

Energy policy 2016-2025

DECARBONIZATION OF ROAD TRANSPORT



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Ministère de l'Énergie et des Ressources naturelles

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PRESENTATION OF THE APPROACH

In 2006, the government adopted the *Québec Energy Strategy 2006-2015: Using Energy to Build the Québec of Tomorrow*, which hinged primarily on the revival and acceleration of the development of Québec's hydroelectric potential, the establishment of a wind power option, the diversification of sources of supply of natural gas and oil, and the promotion of greater energy efficiency.

The time has come to review the Québec government's energy-related priorities and orientations. To this end, it is necessary to examine the needs and expectations in respect of the different energy options that are underpinning Québec society's economic vitality and development. At the same time, this marks an opportunity to reassess the relevance, performance and efficiency of the tools that Québec has adopted to ensure the sound governance, development and responsible use of energy resources.

BACKGROUND DOCUMENTS

The series of background documents that the Ministère de l'Énergie et des Ressources naturelles is making available is intended to sustain reflection that will clarify the situation and challenges specific to contemporary Québec. The background documents seek to delineate the focus of reflection in light of success achieved at home and abroad and to raise questions that enable us to make enlightened choices over the coming decade.

This document contains information and data that establish an overall profile of energy use with respect to road passenger and freight transportation in Québec. It takes stock of initiatives undertaken in recent years in Québec to enhance the efficiency of such energy use and, accordingly, to reduce the greenhouse gas (GHG) emissions produced by transportation activities.

The first section examines the international and Québec contexts from the standpoint of individuals and businesses, both those that use transportation vehicles and those that are developing and marketing vehicles, vehicle components or fuels to operate them. The subsequent sections focus on the energy profile of road passenger and freight transportation in Québec, the energy options that could replace oil, a brief analysis of the contribution of each option that promotes Québec's rapid development, and the challenges and questions concerning the significant changes that a reduction in the carbon dioxide footprint of transportation activities demands. The conclusion emphasizes the key points to consider in the debate on the energy, environmental and economic challenges related to transportation.

Québec is changing. It must reposition itself bearing in mind its energy consumption profile, the global and continental context and the values that Quebecers cherish from the standpoint of economic development, environmental protection and social justice.

DESCRIPTION OF THE CONSULTATION PROCESS

The Québec government will adopt by the end of 2015 an energy policy covering the period 2016 to 2025. The policy will define the orientations that will enable Québec to:

- participate in a rapidly changing worldwide energy and economic context;
- maintain and, indeed, broaden its leadership in the realm of renewable energies;
- enhance its performance in the realms of energy efficiency, behavioural progress and education pertaining to energy and technological innovation;
- pursue the transition to a low-carbon economy;
- make energy resources a lever of wealth creation and social development in all regions.

The policy will stem from a mobilization and consultation approach that calls upon Quebecers and stakeholders in Québec society.

In the fall of 2013, the Commission on Energy Issues in Québec visited Québec's regions to ascertain the concerns and collect the reflections of individuals and organizations interested in the environmental, economic and social issues related to energy. A report containing 57 recommendations was drawn from the 460 briefs, 300 presentations, 250 contributions on the Internet or in person during the 47 public consultation meetings, three workshops with the Aboriginal communities and numerous meetings between the commissioners and experts from the universities or public bodies.

As announced on November 7, 2014, the approach will be pursued through the presentation online of thematic documents, which will broaden reflection by calling upon the round-table forums comprising Québec, Canadian and international experts.

The round-table forums will explore the following themes:

- energy efficiency and innovation
- renewable energy
- hydrocarbons.

A special round-table forum has been added to focus on the decarbonization of road transport.

At the same time as the experts are conducting their deliberations, the public will be invited to comment online the observations, challenges and questions submitted to the experts. Meetings open to individuals and organizations wishing to express their viewpoints to the representatives of the MERN will be organized for each theme. Aboriginal representatives will also be invited to share the viewpoints of their communities.

On the strength of the outcome of the extensive reflection and debate, the government will make public in the fall of 2015 its 2016-2025 energy policy.

INTRODUCTION

Passenger and freight transportation require considerable amounts of energy, mainly petroleum products, whose development and combustion emit greenhouse gases. There is broad consensus in the international scientific community that such emissions are responsible for the climate change that is disrupting our planet.

In Québec, the transportation sector accounts for more than 75% of demand for petroleum products. Québec is not an oil producer and imports all of the petroleum products that it consumes in the form of crude oil that is refined in its territory or refined petroleum products. Road and rail land transportation largely overshadows maritime and air transport both from the standpoint of the distances travelled, the amounts of energy consumed and GHG emissions. This area of activity displays sustained growth that surpasses growth in the economy and the population.

Consequently, road passenger and freight transportation is a priority focal area to achieve the decarbonization of the economy, all the more so since the number of trips is rising constantly, in particular because of typical North American land-use planning that promotes low-density urban sprawl, the development across North America of just-in-time production and delivery methods in small quantities at the right time, and the development of e-commerce that is broadening demand for home delivery services that have become widespread in the commercial sector.

However, since changes in the urban fabric and behavioural change and innovation and the adoption of new technologies are occurring gradually in the transportation sector, the time has come for Québec to establish clear, visionary policy directions in the field. The orientations should enable it to not only reduce its GHG emissions but also to remedy problems that stem from excessive numbers of vehicle trips—traffic congestion, pollution, the degradation of resources, the occupancy by vehicles of urban territory, the loss of natural spaces, and so on—in addition to generating benefits as regards employment, public finances and the quality of life, among other things.

The solutions explored in this document cover all facets of the question, starting with a reduction in the distances to be travelled and reliance on motor vehicles, the adoption of best practices in the realm of passenger and freight transportation, and the use of new technologies that allow for the parsimonious, judicious use of all forms of energy, starting with renewable energies, according to the possibilities available. Accordingly, reliable, renewable, abundant electricity that emits limited GHG is one of Québec's strengths to gradually free itself from petroleum products in the road transport sector.

1 - THE GLOBAL CONTEXT

1.1 - THE CHALLENGE THAT CLIMATE CHANGE IS POSING

While the economy is the main concern of populations and governments, the world's leading decision-makers, political leaders, major financial institutions and numerous influential entrepreneurs now agree that the climate is posing the biggest challenge that humankind has ever faced.

The transportation sector appears to account for roughly 23% of worldwide anthropogenic GHG emissions,¹ more than half the rate in Québec, because the share of emissions related to electricity generation stands at 26% worldwide but is almost zero in Québec. At the global level, road transport alone accounts for 72% of such emissions, and rail transport, 1.6%.

1.2 - THE GLOBAL ECONOMY

Since the end of the recession in 2008, the global economy has rebounded slowly with marked discrepancies from one region to the next, which reflects considerable fragility. The International Monetary Fund (IMF) has noted that the recent drop in oil prices will boost worldwide growth. However, this impetus should be more than offset by negative factors, in particular sluggish investment.

Impact on road transport

Even uncertain, fragile worldwide economic growth is engendering a steady increase in the volumes of goods transported by road the world over. The global market for light vehicles and heavy trucks is the most convincing indicator of such growth.

According to Scotiabank, demand for heavy trucks has risen sharply in North America over the past two years. It is also rising in parts of Asia and is beginning to stabilize in Western Europe and China.² Broader fleet renewal also stems from the adoption of new standards governing pollutant emissions, as has been the case in China since January 1, 2015.

¹ IPCC (2014), *Climate Change 2014: Mitigation of Climate Change*, Working Group III Report, 5th Report, Chapter 8, pages 323 to 387.

² Scotiabank (2015), *Analyse économique mondiale — Marché mondial de l'automobile* [online] [gbm.scotiabank.com/English/bns_econ/auto_f.pdf] (consulted on March 24, 2015).

The uneven economic context from one region to another and the drop in oil prices is also affecting worldwide sales of light-duty vehicles. China and the United States have experienced growth of more than 10% while vehicle purchases have also picked up in Western Europe as economic conditions have rallied. Purchases have declined in other Asian countries such as Japan and Thailand. The market in South America also remains sluggish. In Canada and the United States, sales of cars and light trucks are rising,³ sustained by an improving labour market, renewed consumer confidence and low interest rates and gas prices.

While owning a private motor vehicle is no longer the foremost desire of young North Americans reaching adulthood⁴ and reliance on automobiles to travel in big North American cities is dwindling,⁵ the fact remains that access to this means of transportation continues to symbolize success in many countries where individuals aspire to the middle class.

1.3 - THE ENERGY CONTEXT

According to the International Energy Agency (IEA), final energy consumption doubled between 1973 and 2012.⁶ It should continue to grow in coming decades because of worldwide demographic vitality and the development of the emerging economies.

Fossil fuels now satisfy more than 80% of such demand.⁷ New technologies to exploit source rock (shale gas and oil) are significantly delaying the exhaustion of such resources. On the other hand, their development is no longer occurring under the same safety and technical feasibility conditions as in the past. Such development assumes increasingly substantial investments and rising operating costs. The energy required to produce one unit of energy useful to the consumer has increased from 0.31 to 0.49 unit in 40 years.⁸ Lastly, the real or potential repercussions of exploration for and the development of fossil fuels on the environment and population health is arousing opposition.

³ According to the data used by Scotiabank, sales of light trucks in the United States rose by 23% in 2014, an increase attributable to brisk sales of big SUVs (45%).

⁴ U.S. PIRG Education Fund (2013), *A New Direction: Our Changing Relationship with Driving and the Implications for America's Future* [online] [uspig.org/reports/usp/new-direction0] (consulted on March 25, 2015).

⁵ Doug Short (2015), *Vehicle Miles Traveled: A Structural Change in Our Behavior*, Advisor Perspectives, [online] [advisorperspectives.com/dshort/updates/DOT-Miles-Traveled.php] (consulted on March 26, 2015).

⁶ AIE (2014), *Key World Energy Statistics 2014* [online] [iea.org/publications/freepublications/publication/KeyWorld2014.pdf] (consulted on March 26, 2015).

⁷ The document entitled *Worldwide and Continental Trends* produced by the Ministère de l'Énergie et des Ressources naturelles [mern.gouv.qc.ca/peq/fascicule-1.pdf] summarizes the data.

⁸ The figures are based on IEA data (2014).

The share of world total final consumption attributable to transportation activities increased from 23% in 1973 to 28% in 2012, a reflection of the growing importance of freight and passenger transportation. Petroleum products satisfy 96% of such energy demand. Natural gas and electricity account together for less than 0.5% of the energy that all kinds of transportation vehicles consume. Biofuels account for the remainder.

In Europe and North America, transportation accounts for 20% to 50% of final energy consumption, depending on the region. Accordingly, transportation is the predominant energy consumption sector in several industrialized nations such as the United States, France and the United Kingdom, or provinces such as Ontario and Manitoba, or ranks second after the industrial sector in Québec and Alberta.

Because of policies intended to reduce reliance on oil as a principal fuel, a number of governments are initiating diversification in favour of renewable fuels such as ethanol and biodiesel. Biofuels account in some countries for 5% or more of energy needs, both in Europe (France, Germany and Sweden) and in the United States (New York, Rhode Island and California). Brazil ranks first in this respect since biofuels account for 16.6% of national fuel needs in the transportation sector.⁹

⁹ Empresa de Pesquisa Energética (2014). *Balanço Energético Nacional 2014 – Relatório síntese, ano base 2013*. [https://ben.epe.gov.br/downloads/Síntese%20do%20Relatório%20Final_2014_Web.pdf] (consulted on April 6, 2015).

2 - THE QUÉBEC CONTEXT

The fight against climate change is a challenge that has transcended the Québec government's missions and priorities since 1998.¹⁰ In 2009, Québec committed itself to pursuing its efforts to reduce by 20% by 2020 its GHG emissions in relation to 1990.¹¹ In 2011, it launched *The 2011-2020 Action Plan for Electric Vehicles*, a key measure to attain this objective. The action plan proposes ambitious targets including sales of hybrid or electric vehicles equivalent to 25% of annual new light-duty vehicle sales by 2020. Under the action plan, in 2030, 1.2 million electric vehicles will operate on Québec roads (18% of registered light-duty vehicles), which will reduce gasoline consumption by 1.5 billion litres and GHG emissions by 3.5 million tonnes. The plan also calls for 95% of all travel on mass transit systems to rely on electricity. It is in this spirit that Québec's representatives will closely monitor the international community's deliberations to agree on new commitments at the Paris Climate Change Conference 2015 this fall.

