuel, and acts as an incentive to reduce emissions.

2.2.2 Alberta

In Alberta, Canada's highest-emitting province, GHGs from transportation amounted to 32.5 Mt, or nearly 12% of the provincial total in 2015. Of this, emissions from freight accounted for roughly 61% of total transport emissions, and most of these were from heavy-duty trucks.[55]

Trucks move upwards of 60% of all freight within the province of Alberta and handle approximately $9 billion of Alberta's non-pipeline international exports. From 2003 to 2013, registrations of heavy-duty trucks increased 57%, and the vehicle population of the Alberta trucking industry now represents roughly 25% of the national population of heavy-duty vehicles. In terms of rail, CN Rail and Canadian Pacific Railway operate approximately 9,600 kilometres of provincial track, and transport over 60 million tonnes

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

[54] BC SCRAP-IT Program Society, "Commercial Truck Program." https://scrapit.ca/commercialtruckprogram/

[55] *NIR 2017*, Part 3, Table A11-19 and Table A12-10.

into and out of the province annually. Alberta also has intermodal facilities in Calgary and Edmonton to facilitate access to growing container markets in Asia.[56]

The Government of Alberta's most recent Transportation Business Plan[57] and Transportation Annual Report[58] outline measures to support a more efficient, multi-modal transport system. However, the province's most significant action to address GHG emissions from freight transportation to date is the carbon levy announced in late 2015 under the Alberta's Climate Leadership Plan.

In addition, the province partners with Natural Resource Canada's FleetSmart program to offer training and awareness programs that promote efficiency practices among heavy-duty truck drivers and operators. Recently, the Ministry of Transportation has been running a limited pilot program to confirm the fuel efficiency gains of new generation wide-base single tires, also known as "super singles."[59]

Past actions in this domain include provincial funding for the Alberta Renewable Diesel Demonstration project, which studied the performance of low-level renewable diesel fuel blends in cold weather conditions, and confirmed their operability in the Canadian climate.[60] This work provided the basis for enacting the province's renewable fuel standard regulation, which requires an average 2% renewable content in diesel and 5% renewable alcohol in gasoline sold in Alberta.[61] Efforts to address emissions from freight through changes in fuel composition have also been supported by Emissions Reduction Alberta. The agency's current portfolio includes two investments focused on reducing the GHG intensity of fuels: development of a natural gas "dual fuel" blending system for

[56] Government of Alberta, "Logistics and market access: About the industry." http://www.albertacanada.com/business/industries/lma-about-the-industry.aspx

[57] Government of Alberta, *Ministry of Transportation Business Plan 2017-2020* (2017). http://finance.alberta.ca/publications/budget/budget2017/transportation.pdf

[58] Alberta Transportation, *Transportation Annual Report 2015-16* (2016). https://www.transportation.alberta.ca/Content/Publications/production/AnnualReport2015-16.pdf

[59] Alberta Transportation, *New Generation Wide Base Single Tires Limited Pilot* (2016). https://www.transportation.alberta.ca/documents/NGWBST-FAQ.pdf

[60] Climate Change Central, *Alberta Renewable Diesel Demonstration Final Report* (2009). http://www.renewablediesel.ca/

[61] Alberta Environment and Parks, "Renewable Fuels Standard.". http://aep.alberta.ca/climate-change/programs-and-services/renewable-fuels-standard/default.aspx

heavy-duty diesel vehicles, and a "drop-in" renewable diesel that can displace regular fossil fuels in existing engines and fuel distribution systems.[62]

In sum, the provincial government has undertaken various initiatives that support emissions reductions from freight, but has yet to introduce a coordinated focus on goods movement in its transportation planning activities. However, goods movement planning is a focus in the transportation planning processes of Alberta's two major urban centres.

In particular, the City of Edmonton has led the way with the 2014 release of a comprehensive goods movement strategy as part of the implementation of its current Transportation Master Plan.[63] The Edmonton goods movement strategy is notable for its survey of actionable options for managing the City's growing volume of commercial transportation so as to increase efficiency, reduce environmental impacts, and improve safety. The strategy recognizes Edmonton's status as a major manufacturing, logistics and distribution centre, and as a hub for the Albertan oil and gas industry. It profiles major goods movement generators in the Edmonton region, including industrial and energy parks, intermodal facilities, and the Edmonton International Airport. It also identifies key goods movement corridors.

The strategy's implementation mechanism is a new Goods Movement Task Force consisting of government, industry, and community representatives, as well as a working committee. With respect specifically to GHG mitigation, the strategy commits the City and the task force to advocate for greater fuel efficiency and emissions testing, as well as mechanical inspections, to be conducted on heavy-duty vehicles by the Province.[64]

Calgary's transportation plan includes a set of policies to support efficient goods movement, but the City of Calgary has not developed a standalone goods movement strategy and does not consider emissions reduction an explicit priority for goods movement in existing policy documentation.[65]

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[62] Emissions Reduction Alberta, *Emissions Reduction Alberta Projects* (2017). http://www.eralberta.ca/wp-content/uploads/2016/09/ERAProjectSheet-February2017.pdf

[63] City of Edmonton, *The Way We Move: Transportation Master Plan* (2009). https://www.edmonton.ca/city_government/city_vision_and_strategic_plan/the-way-we-move.aspx

[64] Ibid.

[65] City of Calgary, *Calgary Transportation Plan* (2009). http://www.calgary.ca/Transportation/TP/Documents/CTP2009/calgary_transportation_plan.pdf

The Calgary Transportation Plan also recognizes Calgary's central role as a trucking hub at the intersection of major highways. The plan includes a map designating a new primary goods movement network to facilitate the movement of goods and services within and through Calgary. The network does not predetermine all future truck routes, but establishes high-priority goods movement corridors where activity will be concentrated. City bylaws apply to heavy- and medium-duty trucks, which are required to use council-designated truck routes. However, light-duty commercial vehicles (which are not subject to these bylaws) account for up to 50% of the distance travelled by all commercial vehicles in the city.[66]

2.2.3 Ontario

Greenhouse gas emissions from transportation in Ontario grew from 41 Mt in 1990 to 55 Mt in 2015. This growth trajectory, along with significant downward trends in emissions from electricity and other industries, has made transportation Ontario's largest-emitting sector, at 33% of the provincial GHG total in 2015.[67] Approximately 11 million passenger and commercial vehicles currently use Ontario roads.[68] Although passenger transport still accounts for the majority of emissions within the sector, road- and rail-based freight together are the second-largest and the fastest-growing portion of emissions from transportation. Having increased 142% since 1990, emissions from heavy-duty trucks and rail freight are now responsible for 18.7 Mt, or just over 10% of total provincial emissions.[69]

The volume of road freight activity (measured in tonne-kilometres) in Ontario has also increased dramatically, by 242% over the period from 1990 to 2014. Meanwhile, energy intensity has dropped 21% and the GHG emissions intensity of energy used for freight transport has remained virtually unchanged.[70] Against the general increase in emissions from on-road freight, these trends once again demonstrate that gains in efficiency are being overwhelmed by increases in overall freight activity.

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[66] Ibid., 36.

[67] *NIR 2017*, Part 3, Table A12-7.

[68] Ontario Ministry of the Environment and Climate Change, *Ontario's Five Year Climate Change Action Plan 2016-2020* (2016). https://www.ontario.ca/page/climate-change-action-plan

[69] *NIR 2017*, Part 3, Table A12-7.

[70] Natural Resources Canada, Comprehensive Energy Use Database, "Table 11: Freight Road Transportation Secondary Energy Use and GHG Emissions by Energy Source." http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=tran&juris=on&rn=11&page=4

Transportation planning

Multiple policy frameworks in Ontario pertain to the governance of freight movement and influence emissions from commercial transportation. The government's most recent provincial policy statement, issued in 2014 under the Planning Act, provides a clear statement of provincial land use planning policy directions. Among other directions, the policy statement contains language promoting environmental protection and transportation efficiency: for instance, it requires the long-term protection of major goods movement facilities and corridors; and it encourages support of energy conservation and efficiency, air quality improvements, GHG reductions, and climate change adaptation efforts through land use and development patterns that "focus freight-intensive land uses to areas well-served by major highways, airports, rail facilities, and marine facilities".[71]

The Ministry of Transportation (MTO) published a comprehensive set of Freight-Supportive Guidelines in 2016. This document coordinates land use planning with freight mobility planning, and is intended to assist municipal planners, civil engineers, developers, and others involved in planning policy updates, development application reviews, or transportation system planning.[72] The guidelines provide best practices for incorporating freight into land use and transportation plans at all scales, and will inform site design, road design and operational practices. Though implementation of these guidelines is voluntary, they encourage municipalities to evaluate their own freight needs and priorities.

Another major policy framework influencing freight transport and emissions in Ontario is the Regional Transportation Plan (RTP), *The Big Move,* developed by Metrolinx for the Greater Toronto and Hamilton Area (GTHA).[73] The Big Move was released in 2008 and is currently under a legislated 10-year review. The revised draft RTP is expected to be released for comment this summer with an anticipated final release towards the end of 2017.[74] Encompassing the mobility arrangements of the six regions, 30 municipalities,

[71] Ontario Ministry of Municipal Affairs and Ministry of Housing, *Provincial Policy Statement, 2014* (2014), sections 1.6.8.2 and 1.8.1.d. http://www.mah.gov.on.ca/Page10679.aspx

[72] Ontario Ministry of Transportation, *Freight-Supportive Guidelines* (2016). http://www.mto.gov.on.ca/english/publications/freight-supportive-guidelines.shtml

[73] Legally called the Greater Toronto Transportation Authority, Metrolinx is the Crown agency responsible for integrating road and transit planning across the Golden Horseshoe region.

