



# Decarbonizing Transportation in Canada



Report of the Standing Senate Committee on Energy,  
the Environment and Natural Resources

The Honourable Richard Neufeld, Chair  
The Honourable Paul J. Massicotte, Deputy Chair

June 2017

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# Members

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The Honourable Richard Neufeld, Chair

The Honourable Paul J. Massicotte, Deputy Chair

and

The Honourable Douglas Black

The Honourable Joseph A. Day

The Honourable Tony Dean

The Honourable Joan Fraser

The Honourable Rosa Galvez

The Honourable Diane Griffin

The Honourable Daniel Lang

The Honourable Michael L. MacDonald

The Honourable Elaine McCoy

The Honourable Percy Mockler

The Honourable Dennis Glen Patterson

The Honourable Judith G. Seidman

The Honourable Howard Wetston

*Ex-officio members of the Committee:*

The Honourable Senators Peter Harder, P.C. (or Diane Bellemare) and Larry W. Smith (or Yonah Martin).

*The committee would like to recognize the following Senators who are no longer serving members of the committee whose contribution to the study was invaluable:*

The Honourable Senator Grant Mitchell

The Honourable Senator Pierrette Ringuette

The Honourable Senator Don Meredith (retired)

*Other Senators who have participated from time to time in the study:*

The Honourable Senators: Ataullahjan, Bellemare, Enverga, Green, Johnson (retired), Martin, McIntyre, Omidvar, Raine, and Runciman.

*Parliamentary Information and Research Service, Library of Parliament:*

Sam Banks, Jesse Good and Marc LeBlanc, Analysts.

*Senate Committees Directorate:*

Maxime Fortin, Clerk of the Committee

Brigitte Martineau, Administrative Assistant

# Order of Reference

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Extract from the *Journals of the Senate*, Thursday, March 10, 2016:

The Honourable Senator Neufeld moved, seconded by the Honourable Senator Frum:

That the Standing Senate Committee on Energy, the Environment and Natural Resources be authorized to examine and report on the effects of transitioning to a low carbon economy, as required to meet the Government of Canada's announced targets for greenhouse gas emission reductions. Recognizing the role of energy production, distribution and consumption in Canada, the committee shall be authorized to:

- (a) identify and report on the impact transitioning to a low carbon economy will have on energy end users, including Canadian households and businesses;
- (b) identify and report on the most viable way the following sectors — electricity, oil and gas, transportation, buildings and trade-exposed energy intensive industries — can contribute to a low carbon economy in meeting Canada's emission targets;
- (c) examine and report on cross-sector issues and undertake case studies, if necessary, on specific programs or initiatives aimed at reducing greenhouse gas emissions;
- (d) identify areas of concern and make any necessary recommendations to the federal government that will help achieve greenhouse gas emission targets in a manner that is sustainable, affordable, efficient, equitable and achievable.

That the committee submit interim reports on identified sectors, cross-sector issues and case studies and submit its final report no later than September 30, 2017, and that the committee retain all powers necessary to publicize its findings until 180 days after the tabling of the final report.

After debate,

The question being put on the motion, it was adopted.

Charles Robert

*Clerk of the Senate*

<p>The committee has held 45 hearings and heard from 120 witnesses consisting of government officials and representatives, industry representatives, energy experts, university students and environmental organizations. Committee members conducted site visits and had fact finding meetings in Vancouver, Kitimat and Prince George, British Columbia, Calgary, Alberta, Estevan, Saskatchewan, Sarnia and Hamilton, Ontario, Montreal and Varennes, Quebec, St. John's, Newfoundland and Labrador, Summerside, Prince Edward Island, Saint John, New Brunswick and Halifax, Nova Scotia.</p>
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# Executive Summary

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The Standing Senate Committee on Energy, the Environment and Natural Resources is studying what it will cost ordinary Canadians and businesses to meet Canada's greenhouse gas (GHG) reduction targets. It is examining the effect Canada's GHG reduction targets will have on five sectors of the Canadian economy: electricity, transportation, oil and gas, buildings, and emission-intensive, trade-exposed, industries that are mostly heavy industries that compete in international markets such as steel and cement manufacturing.

This second interim report addresses the transportation sector and follows a first interim report that focused on the electricity sector. The committee's final report is expected to be released at the end of 2017 and will include any necessary recommendations to the federal government that will help achieve its GHG reduction commitments in a manner that is sustainable, affordable, efficient, equitable and achievable.

In December 2015, Canada, along with 194 other countries, reached an agreement in Paris to address climate change. Canada faces a herculean task to meet its GHG emission reduction target under the Paris Agreement — the elimination of 219 megatonnes of GHG emissions by 2030, a reduction of 30% below 2005 levels. To achieve this goal, Canada will need to reduce GHG emissions across all sectors of the economy.

Decarbonizing transportation in Canada –by deploying increasing numbers of alternative vehicles, improving vehicle fuel efficiency, shifting away from petroleum-based to cleaner fuels, and by designing low emission transportation alternatives through community and infrastructure investment, for example – brings the potential for much lower domestic GHG emissions across the economy. It brings challenges as well.

Greenhouse gas (GHG) emissions from the transportation sector accounted for almost a quarter (23%) of all GHGs in the country, second only to the oil and gas sector as the largest source of GHG emissions in Canada. Passenger and freight vehicles are responsible for the majority of transportation emissions, a function of the need to move people and goods throughout Canada's vast geography. Despite an increased number of vehicles on the road, emissions are expected to decline 8% from 2005 levels by 2030 due to more stringent fuel efficiency standards, design and technological changes, and the adoption of alternative fuels such as electricity, natural gas and hydrogen.

As noted in this committee's electricity sector interim report, Canada's electricity system is over 80% non-emitting and among the cleanest in the world. This is a major national advantage and will provide the backbone of a transportation system fueled by clean electricity. The electrification of vehicle transportation will be advanced by the widespread adoption of electric vehicles on the road and the enhancement and electrification of public transit. In fact, a recent analysis by the International Energy

Agency on ways to meet the Paris Agreement commitment of limiting global temperatures to below 2 °C finds that to achieve this climate objective, a deep transformation of energy production and consumption needs to occur by 2050. Among its list of major measures that must be undertaken to reduce emissions in the electricity, industrial and building sectors, it suggests that 7 out of every 10 new cars would need to be electric, compared with 1 in 100 today. In Canada, electric vehicles currently represent only a small fraction of vehicles on the roads. Measures aimed at greatly expanding their numbers are expected to increase electricity demand and therefore will require investments in electricity and transportation infrastructure. Investments to electrify buses and commuter trains are required as well. The challenge will be to ensure that these investments deliver emissions reductions in a way that is effective, affordable and fair to Canadians while representing good value for public money spent.

Investments in public transit will also require some behavioural changes on the part of commuters. Unless taking transit is easier, faster and cheaper than taking a car for one's daily commute, investments will not result in the desired emission reductions.

Vehicle fuel efficiency standards are an important policy tool for lowering road transportation emissions. Experience with vehicle fuel efficiency standards has shown that vehicle manufacturers can achieve better performance over time when there is regulatory certainty, but uncertainty over federal emission reduction policies in the United States (U.S.) could hinder further efficiency gains in internal combustion engines in Canada. Because the auto manufacturing sectors in both countries are highly integrated, and are covered by vehicle emissions standards that are aligned between Canada and the U.S., Canada's current efforts to increase the stringency of fuel efficiency may prove difficult if the U.S. opts to pull back from its previously-announced standards. Improvements in vehicle fuel efficiency will increase their purchase price, and while these costs are expected to be recovered through fuel savings, they present an additional and mandatory immediate up-front cost for purchasers.

To reduce the GHG emissions produced by internal combustion engines, biofuels like ethanol and biodiesel can be blended with petroleum fuels. Federal regulations already require biofuel blends in all gasoline, diesel and heating oil, and several provinces also have renewable fuel mandates. The Pan-Canadian Framework on Clean Growth and Climate Change commits federal, provincial and territorial governments to work with industry and other stakeholders to develop a national clean fuel standard.

The Pan-Canadian Framework on Clean Growth and Climate Change also defines a plan for a national carbon pricing framework that, depending on design, could apply in some provinces and territories to transportation fuels. These carbon costs are expected to be borne by consumers of fossil fuels, sending a price signal that should shift transportation markets as the carbon price rises over time. As markets respond to the carbon price, consumers will choose lower-GHG emitting transportation options over more heavily-



emitting ones. Some provinces are using carbon pricing revenues to subsidize alternative vehicle purchases and build out alternative charging and refuelling infrastructure, while considering the fairness of carbon pricing on lower-income Canadians who will pay a disproportionate carbon cost compared to wealthier ones.

Avoiding the worst impacts of climate change by, as a first step, meeting Canada's 2030 GHG emission reduction targets under the Paris Agreement is going to be a huge challenge. To put it in context, if all the cars, trucks, planes, trains and ships were to disappear from Canada by 2030, we would still fall far short of meeting our national GHG reduction commitments.

The committee believes Canadians should have a real understanding of what will be necessary to meet Canada's GHG reduction targets. An increase in transportation costs is a reminder of the real dollars-and-cents costs ordinary Canadians will face in the transition to a lower-carbon economy.

# Addressing Climate Change

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Climate change mitigation is an immense, pressing and complex global challenge. Climate change is a destabilizing threat to global health and security that could define the next century more than any other. The effects of climate change are already observed: for example, rising temperatures, changing precipitation patterns, and an increase in the occurrence of extreme weather events.<sup>1</sup> For several decades, many countries including Canada have postponed difficult decisions needed to curb greenhouse gas (GHG) emissions. Clearly, this is not an easy problem to fix. However, the problem will not simply go away and it can no longer be deferred to future generations.

Everyone shares the atmosphere, which means addressing climate change requires an ambitious level of global co-operation. On 12 December, 2015, Canada and 194 other countries party to the United Nations Framework Convention on Climate Change reached an agreement in Paris to limit global average temperatures increases to less than 2 °C above pre-industrial levels and to pursue efforts to achieve 1.5 °C.<sup>2</sup> To many, this was a pivotal moment in the effort to address climate change because both developed and developing countries were part of the agreement and together they represent most of the world's emissions.

Since the Paris Agreement, the United States has changed the direction of U.S. trade, energy and climate change policies. The United States is Canada's largest trading partner. The two countries share highly integrated economies where goods move freely across the border, often in shared supply chains.

Climate change is occurring as global energy demand is growing. The International Energy Agency estimates that global energy use will increase nearly one third by 2040 due to increased demand from emerging economies.<sup>3</sup> Also, current low prices for oil are challenging policy efforts to switch to cleaner fuels. Meanwhile, some countries are grappling with a protracted and slow global economic recovery where many people around the world are more worried about retaining or finding a job than tackling climate change, especially since its worst consequences will not be felt for several decades, if not a century.

## Canada's Emission Commitment

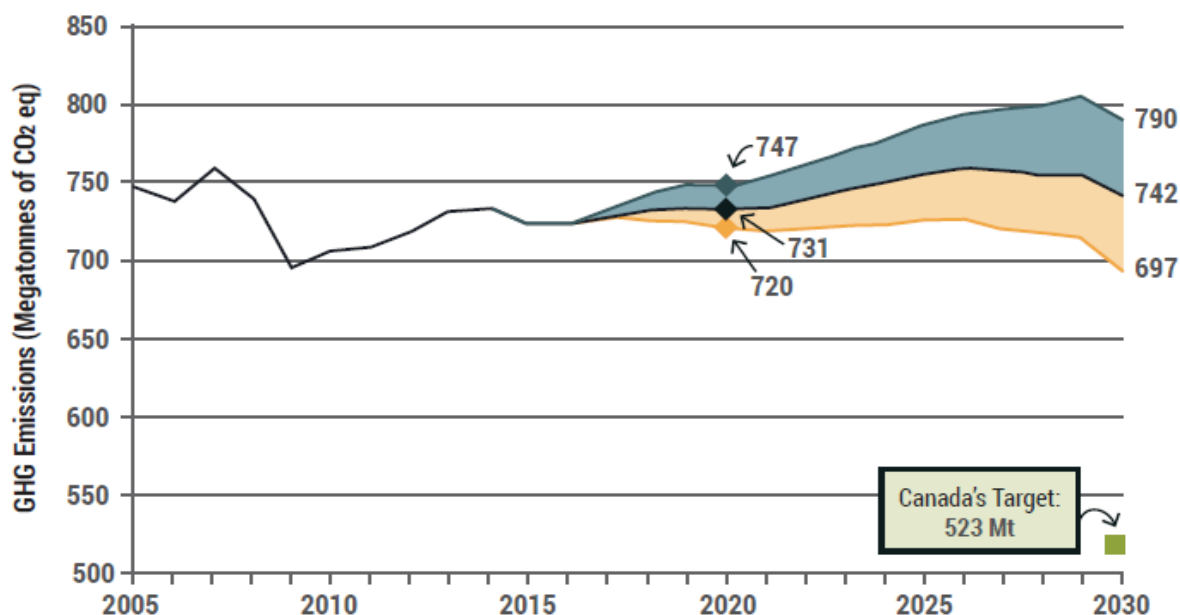
GHGs are not an ordinary pollutant. They are associated with almost every activity, product and service and are supported by long-lived capital infrastructure.<sup>4</sup> Addressing climate change will require a rapid and substantial retooling of energy systems that have supported economies for nearly a century. Unlike the past, it is a transition chiefly driven by public policy and it will not be cost-free.

Canada's emission target submitted to the Paris Agreement is 30% below 2005 levels by 2030. The 2030 target is a minimum target. Further reductions will be needed to reach the Paris Agreement's ambition of 80% reduction from 2005 levels by the second half of the century.<sup>5</sup>

In the wake of the Paris Agreement, federal, provincial and territorial governments have committed to working together to reduce emissions. In December 2016, Canada's First Ministers released the Pan-Canadian Framework on Clean Growth and Climate Change with the exception of Saskatchewan and Manitoba which did not adopt the Framework.<sup>6</sup> The Framework builds on previously announced initiatives such as a national minimum benchmark price on carbon emissions and an acceleration of the phase-out of traditional coal-fired electricity units.

The following projections from Environment and Climate Change Canada (Figure 1) include the latest forecasts for gross domestic product (GDP) and oil and gas prices and production. They also include new federal, provincial and territorial government measures that have legislative or funding certainty as of 1 November, 2016. The projections show a range of GHG emission level outcomes based on the uncertainty inherent in modeling climate policy and other macroeconomic conditions that are beyond the control of government. The reference case scenario assumes business-as-usual oil and gas prices and GDP growth and is contrasted with scenarios assuming high oil and gas prices and GDP growth and one with low oil and gas prices and GDP growth.

**Figure 1: Canada's Emissions Projections in 2020 and 2030 (MT CO<sub>2</sub> eq)**



Note: Mt CO<sub>2</sub> eq. = megatonne (1 million tonnes) of carbon dioxide equivalents. Different greenhouse gases have different global warming potentials depending on their lifetimes in the atmosphere and how efficiently they contribute to the greenhouse effect. The global warming potential of the different greenhouse gases can be expressed in relative terms to those of carbon dioxide, known as carbon dioxide equivalents, or CO<sub>2</sub> eq.

Source: Environment and Climate Change Canada, [Canada's 2016 greenhouse gas emissions Reference Case](#)

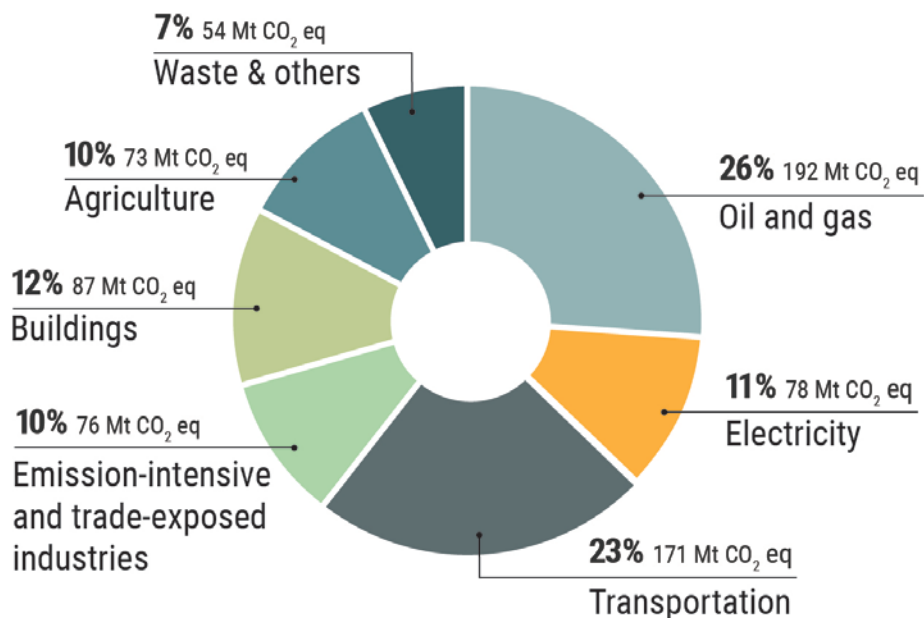
**Legend: Emissions projections in three scenarios:**

- 1** High oil and gas prices and high GDP growth – blue line
- 2** The “reference case” representing business-as-usual oil and gas prices and GDP growth – black line
- 3** Low oil and gas prices and low GDP growth – yellow line

Assumptions	High	Reference	Low
Average Annual GDP Growth (2014-2030)	2.3%	1.7%	1.0%
2030 West Texas Intermediate Oil Price (2014 US\$/bbl)	111	81	42
2030 Henry Hub Natural Gas Price (2014 US\$/GJ)	4.62	3.72	2.89

These emissions projections incorporate oil and gas price forecasts set out in the National Energy Board's energy outlook, *Canada's Energy Future 2016: Update – Energy Supply and Demand Projections to 2040*, published in October 2016. As noted by Environment and Climate Change Canada, the energy price assumptions for 2030 are consistent with other major price forecasts.<sup>7</sup> The average 2016 prices for West Texas intermediate oil was \$43.14 (US\$/bbl), and the Henry Hub Natural gas price was \$2.11 (US\$/GJ).