The impact of climate change is already apparent in Québec. The operation, maintenance, management and rehabilitation of transportation or energy infrastructure have already been or will be affected. In the territory that the Northern Plan covers, the degradation of permafrost, changes in ice cover and in stormy weather are affecting ground, air and maritime transportation and industrial infrastructure. In coastal zones, in particular along the St. Lawrence River, *Québec's Maritime Strategy* will have to contend with the impact of more widespread marine submersion and coastal erosion stemming from the limited extent of ice cover. Climatic factors also significantly affect road networks. Moreover, in southern Québec, climate change will also have certain positive impacts.¹²

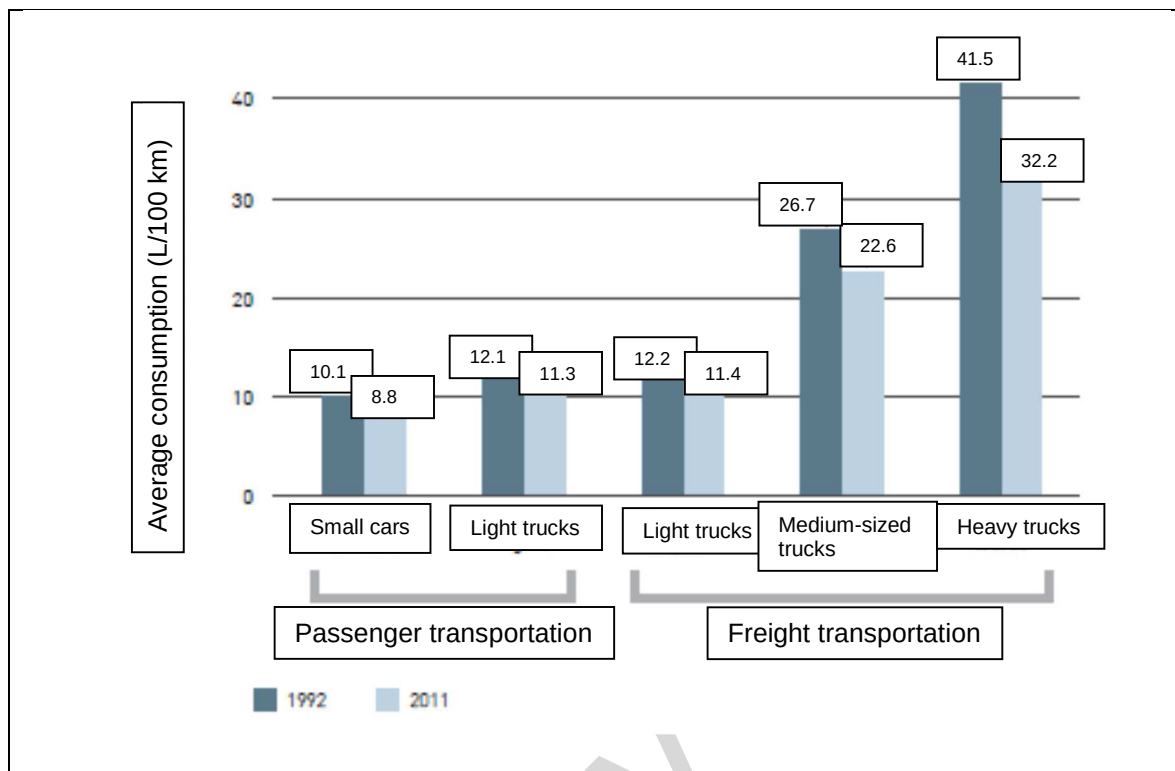
According to the Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (MDDELCC), in 2011, the road, air, maritime, rail and off-highway transportation sector generated 36 MT of CO₂ equivalent, i.e. 44% of total emissions in Québec. Road transport alone accounted for 76% of transportation-related GHG emissions, i.e. 34% of total emissions. While Québec achieved in 2012 the 6% GHG emission reduction target in relation to 1990 that it set within the framework of the *Kyoto Protocol*, such emissions in the road transportation sector rose by 33%, thus increasing its relative share of the energy profile by 7 percentage points. The figures reflect structural changes in the economy and new transportation practices but also the failure of the measures employed until now to reduce travel and enhance the energy and environmental efficiency of travel.

¹⁰ Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (2008), *2006-2012 Action Plan: Québec and Climate Change — A Challenge for the Future*, 54 pages.

¹¹ Gouvernement du Québec (2009), *Gazette officielle*, 141st year, No. 49, Décret 1187-2009, November 18, 2009.

¹² Ouranos (2014), *Vers l'adaptation — Synthèse des connaissances sur les changements climatiques au Québec* [online] [ouranos.ca/fr/synthese2014/] (consulted on March 26, 2015).

Figure 1: Average consumption by means of transportation (1992 and 2011)



Sources: Ministère de l'Énergie et des Ressources naturelles and Natural Resources Canada.

Québec emits the least GHG per capita of the Canadian provinces. However, in order to do even better, the transportation sector offers the best potential to ensure that Québec society reduces its emissions, becomes more prosperous and innovative, and less dependent on fossil energies.

Through its *2013-2020 Climate Change Action Plan* and revenues from the GHG emission cap-and-trade system—the so-called carbon market—Québec is multiplying its efforts to achieve its target, based on that of the European Union, to reduce by 20% by 2020 its GHG emissions in relation to 1990.

Table 1: GHG emissions in the Québec transportation sector in 1990 and in 2011

Mode of transportation	Emissions (MT of CO ₂ equivalent)		Change in emissions between 1990 and 2011		Sector's share 2011
	1990	2011	MT of CO ₂ equivalent	%	%
Road transportation	20.61	27.40	6.79	32.9	33.8
▪ Automobiles	12.00	10.57	-1.43	-11.9	38.6
▪ Light trucks	3.91	7.89	3.98	101.8	28.8
▪ Heavy-duty vehicles	4.56	8.83	4.27	93.6	32.2
▪ Other road transport	0.14	0.11	-0.03	-19.6	0.4
Air transport	0.82	0.62	-0.21	-25.3	0.8
Rail transport	0.57	0.90	0.33	57.2	1.1
Maritime transport	1.41	0.99	-0.42	-29.8	1.2
Other transportation**	4.31	6.01	1.70	39.5	7.4
Total	27.72	35.90	8.19	29.5	44.3

* The "Other road transport" category includes, in particular, motorcycles and natural-gas-powered vehicles.

** The "Other transportation" category includes off-road vehicles and pipeline transportation.

Source: Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques.

Québec's energy profile is characterized by the satisfaction of 40% of demand through electricity generated by means of renewable sources. Oil and natural gas, entirely imported, satisfy 38% and 14%, respectively, of demand, while locally produced biomass covers just over 7% of our needs, mainly in the form of energy wood.¹³ It should be noted that Hydro-Québec anticipates that available electricity will exceed demand throughout the coming decade.

In 2011, the transportation sector used 27% of the final energy consumed in Québec, but above all, 75% of all petroleum products.¹⁴ Natural gas and electricity account for a negligible fraction (less than 1%) of the fuel used for land transport.

Québec's economic situation reflects that of the world overall. According to Laurentian Bank Securities, we are in a transition period. The driving force for growth is changing, from household demand to exports and investments. Budgetary and fiscal uncertainty are rising, real estate and public investments are flagging, and the weaker dollar and more vigorous American demand are sustaining exports despite ongoing laboured international competitiveness.¹⁵

¹³ The document entitled *Statistical Profile of Energy in Québec* produced by the Ministère de l'Énergie et des Ressources naturelles [mern.gouv.qc.ca/peq/fascicule-2.pdf] presents the data in greater detail.

¹⁴ The deficit in the trade balance stemming from purchases of fuel used by road vehicles stood at roughly \$9.2 billion in 2012, including interprovincial trade in refined petroleum products.

¹⁵ Laurentian Bank Securities (2014), *Perspectives économiques 2014-2015 — L'économie canadienne en transition* [online] [economistesquebecois.com/files/documents/5l/d5/leita0-24-f-vrier.pdf] (consulted on March 25, 2015).

The economy, job creation and fiscal consolidation are the Québec government's priorities. Two major projects will contribute to the attainment of its economic priorities: the revival of the Northern Plan and Québec's *Maritime Strategy*. In addition to the two major projects, the government intends to enhance employment and productivity by supporting innovation and making strategic use of Québec's electricity surpluses.

The fairly significant share of natural resources and primary processing products, especially aluminium, and the transition of its economy to a knowledge-based and service economy mean that Québec is suffering the after-effects of sluggish American and worldwide economic revival. On the other hand, forest and agricultural bioresources are renewable energy resources on which Québec society can possibly rely to ensure its prosperity and pursue the decarbonization of transportation.

Both Québec's economic fabric and socioeconomic determinants are changing. Commercial space is becoming fragmented and located farther from residential areas while growing numbers of inhabitants in the regions are migrating to urban centres. The number of vehicles per capita is rising, the number of motor vehicles is increasing three times faster than the population, and the relative share of light trucks—sport utility vehicles or SUVs—in the light-duty vehicle fleet is also increasing.¹⁶ Similarly, the total distance traveled is rising at a sustained pace because of urban sprawl and improvements in the road network on the periphery of all major urban centres. Lastly, the enhancement of the energy efficiency of internal combustion vehicle engines is being partly offset by the increased power, weight and accessories that equip privately-owned motor vehicles.

Road freight transportation occupies a central place in the functioning of Québec's economy and in the North American economic space. Because of its competitive advantages from the standpoint of flexibility, rapidity and cost, road transport dominates the other modes of freight transportation in Québec and in North America. Indeed, it is estimated that nearly half of the tonnage transported in Québec, all markets combined, is carried by truck, while rail and maritime transport share the remainder. Air transport, which is mainly used to carry passengers, accounts for less than 1% of the volumes of the goods transported.¹⁷

Road freight transportation activities are growing steadily. Indeed, spurred by economic growth and logistics services, the volume of goods transported and the number of tonne-kilometres recorded between 2004 and 2009 annual growth on the order of 6.0% and 7.5%, respectively. The growth rates should decline in the coming years.

While the 158 000 heavy-duty road vehicles—including buses—represent a small proportion of the vehicles registered in Québec (roughly 2.6%), they consume nearly one-third of the petroleum products used for road transportation, mainly diesel. They account for one-third of GHG emissions and 80% of the particulate emissions attributable to the sector. They are thus an ideal target from the standpoint of the decarbonization of transportation.

¹⁶ Société de l'assurance automobile du Québec (2013), *Données et statistiques 2013* [online] [saaq.gouv.qc.ca/documents/documents_pdf/nous/donnees_statistiques.php] (consulted on March 30, 2015).

¹⁷ Ministère des Transports du Québec (2009), *Politique sur le transport des marchandises 2009-2014 — Le Québec en route*, Québec, 88 pages.

3 - The avoid-shift-improve approach

The avoid-shift-improve approach¹⁸ helps to group together and logically analyze initiatives related to energy efficiency and GHG emission reduction in the transportation sector. Its three components are described below.

Avoid

This component comprises initiatives to avoid or reduce passenger travel and to shorten travel distances. Indeed, active utilitarian travel meets specific conditions respecting distance and land-use planning. Integrated land-use and transportation planning, the increasing concentration of population in cities, and the construction of dwellings and offices near mass transit hubs are examples of measures that can be adopted to avoid or minimize travel. Logistics that reduce the number of heavy goods vehicles travelling empty is also an avoidance measure.

Shift

This component refers essentially to the transition from solitary use of a privately-owned motor vehicles to public transit or carpooling services, which are more efficient both from an energy and an environmental standpoint. In the case of freight, when the volume and distance warrant doing so, the shift to road trains and rail is an alternative that is preferable to simple trucks.

Improve

This component comprises three types of measures:

- 1) the enhancement of the energy efficiency of existing motor vehicles;
- 2) the use of alternative fuels with lower carbon dioxide footprints, in particular biofuels and natural gas;
- 3) the replacement or assistance of an internal combustion engine powered by a battery or a fuel cell (hydrogen). The latter demands considerable caution to avoid simply shifting GHG emissions from the point of use of the fuel—the vehicle—to the production plant.

To obtain fundamental, enduring change, it is important for interveners to apply the three components under an integrated land-use and transportation planning approach.

¹⁸ Eltis. Factsheet: *Sustainable Urban Transport: Avoid-Shift-Improve (A-S-I)*. [<http://www.eltis.org/discover/news/factsheet-sustainable-urban-transport-avoid-shift-improve-s-i-0>] (consulted on March 30, 2015).
IEA (2013), *Policy Pathways: A Tale of Renewed Cities*. [<http://www.iea.org/publications/freepublications/publication/policy-pathways---energy-efficiency-in-urban-transport-systems.html>] (consulted on March 30, 2015).

In the short term, Québec must make changes that require prompt decision-making. Certain solutions can be implemented quickly and should be emphasized. In the medium term, certain options that better harmonize with our economic, social and environmental objectives can help Québec to develop otherwise than through the historic approach adopted. The solutions analyzed in this document can all contribute to Québec's development. We must, therefore, regard them as mutually complementary alternate solutions to be used at the right time and in the right place.

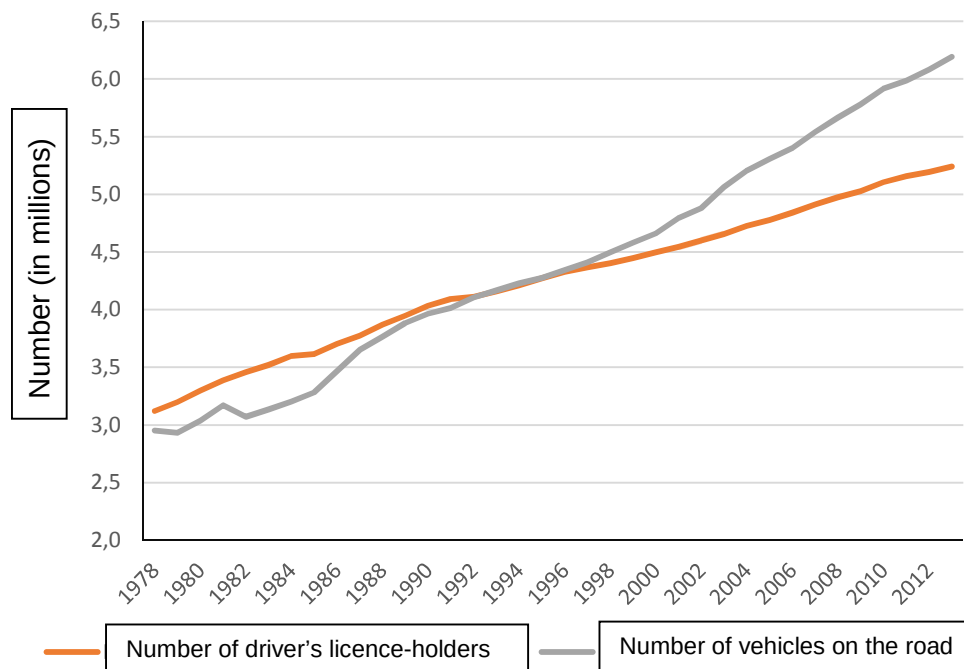
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4 - THE PROFILE OF ROAD TRANSPORT IN QUÉBEC

4.1 - PASSENGER TRANSPORTATION

In Québec, the number driver's licence-holders has risen, on average, by 1.5% per year since 1978 and stood at 5 241 864 in 2013.¹⁹

Figure 2: Change in the number of vehicles on the road and the number of driver's licence-holders in Québec (1978-2013)



Source: Société de l'assurance automobile du Québec.