[74] Metrolinx, "Regional Transportation Plan" (2008). http://www.metrolinx.com/en/regionalplanning/rtp/. The review will incorporate findings from the 2011 Metrolinx GTHA Urban Freight Study. See also: http://www.metrolinx.com/en/regionalplanning/goodsmovement/urban_freight_study.aspx

and 10 transit agencies under Metrolinx jurisdiction, the RTP outlines a 25-year vision for transportation in and through Canada's most populous region. It identifies a number of goals and objectives relevant to freight, including reduced GHG emissions, reduced dependence on non-renewable resources, multi-modal integration, and efficiency and effectiveness.[75] To achieve these goals, the plan sets out 10 strategies describing priority actions and supporting policies. Two of these strategies directly concern freight and on-road commercial transport: (1) improving road and highway network efficiency, and (2) improving goods movement within the GTHA, and with adjacent regions, through the development of a comprehensive strategy for goods movement.[76]

MTO has also set in motion a planning process to develop a Greater Golden Horseshoe Multimodal Transportation Plan. The Multimodal Transportation Plan will be a first its kind in Ontario and seeks to optimize transportation investments across modes, and to address current challenges — especially congestion — in light of projections for the region's population to reach 13.5 million people by 2041.[77] Further, in partnership with the Ministry of Northern Development and Mines, MTO is developing a Northern Ontario Multimodal Transportation Strategy to support the implementation of transportation directions in the Growth Plan for Northern Ontario.[78] This plan considers a 25-year time frame, and is scheduled for final publication by the end of 2017.

Climate planning

Government initiatives that consider the efficiency and impact of freight movement also exist outside the realm of transportation planning strategies. The Ontario Climate Change Action Plan, released by the Province in June 2016, contains several provisions targeting emissions from freight transport. Recognizing the primary contribution of the sector to overall provincial GHGs, the plan establishes transportation as its first action area, and sets an objective for the province to become "a North American leader in low-

[75] Metrolinx, *The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area (GTHA)* (2008). http://www.metrolinx.com/thebigmove/en/goals/. See also: http://www.metrolinx.com/en/regionalplanning/bigmove/big_move.aspx

[76] Ibid., "4.0 Strategies." http://www.metrolinx.com/thebigmove/en/strategies/. See also Metrolinx, *The Big Move: Baseline Monitoring Report* (2013), 21. http://www.metrolinx.com/en/regionalplanning/bigmove/The_Big_Move_Baseline_Monitoring_Full_Report_EN.pdf

[77] Ontario Ministry of Transportation, "Greater Golden Horseshoe Transportation Plan" (2016). http://www.mto.gov.on.ca/english/transit/greater-golden-horseshoe-transportation-plan.shtml

[78] Ontario Ministry of Northern Development and Mines, "Northern Ontario Multimodal Transportation Strategy." https://nomts.ca/

carbon and zero-emission transportation."[79] Of the five priority actions under the transportation area, two are particularly relevant to the promotion of low-carbon goods movement.

The first priority is to increase the availability and use of lower-carbon fuel. This priority will consist of three main action items:

- regulation to increase the renewable content of fuels[80]
- funding to fuel distributors for "high-blend" sustainable biofuels and infrastructure upgrades
- a pilot program to develop methane from agricultural materials or food waste ("second-generation" or advanced biofuels).

In total, the Action Plan expects to allocate the low-carbon transportation fuel priority between $115 million and $175 million, and lead to an estimated 2 Mt reduction of GHGs in 2020 at a cost of $20 per tonne of CO_2e reduced.

The second freight-related transportation priority under the action plan is to increase the use of low-carbon trucks and buses. This priority consists of three actions that will be funded with an amount between $215 million and $290 million:

- a re-launch of the Green Commercial Vehicle Program, which will offer rebates to qualifying companies aiming to adopt electric or natural gas-powered trucks, aerodynamics retrofits, anti-idling devices, and electric trailer refrigeration[81]
- $75–100 million to collaborative efforts with industry to establish a network of natural gas and low- or zero-carbon fuelling stations,
- $15–20 million dedicated to a study on improving the competitiveness of Ontario's five licensed freight short-line railways which carry goods for distances up to 300 km.

These three projects are set to begin in the 2017–18 timeframe, and are projected to yield 0.4 Mt of GHG reductions in 2020 at a cost of $100 per tonne.[82]

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[79] Ontario Ministry of the Environment and Climate Change, *Ontario's Five Year Climate Change Action Plan 2016-2020* (2016). https://www.ontario.ca/page/climate-change-action-plan

[80] This would update the province's 2007 Ethanol in Gasoline Regulation, which requires a minimum 5% ethanol content in gasoline. The intention of the new Renewable Fuels Standard will be to achieve a 5% reduction in GHG pollution from gasoline by 2020. See https://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTI4OTAz&statusId=MTk0OTQ4

[81] A program evaluation of Ontario's previous GCVP (launched in 2007 under the province's *Go Green* action plan on climate change) showed mixed results. See Environmental Commissioner of Ontario, *Rethinking Energy Conservation in Ontario - Results: Annual Energy Conservation Progress Report 2009, Vol. 2.* (2010). http://docs.assets.eco.on.ca/reports/energy/2009/2009-Energy.2.pdf

Ontario has several other pre-existing freight-focused regulations and initiatives that bear on emissions from goods movement. Most heavy-duty trucks in Ontario (and in Quebec) are required to use electronic speed limiters that cap top speed at 105 km/hr. Since speed limiters have a beneficial effect on fuel efficiency, they also decrease emissions—though they are promoted mainly as a safety requirement.[83]

To address the fuel carbon intensity of freight, Ontario has set in place the Greener Diesel Regulation under the Environmental Protection Act (2014).[84] Over three years, this phased in a requirement for a minimum bio-based diesel content of 4% of total diesel and lower its life cycle GHG intensity by 70%. The regulation allows fuel suppliers to lower their minimum volume requirements if the fuels they supply have a lower GHG intensity than the standard; in this way, it creates an incentive for greater use of renewable fuels with lower carbon intensities. Fuel suppliers may also purchase compliance units through the purchase of credits generated by other fuel suppliers.[85]

Ontario has also improved the efficiency (and thus emissions) of freight-based transportation through its Long Combination Vehicle Program.[86] Finally, the MTO completed an off-peak delivery pilot during the 2015 Pan Am/Parapan Am Games as a strategy to mitigate congestion during the Games and assess the longer-term potential of off-peak delivery in Ontario.[87]

Region of Peel: A case study in goods movement planning

The Region of Peel's freight management efforts are a leading example of what municipalities can aspire to do to improve the efficiency of moving goods. The project has strong leadership from the top, set by the Peel Regional Council, and from within all

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[82] Ontario Ministry of the Environment and Climate Change, *Ontario's Five Year Climate Change Action Plan 2016-2020* (June 2016). https://www.ontario.ca/page/climate-change-action-plan.

[83] Ontario Ministry of Transportation, "Commercial safety vehicle requirements." http://www.mto.gov.on.ca/english/trucks/commercial-vehicle-safety-requirements.shtml. See also Transport Canada, "Heavy Truck Speed Limiter Reports." https://www.tc.gc.ca/eng/motorvehiclesafety/safevehicles-motorcarriers-speedlimiter-index-251.htm

[84] Government of Ontario, "Greener diesel regulation." https://www.ontario.ca/page/greener-diesel-regulation

[85] Environment and Climate Change Canada, *Clean Fuel Discussion Paper* (2017). http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=D7C913BB-1

[86] Ontario Ministry of Transportation, "Long Combination Vehicle Program" (2017). http://www.mto.gov.on.ca/english/trucks/long-combination-vehicles.shtml

[87] Dianne Zimmerman and Lindsay Wiginton, *Improving Urban Freight Efficiency* (Pembina Institute, 2017). http://www.pembina.org/pub/improving-urban-freight-efficiency

three municipalities (Brampton, Mississauga, and Caledon); a well-staffed and dedicated team; a goods movement strategy and action plan that is revised every few years and, importantly, funding to implement solutions.

The region's geographic location places it at the intersection of east-west and north-south trade routes into the U.S., and its proximity to the City of Toronto enhances this logistical advantage. Peel's transport system includes seven provincial expressways and two intermodal rail yards. The region is also home to Canada's largest air cargo hub and the Greater Toronto Airport Authority — the second largest employment zone in Canada.

Given these conditions and the associated economic and employment opportunities,[88] the Region of Peel has taken a systematic approach to achieve its goods movement objectives. The Region's approach makes it one of the few Canadian cities to have an official, dedicated goods movement strategy that also includes sustainability principles.

Below is a timeline of the studies, plans and actions taken by Peel to provide a glimpse into efforts to date:[89]

- Early 2000s: Initial goods movement studies were undertaken, which recommended the Region of Peel form a task force that included all levels of government and the private sector to develop a goods movement strategy.
- 2004: Establishment of the first goods movement strategy within the region's transportation plan. This was based on a study commissioned by the region early in the year to assess the state of the goods movement transportation system in Peel and identify strategic options for addressing longer-term goods movement transportation.
- 2009: Establishment of Peel Region Goods Movement Task Force by the regional council. The task force brought together private and public stakeholders interested in improving the efficiency of goods movement.
- 2011: "Improve goods movement" became a term of council priority for the 2011–2014 council term in Peel Region. This was renewed for the 2014–2018 council term. The purpose of the priority is to continue to preserve and improve the region's goods movement network in order to maintain and enhance the quality of life of the community.

[88] Approximately $1.8 billion in goods is moved to, through and from Peel Region every day and four in every nine jobs depend upon this industry. https://www.peelregion.ca/pw/transportation/goodsmovement/

[89] A detailed timeline is available on Region of Peel's website: http://www.peelregion.ca/pw/transportation/goodsmovement/resources.htm#peel

- 2012: Creation of Peel's Goods Movement Strategic Plan (2012–2016). The plan outlined four strategic directions that cover 23 action items.[90]
- 2015: The Region of Peel conducts a Goods Movement Economic Impact Analysis,[91] "an innovative study which uses goods movement economic indicators related to GDP to provide a snap shot of the current situation in Peel."[92] It was sent to the federal and provincial governments to provide relevant information about infrastructure needs.
- 2017: Council approved Peel's next Goods Movement Strategic Plan (2017–2021). The plan addresses the goods movement issues, trends and needs that were identified using technical analysis and an extensive consultation process. It combines initiatives to meet current needs as well as a long-term vision for the goods movement system.
- A Goods Movement Long Term Plan is currently being developed that will guide Peel to 2041. This is part of Peel's Transportation Master Plan and will address major challenges that the region is expected to face over the coming decades.