**Figure 2 – Canada's Emissions Breakdown, 2014 (Mt CO<sub>2</sub> eq)**



**Table 1 – Reference Case Emissions Projections by Economic Sector (Mt CO<sub>2</sub> eq)**

<b>EMISSIONS PROJECTIONS (REFERENCE CASE) BY ECONOMIC SECTOR –CANADA (Mt CO<sub>2</sub> eq)</b>				
	2005	2014	2020	2030
Oil and Gas	159	192	201	233
Electricity	118	78	64	34
Transportation	171	171	168	157
Emissions Intensive & Trade Exposed Industries	88	76	85	97
Buildings	85	87	89	94
Agriculture	70	73	72	74
Waste & Others	56	54	51	53
<b>Total</b>	<b>747</b>	<b>732</b>	<b>731</b>	<b>742</b>
<b>Emission Target</b>				<b>523</b>
<b>Difference</b>				<b>(219)</b>

Figure and table prepared by the Library of Parliament using data obtained from Environment and Climate Change Canada, [Canada's 2016 Greenhouse Gas Emissions Reference Case](#).

Note: Includes new federal, provincial and territorial government measures that have legislative or funding certainty as of 1 November, 2016.

Note: Numbers in all figures and tables may not add up to the total due to rounding.

The 2030 target is ambitious. According to Environment and Climate Change Canada projections as of November 2016, Canada must reduce annual emissions by 219 megatonnes of carbon dioxide equivalent (Mt CO<sub>2</sub> eq) in order to meet its 2030 target. To put this into context, it is nearly equal to the projected emissions from Canada's entire oil and gas industry in 2030, which are expected to be 233 Mt CO<sub>2</sub> eq.

Achieving the 2030 target will require a herculean shift in how energy is produced and consumed in Canada. For the years beyond 2030, one must imagine a society essentially transformed and decarbonized. The projections in Figure 1 do not include broader strategies or future measures within existing plans where details are still under development such as federal fuel standards for heavy-duty vehicles, methane reduction regulations and the proposed clean fuel standards and the coal-fired generation phase-out by 2030.

Canadians must do their fair share to address climate change. However, one should keep in mind that Canada's portion of global emissions is relatively small at 1.6 %.<sup>8</sup> Canada's share is expected to decline as emissions from emerging countries such as China, India, Brazil and Indonesia increase steadily in the future.<sup>9</sup> That being said, every nation's effort to address climate change adds up and collective action will be the only way to meet this challenge. ***If Canada does not make a concerted effort to meet its own targets then how can we, as an advanced economy, ask other nations to meet theirs?*** Canada's global reputation and credibility would be damaged if we failed to act.

The U.S. has announced its intention to withdraw from the Paris Agreement, challenging global climate change co-operation efforts, potentially making it harder for the rest of the world to achieve stringent emission reductions. If we are not all in it together, it will make little difference to the atmosphere if Canada meets its targets.

The committee recognizes that there are opportunities created by the clean energy economy, but the transition of the speed and magnitude being considered will affect the lives and pocketbooks of all Canadians and most likely unevenly. ***The question is how much of our welfare are we willing to risk to meet our climate change commitments? On the other hand, how much do we risk in delaying emission reduction policies?*** If we wait until the future to act, it will likely be more costly to decarbonize since the pace of the transition would have to accelerate.

# Transportation Overview

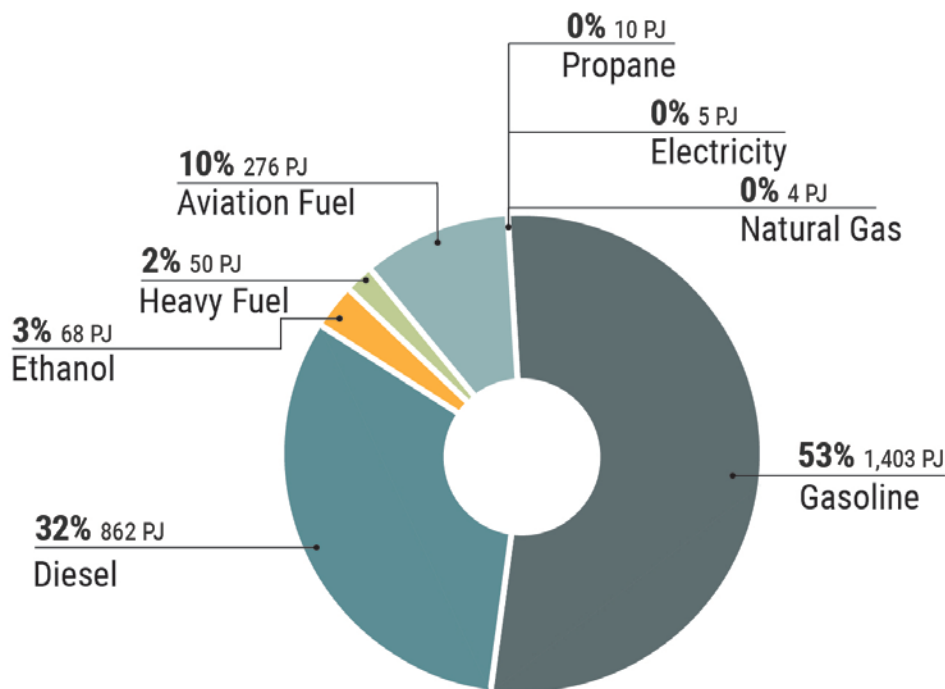
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Transportation is an indispensable part of society as it is woven into nearly every activity. It is how we get to work, to play and to the services we require. Canada's transportation systems make up a vast network of transportation modes connecting people and goods by road, rail, water and/or air across the country and abroad.

## Transportation Fuels and Emissions

Transportation in Canada and in the rest of the world is fuelled almost exclusively by refined petroleum products derived from crude oil, namely motor gasoline, diesel, aviation fuel and heavy fuel oil mainly used in marine vessels. The exception is ethanol and electricity, which accounted for a small amount of fuel used in transportation in Canada, 3% and 0.2% respectively, in 2014.

**Figure 3 – Transportation Energy Use in Canada, 2014 (PJ)**



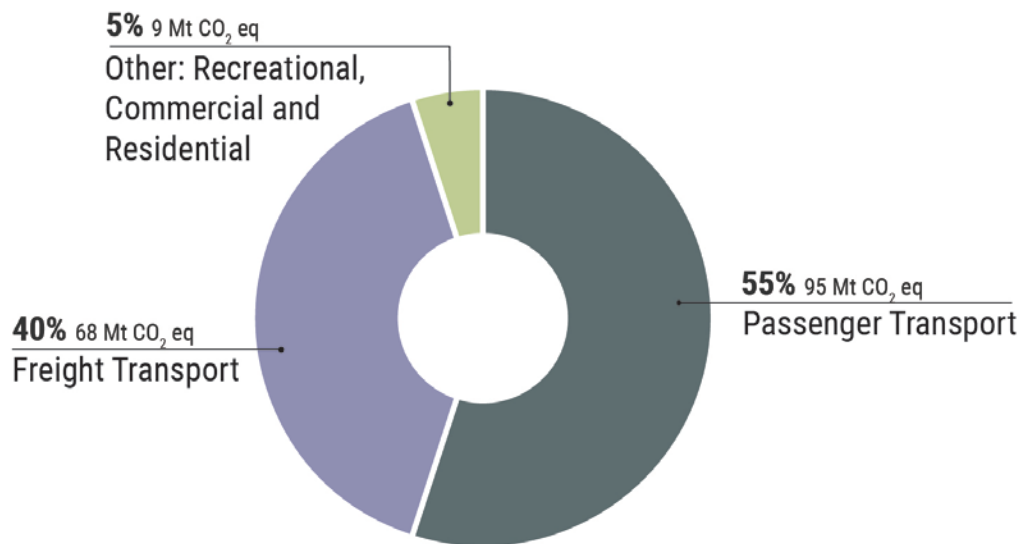
Note: PJ = petajoule

Source: Natural Resources Canada, [Comprehensive Energy Use Database](#)

Vehicles are principally used to move people and freight. Freight includes all food products, manufactured and other processed goods, and commodities such as coal, crude

oil, wood products, potash, grain, and metals and minerals. To a lesser extent, vehicles are used for off-road commercial and industrial purposes such as mining and farming, as well as for recreational and residential purposes. In 2014, the movement of people accounted for 95 Mt CO<sub>2</sub> eq while freight was 68 Mt CO<sub>2</sub> eq. Transportation emissions are largely a function of population levels and changes in disposable income and global and domestic GDP. Freight transportation, because it involves the movement of goods, is highly influenced by the level of economic activity.<sup>10</sup>

**Figure 4 – Canada's Transportation Emissions, 2014 (Mt CO<sub>2</sub> eq)**

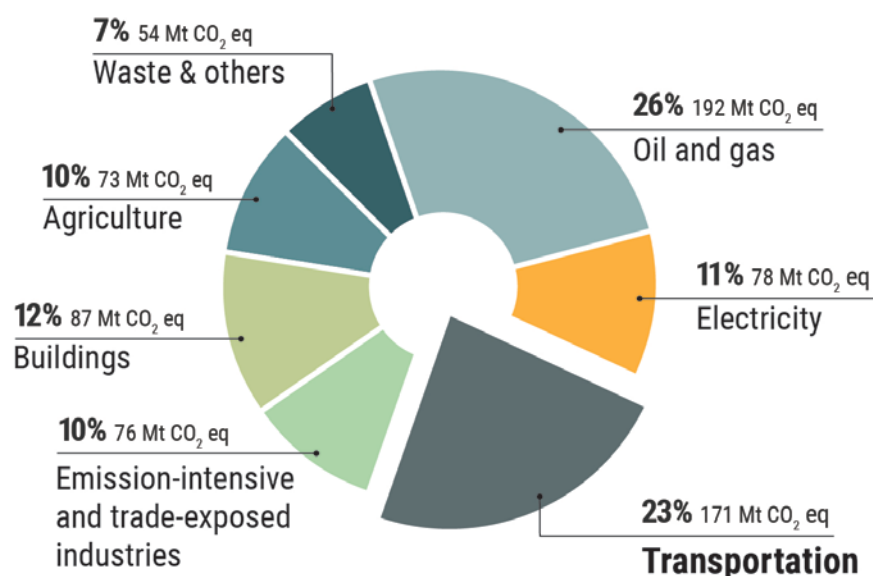


Source: Environment and Climate Change Canada, [Canada's 2016 greenhouse gas emissions Reference Case](#)

In 2014, the transportation sector was the source of 23% of greenhouse gas (GHG) emissions in the country. It is second only to the oil and gas sector as the largest source of GHG emissions in Canada. Transportation emissions are widely distributed as they originate from millions of independent sources, for example each vehicle's tailpipe. GHGs that are produced by the combustion of petroleum fuels consist predominantly of carbon dioxide and smaller amounts of nitrous oxide.<sup>11</sup>



**Figure 5 – Canada's Emissions by Economic Sector, 2014 (Mt CO<sub>2</sub> eq)**



Source: Environment and Climate Change Canada

Emissions from the transportation sector are projected to decrease to 157 Mt CO<sub>2</sub> eq by 2030, down from 171 Mt CO<sub>2</sub> eq in 2014.

As noted earlier, Canada committed to reducing our emissions 30% below 2005 levels by 2030. This means that by 2030, we must reduce our emissions by 219 Mt CO<sub>2</sub> eq. This is a challenging target and a very tight deadline, with just 13 years to achieve substantial reductions. To put this in perspective, if all the cars, trucks, railcars, planes and marine vessels were to disappear by 2030, it would account for 157 Mt CO<sub>2</sub> eq, far short of what is needed to achieve Canada's target.

Nonetheless, it is imperative that we reduce emissions in transportation in order to make progress towards preventing the worst aspects of climate change and the following sections discuss options on how we can best move toward this goal, examining road, air, rail and marine transportation.

# Road Transportation

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Canada is a vast country and Canadians are highly dependent on road vehicles to travel long distances between cities. Also, compared to the rest of the world, Canadians rely more on cars for urban mobility.<sup>12</sup> Road transportation, mainly by trucks, is the most important means of trade between Canada and the United States, our largest trading partner. The total value of truck traffic between Canada and the U.S. in 2015 was \$410 billion, almost evenly split between exports to the U.S. (\$206 billion) and imports from that country (\$204 billion).<sup>13</sup> There were approximately 24 million registered road motor vehicles in Canada in 2015 and together they account for nearly 80% of all transportation emissions. Therefore, any meaningful reduction in the country's emissions requires addressing those that come from road vehicles.

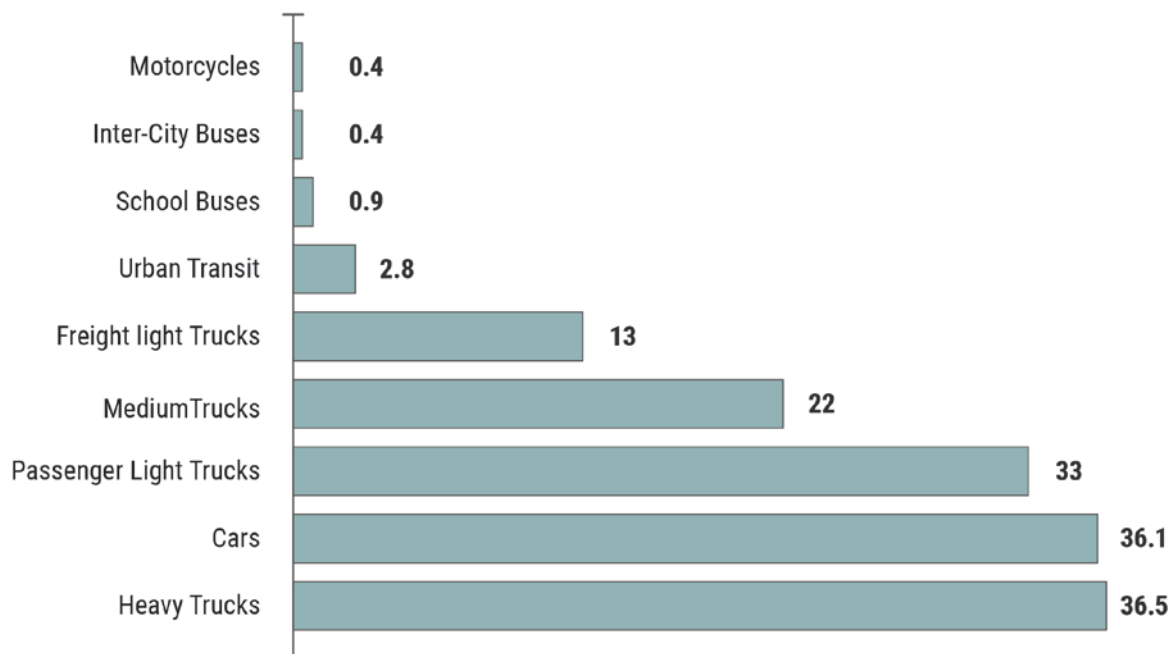
Cars, light trucks, sport utility vehicles (SUVs) and mini-vans are considered light-duty vehicles and together they produced 69.1 Mt CO<sub>2</sub> eq or 48% of total transportation emissions in 2014. Light duty vehicles account for 92.2% of all vehicles on the road, while medium and heavy-duty vehicles represent 4.5%. However, medium and heavy-duty trucks together emit approximately the same level of GHGs as all light duty vehicles, even though there are far fewer of them on the road. This is because trucks are typically driven much greater distances than cars.