At the same time, the total number of vehicles on the road in the province has also increased, on average, by 2.1% per year since 1978, for a total of 6.2 million vehicles, including 4.5 million passenger vehicles (light trucks and automobiles), 8 286 taxis, 8 159 buses and 10 335 school buses. The proportion of automobiles in the light-duty vehicle fleet fell from 76% in 2000 to 67% in 2013.²⁰

¹⁹ Société de l'assurance automobile du Québec (2013), *Données et statistiques 2013* [online] [saaq.gouv.qc.ca/publications/nous/statistiques2013.pdf] (consulted on March 13, 2015).

²⁰ *Idem.*

4.1.1 - Light-duty vehicles

Growth in the light-duty vehicle fleet has outstripped that in the population. Indeed, between 2000 and 2009, the number of motor vehicles increased by 24%, as against 5.8% population growth. During the same period, the motorization rate of the population thus increased from 458 vehicles per 1 000 inhabitants to 537.²¹

In Québec, a car travels, on average, 14 300 km annually.²² Between 1990 and 2011, the average distance declined by 10% in the case of cars and 9% in the case of light trucks (including SUVs).²³ The reduction is attributable to an increase in the number of vehicles in Québec households.

The vehicle occupancy rate in the Montréal and Québec City regions stands at 1.2 persons per vehicle.²⁴⁻²⁵

4.1.2 - Public transit

Buses and commuter trains

In major cities, public transit is essential to ensure smooth travel. In addition to its economic role in enabling workers to travel, it fulfils a significant social function, in particular by enabling clienteles who do not possess a driver's licence or who do not own a vehicle—young people, seniors, the disabled or simply individuals who choose not to do so—to travel.

In Québec's big cities, public transit is provided by public transit companies and the Agence métropolitaine de transport (AMT). In periurban areas and rural communities, the municipalities or groups of municipalities offer such services, e.g. intermunicipal transit authorities in the Montréal area, which assign the operation of their services to private carriers. In addition to the Métro network and the five commuter train lines in Greater Montréal, buses and taxis provide public transit.

²¹ Société de l'assurance automobile du Québec (2013), *Données et statistiques 2013* [online] [saaq.gouv.qc.ca/documents/documents_pdf/nous/donnees_statistiques.php] (consulted on March 30, 2015). Institut de la statistique du Québec (2009), *Le bilan démographique du Québec 2009* [online] [stat.gouv.qc.ca/statistiques/population-demographie/bilan2009.pdf] (consulted on March 30, 2015).

²² Natural Resources Canada (2010), *2008 Canadian Vehicle Survey Update Report*, 39 pages.

²³ HEC (2015), *État de l'énergie au Québec*, 33 pages.

²⁴ Société de transport de Montréal (2013), *La mobilité des personnes dans la région de Montréal*, highlights, 26 pages.

²⁵ Réseau de transport de la Capitale, Société de transport de Lévis and Communauté métropolitaine de Québec (2011), *La mobilité des personnes dans la région de Québec*, highlights, household survey section, 39 pages.

Table 2: The organization of public transit in Québec cities²⁶

Type of region	Entity (metropolitan area, urban agglomerations or transportation agencies)
Metropolitan areas served by a public transit authority (PTA)	Montréal area: three PTAs, the Agence métropolitaine de transport and 12 intermunicipal transit authorities Capitale-Nationale region: two PTAs (the RTC and the STLévis) The Gatineau, Sherbrooke, Saguenay and Trois-Rivières areas: one PTA per region
Urban agglomerations served by a municipal or intermunicipal transit authority	The Drummondville, Granby, Rouyn-Noranda, Baie-Comeau, Rimouski, Victoriaville, Val-d'Or, Salaberry-de-Valleyfield, Sept-Îles, Shawinigan, Saint-Georges and Thetford Mines urban agglomerations
Urban agglomerations not served by a municipal or intermunicipal transit authority	Alma, Rivière-du-Loup, Amos, Matane, La Tuque, Dolbeau-Mistassini, Cowansville and Lachute There is no municipal or intermunicipal transit authority in the regions but the regional county municipality (RCM) may organize a rural or regional public transportation service

Source: Ministère des Transports du Québec.

Park-and-ride lots and reserved lanes reduce the number of vehicles on roads, which enhances the smoothness of travel and contributes to decongesting urban areas. The Québec government recently began to fully fund reserved lanes.

Carsharing services

Carsharing services or self-service cars are advanced mobility services that offer the flexibility of a car but eliminate for users the need to own one. The vehicles can be reserved on an hourly or daily basis and billing for their use combines the time used and the number of kilometres travelled. This formula replaces, in essence, the ownership of a common consumer good, an automobile, with the sale of a service.²⁷

²⁶ Ministère des Transports du Québec (2013), *Politique de mobilité durable*, consultation paper, Québec, 60 pages.

²⁷ Benoit Robert (2005), *Recueil de textes sur Communauto inc. : le plus ancien service d'auto-partage en Amérique du Nord* [online] [communauto.com/images/RecueilDeTextes.pdf] (consulted on March 19).

Box 1: The impact of carsharing services on fuel consumption and greenhouse gas emissions

Carsharing services are growing rapidly in the world. A presentation by Frost and Sullivan indicates that their popularity is growing by roughly 40% a year.

Communauto in Québec launched the first North America carsharing service. It is established in four Québec cities and has a fleet of 1 200 vehicles. Car2go recently set up operations in Montréal and offers roughly 340 self-service vehicles.

Researchers have attempted to ascertain whether carsharing services help reduce automobile ownership per household and the number of vehicles on the road. A summary of the studies reveals that one shared vehicle can replace between 4 and 13 vehicles, delay or even eliminate the intention to acquire a vehicle among 25% of the services' users, and reduce GHG emissions by more than 25%.

In fact, the users of such a service significantly reduce their motorized trips, better coordinate them and, of necessity, opt more often for active transportation.

In Québec, an analysis of the travel behaviour of households in the Montréal area concluded that the automobile utilization rate is significantly lower than average when households have access to a carsharing service.

Sources: * Frost and Sullivan (2014), *Future of Mobility: Corporate Carsharing* [online] [fr.slideshare.net/FrostandSullivan/corporate-carsharing-3-1814] (consulted on March 23, 2015).

** Scott Le Vine, Alireza Zolfaghari, and John Polak (2014), *Carsharing: Evolution, Challenges and Opportunities*, Centre for Transport Studies, Imperial College London [http://www.acea.be/uploads/publications/SAG_Report_-_Car_Sharing.pdf].

*** Louiselle Sioui, Catherine Morency, Martin Trépanier (2012), "How Carsharing Affects the Travel Behavior of Households: A Case Study of Montreal, Canada", *International Journal of Sustainable Transportation*.

Taxis

The Québec taxi industry encompasses roughly 8 000 taxi owner's licences, 242 licences restricted to the transport of disabled passengers and 309 limousine licences, for a total of 21 000 drivers. A vehicle used as a taxi travels, on average, more than 70 000 km per year. Québec taxis emit 200 000 tonnes of CO₂ annually, for an annual average per vehicle of 25.5 tonnes, compared with 4 tonnes of CO₂ per year, on average, for privately-owned motor vehicles. Taxis thus emit five or six times more carbon dioxide than privately-owned motor vehicles.

Indeed, the fuel consumption of taxis is high because of the nature of stop-and-go traffic and the models of vehicles usually operated. The conventional taxis on the roads in Québec are often mid-sized sedans whose consumption ranges from 11 to 15 L/100 km in the urban environment.²⁸

²⁸ CPCDIT-ITAQ (2013), *Étude de faisabilité — Projet de démonstration de taxis électriques au Québec* [<http://www.itaq.qc.ca/etude-de-faisabilite-projet-de-demonstration-de-taxis-electriques-au-quebec/>].

4.1.3 - Active transportation

Active transportation includes walking, cycling and any other means of travel that requires human effort, including means that involve assistance by an electric motor to compensate a physical disability or limitation, such as an electric power-assisted bicycle, a wheelchair, a four-wheel electric scooter or any other mobility equipment.²⁹

Active transportation has numerous advantages. In particular, it enables individuals who engage in it to remain physically active, thereby affording them an opportunity to affect their health in a positive manner. It is readily accessible, inexpensive and facilitates social contacts, in addition to reducing traffic congestion, noise, odours, air pollution and GHG emissions. It also reduces transportation-related expenses such as gasoline and parking. For this reason, under the Ministère des Transports' *Politique sur le vélo* the government has supported the development of bicycle lanes since 1995.

Québec stands out from the other Canadian provinces and the United States in the realm of active transportation since nearly twice as many Quebecers appear to rely on bicycles for recreational purposes or travel than the North American average. When the urban structure is appropriate, the mode share of active transportation is as significant in Québec as in the European countries. Accordingly, it stood at 38.3% in the Plateau-Mont-Royal district in Montréal (2008), compared with 46% in the Netherlands and 34% in Germany. Furthermore, the number of bicycle trips rose by 33% in Montréal's central neighbourhoods between 2008 and 2013. On the other hand, walking and cycling in the Greater Montréal area account, on average, for barely 13% of travel.

²⁹ Public Health Agency of Canada (2005), *What is Active Transportation?* [online] [<http://www.phac-aspc.gc.ca/hp-ps/hl-mvs/pa-ap/at-ta-eng.php>] (consulted on March 18, 2015).

4.2 - TRAVEL PATTERNS³⁰

In 2006, in Québec, 78.2% of workers used an automobile to go to work.³¹ This trip purpose accounts for roughly half of all trips. The average distance between the home and the workplace is rising gradually. Accordingly, between 1996 and 2006, the median distance travelled by workers increased from 6.9 km to 7.8 km.³² The distance, combined with increased congestion, is substantially lengthening commuting time, which stands, on average, at 22 minutes in Québec City, 19 minutes in Sherbrooke and 30 minutes in Montréal. In the latter region, the breakdown shows that workers who rely on buses take, on average, 40 minutes, those who use the Métro, 44 minutes, and motorists, 24 minutes.³³

4.2.1 - Mode share of means of transportation

In recent years, a reduction has been noted in the mode share of active transportation (walking and cycling) in favour of solo car use and mass transit. Indeed, in Canada the proportion of workers who walk to work declined from 6.4% in 2006 to 5.7% in 2011 while the proportion of commuters cycling to work remained stable at 1.3%.³⁴ The same phenomenon is observable in the Québec, Montréal and Sherbrooke areas.

In Canada, in 2011, 12% of workers used mass transit to go to work compared with 11% in 2006. Figure 3 indicates the proportion of commuters who use mass transit in big Canadian cities.

³⁰ Origin-destination surveys offer a profile of travel patterns in metropolitan cores by all modes of transportation in order to adapt transportation policies and projects to genuine public needs. The results of recent surveys in Montréal (2013), Sherbrooke (2012) and Québec City (2011) are available online.

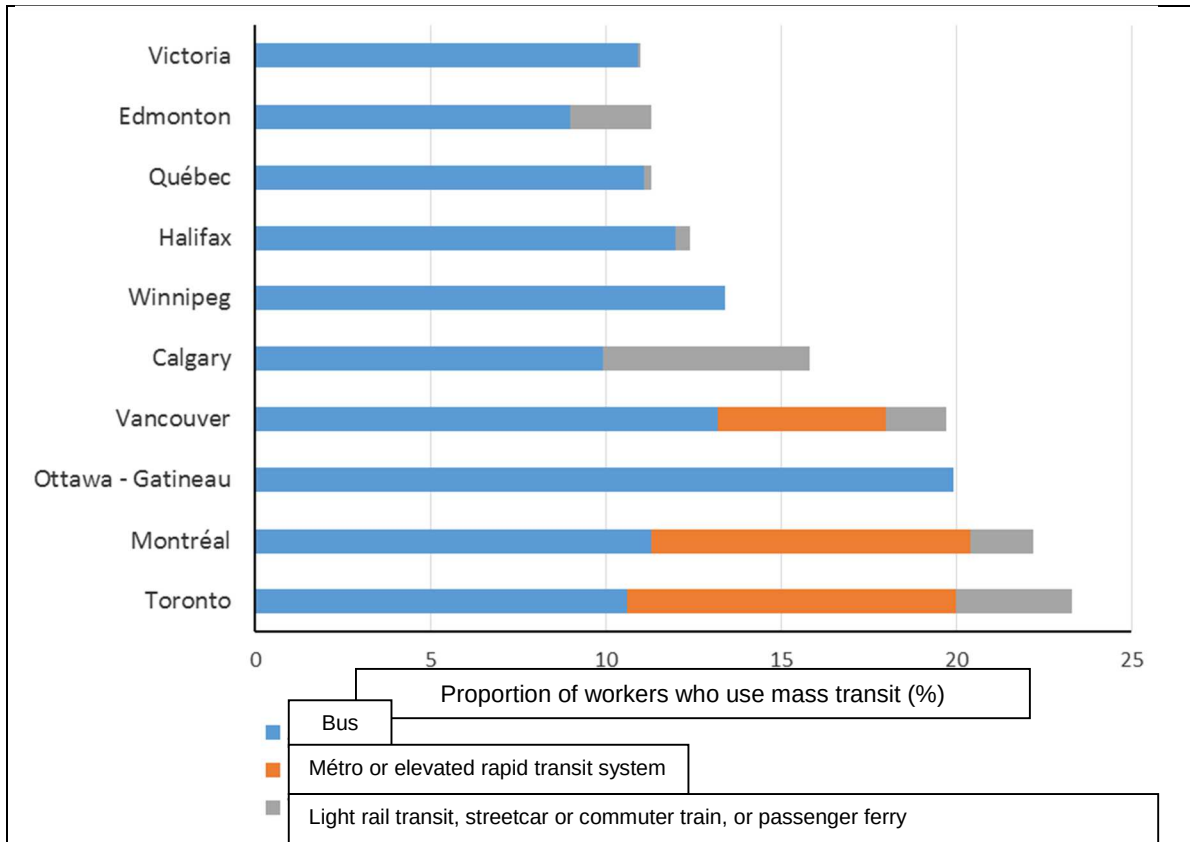
³¹ Statistics Canada (2008), *Commuting Patterns and Places of Work of Canadians, 2006 Census: Findings*, Ottawa, 44 pages.