2.2.4 Quebec

As with its more populous neighbour, Quebec's largest source of GHGs is its transportation sector, which in 2015 produced over 31 Mt of emissions — roughly 39% of the provincial total. In the same year, freight transport produced 11.5 Mt of emissions, 85% of which was attributable to heavy-duty diesel trucks and heavy-duty gasoline vehicles. Thus, freight is currently responsible for a 37% share of transport emissions and a 14% share of total GHGs in the province of Quebec.[93]

Quebec is unique among Canadian provinces in that it has renamed its Ministry of Transportation the Ministry of Transportation, Sustainable Mobility, and Transportation Electrification (MTQ). In doing so it has given an explicit signal regarding the current ministerial mandate for transportation. MTQ has developed a

[90] Dan Labrecque, *Region of Peel Goods Movement Strategic Plan – 2015 Status Update,* Report to Council (2015). https://www.peelregion.ca/pw/transportation/goodsmovement/pdf/goods-movement-status-update-report-2015-nov26-2015.pdf

[91] WSP Canada, Inc., *Region of Peel Goods Movement Economic Impact Analysis Draft Report* (2015). https://www.peelregion.ca/pw/transportation/goodsmovement/pdf/peel-region-GMEIA-full-report-12Nov15.pdf

[92] Dan Labrecque, *Region of Peel Goods Movement Economic Impact Analysis Study*, Report to Council (2015). https://www.peelregion.ca/pw/transportation/goodsmovement/pdf/peel-GMEIA-council-report-nov26-2015.pdf

[93] *NIR 2017*, Part 3, Tables A11-11 and A12-6.

standalone Transportation Electrification Action Plan (TEAP) for 2015–2020.[94] The TEAP complements the province's current Climate Change Action Plan (2013–2020)[95] and focuses on making the province a leader in electric vehicle use and manufacturing. While much of the plan is dedicated to the electrification of the passenger vehicle fleet, the plan also includes new measures to support freight transportation electrification initiatives. The first set of measures will support showcase or commercial demonstration projects in the freight transportation sector.[96] A primary aim will be to help entrepreneurs close first sales on new technologies whose real-world utility or reliability has not yet been fully proven to the market. This transport electrification project funding will be added as a component of Quebec's existing assistance program for improving maritime, air, and rail transport efficiency. For trucking, large-scale projects are supported as a component of the existing *Écocamionnage* trucking program.[97]

A second set of measures under TEAP involves the creation of electrification incentives in maritime, air, and rail transportation, as well as in intermodal transport and green trucking. TEAP provides funding enhancements under three existing programs:

- Assistance program for improving maritime, air, and rail transportation efficiency (*Programme d'aide à l'amélioration de l'efficacité du transport maritime, aérien et ferroviaire*)
- Écocamionnage (green trucking)
- Program to reduce or avoid greenhouse gas emissions through the development of intermodal transportation (*Programme visant la réduction ou l'évitement des émissions de gaz à effet de serre par le développement du transport intermodal*).

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[94] Gouvernement du Québec et Ministère des Transports du Québec [MTQ], *Propelling Québec Forward With Electricity: Transportation Electrification Action Plan 2015-2020* (2015). http://transportselectriques.gouv.qc.ca/wp-content/uploads/CIAO-050-LG2-MTQ-Rapport2016ENv2.1_.pdf

[95] Quebec Ministry of Sustainable development, Environment, and the Fight against climate change, *2013-2020 Climate Change Action Plan* (2013), http://www.mddelcc.gouv.qc.ca/changementsclimatiques/plan-action-fonds-vert.asp

[96] The Fonds vert, or Green Fund, is the funding pool originally created in 2006, whose revenues now derive mainly from Quebec's carbon market (a cap-and-trade system, like Ontario). The fund also collects revenue from mandatory licensing fees charged for the elimination of waste materials, and for the use of water. See Quebec Ministry of Sustainable development, Environment, and the Fight against climate change, "Fonds vert." http://www.mddelcc.gouv.qc.ca/ministere/fonds-vert/index.htm

[97] This program recently concluded at the end of March 2017, but is expected to be re-funded up until 2020. See MTQ, "Programme d'aide Écocammionnage." https://www.transports.gouv.qc.ca/fr/aide-finan/entreprises-camionnage/aide-ecocamionnage/Pages/aide-ecocamionnage.aspx

Quebec has also allowed the use of long combination vehicles (pulling multiple trailers behind a single tractor truck), and has implemented a truck speed limiter regulation that matches the limit (under which top speed is capped at 105 km/hr) imposed in Ontario, to enable fuel efficiency.

2.3 Freight industry actors

Within the freight industry, there are five major categories of freight service provider. Each type of provider has different types of customers, scales of operation, and challenges.

Courier and logistics companies

These are major multi-national organizations that provide courier or logistics services as their main service for clients. Some well-known logistics companies are UPS, FedEx, DHL, Purolator and Canpar.

Large for-hire freight operators

Colloquially known as trucking companies, these companies move goods through trucks and trailers. Most of these trucking companies operate at a regional scale and will sometimes partner with local owner-operators to move goods.

Small owner-operated freight operators

Owner-operators are often self-employed drivers who own their trucks, or are part of a small company. They provide transportation services for general freight, liquid and dry bulk, forestry products and other specialized freight.

Vocational trucks

Vocational trucks are designed for a specific function or industry. They are often used to perform a specialized task or to transport a specific kind of goods, such as cement, garbage, fuel and livestock.

Private fleets

Many large retailers control the transportation and distribution of their goods from suppliers to retail stores. Examples of such companies include retailers (e.g. Walmart, Loblaws and Canadian Tire), product manufacturers (e.g. Nestle and Coca-Cola), and some franchise restaurants (e.g. McDonald's and Tim Hortons),

which transport goods from central warehouses directly to customers and franchise locations.

The diversity of the actors who determine freight movement is also reflected in the number of distinct industry organizations and associations active in Canada. These industry interest groups represent freight users and providers across different sections of the supply chain, and include:

- Canadian Industrial Transportation Association
- Supply Chain Management Association
- Canadian Trucking Alliance (federation of provincial trucking associations)
  - B.C. Trucking Association (CTA affiliate)
  - Ontario Trucking Association
- Trucking HR Canada (formerly Canadian Trucking Human Resources Council)
- Private Motor Truck Council of Canada
- Canadian Courier and Logistics Association
- Canadian Natural Gas Vehicle Alliance
- Canadian Airports Council
- North American Council for Freight Efficiency
- Canadian International Freight Forwarders Association
- Freight Management Association of Canada
- Owner-Operator's Business Association of Canada
- Heavy Duty Aftermarket Canada
- Railway Association of Canada
- Association of Canadian Port Authorities
- Canadian Airports Council

2.4 Freight-related data sources

There are many sources of quantitative and qualitative data pertaining to the movement of goods in Canada. Much of this information is collected in surveys administered by Statistics Canada, sometimes under contract to, or in collaboration with, Transport Canada or Natural Resources Canada. Over the years, some statistical programs — such as the Fuel Consumption Survey and Annual Trucking Survey — have been discontinued, but Statistics Canada currently maintains 22 active data collection

programs covering Canada's transport system.[98] With respect to freight, information is available on the financial health and performance of the transport modes (air, rail, road, water); the origins and destinations of different commodity types; vehicle registrations and sales; railway carloadings and tonnage of transported commodities; fuel usage by mode and by area/province; and more. Active programs include:

- Air Carrier Operations in Canada Quarterly Survey
- Airport Activity Survey
- Canadian Civil Aviation – Annual Report
- Couriers and Messengers Services Price Index
- Dangerous Goods Accident Information System
- For-hire Motor Carrier Freight Services Price Index
- Gasoline and Other Petroleum Fuels Sold
- Monthly Civil Aviation Survey
- New Motor Vehicle Sales Survey – Monthly
- Rail Commodity Origin and Destination Statistics
- Railway – Annual Report
- Railway Carloadings Survey – Monthly
- Trucking Commodity Origin and Destination Survey
- Vehicle Registrations

Statistics Canada also sometimes combines datasets to produce new analytical tools. For instance, the department recently used trucking and rail commodity origin and destination data (from 2004–2012) to build an interactive infographic that visualizes Canada's domestic regional trade flows.[99]

In addition to Statistics Canada's suite of transportation surveys, Natural Resources Canada has maintained the National Energy Use Database since 1991. This database provides a statistical overview of Canada's sectoral energy use and greenhouse gas emissions, with the GHG emissions data drawn from Environment and Climate Change Canada's National Inventory Report. To support energy efficiency initiatives, and fulfill reporting requirements under the federal Energy Efficiency Act, the database supplies information on major sectoral activities and relevant indicators influencing energy use. For the transport sector, freight transport GHG emissions are given by energy source

[98] Statistics Canada, "Transportation: Complete list of surveys and statistical programs" (2017). http://www23.statcan.gc.ca/imdb/pIX.pl?Function=getThemeSV&PItem_Id=97413&PCE_Id=540&PCE_Start=01010001&CItem_Id=97413&CCE_Id=540&CCE_Start=01010001&lang=en

[99] Statistics Canada, "Visualizing domestic regional trade flows in Canada." http://www.statcan.gc.ca/pub/11-627-m/2016005/m-c03-eng.htm

and by region, while activity levels are available in aggregate and by mode. With respect to on-road freight, it should be noted that NRCan previously administered the Canadian Vehicle Survey,[100] which measured the annual populations and activity of different classes of road vehicles, but this program was discontinued in 2009.[101]

Federal data-gathering efforts pertaining to goods movement sometimes complements or builds upon data collection relevant to goods movement conducted at the provincial level. For instance, Ontario's Ministry of Transportation periodically conducts the Commercial Vehicle Survey, with the last survey conducted in 2012. This survey produces information on truck travel and commodity flows through the provincial highway network and other significant truck corridors. It also includes basic information about the commercial vehicles sampled, hourly commercial vehicle traffic volumes on provincial highways, average daily vehicle trip activity, and average daily values and weights of commodities moved.