**Table 2 – Total Road Motor Vehicles Registered in Canada, 2015**

Light-duty vehicles	22,067,778
Medium-duty	591,897
Heavy-duty	464,322
Buses	90,551
Motorcycles and mopeds	709,258
<b>Total</b>	<b>23,923,806</b>

Source: Statistics Canada Vehicles registrations, [Cansim table 405-0004](#)

**Figure 6 – Road Transportation GHG Emissions Canada, 2014 (Mt CO<sub>2</sub> eq)**

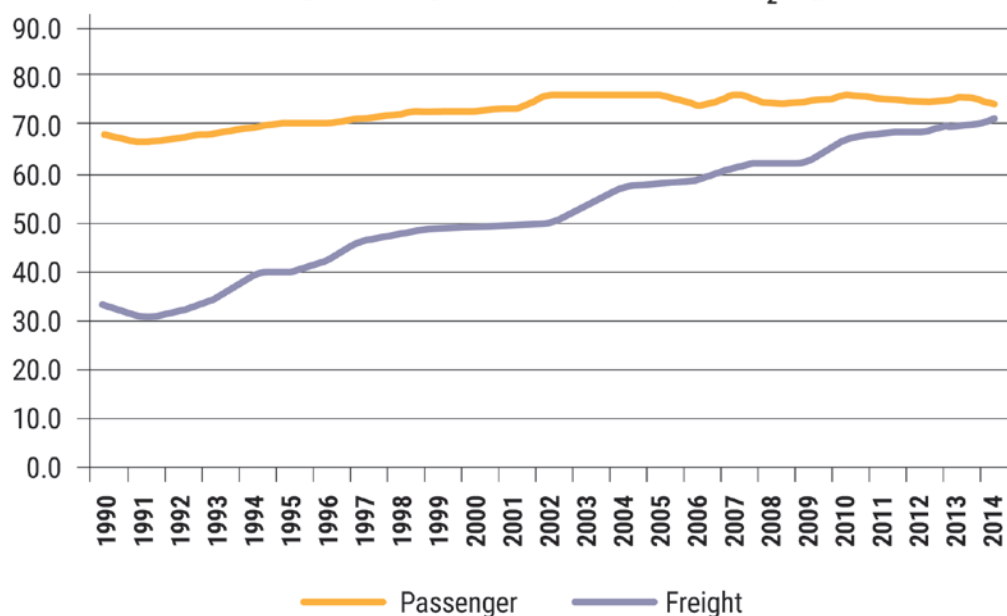


Source: Natural Resources Canada, [Comprehensive Energy Use Database](#)

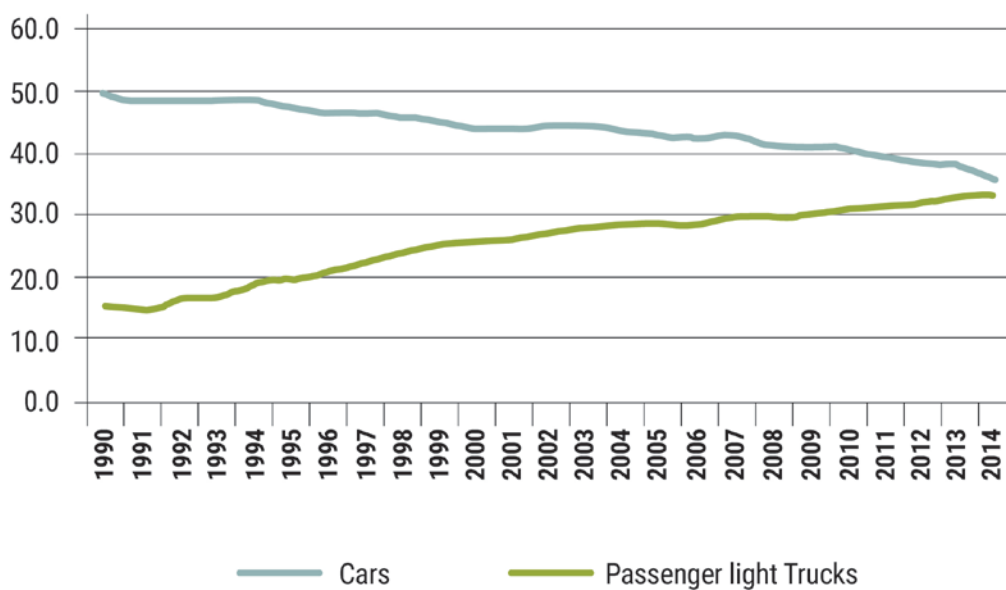
## Trends

Total emissions from road transportation have grown over the last two decades although the rate of growth has slowed since 2005 –this is mainly due to improvements in vehicle fuel efficiency. For example, although the number of road vehicles in Canada has increased by 27% since 1999, overall emissions levels have remained relatively constant.<sup>14</sup> However, there are two trends that are increasing emissions. First, over the last two decades, light passenger trucks including SUVs and minivans have grown in popularity among Canadians. These vehicles have higher fuel consumption ratios than cars. Second, during the same period, there has been steady growth in emissions from freight transportation reflecting the increase in use of medium and heavy trucks that haul goods.

**Figure 7 – Canada's Road Transport Emissions by Passenger and Freight Transport, 1990-2014 (Mt CO<sub>2</sub> eq)**



**Figure 8 – Canada's Passenger Vehicle Road Emissions, 1990-2014 (Mt CO<sub>2</sub> eq)**



Source: Natural Resources Canada, [Comprehensive Energy Use Database](#)

## Reducing Emissions in Road Transportation

The automobile is among the most important consumer products of the last century. Is it poised for significant reinvention in the coming years? During the committee's visit to McMaster University's Institute for Transportation and Logistics in Hamilton in November 2016, committee members were told that the auto industry will change more in the next five years than it has in the last 50 years. Much of this transformation is linked to reducing emissions from road vehicles using new vehicular applications of information technologies (IT) combined with advances in fuel efficiency and low or non-emitting emission propulsive systems. The switch to electrified vehicles for public transport and personal use is posited as a way forward in reducing emissions. Many car companies have fully or partially electric vehicles on the market. It is difficult to estimate the timeline of adoption of these new technologies on a broader scale.

### Vehicle Emission Standards

The auto manufacturing sectors in Canada and the United States are highly integrated, and there is a long history of collaboration in working towards the alignment of emission standards. Starting in 2011, federal regulations were introduced that establish

#### *Canada's Automotive Sector*

*The Canadian automotive sector produces a full range of light-duty vehicles including cars, vans and trucks. It also produces heavy-duty trucks, transit buses, school buses, military vehicles; and a wide range of parts and components. The sector directly supports over 550,000 jobs across Canada.*

progressively stringent annual emission standards applied to companies that manufacture or import new light-duty vehicles into Canada for model years 2011-2016. These regulations were later amended to apply to model years from 2017 to 2025. Also, emission standards were developed for heavy-duty vehicles for model years 2014-2018. Canadian vehicle emission standards are aligned with the U.S. In March 2017, the U.S. administration ordered a review of the U.S. vehicle fuel-efficiency standards for cars and light-duty trucks for model years 2022 to 2025 to determine their appropriateness.<sup>15</sup> This review is to be completed by April 2018. The implications this may have for

harmonized fuel standards between Canada and the U.S. remain to be seen.

Many witnesses underscored the sweeping impact regulated emission standards are having on the North American automotive sector. The regulations not only compel manufacturers to improve emissions from vehicles powered by internal combustion engines (ICE) through shifts in design, IT systems and materials, but they also encourage the adoption of alternative fuels and technologies such as electric vehicles (EVs), hydrogen fuel cells and natural gas vehicles.

Mark Nantais, President of the Canadian Vehicle Manufacturers' Association, explained that the regulations go far beyond business-as-usual for the industry.<sup>16</sup> They require

manufacturers to overcome significant technical challenges involving sizable increases in manufacturing costs. He told the committee, “I can think of no other product that is required by regulation to reduce greenhouse gas emissions to such an extent.”<sup>17</sup> He also noted the already impressive gains in fuel efficiency realized in the industry:

Through an unprecedented 3 to 5% year-over-year improvement requirement, 2025 model year light duty vehicles are projected to emit 50% less greenhouse gas emissions compared to a 2008 model year vehicle. If you calculate from the model year 2011, this will result in an estimated cumulative reduction of 266 million tonnes of carbon dioxide equivalent emissions from the light duty fleet on a national basis.<sup>18</sup>

Louis Thériault, Vice President of Public Policy of the Conference Board of Canada, pointed out that a 30% reduction in emissions by 2030 from 2005 could be reached in road transportation if car manufacturers achieve the ambitious goals set out in regulated fuel efficiency standards for ICE vehicles.<sup>19</sup> However, he emphasized that the automotive industry would have to overcome significant technical challenges especially from the heavy-truck segment of the industry to achieve this goal.

Louis Thériault believed that alternative technologies such as electric or natural gas vehicles would likely not contribute significantly to the country’s 2030 target but would be essential in meeting Canada’s longer-term emission target of 2050.<sup>20</sup>

### **Heavy-Duty Truck Emission Standards**

The federal government is developing emission standards for post-2018 model years for heavy-duty vehicles and engines.<sup>21</sup> In 2016, the U.S. finalized its phase II emission rules for heavy trucks. In the past, Canada has pursued a common approach to vehicle emission standards with the U.S. The American standards apply to vehicle engines and certain trailers for the model years 2018-2027 and to model years 2021-2027 for semi-trucks, large pickup trucks, vans, and all types and sizes of buses and work trucks. The trailer standards include using devices to reduce aerodynamic drag, low rolling resistance tires, lightweight components, and tire pressure monitoring and automatic tire inflation systems.



*Medium and heavy-duty vehicles represent 4.5% of all vehicles on the road.* Photo Credit: iStock

Jonathan Blackham, Policy and Government Affairs Assistant for the Canadian Trucking Alliance, recognized that given the amount of cross-border traffic between both countries, harmonization with the U.S. is desirable but said that exceptions must be made

with the new trucking regulations.<sup>22</sup> He stressed that any technology approved by regulation must be proven to operate safely and efficiently in Canada's unique geographical environment and harsher winter conditions. Also, he stressed that regulations should reflect the differences in weight and safety requirements between both countries. For example, some Canadian provinces allow heavy trucks to carry more weight compared to their American counterparts.

Mr. Blackham also provided the committee with a statement indicating emission reduction measures will increase costs within the trucking industry, proposing that "[a] \$50 per tonne carbon price could increase diesel prices by 11 cents per litre".<sup>23</sup>

## **Alternative Vehicle Technologies**

Most road vehicles in Canada and around the world are propelled by an internal combustion engine (ICE). It is a technology that has advanced for many decades supported by liquid petroleum fuels such as gasoline and diesel. These fuels are highly portable, storable and extremely energy dense. They are convenient to use since refuelling only takes five to ten minutes. ICEs are served by mature, reliable and vast distribution and retail systems for liquid fuels and by numerous established services such as engine repair shops.

It is very difficult for new and alternatively fuelled vehicular technologies to displace the market dominance of ICE vehicles. However, many witnesses felt that the prospects for low or zero emission vehicle technologies have never been better given the need to address climate change and they stressed that Canada must be part of this growing industry.

### **Electric Vehicles**




Electric vehicle (EV) technology is commonly associated with automobiles and to some extent light trucks, but there is a wide range of vehicular applications including buses, motorcycles, bicycles, vans and delivery trucks. To date, EV technology is not a commercially viable option for long-haul heavy trucks carrying heavy freight due to range limitations and the size of the battery needed to move the trucks.

There is a wide variety of EV technologies. They can be grouped into three broad categories (Table 3):

- Hybrid-electric vehicles (HEVs) – the propulsion system combines the conventional internal combustion engine with an electric powertrain.
- Plug-in hybrid electric vehicles (PHEVs) – the propulsion system is primarily driven by battery packs which are recharged by plugging into the power grid but it is also equipped with a conventional combustion engine to propel the vehicle, and recharges the batteries. PHEV's electric battery range is approximately 60 km.

- Battery electric vehicles (BEVs) – the propulsion system is exclusively powered by rechargeable battery packs. There is no fuel tank. These vehicles can have a range of 100 to 400 km.<sup>24</sup>

**Table 3 – Vehicle Type and Refuelling Options**

Vehicle Type		Gasoline/Diesel	Electricity
Hybrid (HEV)		X	
Plug-in Hybrid (PHEV)		X	X
Battery Electric (BEV)			X

Source: Table prepared by the Library of Parliament using data from [Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study](#), 2015.

According to Mark Nantais of the Canadian Vehicle Manufacturers' Association, 25 new plug-in EV models have been introduced in Canada since 2011 and this will rise to 29 by 2017.<sup>25</sup> Today the number of EVs on the road is not significant, but the data show a nascent market sector on the rise.

Aad van Bohemen, Head of Energy Policy and Security Division at the International Energy Agency, told the committee there are good opportunities for more electric vehicles. In a follow-up submission, the IEA provided the committee with a recent analysis that suggests that by 2050, 7 out of every 10 new cars would need to be electric, compared with 1 in 100 today, if the world is to meet the Paris Agreement commitment of limiting global temperatures to below 2° C.<sup>26</sup> This was only one of many major measures that would have to be undertaken to meet the climate objective. Like most countries, Canada is nowhere near that target.

Indeed, there are approximately 25,000 EVs on the road today which is about 0.1% of all cars and light-duty trucks in Canada -half of Canadian EVs are registered in Quebec. Witnesses attributed Quebec's large share of Canada's EV fleet to a number of factors, including: the low cost of electricity in Quebec; subsidies of up to \$8,000 per vehicle provided by the provincial government; Hydro-Québec making EVs a strategic priority in Quebec as early as 2009, supported by equipment pilots to verify technology performance and investments in the provincial Electric Circuit EV charging network; and strategic partnerships among government, private sector, academia, and non-governmental partners.<sup>27</sup>



Canada's high proportion (nearly 80%) of non-emitting electricity generation makes EVs an attractive option to reduce GHG emissions in most regions of the country. Louis Beauchemin, Senior Director of Subsidiary Management of Hydro-Québec, argued that even if the electricity is sourced from a coal-fired plant, EVs are cleaner to run than ICE vehicles, as long as it is a new generation coal plant.<sup>28</sup>

An analysis commissioned by Hydro-Québec assessing the environmental benefits of an electric vehicle powered by electricity produced in Quebec rather than a vehicle powered by gasoline noted:

Most of the environmental impact of an electric vehicle occurs at the manufacturing stage, while that of a conventional vehicle occurs when it is in use. At the time of purchase, an electric vehicle has a bigger footprint than a conventional vehicle. However, after being driven for some 300,000 km, the former's greenhouse gas emissions are much lower than those of the latter—between 55% and 80% lower.<sup>29</sup>

Chantal Guimont, President and Chief Executive Officer of Electric Mobility Canada, explained that fuel costs for EVs can be less than a quarter of the cost than for ICE vehicles depending on the region in Canada. However, incentives are still seen as necessary to stimulate market demand and help overcome obstacles preventing wider EV adoption.<sup>30</sup> These obstacles include:

- Vehicle range anxiety;
- Battery life and durability;
- Longer refuelling times and lack of charging stations;
- Higher purchase cost and uncertainty of after-market re-sale; and
- Lack of information, awareness and familiarity with the technology.

Quebec, Ontario and British Columbia all provide rebates for EV purchases of up to \$8,000/EV, \$14,000/EV, and \$5,000/EV for each province, respectively. Ms. Guimont



*In Surrey, British Columbia, Powertech Labs are testing clean transportation solutions.* Photo Credit: Senate of Canada

acknowledged that incentives on a luxury EV like a Tesla may subsidize EV purchases by wealthy individuals who could likely afford one without an incentive, but said that policy solutions could address this. She argued that, in fact, Quebec EV incentives make many EV models economic for moderate-income households.<sup>31</sup>

The committee heard that the equipment cost for a new fast-charging EV refuelling station is about \$30,000, but that variable soft costs associated with installation (engineering, wiring, grid capacity upgrading, access to electricity, regulatory issues, etc.) can see the combined cost of equipment and installation rising to as much as \$100,000, which is location dependent. Mr. Beauchemin of Hydro-Québec explained that the utility's aggressive expansion of its network of EV charging stations has attracted significant private capital from over 180 municipalities, institutions and businesses that partner with Hydro-Québec. These partners purchase and install one or more standard or fast-charge stations, which generate an income for the partner. Partners receive all the income generated from standard charging stations, and a share of the income generated from fast-charging stations.<sup>32</sup> As a result, Hydro-Québec has paid for very few charging stations itself:

We have a project where we were the lowest bidder to install charging stations in [Ontario], including Cornwall and Ottawa, and we are doing that now. It has to be completed by the end of March. Almost all of that is being done by partners who see the advantage of having a charging station, and then they can charge whatever they want: \$1 an hour, \$2.50 a day or \$10 per hour if it's fast-charging. They know they will attract people to Tim Hortons or St-Hubert or their shopping centre. It's a win-win.<sup>33</sup>

The committee heard from many electric utilities that there is sufficient electricity supply to accommodate the increase in the number of EVs. However, Steven McCauley, Acting Chief Executive Officer of Pollution Probe, told the committee that the capacity of the electric grid to handle charging requirements at the neighbourhood level may be an issue.<sup>34</sup>

Regarding the end-of-life for EV batteries, the committee heard that today there are few companies engaged in EV battery recycling, but that this is a function of the low supply of used batteries.<sup>35</sup> EV batteries have a life of about nine years, according to Ms. Guimont, with potential non-automotive applications beyond that, so there could be secondary markets for end-of-life EV batteries. As demand for battery recycling and applications for diminished EV batteries increases, she expects that markets will respond to supply these products and services.