³² *Idem*.

³³ Statistics Canada (2015), *Commuting to work* [online] [www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-012-x/99-012-x2011003_1-eng.cfm] (consulted on March 16, 2015).

³⁴ *Idem*.

Figure 3: Proportion of workers who use mass transit to go to work, by census metropolitan area, in 2011³⁵



Source: Statistics Canada.

4.3 - FREIGHT TRANSPORTATION

In 2013 there were 135 458 trucks and fifth-wheel tractors registered in Québec.³⁶ It is estimated that 37% of the vehicles were fifth-wheel tractors and that the remaining 63% were straight trucks.³⁷

Total intercity travel for all types of truck registration and the total distance travelled on Québec roads should increase by 40% by 2026, to 400 000 trips and 143.6 million km per week.³⁸

³⁵ *Idem.*

³⁶ SAAQ, *Bilan 2013 des taxis, des autobus, des camions lourds et des tracteurs routiers.*

³⁷ Special MTQ compilation.

³⁸ CPCS (2013), *Étude multimodale sur le transport des marchandises au Québec*, study conducted on behalf of the MTQ.

The energy efficiency of trucks is improving constantly. Accordingly, in 2012, despite a higher volume of activity, heavy goods vehicles consumed 2.5% less energy than the preceding year.³⁹

³⁹ MTQ, Section statistiques camionnage [online] [mtq.gouv.qc.ca/centredocumentation/Documents/Usagers/Véhicule%20lourd/statistiques/Deplacements_camions_2006-2007.pdf].

5 - ALTERNATIVE FUELS

The challenge posed by the decarbonization of motorized trips has encouraged numerous businesses to develop new vehicle motorization and energy supply solutions. Gasoline and diesel, fuel petroleum products used in internal combustion engines (ICEs), serve as a reference point.

While this form of energy has conquered the planet since its discovery 150 years ago, it offers numerous, decisive advantages:

- its liquid state makes it easy to handle, transport and transfer from one tank to another;
- it does not freeze;
- it offers very high energy density both from the standpoint of weight and volume;
- it is chemically stable;
- it is, moreover, available in abundance.

No other fuel or energy vector offers all of these qualities. The success of petroleum products in supporting industrialization and economic growth has engendered a worldwide problem: the likely warming of the planet's temperature, which is threatening the balance of the biological and geoclimatic systems that sustain life as we know it.

This section briefly presents the main forms of energy and motorization that facilitate passenger and freight transportation while very substantially reducing dependence on petroleum products and, consequently, reducing GHG emissions.

The key challenge to developing a competitive "fuel" is not simply technological in nature. Several factors must be considered to replace fossil fuels, including the weight and volume of the fuel, or what takes the place of them, and the weight and volume of the tank, which consumers expect to contain sufficient energy to travel 500 km. The other crucial factor in a consumer-user-payer's decision to opt for a fuel is the time it takes to fill up the tank.

Gases or liquefied products compressed under high pressure demand fairly big tanks and are roughly four times heavier than a full gasoline tank. The filling time, on the other hand, is comparable to that for fuel petroleum products. As for electrochemical batteries, the volume and weight of the energy reservoir are 15 and 20 times bigger, respectively, than for fossil fuels and a quick charge away from home lasts roughly 30 minutes for a full charge using a 400-V DC fast-charging station.

A number of other factors obviously come into play in communities, including safety at all stages, supply guarantees, accessibility in the territory, an array of environmental and social consequences, the cost of the public resources required to establish a valid distribution network, and the positive economic, social and environmental spinoff anticipated at home and elsewhere from any of these forms of energy.

5.1 - FOSSIL FUELS AND INTERNAL COMBUSTION ENGINES

5.1.1 - Background

In Québec, more than 98% of light-duty vehicles use gasoline while 95% of heavy-duty vehicles, trucks, buses, and machinery run on diesel fuel. The internal combustion engines in such vehicles hinge on a technology developed in the mid-19th century. Since then, they have been subject to constant improvement that is enhancing their energy efficiency ratio (GHG reduction) or other characteristics (smoothness of operation and reduction of weight, noise and pollutants such as NO_x, SO_x, HC and CO).

The maximum energy efficiency ratio of the ICE is, however, limited to roughly 35% in the case of spark-ignition (gasoline) engines and 45% as regards compression-ignition (diesel) engines.

The final energy yield in a light-duty vehicle powered by an ICE stands at between 10% and 15%. In the case of a heavy-duty vehicle, the yield falls between 5% and 10%. The acceptance of such a low energy efficiency ratio is possible through the combined effect of two factors:

- 1) fuel petroleum products have a high energy density;
- 2) historically, crude oil has been an energy source accessible at very low cost, on the order of several dollars a barrel. Even now, the reserves in Saudi Arabia, the world's foremost producer, are being developed at a cost of less than \$10 a barrel.

5.1.2 - Requisite distribution infrastructure

The fuel petroleum product distribution system is well established and relies on roughly 2 900 service stations in Québec, half of which supply diesel fuel. Mega service stations reserved for heavy trucks are also found along highways. Tank trucks supply all of these sales outlets, mainly from the Suncor refineries in Montréal-East and the Énergie Valero refineries in Lévis.

5.1.3 - Energy efficiency and GHG emissions

The regulation of the fuel consumption and GHG emissions of light-duty vehicles is the main means by which American and Canadian governments encourage automakers to market fuel-efficient vehicles. The situation is similar with regard to heavy-duty vehicles, in respect of which regulations governing fuel consumption and GHG emissions are in force in the United States and Canada for the period 2014-2018. Talks are under way with the industry for a second phase covering the period 2018-2024.

5.1.4 - Potential contribution to the decarbonization of road transport

Under the impetus of governments, automakers continue to invest in the improvement of the ICE and overall vehicle performance. The following are examples of technologies that automakers have introduced to comply with regulations:

- the direct injection of fuel in the cylinder;
- the addition of a turbocompressor to provide occasional bursts of power and that reduces the engine displacement;
- the use of light materials such as aluminum;
- hybrid technology, which combines gasoline and electric motorization and thus achieves considerable gains.

5.2 - BIOFUELS

5.2.1 - Background

Biofuels, which are produced from organic matter, can replace gasoline (ethanol) or diesel (renewable diesel fuel). In Canada, gasoline must contain, on average, 5% renewable fuels and diesel fuel, 2%, pursuant to Environment Canada's *Renewable Fuels Regulations*. In the United States, under the *Renewable Fuel Standard* (RFS), the proportion of ethanol is now approximately 10% for gasoline and 2% for renewable diesel fuel.⁴⁰ The figures should increase significantly with the advent of technologies that allow for the production of fuels from cellulosic biomass.

In the United States, 80% of gasoline-powered vehicles can use up to 15% ethanol (E15). Some 7% of light-duty vehicles operate on flex fuel,⁴¹ i.e. they can use a mixture comprising up to 85% ethanol. As for compression-ignition (diesel) engines, most engine manufacturers honour warranties on up to 20% (B20). Certain manufacturers even allow the use of pure renewable diesel fuel, i.e. B100.⁴² Accordingly, it can be asserted that the North American automotive industry has adapted to the use of biofuels.

It is also possible to use biogas derived from the digestion of organic matter to produce renewable natural gas, which is used in vehicles that are converted to use this gaseous fuel. This is the case with Québec residual material management firms that use biogas derived from their own technical landfill sites to operate their garbage trucks and to offer it to their clientele through a filling station open to the public.

⁴⁰ USEPA (2014), *EPA Proposes 2014 Renewable Fuel Standards*, 2015 Biomass-Based Diesel Volume, 4 pages.

⁴¹ USDOE, *Flexible Fuel Vehicles* [online] [afdc.energy.gov/vehicles/flexible_fuel.html] (consulted on March 30, 2015).

⁴² Federal Equipment Company, OEM Statement Summary Chart [online] [biodiesel.org/using-biodiesel/oem-information/oem-statement-summary-chart] (consulted on March 30, 2015).

5.2.2 - Requisite distribution infrastructure

Biofuels are usually integrated into the distribution structure of petroleum products. Accordingly, ethanol and renewable diesel fuel are either blended at the refinery or by a wholesaler then shipped to service stations for retail sale. There are still no service stations in Québec that offer 85% ethanol fuel but there are 2 600 such outlets in the United States.⁴³

Biodiesel (fatty acid methyl esters [FAME]) producers in Québec also directly sell their product to truck fleets or construction companies to enable this clientele to benefit from incentive-based pricing.

5.2.3 - Energy efficiency and GHG emissions

Biofuels have a lower energy density than fossil fuels (33% less for ethanol in relation to gasoline and 10% less for renewable diesel), which reduces accordingly the distance travelled using the same volume of fuel. GHG emission reduction stands at roughly 50% or even more.⁴⁴ Biofuels also emit less pollutants such as sulphur or fine particles and, in the event of spills, have more limited environmental impacts.

5.2.4 - Potential contribution to the decarbonization of road transport

Biofuels offer a partial solution to the gradual decarbonization of road transport. Québec possesses biodiesel (FAME) production infrastructure of roughly 80 million litres per year, which is mainly exported, since imports of hydrogenation-derived renewable diesel (HDRD) satisfy 90% of the Québec market. In the same way, Québec's ethanol production capacity stands at 175 million litres per year and is consumed locally. Roughly 300 million litres must nonetheless be imported from Brazil or the United States to attain the federal target of 5% ethanol in gasoline.

The corn and waste vegetable oils used to produce the fuels are available in limited quantities in Québec. On the other hand, sources of cellulosic biomass such as urban and industrial residual materials and forest and agricultural biomass could be developed to satisfy the local biofuels market and to supply the export market.

Broader reliance on renewable biofuels produced locally would reduce GHG emissions and the trade deficit stemming from oil imports to produce fuels. In the road transport sector alone, bearing in mind imports, exports and interprovincial trade in crude oil and petroleum products, according to Ministère de l'Énergie et des Ressources naturelles estimates the total net deficit stood at roughly \$9.2 billion in 2012.

⁴³ USDOE, Ethanol Fueling Station Locations [online] [afdc.energy.gov/fuels/ethanol_locations.html] (consulted on March 30, 2015).

⁴⁴ (S&T) Consultants Inc. (2010), *Analysis of Biofuel Pathways Using GHGenius*, 146 pages.

5.3 - COMPRESSED OR LIQUEFIED GASEOUS FUELS

5.3.1 - Background

Propane and compressed natural gas (CNG) or liquefied natural gas (LNG) are fossil fuels used mainly to operate heavy-duty vehicles.⁴⁵ However, they have the advantage of emitting less GHG and costing less than diesel fuel.

In the propane gas industry, there is currently only one technology applicable to diesel-powered trucks, which consists in installing a conversion kit whose cost is closely linked to that of the propane gas tank.

As for natural gas and heavy-duty vehicles, the market offers two technologies for new class 7 and class 8 trucks. The first technology uses 100% CNG and requires neither a catalytic converter nor a particle trap on the exhaust. The second technology uses 95% LNG.

It is also possible in existing vehicles to replace up to 50% of diesel fuel with natural gas (CNG or LNG) injected into the intake manifold. The cost of the latter option is appreciably lower than the cost of the two technologies adapted to new trucks.

5.3.2 - Requisite distribution infrastructure

Compressed or liquefied gaseous fuels (propane, CNG and LNG) require a separate distribution network, mainly to satisfy cost constraints related to the installation of filling stations.

In the case of propane, a distribution network exists in Québec with 250 filling stations spread throughout the heavily inhabited territory. New filling stations can be installed quickly and are relatively inexpensive.

The refilling infrastructure required for compressed natural gas is costly, mainly because of the need for a compressor. Québec now has 10 private and public filling stations. The natural gas distribution network can supply the filling stations.

Liquefied natural gas filling infrastructure requires, among other things, the installation of a compressor and cryogenic storage. Québec now has five LNG fuelling stations.

An appreciably more extensive network must be planned for each of three forms of energy to satisfy significant demand for fuel. Indeed, this is the key obstacle highlighted by potential users when the time comes to examine the operating conditions pertaining to a new energy sector for road transport.

⁴⁵ Light-duty vehicles are also suited to conversion to propane in the current vehicle market. However, the fuel tank must occupy sufficient space that does not unduly restrict transport volume. Consequently, pickup trucks used for commercial purposes are the most favourable market. Moreover, American automakers are confining to several models of pickup trucks their offerings of light-duty vehicles that run on compressed natural gas. Lastly, no light-duty vehicle is equipped to run on liquefied natural gas.

Box 2: The Blue Corridor

The Blue Corridor is the first freight transportation corridor using liquefied natural gas vehicles in Canada. It follows highways 20 and 401 between the Québec City area and the Toronto area. Each week, roughly 49 000 heavy-duty vehicle trips occur on this section of highway.

Developed under the impetus of Gaz Métro Solutions Transport (GMST), the Blue Corridor now comprises five refuelling stations along highways 20 and 401:

- two private refuelling stations at Robert Transport in Boucherville and in Mississauga;
- three public refuelling stations opened over the past year in Lévis, Sainte-Julie and Cornwall, Ontario.

All told, the Blue Corridor supplies 138 heavy trucks belonging to six firms with LNG. The Blue Corridor development strategy is ongoing and is adding natural gas refuelling stations in a strategic, flexible manner and according to market needs. A sixth refuelling station will open this year in Rivière-du-Loup.