Beyond publicly available national data produced and aggregated by government departments, there is also a great deal of private data owned and generated by shippers, couriers, and other participants in the freight system. Some proprietary datasets are available for purchase, though these are often quite expensive. In addition, some Ontario jurisdictions have implemented or are designing their own regional freight data collection programs. This includes efforts by the Region of Peel (in partnership with Transport Canada, Metrolinx and industry), as well as the Greater Toronto and Hamilton Area Freight-Related Data Collection Framework developed by Metrolinx and the University of Toronto.[102]

While the federal and provincial civil service maintain a general picture of how, where, and what freight is moved throughout the country, it is fair to assert that Canada has never developed a comprehensive, integrated national freight data collection program. In part, this is because freight movements are much more complex than passenger travel — especially with the emergence of spatially dispersed supply-chain logistics (e.g. in automobile and aircraft production) — and because freight movements involve many

[100] Statistics Canada, Canadian Vehicle Survey: Annual. 53-223-X. http://www5.statcan.gc.ca/olc-cel/olc.action?objId=53-223-X&objType=2&lang=en&limit=1

[101] Natural Resources Canada, *2009 Canadian Vehicle Survey Summary Report* (2009). http://oee.nrcan.gc.ca/publications/statistics/cvs/2009/factsheet/factsheet.pdf

[102] Metrolinx, *A Plan for Urban Goods Movement Data in the GTHA* (2013). http://www.metrolinx.com/en/regionalplanning/goodsmovement/research_and_projects.aspx

more agents and shift much more rapidly than commuting patterns.[103] In the United States, where high-level attention to freight planning and analysis is more institutionally entrenched, the Transportation Research Board has provided important thought leadership on the need for, and design of, a national freight data framework.[104] It has called upon the federal Department of Transportation to lead in coordinating national freight data collection in the U.S., and has published numerous book-length reports and practitioner guidebooks to support this call through its National Freight Cooperative Research Program (NFCRP). Analyses of comparable sophistication are currently lacking in the Canadian context, though many of the conclusions and recommendations of the NFCRP are transferable to, and useable by, Canadian freight transport planners and decision-makers.

[103] Rick Donnelly, "Review of Freight Survey Collection Techniques," in *A Concept for a National Freight Data Program*, Committee on Freight Transportation Data: A Framework for Development (Transportation Research Board, 2003), 88. http://onlinepubs.trb.org/onlinepubs/sr/sr276.pdf

[104] The Transportation Research Board is a division of the U.S. National Research Council that is jointly administered by the National Academies of Sciences, Engineering, and Medicine.

3. Addressing greenhouse gases from freight transport

3.1 Classifying freight emissions and main mitigation options

In order to understand existing and potential initiatives to reduce GHGs from freight, it is helpful to consider the general factors responsible for emissions in the sector. For any transport modes, direct emissions can be helpfully understood using the explanatory categories promoted by the Intergovernmental Panel on Climate Change (IPCC).[105] This approach breaks down GHG emissions into four categories, described below with respect to on-road freight.[106]

Activity

The level of activity for on-road freight transport can be measured by total tonne-kilometres per year (t-km/yr), or alternatively by vehicle-kilometres travelled (VKT). As with road-based passenger transport, activity level is related in a positive feedback loop with the state of the economy, or the GDP, and is itself broadly driven by factors like population, geography (e.g. how the goods production facilities are dispersed), and climate.[107]

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[105] Ralph Sims, Roberto Schaeffer, et al., "Transport," in IPCC, *Climate Change 2014: Mitigation of Climate Change.* Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. http://www.ipcc.ch/report/ar5/wg3/

[106] First developed by the International Energy Agency on behalf of the World Bank, this schema is derived from the ASIF identity, which breaks down the GHG emissions of transport into variables of a generic equation: GHG = **A**ctivity x modal **S**hare x energy **I**ntensity x carbon intensity of **F**uel. The ASIF identity is used in prominent integrated assessment models of the transport sector (e.g. AsTra in Europe) and in the IEA Mobility Model. See Lee Schipper et al., *Flexing the Link between Transport and Greenhouse Gas Emissions: A Path for the World Bank* (International Energy Agency, 2000). For a brief description of ASIF, see "ASIF-scheme for GHG emissions of transport," http://www.astra-model.eu/ASIF-scheme.htm

[107] Allison Robins, James Knowles, and Len Coad, *A Long, Hard Road: Reducing GHG Emissions in Canada's Road Transportation Sector by 2050* (The Conference Board of Canada, 2015). http://www.conferenceboard.ca/e-library/abstract.aspx?did=7491

Energy intensity

Energy intensity denotes the energy consumed per unit of activity. In the case of freight, this would be measured in megajoules (or litres) per tonne-kilometre (MJ/t-km). The energy intensity of freight activity results from a combination of vehicle technology (i.e. vehicle design and engine efficiency), fuel energy content, and driver behaviour during operation.[108]

Fuel carbon intensity

Emissions from freight and other transport activities are also determined by the carbon content of the fuels consumed. Fuel carbon intensity is measured as the amount of carbon emitted per unit of energy demand (t CO_2eq/MJ), and differs depending on the fuel.

System infrastructure and modal choice

This component of emissions encompasses both the level and kind of transportation infrastructure that freight stakeholders can access. Infrastructure level will determine the availability of different transport options to freight actors (e.g. shippers, carriers, receivers), and thus affect decisions about modal choice.

Reducing fuel carbon intensity

By taking advantage of the fact that fuels differ in their "well-to-wheel" carbon emissions intensity (including non-CO_2 GHG emissions), governments can set policy to reduce the average fuel carbon intensity of a regulatee or jurisdiction. For example, as noted in Section 2, several provinces have moderately reduced emissions through the use of biofuel or renewable fuel blending mandates on fuels intended for use in conventional combustion engines. Greater reductions can be achieved by more fundamental shifts, such as the substitution of petroleum fuels with lower-carbon alternatives like clean electricity and hydrogen. Encouraging the innovation required for such substitutions is a main regulatory objective of the federal government's recently announced Clean Fuel Standard, a low-carbon fuel standard currently under development that will require gradual reductions in the life cycle GHG emissions intensity of fuels supplied in Canada. Inspired by similar policies in California and the EU, Canada's Clean Fuel Standard will in fact be the first of its kind to extend the coverage of its GHG intensity standards beyond transportation fuels to include the industrial and buildings sectors.

[108] "Transport," in IPCC, *Climate Change 2014*.

The rest of this section presents a more detailed discussion of opportunities for decarbonizing freight, with the emphasis placed on trucking. Following a discussion of the complexity of the freight sector, we present options for reducing emissions from trucking. The concluding section briefly reviews lessons from the ongoing experience of transport system reform in California and the European Union, jurisdictions that have led the way in promoting policies and practices for more environmentally sustainable freight.

3.2 The complexity of the freight sector

Actions and strategies for addressing emissions from freight transport can be conceptualized in different ways. For carriers working directly to move goods, improvements in business efficiency and productivity hold the promise of lower costs, higher profits, and better environmental records. For those reliant on freight services, the availability of low-carbon transport options can help to 'green' supply chains, respond to consumers' and investors' sustainability expectations, and drive competitiveness. For planners and policy-makers at different levels of government hoping to facilitate trade while also working to meet climate commitments, goods movement is a challenging but essential part of efforts to transform transportation systems for a low-carbon economy.

To understand which solutions are likely to be most effective, policy-makers need to recognize and understand the sector's diverse nature. Freight service providers and their customers vary greatly in terms of size, operational scope, distance being traveled (long-haul, drayage or last mile delivery) and type of goods moved. The trucking industry, in particular, is quite varied: carriers exist as large, vertically integrated companies that lease continental or regional fleets; as mid-size firms or the private fleets of larger retailers, manufacturers, or restaurant franchises; and as independent owner-operators. Trucking is also a heavily populated industry, which means it is a competitive and low-margin business.

As a result of this complexity, the full potential for emissions reduction in the freight sector cannot be achieved by a single or one-size-fits-all policy solution. Instead, emissions reductions will depend on the cumulative effects of many tailored, situation-specific efforts and collaborative initiatives undertaken by diverse actors.

3.3 Further challenges

The diversity of the sector is only one aspect of the challenge in reducing the environmental impact of freight. Another is the fact that there is not always a clear technological ” when it comes to upgrading or switching vehicles, equipment and fuels. For example, options for fuel decarbonization include compressed natural gas (CNG), liquid natural gas (LNG), biofuels, hydrogen, and electricity, and each of these has its own advantages and disadvantages in terms of cost, life cycle emissions, energy content, current applications, availability, and so forth. A variety of technological solutions may exist depending on the particular part of the freight supply chain being addressed, and more advanced technologies targeting the same problem may be under development. Many technical options, such as “lightweighting” or aerodynamic upgrades, are already able to reduce fuel consumption and emissions cost-effectively. Other more advanced options, such as fuel-switching and engine upgrades, hold great potential, but require a substantial level of capital investment.[109]

To account for uncertainty around the best options for technology change, and to recognize the costs faced by actors who work with lean margins, policies to address the emissions and fuel economy of freight must be flexible and adaptable. In the case of regulatory action, such as under the incoming Phase II GHG emissions and fuel efficiency standards,[110] care must also be taken to ensure that new requirements have the confidence of the drivers themselves, since drivers are the final users and adopters of technologies and operational practices.

This points to the importance of testing. If an untested technology is mandated, and then fails to perform reliably or creates unanticipated problems, the regulator risks achieving its overarching objective by undermining drivers’ and companies’ support for the regulatory program.[111] As Canada frequently adopts regulations and technologies

[109] Paul D. Larson, Arne Elias, and Jairo Viafara, “Toward Sustainable Trucking: Reducing Emissions and Fuel Consumption,” *Transportation Journal* 52, no. 1 (2013).

[110] The EPA’s Phase II regulations for heavy-duty vehicles were finalized in summer 2016. The regulations mirroring the U.S. national standards in Canada are currently under development. Draft regulations and the associated Regulatory Impact Analysis Statement were posted in *Canada Gazette, Part 1* in March, 2017. See *Regulations Amending the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations and Other Regulations Made Under the Canadian Environmental Protection Act, 1999*. https://www.ec.gc.ca/lcpe-cepa/eng/regulations/DetailReg.cfm?intReg=241

[111] Canadian Trucking Alliance, *White Paper on Proposed Phase II Green-House Gas Emissions & Fuel Efficiency Regulations for Heavy Trucks in Canada* (2016). http://cantruck.ca/wp-content/uploads/2016/01/CTA-GHG-SMART-whitepaper_public.pdf

used in the U.S., we must be careful to ensure these are tested and proven to work in Canada's geography and climate.