### **Hydrogen Vehicles**

A hydrogen fuel cell is an electrochemical energy conversion device that uses hydrogen to produce electricity. It operates like an electric battery but does not require electrical recharging. Hydrogen fuel cells do not produce GHGs or other harmful emissions -their only by-product is water vapour.<sup>36</sup>

The key challenge with hydrogen fuel cells or any other hydrogen-based technology is the supply of hydrogen. As pure hydrogen is not found in nature, energy consuming

methods are needed to produce it. Mostly, it is obtained from steam reforming natural gas, which releases carbon dioxide<sup>37</sup> or by applying electrical current to water to release the hydrogen in a process called electrolysis. While making hydrogen is energy-intensive, the process can be made cleaner if the electricity used for the electrolysis comes from non-emitting sources. As well, hydrogen has high energy content and, once produced, can be stored for later use, an advantage over many renewable energy sources.

There are only a small number of personal hydrogen fuel cell vehicles in Canada; most hydrogen fuel cell vehicles are forklifts, airport baggage-tuggers and shuttle buses. According to Eric Denhoff, President and Chief Executive Officer of the Canadian Hydrogen and Fuel Cell Association, most of the hydrogen fuel cell vehicles on the road today are leased and only available in Vancouver and Toronto.<sup>38</sup> He said that technology is improving and costs are reducing but today there are no low-cost entry level hydrogen vehicles on the market in Canada.

Eric Denhoff believes EVs and hydrogen vehicles each have a role to play in addressing emissions. He explained that hydrogen vehicles have the advantage of extended range capacity and shorter refuelling times and that hydrogen vehicles are better suited for heavier vehicles.

### **Natural Gas Vehicles**

Natural gas used in road vehicles must be carried and stored on the vehicle in a way that reduces its volume. There are two methods to do this. It can either be compressed at high pressure in cylinders - this is called compressed natural gas (CNG) - or it can be cooled to minus 162° C in stainless steel tanks and vaporized before injection into the engine; this is referred to as liquefied natural gas (LNG).

Bruce Winchester, Executive Director of the Canadian Natural Gas Vehicle Alliance, told the committee that the focus of the industry for natural gas vehicles was on medium and heavy-duty vehicle fleets.<sup>39</sup> By converting to natural gas, Mr. Winchester explained that GHG emissions could be reduced by 17% for heavy trucks and fleet operators could save on fuel costs. However, he conceded there are both financial and technical barriers preventing long-haul freight operators from investing in natural gas engines or engine conversions. Also, the recent decline in diesel fuel prices is reducing the attractiveness of switching to natural gas.

Jonathan Blackham of the Canadian Trucking Alliance agreed that there is hesitation on the part of the trucking industry to adopt natural gas-fuelled vehicles. He explained that truckers:

...know that if they purchase a diesel engine tractor with X, Y, Z technology they can run it for five years and sell it on the next market. It enjoys its next life, and that person buys it at a price then sells it on to its third life. These are all things that factor in when you're buying

technology. The technicians they have in their service bays know how to service diesel engines. They are familiar with that. There is a whole host of considerations that lead to that hesitation. So switching fuels is not a trivial matter for a trucking company.<sup>40</sup>

In order to facilitate the purchase of natural gas trucks, Mr. Blackham listed four considerations:

- 1) Purchase of alternative-fuel trucks must be incentivized;
- 2) Fuelling infrastructure must be developed;
- 3) Support should be provided for modifying service bays and equipment changes; and
- 4) Regulations must change to account for the heavier weight of natural gas vehicles.<sup>41</sup>

### **Automated and Connected Vehicles**

Self-driving vehicles are no longer an idea bound to the realm of science fiction. Today, car manufacturers and major information technology companies are competing to develop and deploy these vehicles. Self-driving vehicles could transform our relationship with the automobile and in so doing have a considerable impact on society.

Automated vehicles (AVs) are equipped with artificial intelligence, sensors and global positioning systems (GPS) that communicate (or “connect”) with each other so that the driver is not expected to constantly monitor the road. In fact, automated vehicle technologies are already common in today’s road-vehicles. They include collision-avoidance, intelligent cruise control (including braking), and automated parking. These are sometimes referred to as semi-automated driver assistance systems rather than truly self-driving vehicles.

Barrie Kirk, Executive Director of the Canadian Automated Vehicles Centre of Excellence, explained that while the biggest single benefit of automated vehicles will be improved safety through reduced collisions, fatalities and injuries, the environmental advantages may be substantial.<sup>42</sup> Self-driving vehicles are expected to drive more efficiently than humans and their connected nature could reduce traffic congestion. He pointed out that most autonomous vehicles are being developed to run on electric power, thus reducing their emissions at the tailpipe. The merging of self-driving vehicles with drive-sharing services could fundamentally transform future urban transportation systems.

***What role will automated and connected vehicles play in the transition to a low-carbon economy? Is it possible that AVs may increase the number of vehicles on the road, since the technology may enable people who currently cannot or do not choose to drive to use a vehicle such as the elderly?***

Barrie Kirk told the committee:

We know that cars had a huge impact on our personal lives in the 20<sup>th</sup> century. They have a huge impact on society, on our cities' urban planning and the world. I'm predicting that, in the 21<sup>st</sup> century, the arrival of self-driving cars will have an impact of equal magnitude. One of the beneficiaries of all of that will be energy and the environment — our carbon footprint.<sup>43</sup>

Ellen Burack of Transport Canada told the committee that the department is actively working with provinces, territories, the U.S. Department of Transportation and other agencies to prepare Canada for the deployment of AVs.<sup>44</sup> ***Should the federal government encourage the deployment of AVs as a means to address climate change?***

## Biofuels

Biofuels are fuels derived from renewable biological sources. Canada's abundant biomass supply is seen as an opportunity for the country to diminish the use of petroleum fuels in nearly all transportation modes. The most common forms of transportation biofuel are those used in road transportation. Ethanol and biodiesel can be blended with petroleum fuels and used in existing ICEs.

<b>Ethanol</b>	<i>A liquid alcohol made of oxygen, hydrogen and carbon used as a substitute for gasoline. It is obtained from the fermentation of sugar or converted starch contained in grains and other agricultural or agri-forest feedstocks. In Canada, ethanol is made principally from corn and wheat.</i>
<b>Biodiesel</b>	<i>A diesel fuel made from renewable materials such as plant oils including canola, soy and flax, or waste cooking oil, animal fats and cellulosic feedstock from agriculture and forest biomass.<sup>45</sup></i>

In Canada, fuel producers and importers are required by federal regulation to have minimum renewable fuel content levels of 5% for gasoline and 2% for diesel and heating oil. In addition, several provinces have introduced renewable fuel mandates for gasoline and diesel. For example, British Columbia has a Low Carbon Fuel Standard in place where fuel suppliers must progressively decrease the average carbon intensity of their fuels. As well, in the Pan-Canadian Framework on Clean Growth and Climate Change, federal, provincial, and territorial governments committed to working with industry and other stakeholders to develop a clean fuel standard for fuels used in transportation, industry and buildings.

Andrea Kent, President of Renewable Industries Canada, explained that:

Biofuels have continued to be proven one of the lowest cost, most effective pathways to taking GHGs out of the transportation sector. Looking at ethanol, it can reduce emissions by as much as 62 % on a life-cycle basis. That is from the very beginning of the process, so from well to wheel, to where it's burned in the tailpipe. Looking at biodiesel,

those GHG emissions, on a life-cycle basis, it can be as high as 99 % compared to petroleum diesel.<sup>46</sup>

She is also proposing an expansion, on an incremental basis, of the federal minimum requirement for renewable fuel content to 10% for gasoline and 5% for diesel. ***Should the federal government increase regulatory biofuel requirements to meet carbon reduction goals? Are biofuel mandates a high-cost way of reducing emissions? Should the government do more to support biofuel production and research in Canada?***

Ellen Burack of Transport Canada pointed out that Canada's substantial biomass capacity represents an opportunity for the country.<sup>47</sup> However, she underscored that technical and financial barriers facing the domestic biofuel supply mean that around half of the ethanol used in Canadian fuel is imported from the United States. The United States also provides generous production subsidies to support its biofuel industry. ***Should Canada match U.S. biofuel production support?***

## **Federal Role in Reducing Road Transportation Emissions**

Jurisdiction over road transportation is shared between the federal, provincial, territorial and municipal governments. The federal government primarily encourages emission reductions in road transportation through vehicle efficiency fuel standards, fuel regulations, research and development on vehicle technology and fuels, industry support programs and through consumer information and awareness initiatives. The federal government also supports transportation infrastructure and transport mode optimization - these are explored in subsequent chapters in the report.

Canada's automotive manufacturing sector is highly export-oriented and integrated with the United States where automotive parts and supplies move freely across the border in shared supply chains. In June 2016, at the North American Leaders' Summit in Ottawa, Canada, the United States and Mexico agreed to align vehicle fuel efficiency and/or GHG emission standards for light- and heavy-duty vehicles by 2025 and 2027 respectively.<sup>48</sup> However, since that time the political landscape has shifted in the United States and it is unclear what the new U.S. administration will do to existing vehicle fuel efficiency regulations. ***Should Canada deviate from U.S. vehicle fuel standards if our southern neighbours reduce their regulatory emission requirements? How will policy misalignment affect the competitiveness of the Canadian automotive industry? Will misalignment lead to regulatory uncertainty and increased administration costs? Will it lead to reductions in investments in the Canadian automotive sector? Can more stringent standards such as fuel-efficient tires or aerodynamic add-ons for heavy trucks be introduced without compromising the flow of cross-border road-transported goods?***

Recently, the federal government announced funding over two years to support charging and re-fuelling stations for alternative transportation. The government has committed \$46.1 million for the demonstration of next-generation charging stations for EVs and \$16.4 million to support expanded infrastructure using commercially available technologies, including electric, natural gas and hydrogen-charging stations along significant transportation corridors.<sup>49</sup> ***Are EVs and other alternatively-fuelled vehicles primarily an option for urban residents? Do vehicle range limitations and lack of public charging stations limit their application in rural communities?***

Three provinces, Quebec, Ontario and British Columbia, have taken early action in encouraging purchases of alternatively-fuelled vehicles, particularly EVs. They provide a suite of measures including financial rebates on the purchase or lease of qualifying EVs and incentives to encourage the installation of charging stations.<sup>50</sup> ***Should the federal government play a larger role in encouraging alternatively-fuelled vehicles? Is support for alternatively-fuelled vehicles a good use of public funds?***

Many witnesses supported greater federal involvement. For example, Chantal Guimont of Electric Mobility recommended a \$3,000 federal rebate for the purchase of EVs and an enhanced federal EV awareness program.<sup>51</sup> Eric Denhoff of the Canadian Hydrogen and Fuel Cell Association recommended preferential tax deductions.<sup>52</sup> On the other hand, Mr. Nantais of the Canadian Vehicle Manufacturers' Association pointed out that EVs cost more to manufacture and the associated CO<sub>2</sub> emission reductions have a marginal cost abatement of about \$300 per tonne, which is much higher than current provincial carbon taxes and higher than what is demanded from other sectors.<sup>53</sup>

In the Pan-Canadian Framework on Clean Growth and Climate Change, federal, provincial, and territorial governments committed to working with industry and other stakeholders to develop a Canada-wide strategy for zero-emission vehicles by 2018.<sup>54</sup> ***What should be the principles and major elements of the strategy? Should a Canada-wide strategy be flexible to accommodate different circumstances in each province and territory? What is the best way to encourage zero-emission vehicles in Canada? Should policies and programs be designed to avoid an uneven playing field between competing technologies or should it target efforts towards a specific goal such as EVs and electrification of the economy?***



***Over 180 municipalities, institutions and businesses partner with Hydro-Québec to install EV charging stations.***

Photo Credit: Hydro-Québec



# Aviation

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Canada's large and rugged land mass, and widely dispersed population makes air transportation an indispensable means of high-speed travel. It serves to link families and individuals to one another and to the world. Air transportation is important for the economy, tourism and trade, especially in the trade of high-value time-sensitive goods. In some remote regions of the country, it is the only means to connect to communities with goods, equipment and services.

## Aviation Emissions

In 2014, emissions attributed to domestic aviation – planes flying domestically with Canadian purchased fuel – were 1% of total emissions in Canada. Emissions from international flights are not apportioned to an individual country. To clarify, flights that take off in Canada and land elsewhere, or take off elsewhere and land in Canada are considered international flights. Global aviation is responsible for approximately 2% of the world's anthropogenic CO<sub>2</sub> emissions; international travel produces about 65% of those emissions.<sup>55</sup>

## Reducing Emissions

Canadian aviation emission reduction policies are influenced by resolutions established by the International Civil Aviation Organization (ICAO), a specialized agency of the United Nations representing 191 member states. It sets international civil aviation standards and practices, which are typically supported by domestic regulations. The ICAO is charged with finding pathways to reduce international aviation emissions.

In response to an ICAO resolution, the federal government released Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation in June 2012.<sup>56</sup> Developed in collaboration with the Canadian aviation industry, it builds on voluntary agreements and initiatives by the industry since 2005 to address aviation emissions. It aspires to improve fuel efficiency by an average annual rate of at least 2% per year until 2020 from a 2005 baseline. However, Teresa Ehman, Chair of the Environment Subcommittee of the National Airlines Council of Canada, told the committee that the industry has targeted a goal of 1.5% from 2005 levels as it is seen as more reasonable, and matches the target set by the International Air Transport Association which represents 290 commercial airlines around the world.<sup>57</sup>

### *Global Aviation Growth*

*Global aviation traffic is expected to be 2.6 times larger by 2030 and 5.7 times larger by 2050 than in 2010. Air traffic volumes will grow in every region of the globe but the largest increases are expected in intra-Asia/Pacific, domestic China/Mongolia and in Europe.*



## **International Aviation Emission Agreement**

In 2010, the ICAO agreed to annual fuel efficiency improvements of 2% and the goal of carbon-neutral growth in aviation from 2020 onward in addition to a handful of measures to help achieve this goal. Further details of these measures were established in October 2016 when the ICAO agreed to implement the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

The Scheme includes commitments to technological and operational improvements of aircraft and land-based operations and the adoption of alternative fuels. It also includes a carbon offsetting mechanism where airline companies have the option to invest in emission reduction projects in other sectors to offset aviation emissions to reach carbon-neutral growth. Teresa Ehman of the National Airlines Council of Canada explained that carbon offsets<sup>58</sup> are seen as necessary to achieve carbon neutral growth after 2020.

## **Improving Fuel Efficiency**

Reducing fuel consumption associated with air travel involves a wide range of operations, procedures and investment upgrades from carriers, agencies and institutions. Marc-André O'Rourke, Executive Director of the National Airlines Council of Canada, representing large passenger carriers, told the committee that the Canadian aviation industry has reduced emissions by an average of 13.2% between 2005 and 2015.<sup>59</sup>

## **Fuel Efficiency of Aircraft**

Each new generation of aircraft improves upon the previous design, making today's aircraft 80% more energy efficient than those flown in the 1960s. Sylvain Cofsky, Executive Director of the Green Aviation Research and Development Network (GARDN), explained that fleet renewal provides significant fuel savings since emissions can be reduced by up to 20% by replacing old airplanes. He also pointed out that the aviation industry has been successful at decoupling emissions from Canadian aviation traffic growth. He said, "Traffic growth is increasing at an average of 5% per year, while CO<sub>2</sub> emissions are growing at around 3 % per year."<sup>60</sup>

Fassi Kafyeke, Senior Director of Strategic Technology and Advanced Product Development of Bombardier Aerospace, member of GARDN, told the committee that there are three areas manufacturers focus on to improve efficiency:

- Reduction in aircraft weight;
- Improvements to the aerodynamics/configuration of the tube and wing design; and
- Replacing hydraulic and pneumatic systems with electric systems.<sup>61</sup>

In February 2016, a new carbon dioxide standard for new airplanes was agreed upon at the ICAO. Transport Canada officials indicated this standard will be incorporated into

Canadian domestic regulations so that all new aircraft will need to meet that efficiency standard going forward.<sup>62</sup>

### **Flight Operations and Land-Based Activities**

Marc-André O'Rourke explained that the industry is working to optimize the efficiency of air traffic control systems, resulting in significant fuel consumption savings.<sup>63</sup> For example, reducing flight time by one minute decreases emissions by close to 100 kg (0.1 tonne) of carbon dioxide per flight.