Compressed natural gas

A second natural gas distribution network to deliver compressed natural gas is being developed at the same time to supply heavy goods vehicles, mainly specialized transportation services for the collection of residual and recyclable materials. Approximately 136 collection trucks using CNG are now operating in Québec and are served by 10 fuelling stations, two of which are private.

Source: Gaz Métro.

5.3.3 - Energy efficiency and GHG emissions

The energy consumption of propane and natural gas is more or less the same as that of diesel fuel, despite a lower energy density than gasoline or diesel fuel. However, there is one exception to the rule, i.e. a diesel engine converted into a spark-ignition engine (with sparkplugs) to consume compressed natural gas.

Furthermore, other technologies are available or about to become available to use compressed natural gas in a compression-ignition (diesel) engine and thus maintain the high level of energy efficiency.

When propane or natural gas are used as the main fuel, GHG emissions are reduced by between 17% and 25%. When gaseous fuels are used in dual-fuel vehicles, essentially with diesel fuel, GHG emissions are reduced, but to a lesser extent, by roughly 10% since the proportion of gas varies from 30% to 50%.

5.3.4 - Potential contribution to the decarbonization of road transport

Compressed natural gas can offer users and suppliers sound profitability in medium-sized and heavy vehicles that travel long distances—more than 150 000 km per year—or subject to intensive use, such as trucks that collect residual matter.

Propane can achieve worthwhile profitability for all types of light-duty vehicles on which it is possible to install a conversion kit and tank and that travel more than 25 000 km per year.

In the case of dual-fuel conversion kits—propane-diesel, CNG-diesel, LNG-diesel—all heavy-duty vehicles equipped with a compression-ignition (diesel) engine can be equipped with such a kit, but the desired profitability will apply to vehicles less than three years old that travel a minimum of 100 000 km per year.

5.4 - ELECTRICITY

5.4.1 - Background

In late February 2015, there were 5 459 partially or wholly electric vehicles on Québec roads. Car dealers offer more than 10 models.

Rechargeable hybrid vehicles are equipped with electric motors and gasoline engines, which operate simultaneously or alternately, depending on driving conditions, and the battery can be recharged using an external electrical outlet. The vehicles have an electric range of roughly 30 km. The rechargeable Prius, the Ford C-Max Energi and the Ford Fusion Energi are examples of rechargeable hybrid vehicles.

Electric vehicles with extended range are equipped with electric motors and internal combustion engines that generate electricity for the electric motor once the battery has reached its minimum discharge threshold and thus extend the vehicle's range. An external electric supply source is required to fully charge the battery. The vehicle's range in electric mode can reach up to 60 km. The Chevrolet Volt and the BMW i3, whose range extender is available as an option, are examples of such vehicles.

Fully electric vehicles operate without fossil fuels. They are equipped with a high-capacity battery that allows a range of from 100 km to 335 km for the Tesla S. The Nissan Leaf, Kia Soul EV, Smart Fortwo, Mitsubishi iMiEV, Ford Focus, Chevrolet Spark and BMW i3 are the other fully electric vehicles.

Some 99% of the electricity generated in Québec is from renewable sources and this energy source emits virtually no GHG. Electric vehicles consume 3.5 times less energy than gasoline-powered vehicles and the price of electrical energy is lower than that of fossil energies. All told, in Québec, the energy to operate an electric vehicle costs roughly one-fifth of that needed to operate a gasoline-powered vehicle. On the other hand, the price of electric vehicles is significantly higher than that of comparable gasoline-powered cars, which means that it takes longer to achieve the economic profitability of the investment.

5.4.2 - Requisite distribution infrastructure

The recharging infrastructure consists in installing electric charging stations at the appropriate locations, such as at home, in the workplace, in public places and along main roads. Given the fairly limited range of most models of electric vehicles now available, to ensure the peace of mind of motorists, the density of public electric charging stations must be high. At present, the public network comprises more than 500 240-V electric vehicle charging stations in three networks: the Electric Circuit, the VERnetwork and the Sun Country Highway. Other charging station networks will increase offerings in the coming months.

The recharging stations are less imposing than gas stations. They rely on the existing electrical power grid and, consequently, are inexpensive from the standpoint of equipment and installation costs.

5.4.3 - Energy efficiency and GHG emissions

With the hydropower option, the energy and environmental efficiency of rechargeable electric vehicles is by far superior to other options. The hydropower option generates virtually no GHG emissions and no pollutant emissions whatsoever. On the other hand, considerable amounts of metals and fairly scarce resources are required to manufacture batteries.

The main component to be improved is the battery, which has two significant limitations: range, especially in the winter, and overly long recharging times.

5.4.4 - Potential contribution to the decarbonization of road transport

The electric vehicle option, especially light-duty vehicles, can contribute significantly to the enhancement of the carbon dioxide footprint of road transport in Québec. This contribution will develop gradually under the impetus of perceptual and cultural changes in the clientele.

What is more, the offerings of automakers are still scarcely diversified and are, above all, limited from the standpoint of delivery in Québec, which is curtailing the genuine impact of this solution.

5.5 - HYDROGEN

5.5.1 - Background

While the market for hydrogen-powered road vehicles is not significant, a number of automakers have adopted this option. Hydrogen is not available in the environment and must be produced industrially.

Hydrogen-powered vehicles are electric motor vehicles similar to electric or hybrid vehicles. The process consists in using gaseous hydrogen from the tank as a “fuel” to supply a fuel cell that produces electricity to feed one or more electric motors in the vehicle.

While the fuel cell supplies an electric motor like a battery, the main advantages of hydrogen as an energy vector relate to the vehicle's range, which appears to be comparable to that of gasoline-powered vehicles, and the equally comparable filling time. The tank is filled using equipment similar to that used to fill a propane cylinder for a barbecue.

5.5.2 - Requisite distribution infrastructure

The infrastructure required to use hydrogen as a fuel is similar to that used for compressed natural gas or propane. There is only one such distribution outlet in Québec, located in Trois-Rivières, while such outlets are developing rapidly in California, the New England states and New York State and New Jersey. The cost of a filling station is fairly high, i.e. \$1.5 million to \$2 million.

A network of filling stations, modeled on the growing network for liquefied natural gas with 20 stations divided between Montréal and Québec City, is necessary to enable this vehicle option to expand in Québec.

5.5.3 - Energy efficiency and GHG emissions

Despite the current 70% conversion rate from electricity to hydrogen,⁴⁶ the overall yield from well to wheel of this option is one of the best in relation to other energy options in the road transport sector, after rechargeable electric vehicles.

The use of hydrogen with a fuel cell in road vehicles represents a GHG emission reduction of nearly 100% when hydrogen is produced from a clean energy source such as hydroelectricity or wind energy. However, the energy losses in this process are more significant than those observed in direct supply by batteries in electric vehicles. Hydrogen as a fuel is thus a less viable solution from the standpoint of energy efficiency.

What is more, hydrogen is now usually produced from methane (natural gas), which produces GHG and precludes any environmental interest.

5.5.4 - Potential contribution to the decarbonization of road transport

The electricity-hydrogen-fuel cell option for road vehicles has several advantages:

- the GHG emission rate depends on the energy used to produce and compress the hydrogen at the distribution site;
- filling time is similar to that for fuel petroleum products;
- a range of 500 km that requires a network of filling stations more widely spaced than the electricity option.

⁴⁶ ADEME, GRTGaz and GrDF (2014), *Étude portant sur l'hydrogène et la méthanation comme procédé de valorisation de l'électricité excédentaire*, 238 pages. [ademe.fr/etude-portant-lhydrogene-methanation-comme-procede-valorisation-lelectricite-excedentaire] (consulted on March 31, 2015).

From the standpoint of social acceptability, the public is not sufficiently aware of the hydrogen option to have an opinion on its advantages, drawbacks and the risks that the adoption of this option poses in relation to other types of vehicles with low carbon footprints.

5.6 - SUMMARY

Table 3 sets out three characteristics used to compare energy options: the rates of energy consumption expressed in L/100 km or in L/100 km equivalent, the rates of energy consumption in megajoules (MJ)/km, and GHG emissions in g/km.

The rate of consumption in L/100 km or L/100 km equivalent uses common natural units but is not representative of the state of the fuel, its pressure or volume. On the other hand, the rate of consumption in MJ/km allows for an accurate comparison with units common to all forms of energy.

The GHG emission rate in g/km constitutes a means of comparison between forms of energy and incorporates the characteristics of the forms of energy and the energy of the motorization technology per kilometre travelled.

The table reveals that gaseous fuels are advantageous in relation to petroleum products from the standpoint of GHG emissions, with reductions, in particular, in the heavy truck column.

The table clearly shows the advantages of electricity as regards consumption in L/100 km equivalent, MJ/km and g/km of GHG.

The hydrogen option is efficient in respect of the three characteristics but slightly less so than the electricity option.

Table 4 presents the main advantages and drawbacks of each of the energy options examined.

The question of the distribution network is a constant challenge for each of the forms of energy, except for petroleum products. Thus, propane and electricity already have fairly widespread basic networks. In the case of electricity, electric vehicle charging stations must be provided geared to the locations and the desired speed of charging.

For all other forms of energy, except biofuels, the distribution network must be developed either from a nascent network (CNG, LNG), an established network (propane), or from scratch (hydrogen).

Next, the physical properties of each form of energy either offer advantages, as propane does, or pose significant challenges for gaseous fuels such as CNG and hydrogen. LNG is the exception given the numerous challenges that it poses.

Table 3: Comparison of forms of energy used by type of vehicle

Factors	Form of energy	Type of vehicle					
		Trucks	Light truck		Medium-sized trucks	Urban buses	Heavy trucks
			SUVs	Transportation			
Rate of consumption (L/100 km)	Oil	8.4	11.3	11.4	22.4	55.0	31.7
	CNG	-	-	-	22.6	55.6	32.0
	LNG	-	-	-	-	-	32.0
	Propane	-	15.6	15.7	-	-	37.4
	Electricity	2.1	-	-	-	10.1	-
	Hydrogen	3.8	-	-	-	52.9	-
Rates of energy consumption (MJ/km)	Oil	2.9	3.9	4.0	8.6	21.1	12.1
	CNG	-	-	-	8.7	21.3	12.1
	LNG	-	-	-	-	-	12.1
	Propane	-	3.9	4.0	-	-	12.1
	Electricity	0.72	-	-	-	3.6	-
	Hydrogen	1.2	-	-	-	20.2	-
GHG emissions (g/km)	Oil	198.3	266.8	269.2	624.9	1534.4	884.4
	CNG	-	-	-	427.8	1050.4	605.4
	LNG	-	-	-	-	-	619.8
	Propane	-	240.4	242.5	-	-	834.1
	Electricity	0.0	-	-	-	0.0	-
	Hydrogen	0.0	-	-	-	0.0	-

Source: Ministère de l'Énergie et des Ressources naturelles compilation.

Table 4: Advantages and drawbacks of alternative fuels

Fuel	Advantages	Drawbacks
Oil (gasoline and diesel)	▪ Range not comparable ▪ Well established distribution network ▪ Proven mechanical engineering	▪ High GHG emissions and pollutants ▪ Cold starting difficult for diesel engines
Compressed natural gas	▪ Moderate range ▪ Lower energy costs ▪ Reduced GHG emissions ▪ Low additional cost of the vehicle	▪ Limited distribution network ▪ Low energy density
Liquefied natural gas	▪ Considerable range ▪ Lower energy costs ▪ Reduced GHG emissions	▪ Limited distribution network ▪ High additional cost of the vehicle
Propane	▪ Considerable range ▪ Extensive distribution network ▪ Lower energy costs ▪ Reduced GHG emissions	▪ Average energy density
Electricity	▪ Low consumption ▪ Low energy costs ▪ No GHG emissions	▪ Limited range ▪ Limited distribution network ▪ High additional cost of the vehicle ▪ Longer recharging time
Hydrogen	▪ Considerable range ▪ No GHG emissions if produced using non-emitting electricity ▪ Short recharging time	▪ No distribution network ▪ High additional cost of the vehicle

6 - AVOID MOTORIZED TRIPS

6.1 - PASSENGER TRANSPORTATION

Current land-use planning in North America largely promotes low-density monofunctional urban sprawl. In Canada, between 1971 and 2001, metropolitan areas experienced average population growth of 74%. However, during the same period, their geographic size increased on average by 137% and their average density decreased by 29%.⁴⁷

Urban sprawl marks a trend in urbanization and reflects the difficulty of linking transportation and land-use planning. This type of planning, which also appears in cities and towns, engenders low-density settlement, the segregation and polarization of uses, dependence on automobiles and oil, greater distances than previously between homes and workplaces, businesses and services, greater numbers of motorized trips, growing time lost through congestion, increased infrastructure spending, and often less attractive central sectors (vacant lots or derelict buildings).

6.1.1 - Description of measures to avoid trips

The limitation of the number and length of trips and the diversification of means of travel are usually contemplated according to two main types of strategies:

- 1) the consolidation of city centres and central neighbourhoods, inside which eco-neighbourhoods, in particular, can be developed;
- 2) the increasing concentration of population and the diversification of uses in peripheral urbanized areas, within which can be built transit-oriented development (TOD) neighbourhoods.⁴⁸

The consolidation and revitalization of city centres and central neighbourhoods

There is a persistent trend throughout North America to revitalize and repopulate city centres and central neighbourhoods. The trend is apparent more specifically in the development of new residential spaces, the realization of projects centred on commerce and entertainment, and the maintenance of demand for office space. Aside from recycling buildings or the occasional densification of population, the development of such neighbourhoods often hinges on the reallocation mainly for residential purposes of huge industrial or institutional lots. While they can also be applied on the periphery of the urbanized area, the principles of development linked to the notion of the eco-neighbourhood are fully applied in city centres and central neighbourhoods.

⁴⁷ Commission municipale du Québec, 2006.

⁴⁸ Ministère des Affaires municipales, du Loisir et du Sport (2004), *La réduction des émissions de gaz à effet de serre et l'aménagement du territoire*, Québec, 70 pages.