In addition, another significant challenge to addressing emissions from freight is making and maintaining the necessary multi-stakeholder collaborations. Even in jurisdictions that have developed freight strategies or formed advisory or stakeholder groups, implementation is a key hurdle. However, there are also exceptions to this trend, such as the Region of Peel (profiled in Section 2, above).

From a broader continental and systemic perspective, the Commission for Environmental Cooperation[112] has identified seven overarching challenges that the North American freight sector must overcome if it is to reduce emissions and become environmentally sustainable: [113]

- lack of internalization of the external costs of freight transportation
- inadequate coordination among North American transportation agencies
- lack of integrated land use and freight transportation planning
- extensive delays in truck freight movement across borders
- time needed for turnover of inefficient legacy truck fleet
- inadequate funding of transportation infrastructure
- lack of essential transportation data

As part of the substructure of intercontinental and global supply chains, Canadian and provincial freight actors and stakeholders experience versions of each of these problems. By the same token, all participants in goods movement have a contribution to make — and a stake in — the creation of a decarbonized and more sustainable freight system.

[112] The CEC was established in 1994 under the North American Agreement on Environmental Cooperation, which Mexico, Canada, and the United States negotiated and ratified in parallel with NAFTA.

[113] CEC, *Destination Sustainability: Reducing Greenhouse Gases from Freight Transportation in North America* (2011), 6.

3.4 International experiences in freight planning and efficiency

3.4.1 United States

In terms of action to address air pollutants and greenhouse gas emissions from freight in the U.S., two of the most prominent federal programs are the EPA's SmartWay program, which inspired the Canadian counterpart (see Section 2), and the Department of Energy's SuperTruck initiative. Both programs are based on public–private partnerships. With the release of its *SmartWay Vision 2020 Report*, the EPA sets new goals for the program — most notably, an extension of its carbon assessment and sustainability reporting tools to cover the complete supply chain and therefore all modes of freight transport (i.e. including air and marine). In recognition of the fact that SmartWay has served as a template for other countries' efforts to reduce freight emissions, the EPA has also committed to greater global collaboration, and especially to seek alignment between emissions accounting methodologies and tools.[114]

The SuperTruck project is another federal initiative that addresses the challenge of increasing the efficiency of Class 8 combination trucks. These trucks haul the substantial majority of all U.S. freight tonnage (between 70% and 80%); roughly 2.5 million currently operate on American roads.[115] SuperTruck launched in 2009 with the aim of developing, testing, and demonstrating an aggressive 50% improvement in the freight fuel efficiency of heavy-duty Class 8 tractor-trailers from that year. The Department of Energy sponsored 50% of a US$230 million cost-shared partnership with four different teams of major industry manufacturers (Daimler, Cummins/Peterbilt, Volvo and Navistar), each of which leveraged the funding with their own investments to demonstrate new full-scale, system-level vehicle technologies by 2015. Generally, teams sought to increase overall vehicle efficiency through improved powertrain efficiency, idle reduction, reduced aerodynamic drag, weight reduction, downspeeding, reduced tire rolling resistance, and waste heat recovery (which yielded the highest fuel economy gains among all implemented technologies).

[114] U.S. Environmental Protection Agency, *The SmartWay Vision 2020 Report* (July 2015). https://www.epa.gov/smartway/smartway-vision-2020-report

[115] Often referred to as 18-wheelers, Class 8 trucks fall into the heaviest weight category designated by the Department of Transportation (gross vehicle weight rating of 33,001 lbs or more).

As a result of the enormous fuel and efficiency benefits that the program has shown are possible, a new US$80 million round of SuperTruck II funding was awarded in 2016, and set a new target of improving heavy-duty freight hauling efficiency by over 100% relative to the manufacturer's best-in-class 2009 truck.[116]

The U.S. federal government has also moved to impose different regulatory controls on freight movement, and on trucking in particular. The EPA's Phase II GHG heavy-duty vehicle emissions standards are set to phase in new requirements on Class 7 and 8 tractors, trailers, and vocational vehicles over model years 2021 to 2027. In addition, a proposed heavy vehicle speed limiters rule would impose a top speed on trucks.[117] The department estimates that the requirement for speed limiters will save an estimated $1.1 billion in fuel costs and millions of gallons of fuel each year.[118]

California

Amongst both international jurisdictions and U.S. states, California has set the bar in terms of action to encourage greater environmental sustainability and economic efficiency from goods movement. In July 2015, Governor Jerry Brown issued an executive order outlining California's vision for a cleaner freight system that reduces local air pollution and supports the statewide 2030 climate target. Through this order, the governor directed the California Transportation Agency, the California Environmental Protection Agency, the California Natural Resources Agency, and other government departments to produce the California Sustainable Freight Action Plan, which was released in September 2016.[119] The plan also involves the California Energy Commission and the state-level Freight Advisory Committee.

The aim of the plan is to provide high-level integration of investments, policies, and programs across state agencies whose work relates to the sustainability of freight

[116] John O'Dell, "SuperTruck Program Scores Big, Heads into Second 5-Year Phase," *Trucks.com,* October 31, 2016. https://www.trucks.com/2016/10/31/supertruck-program-5-year-phase/

[117] Aaron Marsh, "Suggesting 60-68 mph, FMCSA, NHTSA propose truck speed limiters," *FleetOwner,* August 26, 2016. http://fleetowner.com/regulations/suggesting-60-68-mph-fmcsa-nhtsa-propose-truck-speed-limiters

[118] Federal Motor Carrier Safety Administration, "U.S. DOT Proposes Speed Limiters For Large Commercial Vehicles," August 26, 2016. https://www.fmcsa.dot.gov/newsroom/us-dot-proposes-speed-limiters-large-commercial-vehicles

[119] California Sustainable Freight Action Plan, "About the California Sustainable Freight Action Plan,". http://www.casustainablefreight.org/. The development of the Sustainable Freight Action Plan was informed by existing state strategies, including DOT's California Freight Mobility Plan and a discussion paper by the California Air Resources Board entitled *Sustainable Freight Pathways to Zero and Near-Zero Emissions*.

transport. In this way, it is intended to coordinate future planning, investment, and project selection processes by referring to a set of guiding principles and a long-term vision for the freight system in 2050.

The action plan also sets specific target milestones for 2030, identifies several immediate actions over the next five years to help achieve the long-term vision, and proposes pilot projects to test ideas in the near-term.

The near-term actions for agencies range widely and include working with the state legislature to develop a funding package that spurs new investment in advanced heavy-duty vehicles and low-emissions equipment, and convening a think tank of experts who will provide insight into the future demands that will be placed on California's freight transport system, and into the transformative technologies, solutions and partnerships by which these demands may be met. Other actions include convening industry stakeholders to determine metrics to track whether and how actions influence competitiveness; and convening the California Workforce Development Board and other labour stakeholders to ensure that California's freight transport system has a sizeable and sufficiently skilled workforce to support the state's long-term sustainable freight vision.

Finally, California's specific, quantifiable 2030 targets under the freight action plan are to enhance system efficiency and transition to zero emission technologies.[120]

California's extensive and ongoing consideration of how to promote a more efficient and lower-emitting freight transport system is in many cases complemented by existing freight and urban goods movement plans at the regional and city level.

3.4.2 European Union

Transportation represents approximately one-quarter of GHG emissions in the 28 EU countries. Recognizing that road transport is responsible for upwards of 72% of this total, the European Commission has set a target to cut total emissions from combined

[120] *California Sustainable Freight Action Plan*, Appendix B: Freight Targets. The Plan also includes a third target—or rather a mandate to set one. This third target will establish, through expert and industry consultation, "a target or targets for increased State competitiveness and economic growth within the freight and goods movement industry" (10).
http://www.casustainablefreight.org/documents/PlanElements/AppendixB_FINAL_07272016.pdf

passenger and freight by 60% between 1990 and 2050.[121] It has also recently adopted a low-emission mobility strategy to support this ambitious aim and help meet the EU's commitments under the Paris Agreement. The challenge is formidable for all modes, but especially for on-road freight: carbon dioxide emissions from heavy-duty vehicles in the EU grew 36% between 1990 and 2010, and are currently projected to grow another 58% by 2050.[122]

The EU has so far taken a number of approaches to the decarbonization of freight transport. The main regulatory elements of the low-emission mobility strategy are to promote greater efficiency in the transport system; scale up the use of low-emission alternative energy for transport;, and move toward low- and zero- emission vehicles.

Measures to promote efficiency include the use of new digital technology, such as intelligent transport systems and co-operative ITS;[123] harmonized road pricing regimes; and better multi-modal integration to incentivize a shift towards lower-emitting transport modes (e.g. inland waterways and rail). With respect to the development of low-emissions alternative fuels, the European Commission has indicated that food-based biofuels have a limited role in decarbonizing transport and should not receive public support beyond 2020. Instead, the Commission is working to gradually replace these fuels with more advanced biofuels, renewable natural gas (bio-methane) and synthetic methane, with a view to increasing their uptake by trucks and buses.

The key legislative acts for promoting lower-carbon fuels across the EU are the Fuel Quality Directive[124] and the Alternative Fuels Infrastructure Directive, issued by the European Parliament in 2009 and 2014, respectively.[125] The former requires European fuel suppliers to reduce the average life cycle GHG intensity of the gasoline and diesel

[121] Commission of the European Communities, *White Paper: Roadmap to a Single European Transport Area—Towards a competitive and resource efficient transport system* (European Commission, 2011). http://ec.europa.eu/transport/themes/strategies/2011_white_paper_en

[122] European Environment Agency, TERM 2016: *Transitions towards a more sustainable mobility system,* EEA Report No. 34/2016. https://www.eea.europa.eu/publications/term-report-2016

[123] Cooperative intelligent transport systems (C-ITS) are an emerging technology that includes telematics and direct vehicle-to-vehicle or vehicle-to-infrastructure interaction and communication. It promises to enable road users and traffic managers to share information to coordinate their decisions for greater efficiency and safety, and is thought that it will complement the eventual widespread adoption of autonomous vehicles.