There are 26 airports that make up Canada's National Airport System. In addition, there are over 120 regional, local, remote and satellite airports. Mr. O'Rourke pointed out that airlines and airports are working together on reducing emissions by improving taxi and hold procedures.

Ellen Burack of Transport Canada explained that five major airports in Canada have achieved certification under the Airport Carbon Accreditation (ACA) program. This is an international program that recognizes airport efforts to manage and reduce carbon dioxide emissions through independent assessment and verification.<sup>64</sup> *Should the federal government encourage Canadian airports to pursue certification under the ACA program?*



*The Canadian aviation industry has reduced emissions by an average of 13.2% between 2005 and 2015.*

Photo Credit: iStock

### **Future Aircraft**

Nearly all commercial aircraft are powered by petroleum fuels. However, there is a push to explore alternatively-powered planes to dramatically reduce or eliminate emissions. Fassi Kafyeke told the committee that electric aircraft are currently very small and are powered by batteries or photovoltaic solar panels. However, the weight and duration of power are obstacles.<sup>65</sup> He believed electric hybrid planes will likely be utilized before full electric airplanes. GARDN is exploring hybrid airships to affordably deliver heavy cargo and personnel to remote and isolated locations in Canada.

### **Biojet fuel**

Biojet fuel is made by refining organic materials, such as oilseed, municipal waste, used cooking oil, or forestry and agriculture residue. Biojet fuel is currently being used on a small scale around the world. Several witnesses explained that its wide commercial adoption could be a game-changer for the industry as there are few options to

substantially reduce aviation emissions. Marc-André O'Rourke of the National Airlines Council of Canada told the committee that biojet fuel could reduce emissions by up to 80% over traditional fuels.<sup>66</sup> However, it is not considered a near or mid-term solution. Its potential is generally seen within the 2030-35 timeframe.<sup>67</sup>

Teresa Ehman told the committee that the Canadian aviation industry is setting up a Canadian biofuel supply chain initiative at the Montreal-Trudeau airport.<sup>68</sup> The goal is to identify and solve logistical barriers associated with introducing biojet to an airport's shared fuel system. Also, the initiative will help with developing its standards and the tracking of the life-cycle environmental footprint of biofuels. Sylvain Cofsky argued that Canada should increase biofuel production incentives and research to be on par with those provided by the United States.<sup>69</sup> *Should Canada increase its support for biojet fuels?*

## **Federal Role in Reducing Aviation Emissions**

The federal government has jurisdiction over aeronautics in Canada including airlines, airports and air navigation services. Air transportation emissions are growing both domestically and around the world while at the same time there are few substitutes for aviation's high-speed long-distance service. *Can Canada curb aviation emissions without reducing flight options and maintain affordable air travel?*

Representatives of Canada's airline carriers did not support a carbon tax applied to their industry. It was felt that the carriers are already paying too many fees including security and airport improvement fees and were wary of any additional costs. However, Sylvain Cofsky of the Green Aviation Research and Development Network argued that if there is a tax then a portion of the revenue raised should be reinvested into green aviation operations.<sup>71</sup> *Should aviation fuel be exempt from carbon taxes? If a carbon tax is applied, what should be done with the revenue raised from carbon taxes applied to the aviation sector?*

*Marc-André O'Rourke of the National Airlines Council of Canada calculated that a \$30 carbon tax would translate to ticket prices increasing by an average of approximately \$25.<sup>70</sup>*

*Should further energy efficiency stringency be imposed on the aviation industry beyond the existing voluntary agreement? Should Canada impose more stringent emission targets than those being developed through international agreements? Should Canada support a carbon-offsetting program for domestic aviation?*

Deep emission reductions in the long term require either game-changing technology that is currently in early development stages or a switch to biojet fuel. *How should Canada focus its R&D funding for long-term aviation emission reductions?*

# Locomotion

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Canada has the fifth largest rail network in the world and ranks fourth in the world in volume of goods transported by rail. Every year, Canadian railways move nearly 70% of intercity surface goods (including 40% of Canada's exports) and carry 75 million people.<sup>72</sup>

Canada's two national railways, CN and CP (Class 1 freight), operate roughly three-quarters of Canada's rail network and own 75% of the track. They are the dominant freight rail operators and link important trade corridors with the U.S. and across Canada. Much of the remaining track is operated by 37 short line railways, which feed and deliver cargo to and from mainline railways. Railways specialize in moving heavy, bulk commodities and containerized freight over long distances.<sup>73</sup>

VIA Rail is a federal Crown corporation that provides intercity passenger rail service to over 400 communities across Canada. VIA Rail cars operate on rail lines that are mainly owned by CN and CP.

## Locomotion Emissions

Most locomotives in Canada are diesel-electric. While there are some current pilot projects using LNG-powered engines, and electrification is occurring in some urban passenger rail services, the majority of freight locomotives are diesel-electric, which are the source of nearly all railway GHGs.<sup>74</sup> In 2014, emissions attributed to rail service in Canada were 7.32 Mt CO<sub>2</sub> eq, or 1% of total Canadian emissions.

## Reducing Emissions

Rail systems in Canada and the United States are coordinated to the same standards to allow efficient cross-border movement of rail cars. As Ellen Burack of Transport Canada explained, "Canada has no locomotive manufacturers. Virtually all of our stock is purchased south of the border."<sup>75</sup> Therefore, Transport Canada and the U.S.



*Every year, Canadian railways move nearly 70% of intercity surface goods and carry 75 million people.* Photo Credit: iStock

Environmental Protection Agency (EPA) work together under the U.S.–Canada Regulatory Cooperation Council to promote policy and regulatory alignment, information sharing, and research and technological collaboration. The Council is working to finalize

a Canada–U.S. Voluntary Action Plan to Reduce Greenhouse Gas Emissions from Locomotives.<sup>76</sup>

In a separate but related initiative, Transport Canada and Environment and Climate Change Canada partnered with the Railway Association of Canada through a Memorandum of Understanding (MOU) to reduce emissions. Under the agreement, which initially covered the 2011 to 2015 time frame, the rail industry committed to voluntary reductions in GHG emissions on an intensity basis of 6% by 2015 from 2010 levels for Class 1 freight (CN and CP), short line freight and intercity passenger rail, and 3% from 2010 levels for short line carriers. This MOU was extended to the end of 2016, and industry is working with the federal government to establish new emission targets for years beyond 2016.<sup>77</sup>

### **Improving Efficiency**

Technology plays a critical role in reducing railway emissions. For example, Michael Bourque, President and Chief Executive Officer of the Railway Association of Canada, cited the use of new locomotives with emerging technologies like stop-start devices, anti-idling devices and throttle control systems.<sup>78</sup> He also cited the use of distributed power where fuel savings are achieved by placing locomotive engines in the front, middle and end of long trains. Mr. Bourque emphasized the importance of infrastructure and track maintenance in improving efficiency.

With fuel being the second largest railway expense after labour, the efficient movement of trains on yards and the main line is very important. Heat switchers, rail lubrication and welded rail are just a few examples that make sure trains run smoothly and with less friction.<sup>79</sup>

Yves Desjardins-Siciliano, President and Chief Executive Officer of VIA Rail Canada, explained that significant diesel savings came from improved efficiency following the rebuilding of VIA's locomotive engine fleet. He also underscored the importance of improving train operations by focusing on training and automated communications processes to help locomotive engineers drive more efficiently.<sup>80</sup>

### **Intermodal Switching**

The Railway Association of Canada estimates that if 15% of truck traffic were transferred to rail, Canada would reduce its emissions by 5.6 Mt CO<sub>2</sub> eq.<sup>81</sup> In addition, there would be savings from reduced traffic congestion and wear and tear on the country's roads and highway systems, which are paid by public funds.

Mr. Bourque believed the public sector can play a crucial role in promoting the shift to rail by ensuring that carbon pricing revenues are recycled back into rail infrastructure. He pointed to the Province of Quebec as an example where revenues from its cap-and-trade program are reinvested into programs that allow rail customers to offset the costs



associated with building rail access. Mr. Bourque argued that the federal government could support modal shifts to rail:

We're asking for an investment of \$165 million over five years to support new rail and intermodal infrastructure projects across Canada. We propose that this program be based on the Quebec program and be made available in as many provinces as possible.<sup>82</sup>

Mr. Bourque recommended that the federal government support short line railways in improving locomotive fuel-efficiency and in adopting low-emitting technologies. He argued that these railways have less revenue to invest in capital improvements than larger railways while they often compete directly with trucks, which ride on publicly-funded roads.

Ellen Burack of Transport Canada agreed that switching modes such as from truck to rail can result in emission reductions and efficiency gains and it is something the department is analyzing. However, there are costs associated with intermodal traffic because of the time it takes to transfer freight from rail

to trucks.<sup>83</sup> For some shippers, this delay is not acceptable, so they stay with trucks for the entire route. Ways to reduce the time involved in switching modes are being examined; however, it is recognized that trucks are efficient in providing on-time and point-to-point delivery, moving cargo directly to its destination.



*The Railway Association of Canada estimates that if 15% of truck traffic were transferred to rail, Canada would reduce its emissions by 5.6 Mt CO<sub>2</sub> eq.* Photo Credit: iStock

### **VIA Rail High Frequency Corridor (Quebec and Windsor)**

VIA Rail is proposing to upgrade its existing route along the Windsor–Quebec City corridor to a high-frequency rail (HFR) service. The project is estimated to be \$5.2 billion, which, according to Mr. Desjardins-Siciliano, would require a minimum federal government investment of \$1.2 billion - the rest of the funds would come from private or public investors.<sup>84</sup> The 2016 federal budget committed \$3.3 million to support an in-depth assessment of this proposal.<sup>85</sup>

The HFR service would run on tracks exclusive to VIA's operation so it would not have to yield to freight service and the HFR would be powered primarily by electricity. However, the locomotive engines would be diesel-electric hybrids to allow travel along small segments of non-electric tracks owned by freight companies. Electricity is a less

expensive fuel than diesel but the added costs associated with electricity infrastructure maintenance results in the same overall costs. However, the electricity would be sourced from Hydro-Québec, which is predominantly clean hydroelectricity and, as a result, VIA's own carbon emissions along the corridor would be reduced by 98%.<sup>86</sup>

Mr. Desjardins-Siciliano framed the HFR project as an important contributor to Canada's efforts to transition to a lower-carbon economy. He pointed out that the new rail service would entice travellers to take the train rather than a car. There are as many as sixty million trips taken yearly between Quebec City, Montreal, Ottawa and Toronto. In 82% of those trips, Canadians choose to drive. He forecast that tripling the current train ridership in this corridor "could be equivalent to reducing the Canadian car pool by as much as 2.8 million cars," – a figure just over 10% of the entire passenger car fleet in Canada.<sup>87</sup>

Yves Desjardins-Siciliano pointed out:

High frequency rail...offers tremendous flexibility that will incite more people to opt for the train instead of the car, as you will have a train service available every 45 to 60 minutes, on the hour, from 6 in the morning to 12 at night. It offers the opportunity to eliminate our need for public funds to finance ongoing operating deficits, which has been historical at VIA and reached \$320 million last year.<sup>88</sup>

The potential to improve profitability, in turn, raises the possibility of improving and expanding passenger rail service in other VIA regions, such as Atlantic Canada.

### **Alternative Fuels**

There are a number of fuels that can be used as an alternative to diesel for locomotion. Witnesses highlighted electricity, particularly for the passenger railway services. In the freight sector, biofuels and liquefied natural gas (LNG) are being explored but their pace of adoption is slow.

Several obstacles prevent the industry from introducing alternative locomotive fuels, such as increased costs, investment in new infrastructure and the risk new fuels pose to existing engines. Ellen Burack of Transport Canada explained that engine manufacturers do not guarantee the smooth functioning of diesel locomotives if biofuels levels are increased. Companies do not wish to risk multimillion dollar equipment without a guarantee it will operate efficiently, so asking companies to increase the use of biofuels is challenging.<sup>89</sup>

Nonetheless, it was believed that biofuel is a likely solution to long-term decarbonisation of the rail industry but more work needs to be done to find the right blends, to grow the supply and to ensure equipment can operate effectively and safely.

Michael Bourque of the Railway Association of Canada told the committee that pilot projects for LNG locomotives are underway in North America. For example, in 2012 and

2013, CN piloted LNG-powered locomotives to move freight between Edmonton and Fort McMurray, Alberta. However, he believed the business case for the technology had not quite been reached.<sup>90</sup> Bruce Winchester, Executive Director of the Canadian Natural Gas Vehicle Alliance, recognized that upfront capital investment was an industry challenge in switching to LNG for rail and other transportation modes. He advocated for \$1 billion in strategic investment to support natural gas use in the entire transportation sector.<sup>91</sup>

## **Federal Role in Reducing Locomotion Emissions**

The federal government has jurisdiction over all railways in Canada except those that are exclusively intra-provincial. Transport Canada works with the U.S. Environmental Protection Agency and Railway Association of Canada through voluntary agreements to reduce emissions. The federal government is limited in its use of regulatory influence to drive locomotives manufacturers to build emission-reducing engines since there are no locomotive manufacturers in Canada and the Canadian market is small. ***Accordingly, what are the best policy tools to reduce emissions in the railway sector? How stringent should the next agreement with the Railway Association of Canada be in reducing emissions? How should Canada adapt if the United States reduces the stringency of its requirements to reduce railway emissions?***

Improving rail service between the Quebec-Windsor corridor has been discussed in Canada for many years. ***Is VIA Rail's high frequency rail proposal a more viable option today because of the need to address climate change?***

Trucks and locomotives both haul freight but trucks mostly drive on publicly funded and maintained roads while railways use private tracks. ***Since railways emit fewer GHGs per distance and weight of freight transported, should the federal government provide incentives to level the playing field between trucks and locomotives? Should the federal government target assistance to short line railways? Should the federal government encourage railways to switch from diesel electric engines to less-emitting propulsive systems and/or biofuels?***



# Marine

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Marine transport is Canada's link to international markets, providing low cost shipping of bulk and containerized cargo worldwide. Marine transport is considered the lifeblood of global trade, moving 80% of all goods traded internationally.<sup>92</sup> It moves goods domestically along the coasts, through the Great Lakes region and St. Lawrence River, and to Canadian territories for resupply and resource development. In Canada, marine vessels move passengers through coastal ferry services and cruise ships.

## Marine Emissions

Marine engines are powered by either marine diesel or marine heavy fuel oil. Domestic marine transportation accounted for 1% of total emissions in Canada. These are ships that leave a Canadian port and arrive at a Canadian port. Emissions from all other vessels are considered international emissions.

In 2012, international shipping was estimated to have contributed about 2.2% to the global emissions of carbon dioxide. Similar to aviation, the international portion of marine emissions is not attributed to a single country and shipping was not included in the final text of the Paris Agreement.

## Reducing Emissions

Transport Canada, unlike the aviation or locomotive industries, has not developed voluntary agreements to reduce emissions from domestic marine sector. However, the industry has developed a voluntary environmental certification program for the North American marine industry, which includes ship-owners, ports, terminals, Seaway corporations and shipyards. This initiative is called Green Marine and it began in Canada. The committee was told that Transport Canada supports the program, which challenges participant companies to improve their environmental performance, including GHG emissions.

Ellen Burack of Transport Canada explained that being green makes good business sense:

Fuel represents a large cost to transportation operators, even when fuel prices are lower, and this is continuously driving improvements in efficiency. For example, many international marine shipping companies have adopted voluntarily the practice of slow steaming, which is much more fuel-efficient than operating at full speed.<sup>93</sup>

## International Standards

Global actions to address maritime GHG emissions are developed through the International Maritime Organization (IMO), a specialized agency of the United Nations. The IMO develops standards and recommended practices related to marine shipping.

The IMO agreed to two mandatory mechanisms intended to increase energy efficiency. First, new ships are subject to minimum energy efficiency standards under the Energy

### *Global Shipping*

*There are two broad categories of marine vessels: Canadian registered vessels and foreign-based carriers. Canadian registered vessels move goods nearly exclusively for domestic trade. However, these vessels also undertake trans-border trade with the U.S. In Canada, nearly all overseas movements are performed by foreign-based carriers. Ownership of foreign-based shipping fleets can be complex: a shipping company may be incorporated in Greece and registered in Panama (fly a Panamanian flag) while moving goods from Canada to China.*

Efficiency Design Index (EEDI). Second, all ships are required to implement a Ship Energy Efficiency Management Plan (SEEMP), a performance-based mechanism to improve energy efficiency. These requirements apply to all ships over 400 gross tonnage.<sup>94</sup> EEDI and SEEMP are expected to yield GHG reductions of 13% and 39% from international maritime shipping by 2020 and 2050, respectively, compared to a business as usual case.