The development principles concern, in particular:

- the consolidation and contiguity of urbanization;
- the protection of agri-environments and natural environments;
- the structuring of urbanization and mass transit;
- compactness and density;
- the mix of activities;
- the proximity and diversity of commercial offerings and services;
- the permeability of the urban fabric;
- the priority accorded active travel;
- the environmental and energy performance of buildings.⁴⁹

Aside from the limitation of trips and more extensive reliance on means of transportation other than automobiles, the development of eco-neighbourhoods offers numerous co-benefits such as sound consumption of resources, a more comfortable, congenial living environment, an environment that is more favourable to healthy lifestyles, and lower travel costs for individuals and infrastructure costs assumed by the communities.

Box 3: The adjustment of schedules

The simultaneousness of home-workplace travel is largely responsible for the congestion in transportation networks during rush hour. Staggered work schedules would reduce traffic congestion and GHG emissions. This approach, which France explored in the 1950s, has re-emerged in Europe since the 1990s.

In the early 2000s, trials were conducted in France through collaboration between carriers and the universities. Class starting times were staggered by 15 or 30 minutes and the results observed encouraged the broadening of the practice. A win-win synergy occurs during rush hour. On the one hand, carriers lower their costs by avoiding the operation of additional vehicles during rush hours. Commuters no longer travel in crowded vehicles and do not appear to endure any inconvenience stemming from the adjustment of schedules.

The implementation of adjusted schedules costs very little. Its combination with information and communications technologies (ICT) seems promising with a view to the practice's adaptation to different urban contexts.

Source: Emmanuel Munch (2014), *L'harmonisation des horaires de travail : en finir avec l'heure de pointe?* [online] [metropolitiques.eu/L-harmonisation-des-horaires-de.html] (consulted on March 30, 2015).

⁴⁹ Vivre in ville (2014), *Objectif écoquartiers — Principes et balises pour guider les décideurs et les promoteurs*, 63 pages.

Densification and the diversification of uses in peripheral urbanized areas

In peripheral areas, new urbanization models that affect the scope and means of travel are also emerging, including multi-purpose ensemble projects or soft densification. Multi-purpose ensemble projects include transit-oriented development, an American concept elaborated during the 1990s, which seeks to promote the use of mass transit and carpooling through the establishment of dynamic, multi-purpose neighbourhoods with a radius of 600 m to 1 km on foot from a bus, subway or streetcar station.

Transit-oriented neighbourhoods are high-quality living environments that offer services and businesses that are very well served by public transit. Urban development under this approach is an excellent means of reducing congestion and dependence on the automobile. Aside from the importance attached to structuring urbanization and mass transit, the development of transit-oriented neighbourhoods can readily draw inspiration from the principles specific to eco-neighbourhoods.

Box 4: Transportation costs and determinants of a household's energy consumption

In 2013, Québec households spent, on average, \$10 738 for transportation, which accounts for 21% of total current consumer spending. Indeed, transportation-related spending was, on average, higher than spending on food⁵⁰ and similar to spending on the principal residence.

A study conducted on behalf of the US Environmental Protection Agency analyzed the impact of four variables on household energy consumption.

The findings reveal a 38% reduction in energy consumption in households in transit-oriented neighbourhoods served by mass transit. Without making any particular effort, such households achieve a better energy balance than those in the suburbs living in houses that comply with the latest standards and operating an ecoenergetic vehicle.

Source: US Environmental Protection Agency (2011).

⁵⁰ Statistics Canada, CANSIM, Table 203-0021 and product No. 62F0026M [online] [<http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/famil130f-eng.htm>] (consulted on March 30, 2015).

6.1.2 - The situation in Québec

Eco-neighbourhoods

Because the approach is relatively new, there are few projects in Québec that satisfy the overall principles of eco-neighbourhoods. According to a recent survey by the Ministère des Affaires municipales et de l'Organisation du territoire (MAMOT), projects are planned or being launched, in particular, in Gatineau, Québec City, Rivière-du-Loup, Terrebonne, Victoriaville and Valleyfield.

Transit-oriented development

The establishment of transit-oriented neighbourhoods is one of the priorities of the *Plan métropolitain d'aménagement et de développement* of the Communauté métropolitaine de Montréal (CMM), adopted in 2011.⁵¹

It should be noted that the Québec government and the CMM have granted financial assistance for the planning of seven transit-oriented neighbourhood pilot projects in as many municipalities in Metropolitan Montréal.

6.1.3 - Challenges

The adoption of the urbanization models mentioned earlier raises, among others, two specific challenges:

- receptiveness and the ability to adapt to new methods by the public and private interveners who are developing our living environments;
- the social acceptability of denser, more diversified living environments.

Such challenges exceed the scope of an energy policy aimed at decarbonizing road transport but are part of the requisite comprehensive view.

The sustainable development of the territory offers promising options to remedy or enhance problems linked to passenger transportation. In the medium term, this approach will bolster prosperity and enhance the health and quality of life of society as a whole.

6.2 - FREIGHT TRANSPORTATION

Road freight transportation has grown steadily in recent decades to the detriment of rail and maritime transport. Just-in-time supply management and the development of e-commerce are intensifying recourse to truck transport, which is more flexible and faster. Businesses in this sector are facing growing traffic congestion problems, higher fuel costs and increasingly stringent environmental constraints because of the fight against climate change, which reduces their competitiveness.

⁵¹ CMM (2011), *Plan métropolitain d'aménagement et de développement* (PMAD).

6.2.1 - Description of measures to avoid trips

Transport logistics

Innovation with respect to logistics processes seems to be a promising means of remedying truckers' problems. Studies conducted in Europe and the United States reveal GHG emission reduction exceeding 30% through the adoption of new logistics practices such as the mutualization of transportation services, the pooling of inventories and off-peak travel. However, the generally small size of trucking firms—84% have fewer than 10 employees—limits the capacity of Québec firms to develop sustainable solutions to optimize freight logistics and handling.

Solutions to reduce GHG emissions related to road freight transport are complex and the possibilities for intervention are limited. Innovative approaches are being developed the world over.

Box 5: Reinvent freight transportation through interconnected logistics

Interconnected logistics seeks to mutualize existing logistic networks in order to optimize their operational and energy efficiency and reduce their greenhouse gas emissions. This new approach hinges on the Physical Internet, which transposes to the realm of freight transportation what the digital Internet achieved in the realm of the information and communications technologies. Benoit Montreuil, then the holder of a research chair at Université Laval, introduced the concept of the Physical Internet in 2006. European and America researchers have embraced the concept.

The approach centres, in particular, on collaborative storage centres, road shipments of standardized modular containers that communicate and an Internet-based geolocation system. The approach would ultimately eliminate the existing proprietary freight transportation system and replace it with an open system in which standardized containers would always follow the optimum route.

An interconnected logistics simulation was conducted in 2010-2011 in France through international collaboration by Mines ParisTech (France), Université Laval (Canada), the École Polytechnique Fédérale de Lausanne (Switzerland) and Carrefour and Casino, two major French distributors.

The project focused on 2.5 million trips between the plants of 100 suppliers, warehouses, distribution centres and stores. It revealed that the transition from the existing integrated logistics system to the interconnected logistics system offers the potential to reduce costs by up to 35% by increasing truck loading rates from the current average of 60% to 80%. Lastly, the project achieved a GHG emission reduction on the order of 60%, without hindering delivery times or frequency.

Source: Industrie & Technologies. L'Internet physique : calquer l'organisation des transports sur la structure du Web [online] [industrie-techno.com/l-internet-physique-calquer-l-organisation-des-transports-sur-la-structure-du-web.12581] (consulted on March 30, 2015).

6.2.2 - The situation in Québec

Initiative 15.2 of the *2013-2020 Climate Change Action Plan* allocates \$5 million to the optimization of freight transportation logistics.

The “logistics project” section of the Écocardionnage assistance program of the Ministère des Transports du Québec, now under development, will support projects that enhance the logistics of road haulage firms.

The Government of Canada has announced its intention to bolster regulations on GHG emissions as regards heavy-duty vehicles and engines manufactured after 2018, thereby extending and broadening the definitive regulation already in force for vehicles from model years 2014 to 2018.⁵²

The anticipated regulation would considerably improve the GHG emissions of heavy-duty vehicles and their engines built after 2018. The types of heavy-duty vehicles affected would include but not be confined to big pickup trucks and minivans, tractors, buses and specialized vehicles such as freight trucks, delivery trucks, service trucks, concrete mixers and dump trucks.

The regulation that applies to the 2014 to 2018 model years will reduce by up to 23% the GHG emissions of heavy-duty vehicles in 2018. The new regulation would further improve emission reductions in vehicles manufactured after 2018.

6.2.3 - Challenges

Collaboration by stakeholders in the sector is necessary in order to contemplate the introduction on a broader scale of new practices. Government measures and programs must be adapted accordingly.

⁵² Government of Canada (2014), *Canada Gazette*, Vol. 148, No. 40, October 4, 2014 [online] [<http://www.gazette.gc.ca/rp-pr/p1/2014/2014-10-04/html/notice-avis-eng.php>] (consulted on April 1, 2015).

7 - SHIFT TO BETTER MODES OF TRAVEL

Initiatives to shift travel seek reliance on more energy efficient modes of transportation from an energy and a societal standpoint, in particular mass transit and, in the case of freight, rail and maritime transport.

7.1 - MASS TRANSIT

7.1.1 - The situation in Québec

Under the impetus of the *Québec Public Transit Policy* (2006-2011), urban mass transit service offers jumped by 24.5% between 2006 and 2011 while ridership increased by 11.5%. The policy thus exceeded its objectives over five years of increasing service offerings by 16% and ridership by 8%. Ridership has continued to grow at a rate of roughly 2% per year while the number of trips recorded has risen even faster (7% in 2013).⁵³

This sound performance is attributable to measures such as improved service and the establishment of park-and-ride lots for commuters and 320 km of reserved bus lanes.

Existing measures

Three financial assistance programs support organizations that offer the public mass transit services.

- The Programme d'aide aux immobilisations en transport en commun of the Société de financement des infrastructures locales du Québec (SOFIL) provides financial assistance for mass transit capital projects. Of the \$1.2 billion earmarked for projects between 2005 and 2014, 67% came from sharing the federal excise tax on gasoline and other federal programs to support mass transit. For the period 2014-2019, the program will have a budget of \$983 million, of which the Québec government will provide 51%.
- The Programme d'aide gouvernementale au transport collectif des personnes (PAGTCP) also supports capital projects as well as the operation of mass transit services. For the period 2015-2025, the *Plan québécois des infrastructures en transport en commun* of the Ministère des Transports calls for nearly \$7.2 billion in investments, including \$5.5 billion from this program. Assistance in respect of operations totals roughly \$26 million per year.

⁵³ MTQ (2014), *Rapport annuel de gestion 2013-2014*, 212 pages.

Note: Data for 2013 are preliminary.

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- The Programme d'aide au développement du transport collectif was established in 2006. Its objective is to enable public transit organizations to broaden transit service offerings, promote the development and use of mass transit in the regions, promote modes of transportation in place of the automobile, and financially support travel management centres in their efforts to support the use of forms of transportation other than automobiles. The program falls directly within the scope of the objective of decarbonizing passenger transportation. In force from January 1 to December 31, 2015, the program has a budget allowance of \$140 million and is funded by the Green Fund.

The government is also intervening by supporting the installation of reserved lanes and the adoption of preferential measures for buses, especially in the Montréal and Québec City areas. Reserved lanes enhance the performance of mass transit and its attractiveness by reducing travel time. In Montréal, they also promote intermodality by linking different means of mass transit such as commuter trains, bus terminals and Métro stations, in addition to the establishment of park-and-ride lots.

7.2 - ACTIVE TRANSPORTATION

7.2.1 - The current situation

According to Vélo Québec in its report on cycling in 2010 in Québec:⁵⁴

- in 2010, more than half of Quebecers between the ages of 18 and 74 said they used a bicycle for recreational or utilitarian purposes;
- in 2000, 20% of adult cyclists made occasional or daily use of a bicycle as a mode of transportation. In 2012, this proportion rose to 37%. Accordingly, 372 000 cyclists use a bicycle as the main means of transportation from May to September. When occasional cyclists are added, nearly 1.3 million cyclists rely on a bicycle for utilitarian travel;
- while climatic and urban conditions make winter cycling sometimes perilous, the activity is gaining in popularity. Québec apparently has more than 50 000 year-round cyclists.

Walking also accounts for a considerable share of active travel although a number of very high- or very low-density urban environments are poorly suited to it.

Existing measures

Under the *Politique sur le vélo* and in light of the objectives of the *2013-2020 Climate Change Action Plan*, the Québec government is encouraging alternative modes of transport to the car such as cycling and walking, which are healthier, more economical, ecological and safe.

⁵⁴ Vélo Québec (2010), *L'état du vélo en 2010* [online] [velo.qc.ca/fr/expertise/Etat-du-velo/etat-du-velo-au-Quebec-2010] (consulted on March 27, 2015).

Launched in the fall of 2013, the Véloce program seeks to intensify the establishment of transportation infrastructure that promotes active travel in urban environments and interconnection with the Route verte. In particular, the program supports the development and enhancement of pedestrian and bicycle networks in urban environments.

The Ministère de la Santé et des Services sociaux (MSSS), the Institut national de santé publique du Québec (INSPQ) and the MAMOT have for several years promoted urban planning geared to healthy lifestyles, including walking.