[124] Euopean Union, Directive 2009/30/EC (amending Directive 98/70/EC), "Fuel Quality Directive." http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0030

[125] Euopean Union, Directive 2014/94/EU on the deployment of alternative fuels infrastructure. http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32014L0094

they market by 6% by 2020. The latter facilitates the deployment of publicly available electric recharging points and liquid natural gas and hydrogen filling stations across member states. The Alternative Fuels Infrastructure Directive also promotes interoperability and technical standardization with respect to payments, real-time charging point information, and equipment (such as common plug design across different electric vehicle types). It also supports the sharing of appropriate consumer information on alternative fuels, including a "clear and sound" price comparison methodology.[126]

To complement improved transport system efficiency and the shift to low-carbon fuels, the final prong of the low-emission mobility strategy is to support innovation in vehicle efficiency and greater demand for cleaner vehicles. This includes incentives for further improvements to the internal combustion engine, and a greater focus on policies aimed at trucks and buses.

While heavy-duty vehicles in Europe are already subject to similar air pollution standards as cars, they are not currently covered by fuel efficiency standards (as in the U.S., Canada, Japan, and elsewhere). In recognition of this gap, and of the fact that some European manufacturers already participate in the regulatory schemes of other markets where such standards are in place, the Commission is expediting analysis and consultation efforts to determine appropriate design options for CO_2 emission standards on heavy-duty vehicles.

The EU has also taken other actions to support greater efficiency in the movement of road freight. For instance, it is undertaking a review of the single market with the intention of eliminating restrictions on cabotage — that is, the carriage of cargo or passengers between two points within the same country by a vehicle (or vessel) operator registered in a foreign jurisdiction. It is also developing a framework for information exchange and transport management along the multimodal transport logistics chain.[127] Finally, the EU has developed common rules for tolls and user charges for heavy-duty vehicles, and is in the midst of revising its Eurovignette Directive, which provides the original legal framework for charging heavy-goods vehicles for the use of roads. The

[126] European Commission, *A European Strategy for Low-Emission Mobility,* COM(2016) 501. http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52016DC0501

[127] European Commission, *The implementation of the 2011 White Paper on Transport…five years after its publication: achievements and challenges,* (2016), 43-44. https://ec.europa.eu/transport/sites/transport/files/themes/strategies/doc/2011_white_paper/swd%282016%29226.pdf

revised directive would leverage road charging as a tool to reduce CO_2 emissions and congestion, ensure that road pricing better reflects the true cost of use (while treating occasional users fairly), and guarantee adequate road quality in exchange for the user charge.

Initiatives at the country and city level

As the need for action to address emissions from freight transport has gained greater recognition at the supra-national level, several European countries and cities have also led the way in experimenting with different approaches to increasing the efficiency and sustainability of goods movement.

For example, Germany has instituted a national framework of low-emission zones applicable to all motor vehicles, and more than 200 cities in 10 European countries are operating similar schemes. The rules differ by jurisdiction, but in general the most-polluting vehicles (i.e. heavy trucks) are either banned or charged an access fee based on whether they meet specific emissions criteria.

European cities also provide several examples of best practices for municipal freight management, which is done through a variety of stakeholder engagement and collaborative approaches. Examples include stakeholder forums to pilot projects, and living labs that are testing on-the-ground solutions to improve the movement of goods. The European Commission's City-VITAlity-Sustainability Initiative is a good example of an ambitious effort to improve the efficiency of urban transport in Europe and beyond, while reducing the emissions from the transport sector.[128]

In Barcelona, combined-use lanes designate different lane uses at different times. In Brussels, truck traffic is often directed to retail delivery stations (i.e. small urban warehouses) where they can unload shipments; these shipments are then conveyed to their final destinations by smaller motorized or non-motorized vehicles.[129]

There are also many examples of "freight villages" — planned developments that promote efficiency through the co-location of couriers, forwarders, and other freight support services near major arteries in the road network. In the United Kingdom and

[128] Dianne Zimmerman and Lindsay Wiginton, *Improving Urban Freight Efficiency: Global best practices in reducing emissions in goods movement* (Pembina Institute, 2017). http://www.pembina.org/pub/improving-urban-freight-efficiency

[129] City of Seattle, "Best Practices in Freight Movement," in *Seattle Urban Mobility Plan Briefing Book* (2008). http://www.seattle.gov/transportation/docs/ump/10%20SEATTLE%20Best%20Practices%20in%20Freight%20Movement.pdf

Sweden, cities have also implemented freight quality partnerships or freight networks that establish public-private forums — and sometimes physical infrastructure — for multiple stakeholders to collaborate in identifying solutions to the particular problems of the jurisdiction in question.[130]

3.5 Strategies for decarbonizing freight

As illustrated in Section 1, Canada's national emissions from transportation have increased 42% since 1990, and GHGs from trucking makes up a large part of these emissions. Projections for both regional and international goods movement suggest robust and, in some cases, extreme growth in demand for freight transport through to 2050.[131]

The abatement of emissions from freight transport is therefore unlikely to occur as a result of reduced demand.[132] Since the overarching goal of climate policy vis-à-vis freight remains absolute emissions reductions in the sector, and not reduced economic activity, successful strategies for the decarbonization of goods movement are likely to revolve around actions to reduce the carbon intensity of freight transport. Such efforts can be classified into five mutually supportive categories: supply chain structure, modal shift,vehicle utilization, energy efficiency and energy mix.[133]

Table 1 identifies these decarbonization categories and our list of actions and options. Within this context, we have highlighted key actions and options to both lower emissions and support better business performance. These actions are sorted according to whether they depend on operational practices, technologies, and/or public policies for implementation. Table 1 is followed by a final section highlighting the areas that we expect to focus on going forward.

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[130] Simon Collings, "Freight Quality Partnerships: Case Studies," *Good Practice Case Study 410* (U.K. Department for Transport, 2003), 2. http://webarchive.nationalarchives.gov.uk/20100408192644/http://www.dft.gov.uk/pgr/freight/sustainable/coll_freightqualitypartnerships2/freightqualitypartnerships1.pdf

[131] *ITF Transport Outlook 2017*, 73-79.

[132] To be sure, in some circumstances the avoidance of unnecessary vehicle trips is a valuable and effective way of creating a more efficient and decarbonized freight sector. Avoided trips are the first tool recommended by the IPCC for achieving reductions of direct GHG emissions from freight. See "Transport," in IPCC, *Climate Change 2014*.

[133] Alan McKinnon, "Freight Transport in a Low-Carbon World: Assessing Opportunities for Cutting Emissions," *Transportation Research News* 306 (Transportation Research Board, 2016).

It is important to acknowledge that the actions in Table 1 may overlap, interact, or stack to be mutually supportive. In addition, they fall within a larger policy context that includes broad policy initiatives driving towards decarbonization, as well as provincial and municipal climate action plans and goods movement strategies.

Table 1. Emission reduction categories and actions for freight[134]

Freight decarbonization categories[135]	Actions to support emissions mitigation and fuel economy	Solution Type			Barriers and considerations
		Practice	*Tech.*	*Policy*	
Supply chain structure Supply chains determine the amount of freight activity generated per unit of output. Reducing the number or length of links in the chain can reduce average length of haul. The global nature of our economy has increased the carbon intensity of freight: increasing spatial distribution of manufacturing processes; centralization of inventory in fewer, larger warehouses; more geographically extensive procurement; and longer supply chains.	Localized sourcing or production of goods; also known as "near-shoring."	X			May increase costs (e.g. labour, materials, operational). Can require substantial effort on the part of receivers/retailers to reorganize operations, bring operations in-house, and/or renegotiate contracts with suppliers and carriers.
	Vertical integration of manufacturing processes to reduce the distance and frequency goods have to be moved	X			
	Reducing the number of intermediaries in supply chains or distribution channels (e.g. bypassing wholesalers), or shifting to centralized delivery/drop-off	X			
	Warehouse decentralization: placing smaller warehouses closer to final destinations.	X			Decentralized warehousing would require carbon trade-off analysis to assess net emissions change in overall logistics: gains from transport may be offset by increased inventory and warehousing emissions.
	Private fleets: some freight customers can realize multiple efficiencies (e.g. through guaranteed capacity, improved scheduling flexibility) by operating their own freight transportation services and assets.	X			Requires potentially high level of capital investment and a reliable volume of business. Could lead to increased VKT if companies are using similar transportation routes with partial loads.
Modal shift Freight transport modes vary widely in terms of average carbon intensities. Shifting to lower-intensity modes (typically rail or marine) can be an effective means of decarbonizing goods movement.	Infrastructure expansion to support increased rail capacity (e.g. more intermodal freight hubs and short-line rail).	X		X	Implies (indirect) carbon costs linked to infrastructure construction and maintenance. Rail is constrained to specific corridors and requires substantial investment to access new corridors.
Vehicle utilization *— Capacity* All freight transport modes underuse carrying capacity. Improved load factors generate savings by reducing the vehicle-kilometres necessary to move a given quantity of goods. Maximizing	Increase vehicle load factors (e.g. through optimized routing and freight matching services); minimize empty running.	X	X		Requires data on volumes to assess the potential for improving truck utilization; such data may not be available in real-time, or there may be no platform for sharing between companies. Companies have a strong financial incentive to maximize this already, so may be limited in terms of improvements.

[134] Additional sources: Paul D. Larson, Arne Elias, and Jairo Viafara, "Toward Sustainable Trucking: Reducing Emissions and Fuel Consumption," *Transportation Journal* 52, no. 1 (2013).; Expert interviews (see Appendix B)

[135] McKinnon, "Freight Transport in a Low-Carbon World."