IMO members have agreed to require ships to record and report their fuel oil consumption and other related data. This is the first step in mitigating emissions from existing ships. The second step is to analyze the data, and the third is to undertake action to reduce emissions. Debbie Murray, Director of Policy and Regulatory Affairs of the Association of

Canadian Port Authorities, explained that there is pressure to develop market-based measures, carbon pricing or some other form of decarbonization mechanism.<sup>95</sup>

### **Port Initiatives**

There are 18 major Canadian ports that have legal designation under the *Canada Marine Act* as Canada Port Authorities (CPA). They make up Canada's National Ports System and are designated as being critical to domestic and international trade.

Wendy Zatylny, President of the Association of Canadian Port Authorities, said that Port Authorities are reducing emissions through a wide range of initiatives such as the use of electric vehicles, provision of shore power to docked vessels, solar panels to power port operations, high efficiency light bulbs and conducting energy audits to identify efficiencies and areas for further improvement.<sup>96</sup> Ports are also investigating the use of alternative technologies, such as electrified rubber tire gantry cranes to reduce emissions. She pointed out that the Port Authorities are actively collecting emissions data to better assess the impact of various initiatives.

### *Canadian Ports*

*Major Canadian marine ports are hubs that include cargo and passenger terminals, shipyards, storage facilities, tugboats services and industrial operations. Ports manage facilities and infrastructure that support key transportation corridors connecting shipping to other modes such as trucking and rail services.*

Ellen Burack of Transport Canada said that the department is supporting initiatives that reduce port-related trucking, thereby reducing idling and the associated emissions.<sup>97</sup> Also, Transport Canada provides cost-shared funding for the deployment of marine shore



*Ship in the Port of Vancouver.* Photo Credit: Senate of Canada

power technology at Canadian ports. The program enables ships to plug into the local electrical grid to minimize the use of auxiliary diesel engines while in port. Currently, there are only four ports that have joined the program; they are located in Vancouver, Prince Rupert, Halifax and Quebec City. When asked why more ports have not participated, Wendy

Zatylny explained there are several challenges. For example, the technology is expensive to implement, and the local power supplier has to provide the power at a preferential rate.

In addition, the program favoured cruise ships because those vessels tend to have standardized electrical systems on board that make it easier to plug into the local grids when in ports. She noted this is not the case with all ships:

There is tremendous variability in freight, particularly in bulk, so there's no capability right now, no standardization within the industry that would enable a port to choose a particular plug-in configuration that the greatest number of cargo ships could plug into.<sup>98</sup>

### **Optimizing the Movements of Goods**

Canada's abundant waterways provide an opportunity to optimize the country's marine transportation to reduce emissions. Wendy Zatylny of the Canadian Port Authorities pointed out that a typical Canadian bulk carrier vessel is 700% more fuel-efficient per cargo tonne than a truck and about 74% more efficient than railcars. She explained that opportunities exist to shift from road or rail transport to moving goods by marine vessels through the Great Lakes and St. Lawrence Seaway.<sup>99</sup>

### **Alternative Fuels**

Most marine vessels are propelled by diesel engines that are similar in principle to those found in automobiles. The marine fuel that is most frequently used is heavy fuel oil, which is high in sulfur and generally inexpensive.

Efforts to reduce pollutants, such as nitrogen oxides and sulfur oxides (SO<sub>x</sub>) from ships has led the IMO to designate Emission Control Areas (ECA) and sulphur reduction

targets. The North American ECA includes U.S. and Canadian coastal regions and there is a requirement to adopt lower sulfur fuels or add SO<sub>x</sub> exhaust scrubbers and other technologies to ships.<sup>100</sup> The impact of these new regulations has supported energy efficiency and brought alternative fuels to the forefront as a means for realizing compliance.

The range of alternative fuels includes biodiesel, LNG, ultra-low sulphur diesel (ULSD), and hydrogenation-derived renewable diesel (HDRD). A recurring problem with any new fuel is the lack of bunkering terminals for refuelling and the increase in conversion costs, fuel costs and uncertainty compared to existing heavy fuel oil. *How should the federal government encourage fuel switching in the marine sector?*

### **Federal Role in Reducing Marine Emissions**

The federal government has jurisdiction over nearly all aspects of marine transportation including shipping lines, ferries and ports. The global nature of marine shipping requires international cooperation to reduce emissions. The International Maritime Organization (IMO) does not appear to be as advanced as its counterpart the International Civil Aviation Organization (ICAO) in developing a plan for medium to long-term emission reductions.

The federal government has not developed a voluntary agreement with the Canadian domestic marine sector to reduce emissions. *Should a voluntary marine emission reduction agreement be considered for the sector?*

Canada's Great Lakes and St. Lawrence Seaway provide unique opportunities to ship cargo in Canada. *Can more be done to optimize freight transport in Canada by switching from truck or rail transport to marine shipping? Should the federal government provide incentives to encourage switching to marine shipping?*

The federal government has a number of initiatives that help reduce emissions from Canadian port operations. *How can the federal government build upon the work already done to reduce emissions in Canadian ports?*

# Urban Transportation

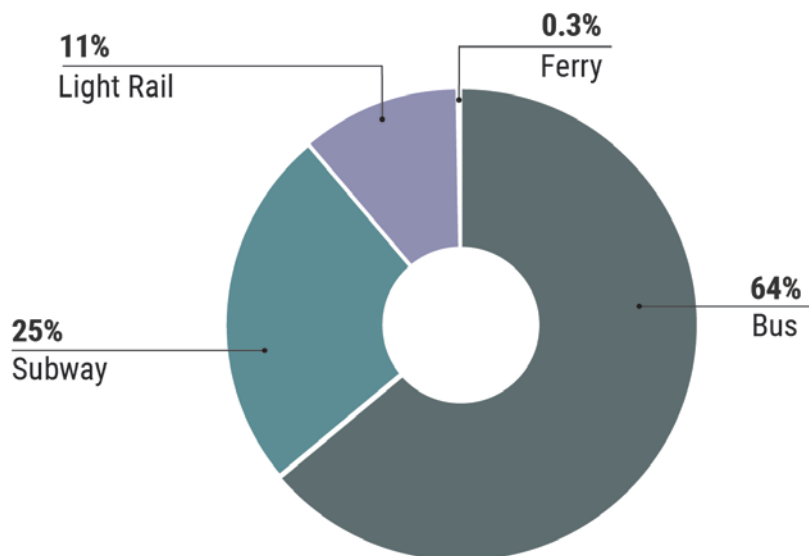
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Canada is a highly urbanized society with roughly 82% of its population living in or near cities.<sup>101</sup> Almost every city and most towns in Canada have some form of public transportation system. Generally, these systems are designed to help mitigate traffic congestion, provide affordable means of transportation and offer services for people with limited mobility. The most common form of public transportation in Canada is the bus. However, some cities also have streetcars, light-rail trains or subways. In most cases, they are designed for passengers to transfer from one mode of transportation to another within the system.

## Commuting Statistics

According to Statistics Canada, roughly 15.4 million Canadians commuted to work while 1.1 million worked at home in 2011. Of those who commuted, 13.5 million went to a usual place of work and another 1.9 million travelled to a location that varied from day to day. Approximately four out of five commuters used private vehicles to get to work. Those who used public transit for the longest part of the trip to work represented 1.8 million (12%) commuters.<sup>102</sup>

**Figure 9 – Breakdown of Use of Public Transit for Commuters, 2011**



Source: Statistics Canada

## **Reducing Emissions**

Municipalities control or influence nearly 50% of Canada's GHG emissions through direct measures such as providing municipal services, operating municipal buildings, fleets and facilities, and indirectly through land use planning, zoning and development, building codes and public transit access.<sup>103</sup> The federal government, in partnership with municipalities and the provincial and territorial governments, has taken a larger role in providing direct infrastructure funding – particularly over the last two decades with respect to public infrastructure programs.

Alex Maheu, Director of Public Affairs of the Canadian Urban Transit Association (CUTA), told the committee that approximately 25% of the need in public transit relates to rehabilitating existing infrastructure such as replacing older vehicles or renovating stations. The other 75% is related to the expanding need for public transit.<sup>104</sup>

## **Public Transit and Urban Design**

Alex Maheu argued that public transit systems could help reduce GHG emissions and traffic congestion by reducing the use of private cars. However, if commuters are to switch from private cars to public transit, it must be seen as an attractive alternative. He said:

The environmental case for investing in public transit is well established. The hard part is actually getting people to change their travel behaviour. The transit industry harbours no illusions that a critical mass of people will suddenly switch from their private cars to transit based solely on the environmental merits of daily transit use. Instead, the key to creating a modal shift in our society will involve... making transit easier, faster and cheaper than taking a car for one's daily commute.<sup>105</sup>

Public transit reduces the most GHGs during peak traffic times. Some witnesses questioned its effectiveness to achieve the same results during off-peak hours. Louis Thériault of the Conference Board of Canada argued that overall, buses are not being optimized in Canadian cities.<sup>106</sup> If a bus lacks riders, then in some cases, taking the bus is more carbon-intensive than taking a car. He emphasized that it is not just the purchase of new technology that is required but a change in behaviour. He believed that carbon pricing could play a role in changing consumer behaviour.

Clark Somerville, President of the Federation of Canadian Municipalities, pointed out that urban planning, zoning and design play an important role in supporting public transit. He emphasized the need to plan for urban growth around transit centres.<sup>107</sup>

## Greening Transit

Transit systems are adopting green procurement and replacement policies, and are looking to build energy-efficient and climate-resilient fixed infrastructure. Alex Maheu explained that the transit industry is seeking to take a leadership role in greening the transportation sector by commercializing and using such alternative propulsion technologies as natural gas, electricity or fuel cells in transit vehicles.<sup>108</sup> He added that hybrid technologies used in buses and trains reduce emissions and often provide more comfortable, quieter rides for passengers.

However, he noted that the high costs of purchasing alternative propulsion systems and supporting infrastructure creates a financial barrier for transit systems that are already struggling financially to provide their current level of service to Canadians. He said:

There is a high incremental cost of purchasing. For example, a diesel bus in Canada is around \$500,000 to procure. If you want to buy an electric bus, it will be around \$1 million. A hybrid would be \$750,000. You can see there is a high incremental cost there, and municipalities have tight operating budgets, and when it comes time to procure vehicles, they have to make these decisions. How far do you want your dollar to stretch? Do you want to buy two buses or one? These are factors they have to take into consideration.<sup>109</sup>

Mr. Maheu told the committee that CUTA worked with its members to create the Canadian Urban Transit Research and Innovation Consortium (CUTRIC) to pursue



industry-academic collaborations in the development of next generation technologies for Canadian transit and transportation systems. The committee was told that the long-term focus of CUTRIC appears to lean towards battery electric vehicles because of the zero tailpipe emissions.

*Public transit reduces the most GHGs during peak traffic times.*

Photo Credit: iStock

## Ride Sharing and Autonomous Vehicles

Fully automated vehicles (AVs) could potentially transform the future of public transit systems. Barrie Kirk, Executive Director of the Canadian Automated Vehicles Centre of Excellence, told the committee that there is a trend towards on-demand, flexible routing and point-to-point transportation provided by driverless vehicles such as taxis.<sup>110</sup> These

AVs may merge with existing ride-sharing services to provide more personal, customized and convenient transit solutions than mass public transit.

Barrie Kirk argued that any request for federal funding for new infrastructure, transit or transportation should include an assessment of the impact of autonomous and connected vehicles. He explained:

The trend towards shared use of autonomous vehicles means driverless taxis. There will be a trend away from personal car ownership to shared electric, autonomous taxis. This is going to permit cities to harness the power of this technology to completely redefine how we plan cities.<sup>111</sup>

Ellen Burack of Transport Canada told the committee that the department is actively working with provinces, territories, the U.S. Department of Transportation and others to prepare Canada for the deployment of these technologies.<sup>112</sup>

### **Federal Role in Reducing Urban Transport Emissions**

The federal government has been active in providing funding for public transportation systems. It provides support from the Federal Gas Tax Fund and the Green Municipal Fund. In the 2016 Budget, the federal government announced \$3.4 billion over three years to upgrade and improve public transit systems across Canada through a new Public Transit Infrastructure Fund. The fund will cover up to 50% of eligible costs for projects such as the purchase of new buses and streetcars, repairing subway tracks and bridges, fixing signals and switches as well as accelerating design and implementation work for future large-scale projects.

*Should the federal government do more to support public transportation? Are investments in public transit systems a good use of public funds to address emission reduction? Should the federal government provide additional support to encourage green transit investment? Should all new funding for public transit include an assessment of the impact of autonomous drive share vehicles?*



## Balancing goals – impact on households and businesses

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Transportation accounts for 23% of all emissions in Canada, with road transportation vehicles responsible for 80% of those emissions. This sector offers the possibility of significant reductions in Canada's transition to a lower-carbon economy, but the committee is mindful of the costs these reductions will have on consumers and businesses.

Improvements in the fuel efficiency of passenger vehicles and freight trucks, as well as investments in public transit to increase ridership are the most sensible means to quickly drive down emissions. Fewer, efficient vehicles emit less. That said, this will come at a cost. For example, Environment and Climate Change Canada (ECCC) estimates that current fuel efficiency standards for passenger vehicles for the model years 2021-2025 will increase the purchase price by \$733 for the model year 2021, rising an additional \$1,829 for a 2025 model year vehicle. However, ECCC anticipates the increased fuel efficiency will more than offset the additional purchase price.<sup>113</sup>

Similarly, improvements in the fuel efficiency of heavy-duty freight tractors and trailers for model years 2018 to 2029 will increase the cost of a new tractor by \$11,322 and new trailers by \$1,237 by model year 2027.<sup>114</sup> Again, the additional cost is expected to be offset by gains in increased fuel efficiency.

As Canada continues to move forward with developing its regulations for heavy-duty freight vehicles and trailers, the United States is reviewing the appropriateness of fuel-efficiency standards for cars and light-duty trucks for the model years 2022-2025. What effect, if any, this may have on Canadian consumers remains to be seen.

In addition to the increased cost to purchase light and heavy-duty vehicles, they are or will be subject to carbon prices levied on the fossil fuels they use. These costs are expected to be passed on to consumers. As carbon pricing systems are designed and implemented in provinces and territories across Canada, their economic impact will depend on decisions each jurisdiction makes. Provinces and territories could opt for a carbon tax or a cap-and-trade system, and will also decide what they choose to do with the revenues. The economic impacts will vary depending on whether they choose to recycle revenues to lower income taxes, provide transfer payments to provincial and territorial residents, or invest in new technologies or encourage innovation.

Enhancement and electrification of public transit will require significant funding and may necessitate further investments in electricity infrastructure. These expenditures will also require some behavioural changes on the part of commuters, and unless taking transit is

easier, faster and cheaper than taking a car for one's daily commute, investments will not result in the desired emission reductions.

While electric vehicles (EVs) show promise in reducing emissions in the longer term, currently they represent a very small market share. Quebec has made significant investments in EV infrastructure to help grow the market, and British Columbia, Ontario and Quebec offer subsidies to increase the number of EVs on the road. Whether public funds should be used to subsidize private vehicle choice is a matter of some debate.

Decarbonizing some modes of transportation will be more challenging. Canada is part of international regimes that set standards and practices for aviation, rail and marine transportation, and is therefore limited in autonomous actions it can take. That said, there are opportunities to be found.

For example, the electrification of rail transport, and particularly passenger rail, can contribute to Canada's emissions reduction goals, but this must be done in a way that is both cost-effective and efficient. Similarly, regulatory measures that increase the use of biofuels in rail transport may lower GHGs, but equipment owners are leery of risking their expensive assets without a guarantee that higher biofuel contents will not damage their engines. The committee also heard that right now there are few options to replace jet fuel for air travel, and that carbon pricing will add to the cost of an airline ticket.<sup>115</sup> While emission reductions must be made, the committee cautions that these must be achieved in a way that is affordable.

# Moving Forward

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Transportation is a cross-cutting sector that touches all of our lives. For many Canadians, transportation is one of the largest contributors to their personal carbon footprint, and the choice of what, where, and when to ride is a key determinant of their lifetime GHG emissions. A number of innovative technology solutions are here or just over the horizon that will allow Canadians to cut their transportation-related GHG emissions significantly, but there are many areas where inertia may be keeping us from achieving that objective.