7.2.2 - Challenges

- The attractiveness of mass transit
- Adequate funding for mass transportation infrastructure and cycling infrastructure in urban environments to allow for efficient commuting by workers
- Recognition of the distinction between recreational and tourism infrastructure (the Route verte) and infrastructure geared to making transportation active—both walking and cycling—efficient and safe during rush hour in urban environments
- Enhancement of the pedestrian potential in urban environments and villages

7.3 - FREIGHT TRANSPORTATION

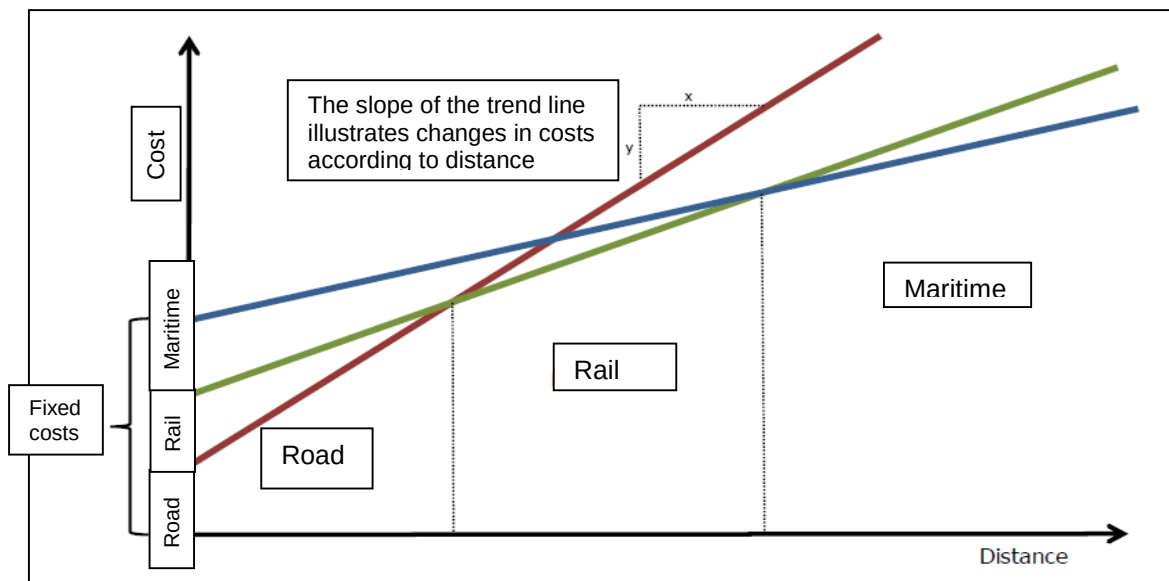
7.3.1 - The situation in Québec

Intermodality and logistics

A study conducted in 2013 on behalf of the Ministère des Transports du Québec designed to evaluate the potential of intermodality revealed, based on a number of criteria linked to the products transported and logistics, the nature and importance of movements of freight carried by truck that can be replaced by another mode of transportation.⁵⁵

⁵⁵ MTQ (2013), *Étude multimodale sur le transport des marchandises au Québec en appui aux PTMD*.

Figure 4: Fixed and variable costs by mode of transportation



Source: Desrosiers Automotive Consultants, *Ventes par constructeur au Québec 1999-2014*, compilation CCAQ.

The findings reveal that only 9% of the trips observed displayed characteristics favourable to modal transfer. Once the trips had been aggregated by regional flows and analyzed according to the total volume of freight and the round-trip balance, the number of potentially intermodal trips fell by 6% of all truck trips. While the figure is small, the volumes concerned are nonetheless big. On the other hand, the analysis of flows reveals that the attainment of the potential for intermodality is uncertain in most instances, for the following reasons:

- the origins and destinations for a of are product are too numerous or dispersed;
- the volume of freight generated by a business is insufficient to benefit from economies of scale and the mutualization of needs, often between competitors, becomes necessary;
- certain distances remain just beyond the established thresholds;
- certain flows seem irregular;
- delivery times and additional costs related to warehousing and handling are often higher for rail and maritime transport than for trucking;
- the specialized equipment required to transport certain products is unavailable;
- there is no regular maritime service and the St. Lawrence Seaway is closed during three winter months for trips to the Great Lakes.

Recourse to trucking is warranted by its more competitive costs in certain situations, its logistics and flexibility that allows for smaller, more frequent shipments.

Box 6: The Ocean Spray cooperative conducts a winning experiment in intermodality

Ocean Spray is an agricultural cooperative specializing in the production of cranberries and fruit juices. Its production sites and plants are located mainly in the northeastern United States, where finished products are shipped by heavy trucks to markets.

Florida supplies the northeastern United States with fresh market garden produce delivered by refrigerated railway cars. Ocean Spray contacted the CSX Railway Company, which was sending empty refrigerated railway cars back to Florida every week, to deliver its own products in Florida. This change in transportation strategy enabled it to achieve a 40% saving in transportation costs, avoid more than 600 truck trips and reduce by 68% the corresponding GHG emissions over one year.

Source: MIT Center for Transportation & Logistics, 2013. Case Studies in Carbon-efficient Logistics, Ocean Spray – Leveraging Distribution Network Redesign. [online] [http://ctl.mit.edu/sites/default/files/library/public/MIT%20CTL%20Ocean%20Spray%20Case%20Study_FNL_0.pdf] (consulted on April 2, 2015).

7.3.2 - Description of measures governing the modal transfer of freight

Under the *2013-2020 Climate Change Action Plan*, the Ministère des Transports du Québec is implementing the Programme visant la réduction ou l'évitement des émissions de GES par le développement du transport intermodal (PREGTI). The program has a \$41-million budget and is supporting the establishment of intermodal projects and the promotion of maritime and rail services.

Box 7: E-commerce and online shopping

E-commerce, a new way of shopping, is leading to a reorganization of travel by consumers, who can now shop without leaving home. The development and optimization of the e-commerce model could contribute significantly to GHG emission reduction.

The findings of a French study that compares trips generated by e-commerce (transportation and delivery) with conventional trips to stores reveal the advantages of e-commerce. The reduction in trips related to e-commerce also includes a number of environmental benefits such as:

- GHG emission reduction;
- a reduction in adverse effects on human health;
- reduced damage to ecosystems;
- a lower average cost per trip for consumers;
- time savings.

Under e-commerce, the consumer's usual trips to stores are replaced by the trips of shippers that more optimally ensure delivery.

Source: École supérieure des technologies industrielles avancées, 2009. *Étude de l'impact environnemental de l'achat sur internet et dans le commerce traditionnel*.

7.3.3 - Challenges

- The competitiveness of alternative transportation
- The rapidity of alternative transportation
- The regularity of flows
- The availability of the equipment necessary to transport certain goods by alternative means
- The navigability of the St. Lawrence River in the winter
- The size of enterprises and the volumes of goods that allow for the attainment of economies of scale

Courtesy Copy

8 - ENHANCE THE PERFORMANCE OF MOTOR VEHICLES

The third area of intervention in the road transport sector is intended to enhance vehicle fuel consumption while reducing the attendant GHG emissions. It therefore seeks to satisfy travel needs by means of more efficient vehicles from an energy and environmental standpoint.

8.1 - PASSENGER TRANSPORTATION

Table 5 presents by theme the key existing and conceivable regulatory, technical or economic and behavioural measures.

8.1.1 - Choice of vehicle

The current situation

In 2014, 420 717 new light-duty vehicles⁵⁶ and 714 620 second-hand light-duty vehicles⁵⁷ were purchased in Québec. Purchasers' preference for sport utility vehicles (SUVs) is a clear trend observed over the past 10 years. Such vehicles accounted for 30.2% of sales in Québec in 2014 and are now more popular than compact cars (29.9%) and subcompact cars (11.5%).⁵⁸

Several factors such as brand reliability, price, safety, comfort, appearance, performance and fuel consumption affect the choice of vehicle. Technological change is occurring gradually in the light-duty vehicle sector as the vehicles are replaced, bearing in mind that their useful life exceeds 10 years.

⁵⁶ Desrosiers Automotive Consultants, *Ventes par constructeur au Québec 1999-2014*, CCAQ compilation.

⁵⁷ Desrosiers Automotive Consultants, *Ventes de véhicules usagés au Québec de 2001-2014 selon la source d'achat*, CCAQ compilation.

⁵⁸ Stéphanie Marin, La Presse canadienne, "Les VUS de plus en plus populaires au Québec," published on March 17, 2015 at 2 p.m. on the La Presse.ca website.

Table 5: Main measures to be considered in passenger transportation

Theme	Current measures	Conceivable measures
Choice of vehicle	Regulatory measures	
	- Emission standards for light-duty vehicles - Emission standards for buses	
	Technical measures	
	Ecoenergetic options	After-sales technologies
	Economic and behavioural measures	
	- Addition2al motor vehicle registration fees - Tools to compare vehicles	Incentives targeting the choice of vehicle
Choice of energy	Regulatory measures	
	Minimal ethanol content	The zero-emission vehicle (ZEV) standard
	Technical measures	
	Alternative energies	
	Economic and behavioural measures	
	- The Drive Electric Program - The Plugged In at Work program - Exemplariness of the government	- Incentives targeting the choice of energy - Support for the implementation of distribution networks
Driving	Regulatory measures	
	- Compulsory fuel-efficient driving courses - Limited idling - Speed limit	
	Technical measures	
	Ecoenergetic options	The use of the information technologies
	Economic and behavioural measures	
		- Pay-for-use - Ongoing training in fuel-efficient driving
Vehicle maintenance	Regulatory measures	
	Mechanical safety inspection	- Compulsory inspection of: - gas emissions of light-duty vehicles - the energy efficiency of vehicles - tire pressure
	Technical measures	
	Scrapping	- Voluntary inspection of the energy efficiency of vehicles - Tire pressure sensors - Choice of tires
	Economic and behavioural measures	
		Awareness campaigns

Emission standards for light-duty vehicles: The Government of Canada will amend the regulations now in force for model years 2011 to 2016 to gradually make more stringent the standards governing GHG emissions for model years 2017 to 2025. Accordingly, light-duty vehicles of the 2025 model year will consume as much as 50% less fuel than those of the 2008 model year. It should be noted that Canada's GHG emission requirements are in line with those of the United States, which are set by the EPA.

Emission standards for buses: The relevant regulation is the one pertaining to heavy-duty vehicles described earlier.

Ecoenergetic options: Certain options offered when a vehicle is purchased significantly reduce fuel consumption, in particular engine displacement and the transmission. Other options inform the motorist about aspects of his driving, such as fuel- consumption indicators.

After-sales technologies: The addition of certain equipment can modify a vehicle in order to reduce its fuel consumption. However, this niche is scarcely developed in the passenger transportation sector.

Additional motor vehicle registration fees: The Société de l'assurance automobile du Québec (SAAQ) collects additional motor vehicle registration fees of up to \$164 per year on vehicles with engine displacements of 4 L or more, in particular to promote the reduction of pollutant emissions from the vehicles and GHG emissions.

Tools to compare vehicles: There are online tools to compare the fuel consumption of new vehicles and to steer consumers to more ecoenergetic choices.

Incentives targeting the choice of vehicle: The choice may be influenced by a discount on the purchase of a less energy-consuming vehicle or an additional cost linked to the vehicle's fuel consumption. Incentives can be paid or collected at the time of purchase through bonus and penalty systems, or in a recurring manner by means of additional motor vehicle registration fees.

Key challenges

- The Québec market and public authorities exert limited influence on automakers' offerings (technological choices) that serve the North American and worldwide market.
- The political acceptability, profitability and efficiency of measures likely to influence individual consumers' choices bearing in mind the high opportunism rate and significant budgetary risks.

8.1.2 - Choice of energy

The current situation

In Canada, road transport mainly relies on motor gasoline (67.1%) and diesel fuel (30%),⁵⁹ fossil fuels that emit GHG. Other fossil energy sources that emit less GHG such as propane and natural gas or renewable energies such as bioethanol and biodiesel can partly or entirely replace gasoline and diesel, with varying degrees of modification to the vehicles. Lastly, certain recent vehicles are equipped with electric motors fed by a rechargeable electrochemical cell, alone or with a gasoline engine. While certain automakers will shortly offer electric vehicles running on a hydrogen-powered fuel cell, this type of vehicle is not yet found on Québec roads.

Minimal ethanol content: Federal regulations stipulate that gasoline must comprise, on average, 5% renewable fuel. The Québec regulation defines the requisite quality to incorporate higher proportions.

The zero-emission vehicle standard: Certain states such as California regulate the sale of zero-emission vehicle (ZEVs). A ZEV standard should set the minimal numbers of battery-powered electric vehicles or vehicles run on hydrogen and fuel cells to be offered and sold in Québec.

Alternative energies: The following table summarizes actual or impending commercial offerings of conceivable energies by type of vehicle.

- ✓ The Cité Mobilité pilot project carried out by the Société de transport de Montréal and Volvo (Nova Bus) consists in testing three electric buses that rely on flash charging by conduction on a route carrying passengers on Montréal streets.
- ✓ The Autobus Lion project consists in operating for a period of nine months six electric vehicles that will travel on various normal school routes and under the same operating conditions as conventional vehicles.

⁵⁹ Natural Resources Canada, Transportation Sector, Table 9: Road Transportation Secondary Energy Use and GHG Emissions by Energy Source [online] [<http://oee.rncan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP§or=tran&juris=ab&rn=9&page=4&attr=0>] (consulted on March 26, 2015).

The Drive Electric Program: Under the program, the Ministère de l'Énergie et des Ressources naturelles offers a discount on the purchase or long-term leasing of an electric or hybrid vehicle and for the purchase and installation of a home charging station. It is targeting the addition of 10 200 electric vehicles on Québec roads by December 31, 2016.

Cumulative results as of December 31, 2014

- ✓ **5 250 electric vehicles**, including **1 969 all-electric vehicles**, were operating on Québec roads.
- ✓ **More than 2 500 240-V** residential, commercial and public **charging stations** were in service in the main networks of the **Electric Circuit⁶⁰** and the **VERnetwork**.
- ✓ In 2014, sales of electric vehicles in Québec more than doubled in relation to 2013.
- ✓ Québec accounts for more than half of electric vehicle sales in Canada.

The Plugged In at Work program: This MERN program offers financial assistance for the purchase and installation of a charging station in the workplace. The program is in force until December 31, 2016 and targets the installation of 3 500 charging stations.