Freight decarbonization categories[135]	Actions to support emissions mitigation and fuel economy	Solution Type			Barriers and considerations
		Practice	*Tech.*	*Policy*	
vehicle utilization is one of the most cost-effective strategies for mitigating freight emissions.[136]					
Vehicle utilization *— Business efficiencies* Logistical collaboration between companies can yield carbon benefits and cost savings. Sharing warehouse facilities and vehicle capacity can improve usage of those assets. *— Regulation of truck size and weight* Amending regulatory restrictions on allowable truck size and weights on certain roads/highways can reduce carbon emissions per tonne-kilometre of freight. Harmonization between jurisdictions can also increase efficient deployment of fleets.	Moving less material (e.g. reduced packaging).	X			Depends on shippers' decision-making and collaboration with carriers.
	Raise limits on truck carrying capacity (lengths over 20 metres and gross weights above 45 tonnes).			X	Heavier loads and LCVs may increase road wear.
	Increase permit supply for high-capacity or Long Combination Vehicles (LCVs) on designated highways. LCVs offer co-benefits including reduced labour needs, vehicle-kms, air pollutants, and accident levels.	X		X	Larger trucks can generate controversy in some communities: appropriate travel corridor must be identified. May require infrastructure changes to support LCVs.
	Night time (off-peak) pick-up and delivery.	X			Can increase labour costs. Community may have noise concerns.
Energy efficiency *— Technologies & operational changes* Advances in (and retrofits to) vehicle technology can increase the energy efficiency of all freight transport modes. The cost-effectiveness of many of these technology upgrades (e.g. aerodynamic profiling) is well established. Fuel savings and efficiency gains can also be generated by operational shifts, such as lower speeds.	Improve truck fuel economy through turbocharging, hybridization, aerodynamic profiling (e.g. side skirts / fairings, gap reducers), and lightweighting.[137]		X		Due to upfront capital costs (and slow turnover of the vehicle population), commercial uptake of advanced fuel-saving technologies, like new engines, can be slow. Uncertainty related to the cost implications of efficiency requirements and GHG emissions standards. Calculations of payback periods may not account for problems (e.g. delays, special maintenance requirements) caused by new technology adoption. Truck operators may be wary of prescribed technologies that have not been tested in real-world conditions. Mandating technologies unsuitable to Canada's climate and operating conditions can erode users' trust in fuel-saving technologies. Regulatory activity does not occur in a void. The trucking industry's past experience with Phase I GHG regulations has created concerns around the implementation of
	Greener vehicle incentive/subsidy programs, such as purchase and lease rebates or tax incentives for plug-in hybrids, battery-electric vehicles, and charging stations. For freight, this could include incentives for natural gas vehicles, or vehicle scrapping programs to take older, higher-emitting trucks off the road.			X	
	Driver training (e.g. SmartWay) and performance incentives (to reduce fuel use and engine idling).	X		X	
	Speed limiters and speed limits (e.g. better fuel economy from "slow-steaming" in maritime shipping; mandated or voluntary use of speed limiters in	X	X	X	

[136] Companies have a profit/savings incentive to maximize load factors, but may be constrained by customer demands and/or service guarantees.

[137] Turbocharging is the technique of improving engine thermal efficiency by pumping more air to the combustion chamber; hybridization means complementing internal-combustion-fuelled vehicle propulsion with an additional power sources, such as batteries (e.g. diesel-electric vehicles); aerodynamic profiling involves streamlining the vehicle body for reduced wind resistance; and lightweighting means altering or eliminating material components of the vehicle to reduce its empty (tare) weight.

Freight decarbonization categories[135]	Actions to support emissions mitigation and fuel economy	Solution Type			Barriers and considerations
		Practice	*Tech.*	*Policy*	
	trucking).				Phase II standards. The successful uptake of requirements under Phase II will depend on the extent to which individual operators (and the industry as a whole) perceive those previous inadequacies to have been addressed.
	Auxiliary power units reduce the need for idling.		X		
	Electrification of truck stops and ports.				
	Engine upgrades.		X		
	Intelligent transportation systems (ITS) (e.g. signage to inform and direct drivers based on real-time traffic conditions).	X	X		
	Wide and low roll resistance tires.		X		
	Platooning and autonomous vehicles.		X		
	Regulation: heavy-duty vehicle GHG emissions standards (e.g. EPA / Environment Canada Phase II).			X	
	Regulation: remove cabotage restrictions.			X	
	Dedicated truck lanes on highways and at border points (e.g. Free and Secure Trade (FAST) Program.			X	
Energy mix The decarbonization of freight logistics will require a shift to near-zero-emission fuel sources. Canada's advantage relative to other countries is that its grid is already quite decarbonized, but large challenges of investment and infrastructure development remain. More affordable, near-term approaches to improving the freight energy mix centre on the use of low-carbon fuels.	Electrification of freight rail lines.		X		High cost of infrastructure build-out Investment in low-carbon technologies that cumulatively result in deeper shifts to the freight energy mix will depend on changing consumer and business purchasing behaviour. Limited availability of some energy mix solutions (e.g. advanced or second-generation biofuels, hydrogen from clean electricity) at scale.
	Widespread deployment of battery charging infrastructure for local delivery vehicles.		X		
	Truck stop and highway network electrification for long-haul trucking (e.g. with overhead wires and diesel-electric hybrids; on trial in Germany, Sweden).		X		
	Fuel switching to progressively lower carbon fuel sources: biofuels, natural gas, hydrogen, electricity.				
	Implementation of the national Clean Fuel Standards		X	X	

As Table 1 shows, there is a wide range of possible actions that freight stakeholders can take to increase the efficiency of their operations while reducing unintended environmental impacts. Of course, not all actions are available to every kind of freight actor, and not all freight actors will have the capacity (or the interest) to undertake decarbonization efforts along each category.

Actions to reorient supply chain structures may be less available to smaller freight purchasers than they are to national and multinational shippers and receivers. And, while there are many technology options and operational changes already available to carriers for increasing the efficiency of their fleets, companies are unlikely to take the risk without being confident in the savings they will receive.[138]

Governments and transportation agencies are usually best placed to pursue the large-scale infrastructure investments that may be required to encourage mode-shifting by the private sector. Similarly, only regulators can modify or harmonize restrictions on vehicle weights and dimensions in a certain jurisdiction. Government also has an important leadership role to play in supporting long-term changes to the energy mix through infrastructure build-out and policy tools like clean fuel standards and carbon pricing.

Despite potential barriers, the diversity of options for addressing freight emissions is an encouraging sign in light of the many stark projections for increased freight traffic (and emissions) over the twenty-first century. This diversity also underscores the interconnected and overlapping character of actions to decarbonize goods movement.

[138] For a comprehensive assessment of the different types of technology and operational options for enhancing the efficiency of heavy-duty trucks—including payback estimates for different technologies—see TruckingEfficiency.org and the associated technology Confidence Reports produced by the North American Council on Freight Efficiency (NACFE). It should be noted that this testing is done in the U.S. and may not always be transferable to the Canadian context: http://www.truckingefficiency.org/

4. Path forward

As illustrated throughout the report, the freight sector involves a wide range of actors, and is covered by a diversity of regulations and programming across all levels of government. As a result of this complexity, the full potential for emissions reduction in freight can only be achieved through many tailored, situation-specific efforts and policies undertaken across the sector.

There is no silver bullet to reducing emissions from freight. Instead, governments, industry, civil society and consumers must partner in an ongoing collaboration to accelerate the adoption of the practices, technologies, and policies that will collectively enhance environmental and competitive performance of the freight sector in Canada. A coordinated, climate-conscious freight policy is one that will not only promote the various proposed solutions, but constructively manage their potential interactions.

Based on our work to date, we see the following as being key areas for further exploration and support.

- Climate policies that broadly impact the Canadian economy and will drive long-term reductions in GHG emissions; specifically, the federal benchmark for carbon pricing and the forthcoming national Clean Fuel Standard. Both of these will need broad engagement and support to ensure effective and equitable implementation.
- Phase 2 heavy-duty vehicle efficiency regulations. These provide a backstop of improvement out to model year 2027. Support for testing to prove technology reliability in Canadian operating conditions will be needed to ensure successful implementation.
- Continued rollout and adoption of available and emerging efficiency technologies (many of which are listed in Table 1), supported and enabled by provincial or federal governments through incentives, rebates and subsidies.
- Carbon pricing, clean fuel standards and efficiency regulations will all, over time, encourage fuel switching across the sector. This can be further supported through build-out of fuelling infrastructure using biofuels and natural gas in the short term, with electric and hydrogen following closely behind.
- Integrating goods movement into land use planning at the regional and municipal level. Our cities and communities can be intentionally designed to support the efficient movement of freight, reduce congestion, and reduce impacts to communities.

As a final note, it is important to understand that the wholesale decarbonization of freight will only occur with deep transformational changes in the organization of the economy. Though we should not discount the complementary importance of policies to support more targeted freight efficiency solutions, there is a wider context in which the solutions discussed in this report must be situated. Thus, broad policy drivers such as the national carbon price, the drive towards electrification, incoming clean/low-carbon fuel standards, changes in land use planning, and changing consumer behaviour will undoubtedly shape the evolution of the freight sector's emission profile. Furthermore, within the next decade, freight transportation is unlikely to escape the influence of disruptive innovations, such as autonomous vehicles and the Internet of Things.[139]

The importance of ensuring the involvement of all necessary stakeholders in the design and implementation of freight solutions can also not be understated: from decision-makers to industry to the drivers directly affected by on-the-ground changes. Another key learning in this report is that economic growth in goods movement does not need to be sacrificed to reduce emissions in the sector. By improving fuel efficiency, businesses — and in turn, customers — can save money, while making the deep emissions cuts necessary to help Canada meet its climate commitments.

As evidenced in Figure 6, the point at which freight emissions surpass passenger emissions is rapidly approaching. We hope that industry and policy-makers recognize the urgency of this growth trajectory and give the goods movement sector the attention it demands. The opportunities to address freight emissions are within our grasp, but there is still more to learn from other jurisdictions and from domestic initiatives already underway.

[139] *ITF Transport Outlook 2017*, 59-60.

Appendix A. Mitigation policy options

The Final Report of the Specific Mitigation Opportunities Working Group, which was struck in the wake of the 2016 Vancouver Declaration, catalogued a comprehensive range of 56 policy options (along with estimates of associated costs) for reducing emissions from transportation, including freight. The policies cover a range of different instruments, including regulation, financial incentives (e.g. grants, tax measures, etc.) and information programs.