This report highlights opportunities to reduce transportation-related GHG emissions through new technologies, regulatory measures, international standards, alternative fuels, targeted climate policies, and investment into intermodal transportation corridors and public transit systems. Early signs point to the willingness of Canadians to purchase alternative vehicles, but the fleet of light- and heavy-duty vehicles in Canada can only turn over so quickly. *Will widespread alternative vehicle adoption come soon enough for Canada to reduce road transport GHG emissions in line with its targets? What role can biofuels play in lowering the GHG emissions of ICEs, particularly as federal-provincial-territorial efforts to develop a national low carbon fuel standard ramp up?*

We note that regulation has been driving fleet GHG emission averages to fall in North America in recent years, providing a map to a lower-emissions future, but *what happens if the U.S. – with whom our emissions standards are aligned – strikes a new path? Will Canada develop its own regulatory approach independent of the U.S.?*

Lower-carbon transportation solutions will help drive the transition to a lower-carbon economy. In decarbonizing the transportation system, a number of policy considerations must be balanced. *What measures will effectively and efficiently reduce the most emissions, and will these be affordable and fair to Canadians? What are the best ways to move people out of private vehicles and on to public transit, where feasible? Electrifying transportation modes where it makes sense to do so can leverage Canada's clean electricity systems, but this may require further investments in electricity infrastructure, and at what cost?* There are no one-size-fits-all solutions and we must balance competing values and interests on the road to lower transportation GHG emissions. We must not lose sight of the reason why we take action on climate change – to preserve and protect our ecosystems for future generations – while not forgetting that taking action requires us all to shoulder burdens, which are our responsibility to bear.

# Appendix A – List of Witnesses

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## March 22, 2016

- *Environment and Climate Change Canada:*
  - Dan McDougall, Assistant Deputy Minister, Strategic Policy Branch;
  - Derek Hermanutz, Director General, Economic Analysis Directorate, Strategic Policy Branch;
  - Mike Beale, Assistant Deputy Minister, Environmental Stewardship Branch.

## April 12, 2016

- *National Energy Board:*
  - Jim Fox, Vice President, Integrated Energy Information and Analysis;
  - Shelley Milutinovic, Chief Economist.

## April 14, 2016

- *Natural Resources Canada:*
  - Jeff Labonté, Director General, Energy Safety and Security;
  - Niall O'Dea, Director General, Electricity Resources Branch;
  - Marc Wickham, Director, Science and Technology Programs, Innovation and Energy Technology Sector, Office of Energy Research and Development;
  - Drew Leyburne, Director General, Energy Policy Branch;
  - Patricia Fuller, Director General, Office of Energy Efficiency;
  - Paula Vieira, Director, Transportation and Alternative Fuels Division;
  - Laura Oleson, Director, Demand Policy and Analysis, Office of Energy Efficiency, Energy Sector;
  - Debbie Scharf, Director, Equipment Division.

## April 19, 2016

- *Canadian Council on Renewable Electricity:*
  - Jacob Irving, President, Canadian Hydropower Association.

## April 21, 2016

- *Canadian Nuclear Association:*
  - John Barrett, President and Chief Executive Officer.

## May 3, 2017

- *Ecologic Institute US:*
  - Max Gruenig, President.
- *TransAlta Corporation:*
  - Don Wharton, Managing Director for Carbon Transition.

### **May 5, 2016**

- *Canadian Electricity Association:*
  - Sergio Marchi, President and CEO;
  - Devin McCarthy, Director, Generation and Environment.
- *Capital Power:*
  - Martin Kennedy, Vice President, External Affairs.
- *Nova Scotia Power Inc.:*
  - Terry Toner, Director, Environmental Services.
- *Canadian Biogas Association:*
  - Jennifer Green, Executive Director;
  - Kevin Matthews, Director;
  - Donald Beverly, Director.

### **May 10, 2017**

- *As an individual:*
  - Andrew Leach, Associate Professor, Alberta School of Business, University of Alberta;
  - Mike Cleland, Senior Fellow, University of Ottawa.
- *HEC Montréal:*
  - Pierre-Olivier Pineau, Professor, Chair in Energy Sector Management.

### **May 12, 2016**

- *Association of Major Power Customers of BC:*
  - Brian Wallace, Counsel;
  - Carlo Dal Monte, Director, Energy, Catalyst Paper Corporation;
  - Karina Brino, President and CEO, Mining Association of BC.

### **May 17, 2016**

- *SaskPower:*
  - Mike Marsh, President and Chief Executive Officer;
  - Guy Bruce, Vice President, Planning, Environment and Sustainable Development.
- *BC Hydro:*
  - Chris Sandve, Director of Policy and Reporting.

### **May 19, 2016**

- *Transport Canada:*
  - Ellen Burack, Director General, Environmental Policy;
  - Jim Lothrop, Director General, Sustainable Transportation Stewardship.

**May 31, 2016**

- *National Airlines Council of Canada:*
  - Marc-André O'Rourke, Executive Director;
  - Teresa Ehman, Chair, Environment Subcommittee.
- *Green Aviation Research and Development Network:*
  - Sylvain Cofsky, Executive Director;
  - Fassi Kafyeke, Senior Director, Strategic Technology and Advanced Product Development, Bombardier Aerospace.

**June 2, 2016**

- *Ontario Power Generation:*
  - Jeff Lyash, President and Chief Executive Officer.
- *NB Power:*
  - Neil Larlee, Director, Strategic Planning.

**June 9, 2016**

- *Canadian Hydrogen and Fuel Cell Association:*
  - Eric Denhoff, President and Chief Executive Officer.
- *Renewable Industries Canada:*
  - Andrea Kent, President.
- *Canadian Automated Vehicles Centre of Excellence:*
  - Barrie Kirk, Executive Director.

**September 27, 2016**

- *Association of Canadian Port Authorities:*
  - Wendy Zatylny, President;
  - Debbie Murray, Director, Policy and Regulatory Affairs.
- *Conference Board of Canada:*
  - Louis Thériault, Vice President, Public Policy.

**September 29, 2016**

- *Canadian Natural Gas Vehicle Alliance:*
  - Bruce Winchester, Executive Director.
- *Pollution Probe:*
  - Steven McCauley, Acting Chief Executive Officer.

**October 18, 2016**

- *Electric Mobility Canada:*
  - Chantal Guimont, President and Chief Executive Officer.
- *Canadian Trucking Alliance:*
  - Jonathan Blackham, Policy and Government Affairs Assistant.

**October 20, 2016**

- *Coal Association of Canada:*
  - Robin Campbell, President.

**October 25, 2016**

- *VIA Rail Canada:*
  - Yves Desjardins-Siciliano, President and Chief Executive Officer;
  - Pierre Le Fèvre, Senior Advisor to CEO and Chief Executive Officer;
  - Bruno Riendeau, Director, Safety and Environment.
- *Railway Association of Canada:*
  - Michael Bourque, President and Chief Executive Officer;
  - Michael Gullo, Director, Policy, Economic and Environmental Affairs.

**October 27, 2016**

- *Canadian Vehicle Manufacturers' Association:*
  - Mark Nantais, President.
- *Fertilizer Canada:*
  - Garth Whyte, President and Chief Executive Officer;
  - Clyde Graham, Senior Vice President.

**November 1, 2016**

- *Canadian Manufacturers & Exporters:*
  - Mathew Wilson, Senior Vice President, National Policy;
  - Nancy Coulas, Director, Energy and Environment Policy.
- *CMC Research Institutes, Inc.:*
  - Richard Adamson, President.

**November 3, 2016**

- *Canadian Urban Transit Association:*
  - Alex Maheu, Director, Public Affairs;
  - Jeff Mackey, Policy Analyst.
- *Hydro-Québec:*
  - Louis Beauchemin, Senior Director, Subsidiary Management;
  - France Lampron, Director, Transportation Electrification.

**November 24, 2016**

- *Sustainable Development Technology Canada:*
  - Leah Lawrence, President and Chief Executive Officer.
- *Alberta Innovates:*
  - John Zhou, Vice President, Clean Energy.

**November 29, 2016**

- *C.D. Howe Institute:*
  - Benjamin Dachis, Associate Director, Research.

**December 1, 2016**

- *PTAC Petroleum Technology Alliance Canada:*
  - Soheil Asgarpour, President.

**December 6, 2016**

- *Council of Canadian Academies:*
  - Eric M. Meslin, President and Chief Executive Officer;
  - Eddy Isaacs, Scientific Advisory Committee Member.
- *In Situ Oil Sands Alliance:*
  - Richard Sendall, Chairman;
  - Patricia Nelson, Vice Chair.

**December 8, 2016**

- *Federation of Canadian Municipalities:*
  - Clark Somerville, President;
  - Dallas Alderson, Manager, Policy and Research.
- *As an individual:*
  - Mark Jaccard, Professor, Simon Fraser University.

**December 13, 2016**

- *Canada West Foundation:*
  - Trevor McLeod, Director of the Centre for Natural Resources Policy.

**December 15, 2016**

- *Canadian Energy Research Institute:*
  - Allan Fogwill, President and Chief Executive Officer.

**January 31, 2017**

- *Global CCS Institute:*
  - Jeff Erikson, General Manager, Americas Region.



**February 2, 2017**

- *Institute for Oil Sands Innovation:*
  - Qi Liu, Scientific Director.
- *Emissions Reduction Alberta:*
  - Steve MacDonald, Chief Executive Officer.

**February 16, 2017**

- *Canada Mining Innovation Council:*
  - Carl Weatherell, Executive Director and Chief Executive Officer.
- *As an Individual:*
  - Jennifer Winter, Assistant Professor, School of Public Policy, University of Calgary.

**February 28, 2017**

- *Chemistry Industry Association of Canada:*
  - Bob Masterson, President and Chief Executive Office;
  - David Podruzny, Vice-President, Business and Economics.
- *Petroleum Services Association of Canada:*
  - Mark A. Salkeld, President and Chief Executive Officer.

**March 2, 2017**

- *Forest Products Association of Canada:*
  - Robert Larocque, Vice President, Climate Change, Environment and Labour;
  - Kate Lindsay, Director, Environmental Regulations and Conservation Biology.
- *Mining Association of Canada:*
  - Brendan Marshall, Vice President, Economic and Northern Affairs.

**March 9, 2017**

- *Canadian Steel Producers Association:*
  - Joseph Galimberti, President.

**March 28, 2017**

- *Aluminium Association of Canada:*
  - Jean Simard, President and Chief Executive Officer.

**March 30, 2017**

- *Cement Association of Canada:*
  - Michael McSweeney, President and Chief Executive Officer;
  - Adam Auer, Vice-President, Environment and Sustainability.

- *Canada's Ecofiscal Commission:*
  - Chris Ragan, Chair.

#### **April 6, 2017**

- *Environment and Climate Change Canada:*
  - John Moffet, Acting Associate Assistant Deputy Minister, Environmental Protection Branch;
  - Derek Hermanutz, Director General, Economic Analysis Directorate, Strategic Policy Branch;
  - Matt Jones, Director General, Climate Policy Office, Strategic Policy Branch;
  - Helen Ryan, Director General, Energy and Transportation, Environmental Protection Branch.
- *Department of Finance Canada:*
  - Sean Keenan, Director, Sales Tax Division, Tax Policy Branch;
  - Gervais Coulombe, Chief, Sales Tax Division, Tax Policy Branch.

#### **April 11, 2017**

- *Shell Canada:*
  - Tim Wiwchar, Portfolio Business Opportunity Manager.
- *Big Moon Power:*
  - Lynn Blodgett, President and Chief Executive Officer;
  - Jamie MacNeil, Country Manager.

#### **April 13, 2017**

- *Canadian Gas Association:*
  - Timothy M. Egan, President and Chief Executive Officer.
- *The Canadian Chamber of Commerce:*
  - Katrina Marsh, Director, Environment and Natural Resources Policy.

#### **May 11, 2017**

- *International Energy Agency:*
  - Tim Gould, Head of Energy Supply Outlook Division;
  - Jean-François Gagné, Head of Energy Technology Policy Division;
  - Sylvia Bayer, Country Desk Officer in the Energy Policy and Security Division;
  - Aad van Bohemen, Head of Energy Policy and Security Division;
  - Peter Fraser, Head of Gas, Coal and Power Division.

**June 8, 2017**

- *Newfoundland and Labrador Oil & Gas Industries Association:*
  - Robert Cadigan, President and Chief Executive Officer.
- *Canadian Association of Petroleum Producers:*
  - Terry Abel, Executive Vice-President;
  - Patrick McDonald, Director, Climate and Innovation.

**June 15, 2017**

- *Canadian Labour Congress:*
  - Donald Lafleur, Executive Vice-President;
  - Chris Roberts, Director, Social and Economic Policy.
- *Canadian Fuels Association:*
  - Peter Boag, President and Chief Executive Officer;
  - Lisa Stilborn, Vice-President, Ontario Division.

# Appendix B – Fact-Finding Missions – List of Witnesses

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## Western Canada – October 2-7, 2016

(Vancouver, Kitimat and Prince George, British Columbia, Calgary, Alberta and Estevan, Saskatchewan)

- *Alberta Electric System Operator:*
  - Miranda Keating Erickson, Vice President Operations;
  - Angela Anderson, External Relations Advisor.
- *ARC Financial Corp.:*
  - Peter Tertzakian, Chief Energy Economist and Managing Director.
- *Canada's Oil Sands Innovation Alliance:*
  - Dan Wicklum, Chief Executive Officer.
- *Canfor Pulp Ltd.:*
  - Martin Pudlas, Vice President, Operations;
  - Peter Lovell, General Manager;
  - Robert Thew, Manager, Strategic Capital and Energy.
- *CanmetENERGY:*
  - Cécile Siewe, Director General, Devon Research Center;
  - Jinwen Chen, Director, Hydrocarbon Conversion;
  - Michael Layer, Senior Program Manager.
- *Legislative Assembly of Saskatchewan:*
  - Lori Carr, Member of the Legislative Assembly.
- *Pembina Institute:*
  - Chris Severson-Baker, Managing Director.
- *Petroleum Technology Research Centre:*
  - Norm Sacuta, Communications Manager.

- *Powertech Laboratories:*
  - Madhvi Ramnial, Manager, Client Engagement and Business Development;
  - Angela Das, Senior Manager, Advanced Transportation;
  - Jeff Turner, Project Manager, Electric Vehicles and Energy Systems;
  - David Facey, Legal Counsel;
  - Frankie Nash, Policy Analyst.
- *Rio Tinto:*
  - Blair Dickerson, Vice President;
  - Richard Prokopanko, Director of Government Affairs;
  - Gareth Manderson, General Manager;
  - Kevin Dobbin, Manager Communications and Communities, BC Works;
  - Manny Arruda, Casting Coordinator, BC Works;
  - Alain Bouchard, Business Partner HSE;
  - Graham Caven, Reduction PTA Trainer, BC Works;
  - Carolyn Chisholm, Principal Advisor, Vice President Canada Office;
  - Marion Egan, Executive Assistant, BC Works;
  - Joe Velho, Coordinator, BC Works.
- *SaskPower:*
  - Howard Matthews, Vice President, Power Production;
  - Sandra Beingessner, Executive Co-ordinator, Executive Offices;
  - Dave Jobe, Director, Carbon Capture and Storage;
  - Mike Zeleny, Tour Ambassador, Carbon Capture and Storage.
- *Seven Generations Energy Ltd.:*
  - Alan Boras, Director, Communications and Stakeholders Relations.
- *University of Calgary:*
  - Dan McFadyen, Program Director, School of Public Policy;
  - Robert Mansell, Academic Director, School of Public Policy;
  - Shantel Jordison, Manager, Extractive Resource Governance Program.

- *University of Northern British Columbia:*
  - Daniel Weeks, President;
  - Daniel Ryan, Interim Vice President, Academic and Provost;
  - Geoffrey Payne, Interim Vice President, Research;
  - Tim Tribe, Vice President, Advancement;
  - Robert Knight, Vice President, Finance and Business Operations;
  - Chris Buse, CIRC Project Lead;
  - Stephen Déry, Canada Research Chair in Northern Hydrometeorology;
  - Kevin Ericsson, Chief Engineer;
  - David Claus, Assistant Director, Facilities Management.
- *Vancouver Fraser Port Authority:*
  - Duncan Wilson, Vice President, Corporate Social Responsibility;
  - Carrie Brown, Director, Environmental Programs;
  - Evangeline Englezos, Director, Community and Aboriginal Affairs;
  - Christine Rigby, Environmental Specialist, Air Emissions.

**Ontario – November 14-17, 2016  
(Sarnia and Hamilton, Ontario)**

- *ArcelorMittal Dofasco:*
  - Sean Donnelly, President and Chief Executive Officer;
  - Tony Valeri, Vice President, Corporate Affairs;
  - Henry Wegiel, Director, Trade and Government Relations;
  - Ian Shaw, Manager, Energy Management;
  - Jim Stirling, General Manager, Environment;
  - Richard Do Couto, Specialist, Corporate Responsibility;
  - Tom Kuhl, General Manager of Primary Manufacturing Technology;
  - Dan Evans, Reliability Coach;
  - Errol Hilado, Process Reliability Specialist.
- *BioAmber:*
  - Mike Hartmann, Executive Vice President;
  - Ann Waddell, Vice president, Government Affairs.
  - Fabrice Orecchioni, Chief Operations Officer.
- *Bioindustrial Innovation Canada:*
  - Sandy Marshall, Executive Director.