These policies were estimated to be capable of collectively reducing emissions by between 7 and 18 Mt, and of costing between $0 and $250 per tonne of CO_2e avoided. The recommendations most directly applicable to freight include: [140]

- Heavy duty vehicle and engine emission regulations and incentives
  - Post-2018 heavy-duty vehicle GHG regulations
  - Incentives for retrofits of in-use heavy-duty vehicles
  - Regulations requiring GHG-reducing technologies for in-use heavy-duty vehicles
  - Scrappage of older heavy-duty vehicles
  - Revised weight and dimension regulations
  - Truck stop electrification
  - Funding for electrified highway pilot projects
- Freight efficiency
  - Incentives for freight logistics and supply chain efficiencies
  - Funding to support modal shift
  - Pricing: per-kilometre charge on heavy goods vehicles

[140] Specific Mitigation Opportunities Working Group, *Final Report* (2016). http://www.climatechange.gc.ca/Content/6/4/7/64778DD5-E2D9-4930-BE59-D6DB7DB5CBC0/WG_Report_SPECIFIC_MITIGATION_OPPORTUNITIES_EN_V04.pdf

A.1 Canadian policy context

The table below highlights some of the main federal legislative and regulatory instruments relevant to the governance of emissions from freight transport. In general, authority to regulate emissions from internal combustion engines in Canada lies with Environment and Climate Change Canada and Transport Canada. Under the Canadian Environmental Protection Act 1999 (CEPA 1999), ECCC is empowered to regulate emissions from on-road engines, as well as from most categories of off-road engines. Authority to regulate emissions from aircraft, railway locomotives and commercial marine vessels rests with Transport Canada. Under different pieces of legislation, depending on the department, regulations have been adopted to control emissions of criteria air contaminants as well as GHGs.

Legislation	Note / Regulation	Status of Regulation	Responsible Department
Canada Transportation Act (1996)	The Act includes a declaration of National Transportation Policy (article 5): "It is declared that a competitive, economic and efficient national transportation system that meets the highest practicable safety and security standards and contributes to a sustainable environment and makes the best use of all modes of transportation at the lowest total cost is essential to serve the needs of its users, advance the well-being of Canadians and enable competitiveness and economic growth in both urban and rural areas throughout Canada."[141]	N/A	Transport Canada
Canadian Environmental Protection Act (1999)[142]	*Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* (SOR/2010-201) The objective of these Regulations is to reduce GHG emissions by establishing mandatory GHG emission standards for new vehicles in the 2011–2016 model years and, in revised regulations, 2017 and beyond. They are aligned with U.S. standards.	Active	Environment and Climate Change Canada (ECCC)
Canadian Environmental Protection Act (1999)	*Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations* (SOR/2013-24)[143] The objective of the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations is to reduce GHG emissions by establishing mandatory GHG emission standards for new on-road heavy-duty vehicles and engines that are aligned with U.S. national standards. The development of common North American standards will provide regulatory alignment across North American markets. This will enable manufacturers to produce more advanced vehicles,	Active	ECCC

[141] Government of Canada, Canada Transportation Act, S.C. 1996, c. 10, section 5. http://laws-lois.justice.gc.ca/eng/acts/c-10.4/page-1.html#h-4

[142] Government of Canada, Canadian Environmental Protection Act, 1999, S.C. 1999, c. 33. Regulations to the act are listed at ECCC, "Regulations and Other Instruments." http://www.ec.gc.ca/lcpe-cepa/eng/regulations/default.cfm

[143] Draft CG1 Regulations and RIAS published March 4, 2017 and are available at http://canadagazette.gc.ca/rp-pr/p1/2017/2017-03-04/html/reg1-eng.php

Legislation	Note / Regulation	Status of Regulation	Responsible Department
	which enhances their competitiveness. The Regulations will apply to companies manufacturing and importing new on-road heavy-duty vehicles and engines of the 2014 and later model years for the purpose of sale in Canada including the whole range of on-road heavy-duty full-size pickup trucks, vans, tractors and buses, as well as a wide variety of vocational vehicles such as freight, delivery, service, cement, and dump trucks. The Regulations will also include provisions that establish compliance flexibilities which include a system for generating, banking and trading emission credits. The Regulations will include additional credits for hybrid vehicles and electric vehicles, as well as for innovative technologies to reduce GHG emissions. The Regulations will include further flexibilities for companies to use a phased-in approach for model year 2014 through 2016 tractors and vocational vehicles. Companies will also be required to submit annual reports and maintain records relating to the GHG emission performance of their vehicles and fleets. Canada's heavy-duty vehicle emissions standards apply to on-road vehicles with a gross vehicle weight greater than 8,500 lb. intended for sale in Canada.[144] The government estimates that over the lifetime of the vehicles from 2014–18 model years, the regulations will result in a reduction of 19.0 Mt of CO_2e.[145] As with the light-duty emissions standards, the majority of the costs associated with the standards are due to upgrading vehicle technology to comply with the regulations. Most likely, manufacturers will increase their prices to recover these costs. However, the resulting fuel savings are anticipated to more than offset the effect on vehicle owners.		
Canadian Environmental Protection Act (1999)	*On-Road Vehicle and Engine Emission Regulations* (SOR/2003-2) Establishes air pollutant emission standards (i.e. for criteria air contaminants, not GHGs) for light- and heavy-duty vehicles and engines (e.g. cars, motorcycles and tractor-trailers).	Active	ECCC
Canadian Environmental Protection Act (1999)	*Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations* (SOR/2011-10) Establishes emission standards that contribute to the reduction of air pollutants from engines, vessels and vehicles. For the first time in Canada, these regulations set Canadian emission standards and test procedures for marine engines, vessels with installed fuel lines or fuel tanks and off-road recreational vehicles. These regulations are in alignment with those of the U.S. EPA.	Active	ECCC
Canadian Environmental Protection Act (1999)	*Off-Road Compression-Ignition Engine Emission Regulations* (SOR/2005-32) Introduces emission standards for diesel engines used in off-road applications such as those typically found in construction, mining, farming and forestry machines.	Active	ECCC
Canadian Environmental Protection Act (1999)	*Sulphur in Diesel Fuel Regulations* (SOR/2002-254) Sets maximum limits for sulphur in diesel fuel for use on-road, off-road, in rail (locomotive), vessels, and stationary engines.	Active	ECCC

[144] Government of Canada, *Canada Gazette Part I*, April 14, 2012, 968.

[145] Ibid., 921.

Legislation	Note / Regulation	Status of Regulation	Responsible Department
Canadian Environmental Protection Act (1999)	Under its Forward Regulatory Plan 2017–2019 for Air Emissions and GHGs[146] (published in the CEPA Registry), ECCC is in the process of finalizing changes and updates to two sets of regulations implicating freight in Canada: *Off-Road Compression-Ignition and Large Spark-Ignition Engines Emission Regulations* The proposed regulations would replace the existing Off-Road Compression-Ignition Engine Emission Regulations. The new regulation would reduce air pollutant emissions from both off-road compression-ignition (diesel) and large spark-ignition (gasoline, propane and natural gas) engines by establishing emission standards and test procedures that are aligned with those of the U.S. EPA.	Under development. Target date for publication in Canada Gazette Part I is 2018.	ECCC
Canadian Environmental Protection Act (1999)	*Regulations Amending the Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations* (for post-2018 and beyond model years) These proposed amendments are the Canadian response to the U.S. EPA's Phase II GHG rule for heavy-duty vehicles. The rules would further reduce GHG emissions by bringing into effect emissions standards and equipment and performance requirements on new on-road heavy-duty vehicles and engines of the 2021 and later model years. For the first time, they will also introduce emission standards for trailers (hauled by on-road tractors) of 2018 and later model years, in alignment with the U.S. standards.	Under development. Proposed regulations and Regulatory Impact Analysis Statement published March 2017 in Canada Gazette Part 1.	ECCC
Canada Shipping Act (2001)	*Regulations Amending the Vessel Pollution and Dangerous Chemicals Regulations* New regulations were adopted in spring 2013 and brought the North American Emissions Control Area (ECA) into force in Canada.[147] The ECA restricts various kinds of air pollution from ships, but does not cover carbon dioxide and other GHGs.[148] Exhaust emissions from vessels contain sulphur oxides, nitrogen oxides and particulate matter. Health Canada and Environment Canada conducted research on these pollutants and found that emissions of these pollutants from vessels were growing significantly and would adversely affect public health and the environment. In accordance with MARPOL Annex VI, new standards to reduce emissions of key air pollutants from Canadian vessels operating overseas are coming into force. These standards will reduce ship-source emissions of sulphur oxide by 96% and nitrogen oxides by 80% by 2020. They lower how much sulphur can be in fuel and require adjustments to vessels' engines. These requirements apply to vessels of 400 gross tonnage and above, except for domestic vessels	Active	Transport Canada

[146] ECCC, "Forward Regulatory Plan 2017 to 2019: Air Emissions and Greenhouse Gases: Proposed Regulatory Initiatives." http://www.ec.gc.ca/default.asp?lang=En&n=DF9C1A4C&offset=1&toc=show

[147] This is a joint initiative of the U.S., Canada, and France (for the islands of Saint-Pierre and Miquelon) under the a 1997 amendment to the International Convention for the Prevention of Pollution from Ships (MARPOL).

[148] Borden Ladner Gervais, "The North American Emissions Control Area now in force for Canada," news, May 8, 2013. http://blg.com/en/news-and-publications/publication_3366

Legislation	Note / Regulation	Status of Regulation	Responsible Department
	that voyage only in Canadian waters. Compliance with the new requirements will ensure Canadian vessels can access ports around the world.[149]		
Railway Safety Act (1985)	*Locomotive Emissions Regulations* Transport Canada is currently developing regulations to limit emissions from Canadian trains for the first time. Regulations would apply to railway companies and cover criteria air contaminants. The rules will also introduce new anti-idling and reporting requirements. The government estimates that, once in effect, these rules will cost the industry $162.3 million over the following decade, and will achieve a reduction of 9.3% and 8% of nitrous oxides and particulate matter, respectively.[150] The move to regulate is being taken in order to align Canadian emissions regulations with similar standards already in effect in the United States. Since 1995, the Canadian rail industry has entered into three successive Memoranda of Understanding with the Government of Canada; the most recent of these MOUs, covering 2011 to 2016, was signed in 2013. These voluntary agreements have formed the basis of rail companies' emissions reductions strategies for both GHGs and criteria air contaminants, the results of which are reported annually by the industry.[151]	Under development. Proposed regulations and Regulatory Impact Analysis Statement published June 2016 in Canada Gazette Part 1.	Transport Canada

[149] Transport Canada, "Regulations amending the Vessel Pollution and Dangerous Chemicals Regulations," info sheet, May 2013. https://www.tc.gc.ca/eng/mediaroom/infosheets-menu-7681.html

[150] "Locomotive Emissions Regulations," Regulatory Impact Analysis Statement is available at http://www.gazette.gc.ca/rp-pr/p1/2016/2016-06-18/html/reg4-eng.php

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Appendix B. List of interviewees and contributors

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