- *Biox Corporation:*
  - Alan Rickard, Chief Executive Officer;
  - Courtney Quinn, Vice President, Finance;
  - Ryan Doell, Operations Manager;
  - Bozena Millivojevic, Production Manager.
- *Canadian Fuels Association:*
  - Lisa Stilborn, Vice President, Ontario Division;
  - Erin Brophy, Communications Manager.
- *CanmetMATERIALS:*
  - Philippe Dauphin, General Manager;
  - Mark S. Kozdras, Program Manager, Automotive Materials;
  - Hitesh Jain, Manager, Business and Contracts.
- *Chemistry Industry Association of Canada:*
  - Bob Masterson, President and Chief Executive Officer;
  - David Podruzny, Vice President, Business and Economics
  - Erika Adams, Director, Communications.
- *City of Hamilton:*
  - His Worship Fred Eisenberger, Mayor;
  - Andrew Grice, Director, Water and Wastewater Operations;
  - Geoff Lupton, Director, Energy, Fleet and Traffic;
  - John Mater, Director, Corporate Assets and Strategic Planning;
  - Dan Chauvin, Director, Woodward Upgrades;
  - Dan McKinnon, General Manager, Public Works;
  - Mark Bainbridge, Acting Director, Hamilton Water
  - Greg Crone, Strategic Initiatives and Policy Advisor;
  - Frank Gazzola, Superintendent, Energy Engineering;
  - Plamen Nikolov, Senior Project Manager, Capital Works.
- *Imperial:*
  - Brian M. Fairley, Sarnia Refinery Manager;
  - George E. Vincent, Senior Regulatory Affairs Advisor;
  - Dave Luecke, Sarnia Chemical Plant Manager;
  - Jon Harding, Community Affairs and Aboriginal Relations Advisor.

- *McMaster University:*
  - Ishwar Puri, Dean Faculty of Engineering;
  - Rob Baker, Vice President Research;
  - Nick Markettos, Acting Director, McMaster Institute for Transportation and Logistics;
  - Altaf Arain, Director, McMaster Centre for Climate Change;
  - Gillian Goward, Acting Associate Dean Research and External Relations;
  - Lori Dillon, Manager, Research Communications;
  - Alex Lawson, Executive Advisor, Public Affairs;
  - Kristen Munro, Manager, Public Affairs;
  - Ali Emadi, Director of MacAUTO;
  - Saeid Habibi, Professor, Mechanical Engineering;
  - Megan Wood, Team Lead, McMaster Engineering EcoCAR3 Team;
  - Theo Abraham, Communications Manager, McMaster Engineering EcoCAR3 Team.
- *NOVA Chemicals:*
  - Rob Thompson, Regional Manufacturing Director;
  - Ken Faulkner, Director of Government Relations;
  - Meaghan Kreeft, Communications Consultant.
- *Sarnia-Lambton Chamber of Commerce:*
  - Shirley de Silva, President and Chief Executive Officer;
  - Monica Shepley, Manager of Advocacy and Policy Development;
  - Mark Lumley, Chairman, Board of Directors;
  - Michael Kooy, 1<sup>st</sup> Vice Chair;
  - Peter Smith, Co-Chair, Energy Committee;
  - Alex Palimaka, Board Member;
  - Cathy MacLellan, Vice President Human Resources and Outreach, Ubiquity Solar;
  - Ed brost, President, Je&M Consulting Ltd.;
  - Maike Luiken, Bluewater Technology Access Centre;
  - Joe Lasowski, CF Industries.
- *Sarnia-Lambton Economic Partnership:*
  - George Mallay, General Manager.
- *Shell:*
  - Helen Bennett, Emerging Regulatory Policy Issue Advisor.



- *Union Gas:*
  - Sarah Van Der Paelt, Director, Distribution Business Development and Strategic Accounts.
- *Suncor Energy:*
  - Michael Kandravy, Director, Fuels Quality and Regulatory Affairs;
  - Michael Southern, Manager, Government Relations.
- *Western Sarnia-Lambton Research Park:*
  - Tom Strifler, Executive Director;
  - Katherine G. Albion, Commercialization Centre Director;
  - Victoria Townsend, Research Engineer and Project Manager;
  - Stephen Reaume, Coordinator;
  - Mike Nesdoly, Manager, Applied Research and Innovation.

**Quebec – February 7-8, 2017**  
**(Montreal and Varennes, Quebec)**

- *AQPER (Association québécoise de la production d'énergie renouvelable):*
  - Jean-François Samray, President and Chief Executive Officer
- *CanmetENERGY:*
  - Gilles Jean, Managing Director;
  - Lisa Dignard, Director, Integration of Renewable and Distributed Energy Resources R&D Program;
  - Éric Soucy, Director, Industry R&D Program;
  - Chantal LeRoy, Acting Director, Building R&D Program;
  - Amélie Richard, Commercialisation Officer.
- *City of Laval:*
  - Stéphane Boyer, City Councillor;
  - Ian Dessureault, Environment Services.
- *Écotech Québec:*
  - Denis Leclerc, President and Chief Executive Officer;
  - Marie-Hélène Labrie, Vice-President of the Board;
  - Élise Laferrière, Vice-Presidente, Partnerships and Operations.

- *Gaz Métro:*
  - Stéphanie Trudeau, Principal Vice-President, Regulations, Clients and Communities;
  - Frédéric Krikorian, Director, Sustainable Development, Public and Governmental Affairs.
- *Hydro-Québec's Research Institute:*
  - Jérôme Gosset, Director;
  - Jean-Pierre Tardif, Advisor – Communications and Marketing.
- *McGill:*
  - Jim Nicell, Professor & Dean of Engineering;
  - Subhasis Ghoshal, Director, Trottier Institute for Sustainability in Engineering and Design;
  - Lauren Penney, Manager, Trottier Institute for Sustainability in Engineering and Design;
  - Benoît Boulet, Associate Dean, Research & Innovation
  - François Bouffard, Associate Professor;
  - Yixin Shao, Professor;
  - Jeff Bergthorson, Associate Professor.
- *Union des producteurs agricoles:*
  - Pierre Lemieux, Second Vice-President;
  - Daniel Bernier, Research and Agricultural Policy Advisor – Environment.

#### **Eastern Canada – May 1-4, 2017**

**(St. John's, Newfoundland and Labrador, Summerside, Prince Edward Island, Saint John, New Brunswick and Halifax, Nova Scotia)**

- *Amec Foster Wheeler:*
  - Jonas Roberts, Climate Change Consultant, Environment and Infrastructures.
- *CarbonCure Technologies:*
  - Jennifer Wagner, Vice-President, Sustainability.
- *City of Summerside:*
  - His Worship Bill Martin, Mayor;
  - Norma McColeman, Deputy Mayor;
  - Greg Campbell, Councillor;
  - Brian McFeely, Councillor;
  - Gordie Whitlock, Councillor;
  - Bob Ashley, Chief Administrative Officer;

- Greg Gaudet, Director of Municipal Services;
  - J.P. Desrosiers, Director of Community Services;
  - Rob Philpott, Director of Finance;
  - Mike Thusuka, Director of Economic Development;
  - Lorri Laughlin, Director of Communications;
  - Sam Arsenault, Waste Water Operations Supervisor;
  - Chad Fraser, Waste Water Treatment Operator.
- *Dalhousie University:*
    - Sara Daniels, Government Relations Advisor;
    - Dr. Steven Mannell, Director, College of Sustainability;
    - Dr. Richard Florizone, President;
    - Dr. Mita Dasog, Assistant Professor;
    - Dr. Ian Hill, Professor;
    - Rochelle Weber, Student;
    - Jon Paul, Student;
    - Colby Deighton, Student;
    - Emma Norton, Alumna.
- *Emera:*
    - Norm Dimmell, P.Eng., Vice-President, Corporate Services;
    - Chris Huskilon, President and Chief Executive Officer;
    - Robert Hanf, Executive Vice-President, Stakeholder Relations and Regulatory Affairs;
    - Lisa Merrithew, Vice-President, Communications and Corporate Affairs;
    - Sharon Scattolon, Facilities Manager;
    - Brad Stronach, HVAC Technician.
- *Fortis Inc.:*
    - Barry Perry, President and Chief Executive Officer;
    - Nora Duke, Executive Vice-President and Chief Human Resource Officer;
    - Gary Smith, President, Newfoundland Power;
    - Karen McCarthy, Director, Communications and Corporate Affairs;
    - Paul Fitzpatrick, Director, Regulatory and Compliance.
- *Government of Newfoundland and Labrador:*
    - Walter Parsons, P.Eng., Assistant Deputy Minister, Energy;
    - Perry Canning, Assistant Deputy Minister, Mines.
- *Irving Oil:*
    - James Walsh, Manager, Government Relations;
    - Graham Little, Government Relations Specialist;
    - Jeff Matthews, Chief Business Development Officer.

- *J.D. Irving:*
  - Mary Keith, Vice-President, Communications;
  - Mark Mosher, Vice-President, Pulp & Paper;
  - Dion Hanrahan, Vice-President, Industrial Business Development;
  - Chris MacDonald, Director, Government Relations.
- *McInnes Cooper:*
  - J. Alex Templeton, Associate.
- *Nalcor:*
  - Gilbert Bennet, Executive Vice-President, Power Development;
  - Mark King, Stakeholder Relations and Communications;
  - Gayle St. Croix, Communications Consultant.
- *Narl Refining LP:*
  - Tim Derksen, Management Program.
- *NB Power:*
  - Kathleen Duguay, Manager, Community Affairs and Nuclear Regulatory Protocol;
  - Brett Plummer, Vice-President Nuclear and Chief Nuclear Officer;
  - Robert Scott, Director, Government Relations;
  - Keith Cronkite, Senior Vice-President Business, Development and Strategic Planning.
- *Newfoundland and Labrador Environmental Industry Association:*
  - Kieran Hanley, Executive Director.
- *NS Power:*
  - Karen Hutt, President and Chief Executive Officer;
  - Sasha Irving, Vice-President Corporate Affairs and Stakeholder Relations.
- *Prince Edward Island Climate Change Secretariat:*
  - Todd Dupuis, Executive Director.
- *Prince Edward Island Energy Corporation:*
  - Heather MacLeod, Manager, Energy Assets.
- *St. John's Board of Trade:*
  - Rhonda Tulk-Lane, Policy and Advocacy Specialist;
  - Nancy Healey, Chief Executive Officer;
  - Dorothy M. Keating, Chair.
- *Transportation, Infrastructure and Energy Efficiency - Prince Edward Island:*
  - Mike Proud, Manager, Office of Energy Efficiency.

- *Trout River Homes Inc.:*
  - Terry and Natalie Perry, Owners.
- *University of Prince Edward Island's Climate Lab:*
  - Dr. Adam Fenech, Director;
  - Hope Parnham, PhD Student.
- *University of Prince Edward Island:*
  - Dr. Robert Gilmour, Vice-President Academic and Research.

- 
- <sup>1</sup> Environment and Climate Change Canada, [Facts on Climate Change](#).
- <sup>2</sup> United Nations Framework Convention on Climate Change, [The Paris Agreement](#).
- <sup>3</sup> International Energy Agency, World Energy Outlook 2016 –Executive Summary.
- <sup>4</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 10 May, 2016 (Mike Cleland, Senior Fellow, University of Ottawa, as an individual).
- <sup>5</sup> Canadian Intergovernmental Conference Secretariat, [First Ministers’ Meeting – Vancouver Declaration on clean growth and climate change](#), Vancouver, British Columbia, 3 March, 2016.
- <sup>6</sup> Government of Canada, [Pan-Canadian Framework on Clean Growth and Climate Change](#).
- <sup>7</sup> Environment and Climate Change Canada, [Canada’s 2016 Greenhouse Gas Emissions Reference Case](#).
- <sup>8</sup> Environment and Climate Change Canada, [Global Greenhouse Gas Emissions](#), figure is based on 2012 global emissions.
- <sup>9</sup> Ibid.
- <sup>10</sup> Transport Canada, Annual Reports, Transportation in Canada 2015.
- <sup>11</sup> Environment and Climate Change Canada, [Canada’s 2016 greenhouse gas emissions Reference Case](#).
- <sup>12</sup> Government of Canada, [Canada’s Mid-Century Long-Term Low-Greenhouse Gas Development Strategy](#).
- <sup>13</sup> Transport Canada, Annual Reports, Transportation in Canada 2015, p. 23.
- <sup>14</sup> Statistics Canada, Vehicle Registrations, Cansim table 405-0004.
- <sup>15</sup> The White House, “[President Donald J. Trump: Buy American and Hire American for the United States Automobile Industry](#),” New release, 15 March 2017.
- <sup>16</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 27 October, 2016, (Mark Nantais, President, Canadian Vehicles Manufacturers’ Association).
- <sup>17</sup> Ibid.
- <sup>18</sup> Ibid.
- <sup>19</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 27 September, 2016, (Louis Thériault, Vice President, Public Policy, Conference Board of Canada).
- <sup>20</sup> Ibid.
- <sup>21</sup> Government of Canada, Canada Gazette, [Canadian Environmental Protection Act, 1999](#), Archived – Vol.148, No. 40 –October 4, 2014.
- <sup>22</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 18 October, 2016, (Jonathan Blackham, Policy and Government Affairs Assistant, Canadian Trucking Alliance).
- <sup>23</sup> Canadian Trucking Alliance, Briefing Note, 2017 Federal Budget, Fall 2016, Written Response to the Standing Committee on Energy, the Environment and Natural Resources, received 16 May, 2017.
- <sup>24</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 18 October, 2016, (Chantal Guimont, President and Chief Executive Officer, Electric Mobility Canada).
- <sup>25</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 9 June, 2016, (Eric Denhoff, President and Chief Executive Officer, Canadian Hydrogen and Fuel Cell Association).
- <sup>26</sup> International Energy Agency and International Renewable Energy Agency, [Perspectives for the Energy Transition.: Investment Needs for a Low Carbon Energy System](#), 2017, p. 89.
- <sup>27</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 3 November, 2016, (Louis Beauchemin, Senior Director, Subsidiary Management, Hydro-Québec); Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 18 October, 2016, (Chantal Guimont, President and Chief Executive Officer, Electric Mobility Canada).
- <sup>28</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 3 November, 2016, (Louis Beauchemin, Senior Director, Subsidiary Management, Hydro-Québec).
- <sup>29</sup> Hydro-Québec, Written Response to the Standing Senate Committee on Energy, the Environment and Natural Resources, 13 February 2017.

- 
- <sup>30</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 18 October, 2016, (Chantal Guimont, President and Chief Executive Officer, Electric Mobility Canada).
- <sup>31</sup> Ibid.
- <sup>32</sup> Hydro-Québec, [Electric Circuit, Become a partner](#).
- <sup>33</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 3 November, 2016, (Louis Beauchemin, Senior Director, Subsidiary Management, Hydro-Québec).
- <sup>34</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 29 September, 2016, (Steven McCauley, Acting Chief Executive Officer).
- <sup>35</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 18 October, 2016, (Chantal Guimont, President and Chief Executive Officer, Electric Mobility Canada).
- <sup>36</sup> Canadian Hydrogen Fuel Cell Association, [What is a Fuel Cell?](#).
- <sup>37</sup> Steam reforming converts methane into hydrogen and carbon monoxide by reaction with steam over a nickel catalyst.
- <sup>38</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 29 September, 2016, (Eric Denhoff, President and Chief Executive Officer, Canadian Hydrogen and Fuel Cell Association).
- <sup>39</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 29 September, 2016, (Bruce Winchester, Executive Director, Canadian Natural Gas Vehicle Alliance).
- <sup>40</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 18 October, 2016, (Jonathan Blackham, Policy and Government Affairs Assistant, Canadian Trucking Alliance).
- <sup>41</sup> Ibid.
- <sup>42</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 9 June, 2016, (Barrie Kirk, Executive Director, Canadian Automated Vehicles Centre of Excellence).
- <sup>43</sup> Ibid.
- <sup>44</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 19 May, 2016, (Ellen Burack, Director General, Environmental Policy, Transport Canada).
- <sup>45</sup> Natural Resources Canada, [Biodiesel](#).
- <sup>46</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 9 June, 2016, (Andrea Kent, President, Renewable Industries Canada).
- <sup>47</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 19 May, 2016, (Ellen Burack, Director General, Environmental Policy, Transport Canada).
- <sup>48</sup> Government of Canada, [Leader's Statement on a North American Climate, Clean Energy, and Environment Partnership](#), June 29, 2016.
- <sup>49</sup> Senate, Standing Committee on Energy, the Environment and Natural Resources, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 19 May, 2016, (Ellen Burack, Director General, Environmental Policy, Transport Canada).
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<sup>58</sup> Emissions trading systems and offsetting -where aircraft operators invest in emission reduction projects to offset growth in their international aviation emissions.

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