Exemplariness of the government: In December 2013, Québec adopted a policy that stipulates that government departments and bodies must, subject to the availability of the type of vehicle sought or the exceptions indicated in the policy, replace all light-duty vehicles or satisfy all new needs with electric vehicles.

- ✓ Since the policy came into force on January 1, 2014, more than 200 electric vehicles have been integrated into the government fleet, which now comprises 350 electric vehicles.

Incentives targeting the choice of energy: There are conceivable benefits for the purchasers or users of vehicles that run on alternative energies. Such advantages can affect, in particular, the additional cost of the vehicle, energy costs, and the conditions of use of the vehicles.

- ✓ A pilot project to allow users of electric vehicles to travel on the lane reserved for buses and carpooling has been under way since November 2014 **on the autoroute Robert-Bourassa in Québec City**.
- ✓ The project is intended to ascertain whether the use by electric vehicles of the reserved lane can improve the free flow of traffic.

⁶⁰ To obtain the most recent list of charging stations, please visit www.lecircuitellectrique.com/trouver-borne.fr.html. As of December 31, 2014, 358 charging stations, including eight quick-charge stations, were listed.

Support for the implementation of distribution networks: Such networks are usually fairly restricted and expensive, which explains the likely need to support their growth to promote the introduction of the vehicles that use them. Some examples are indicated below:

- ✓ The plan to implement a network of charging stations throughout **Québec's territory** includes the addition of 500 stations in the Electric Circuit (Hydro-Québec and its partners), including 50 fast-charging stations.
- ✓ A pilot project to implement a network of charging stations in service areas along autoroute 40 and in the stopovers located along highway 138 between Montréal and Québec City has been carried out. Six of the seven anticipated charging stations along the route—five of which are equipped with 400-V fast-charging stations—have been in service since the fall of 2014.

Key challenges

- **Rebound effect:** A possible increase in the use of vehicles that rely on alternative energies because of their lower operating cost.

8.1.3 - Driving

The current situation

In Québec, certain drivers have never taken a structured driving course before they obtain their driver's licence. Ongoing training is also rare and, above all, takes the form of occupational training organized by the employer. This situation affects the behaviour that motorists adopt, which has significant repercussions on their vehicle's fuel consumption. It should be noted that in the realm of driving safety always takes precedence over energy, although there are recognized links between the two factors.

What is more, automakers are disseminating numerous technology-oriented advertisements aimed at drivers, thereby minimizing the influence of behaviour in driving.

- **Compulsory fuel-efficient driving courses:** Since 2010, the SAAQ's road safety educational program compels student drivers to take a course that includes a module on fuel-efficient driving.
- **Limited idling:** A number of municipalities have adopted by-laws to limit vehicle idling time in their territory.
- **Speed limits:** Compliance with highway and road speed limits can significantly reduce vehicle fuel consumption.
- **Reliance on the information technologies:** Smartphone applications and the Global Positioning System (GPS) offer a number of possibilities to optimize trips by minimizing congestion and travel time.
- **Smart vehicles:** While vehicles are only becoming partially autonomous, in the long term they have the potential to revolutionize modes of travel.
- **Pay-for-use:** A number of automobile insurers are already offering discounts to their clients depending on the style of driving, the time of travel and the distances travelled. This approach can be adopted on a broader scale and indirectly affect fuel consumption.

- **Ongoing training in fuel-efficient driving:** Some training centres already offer training in the workplace, in particular using a driving simulator. More widespread adoption of such training can affect fuel consumption.

Key challenges

- The social acceptability of new training requirements, control measures and the more rigorous application of the regulations in force.

8.1.4 - Vehicle maintenance

The current situation

The fuel consumption of used vehicles is likely to increase over time. Indeed, several mechanical components affect vehicle fuel consumption. A defect or inadequate maintenance can lead to significant additional consumption of fuel.

The Ministère de l'Énergie et des Ressources naturelles has noted that 25% of vehicles six years or older are operating with the check engine indicator lit in Québec.⁶¹ One frequent cause is the improper operation of the control systems for regulated contaminant emissions (CO, NO_x and HC), often linked to a poorly operating engine and increased fuel consumption.

Mechanical safety inspections: The SAAQ requires six-monthly mechanical inspections centred on road safety for certain categories of use or vehicles, in particular buses, taxis and emergency vehicles.

Compulsory inspection of gas emissions of light-duty vehicles: This measure has been discussed for several years in Québec and has been adopted elsewhere in North America, mainly to control emissions of regulated gases (CO and HC).

Compulsory inspection of the energy efficiency of vehicles: The inspection and repair of mechanical components that affect fuel consumption are additional measures to the two preceding types of inspection.

Compulsory inspection of tire pressure: Certain states such as California have adopted regulations to compel automotive service centres to measure and regulate the tire pressure of their customers' vehicles.

Display of the rolling resistance of tires: Compulsory ratings, as for vehicles, could be adopted to steer buyers to tires with low rolling resistance and, therefore, lower fuel consumption.

Voluntary inspection of the energy efficiency of vehicles: The specific service offer concerning the energy inspection of vehicles could be developed in the automotive maintenance industry.

⁶¹ Ministère de l'Énergie et des Ressources naturelles (2012), *Cliniques d'inspection de véhicules légers*, Résultats sommaires, Québec, 32 pages.

Automatic tire pressure sensors: Recent vehicles offer such sensors as an option.

Choice of tires: The choice is the owner's responsibility throughout the useful life of the vehicle and affects fuel consumption.

Scrapping: Since vehicles are usually more polluting and energy-intensive at the end of their useful life, it may be advantageous to eliminate them from the vehicle fleet if the replacement vehicle uses less energy.

Awareness campaigns: Awareness campaigns devoted to the improved maintenance of light-duty vehicles have been conducted for several years in Québec. The information disseminated indirectly includes energy efficiency.

Key challenges

- Efficiency, profitability and acceptability:
 - o compulsory inspection of the gas emissions of light-duty vehicles, including energy efficiency considering the difficulty of establishing direct links between specific components and fuel consumption;
 - o information and awareness-raising focusing on vehicle maintenance;
 - o The development of an energy efficiency culture among automobile owners and in the light-duty vehicle maintenance and repair industry.

8.2 - FREIGHT TRANSPORTATION

Table 6 presents by theme the key existing and conceivable regulatory, technical or economic and behavioural measures pertaining to freight transportation.

Table 6: Main measures to be considered in freight transportation

Theme	Current measures	Conceivable measures
Choice of vehicle	Regulatory measures	
	▪ Emission standards for heavy-duty vehicles	
	Technical measures	
	▪ The Écocardionnage program	▪ Programming engines
	Economic and behavioural measures	
		▪ Optimal mechanical specifications
Choice of energy	Regulatory measures	
	▪ Minimal renewable fuel content	▪ Increase the minimal renewable fuel content to 5% ▪ GHG reduction targets
	Technical measures	
	▪ Alternative energies	
	Economic and behavioural measures	
	▪ The Écocardionnage program	
Driving	Regulatory measures	
	▪ Speed limit set at 105 km/h	
	Technical measures	
		▪ Automatic management system
	Economic and behavioural measures	
	▪ Basic training in fuel-efficient driving	▪ Ongoing training in fuel-efficient driving ▪ Recognition of ecodrivers
Vehicle maintenance	Regulatory measures	
	▪ Mechanical safety inspection ▪ Heavy motor vehicle inspection and maintenance program	
	Technical measures	
		▪ Maintenance centred on energy efficiency ▪ Type of tires ▪ Management of tire pressure
	Economic and behavioural measures	
		▪ Training of and awareness-raising among mechanics

8.2.1 - Choice of vehicle

The current situation

The design of heavy-duty vehicles is more a reflection of federal standards imposed by the EPA in the United States than any other consideration.

Moreover, when a heavy-duty vehicle is purchased, the motorization is usually determined by means of three basic criteria, i.e. the power necessary to maintain cruising speed, the ability to start on a hill, and the maintenance of cruising speed on a 1.5% grade.

GHG emission standards for heavy-duty vehicles: The Government of Canada will bolster existing regulations governing the 2014 to 2018 model years to make progressively more stringent GHG emission standards for model years after 2018. Current regulations stipulate that heavy-duty vehicles of model year 2018 must emit on average 11% less GHG than those of model year 2010. The requirements are in keeping with United States federal standards.

The Écocomionnage program: This program of the Ministère des Transports du Québec promotes the use of equipment aimed at enhancing energy efficiency or alternative fuels to reduce GHG emissions. The main technologies eligible are anti-idling systems, alternative power systems, on-board computers, and devices that improve the vehicle's aerodynamic shape.

Programming engines: Engines have several programmable parameters to optimize their operation according to the characteristics and conditions of use of each vehicle. The engines can be programmed at the time of purchase but also when the conditions of use change.

Fiscal measures applicable to purchases: An increase in the deduction rate for the amortization of trucks and tractors designed for freight transportation for vehicles that use natural gas.⁶²

Optimal mechanical specifications: Beyond the basic criteria considered at the time of purchase of vehicles, it is possible to pursue the optimization of the powertrain according to the anticipated use of each vehicle. The mechanical specification can reduce fuel consumption.

Key challenges

- Authorize on the roads vehicle configurations that are appreciably more efficient, such as double or triple road trains and boat-tails behind truck trailers.
- Determine the efficiency, profitability and acceptability of:
 - o technologies and equipment to reduce fuel consumption under actual driving conditions.
- Better match the choice of vehicle and the needs to be satisfied with a view to energy and economic efficiency.

⁶² Revenu Québec (2011) [revenuquebec.ca/fr/salle-de-presse/nouvelles-fiscales/2011/2011-01-17.aspx] [online].

8.2.2 - Choice of energy

The current situation

In Canada, road freight transport mainly consumes diesel fuel,⁶³ a fossil fuel that emits GHG. Other fossil energy sources that emit less GHG such as propane and natural gas or renewable energies such as bioethanol and biodiesel can partly or entirely replace diesel, with varying degrees of modification to the vehicles.

Minimal biodiesel content: Federal regulations governing renewable fuels require the diesel fuel distributed in Canada to comprise, on average, 2% renewable fuels.

Alternative energies: The actual or impending commercial availability of transportation vehicles designed to use alternative fuels varies by type of vehicle. For example, existing batteries cannot satisfy the energy needs of heavy trucks.

The Écocardionnage program: The program promotes the use of equipment designed to enhance energy efficiency and reduce GHG emissions. Hybrid and all-electric vehicles and natural-gas-powered engines are eligible under the program.

Key challenges

- The absence of structured offerings by vehicle manufacturers makes it very hard to choose an alternative fuel bearing in mind the consequences of such a choice on the guarantees offered

8.2.3 - Driving

The current situation

The driver's behaviour significantly affects the fuel consumption of a heavy-duty vehicle. The literature reports energy-consumption gaps of up to 35% between the best ecodrivers and those who do not take into account their vehicle's consumption when driving. It should be noted that in the realm of driving safety always takes precedence over energy, although there are recognized links between the two factors.

Basic training to obtain a Class 1 driver's licence is not compulsory but is a standard practice in the trucking industry.

Speed limit of 105 km/h: Heavy-duty vehicle operators, whose vehicles are circulating in Québec, must activate and regulate the road-speed governors at a maximum of 105 km/h.

Automatic management systems: Such systems can restrict drivers to certain behaviour that reduces fuel consumption. By way of an example, mention should be made of the automatic management of engine power according to load that is eligible for the Écocardionnage program.

⁶³ Natural Resources Canada, Transportation Sector, Table 9: Road Transportation Secondary Energy Use and GHG Emissions by Energy Source [online]
[<http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP§or=tran&juris=ab&rn=9&page=4&attr=0>] (consulted on March 26, 2015).

Basic training in fuel-efficient driving: Certain transportation training centres include a chapter on fuel-efficient driving in training for new drivers.

Ongoing training in fuel-efficient driving: Some training centres already offer in-house training by means, in particular, of a driving simulator. This approach can be applied on a broader scale and directly affects fuel consumption.

Recognition of ecodrivers: Businesses can implement mechanisms to recognize the best ecodrivers in order to share the benefits.

Key challenges

- Determine the efficiency, profitability and social acceptability of:
 - o compelling changes in the behaviour of experienced drivers;
 - o fuel-efficient driving training considering the erosion over time of the efficiency of behavioural measures and the relatively complex measurement context.
- Determine the effectiveness of information and awareness-raising campaigns aimed at modifying driving habits in an energy efficiency perspective.
- Define objective, equitable performance indicators.

8.2.4 - Vehicle maintenance

The current situation

The knowledge of new technologies and modern management and maintenance methods poses an ongoing challenge to all of the stakeholders concerned. Diagnoses are often partial and overlook other incipient potential problems. Furthermore, maintenance methods centred on energy efficiency are little known and rarely applied. There also appears to be a problem in certain sectors of the trucking industry of the alteration of vehicle antipollution equipment in order to increase performance.

Mechanical safety inspections: The SAAQ requires an annual mechanical inspection of heavy-duty vehicles centred on road safety.

Heavy motor vehicle inspection and maintenance program: This program of the MDDELCC makes provision for measures to reduce regulated gas emissions produced by such vehicles, e.g. particles, volatile organic compounds (VOCs) and carbon monoxide (CO). It thus seeks to enhance air quality and promote proper vehicle maintenance, which can also reduce fuel consumption and GHG emissions. The regulation also includes provisions that prohibit the alteration of the antipollution systems of heavy-duty vehicles.

Maintenance centred on energy efficiency: This measure consists in the inspection and repair of components that affect fuel consumption, in addition to those that affect other vehicle components.

Type of tire: When appropriate, it is preferable to choose radial ply tires instead of studded tires and wide-tread tires rather than twin tires.

Management of tire pressure: Because of the impact on the rolling resistance coefficient, tire pressure affects fuel consumption.

Training of and awareness-raising among mechanics: Mechanics are the first interveners in the realm of maintenance, which explains the value of involving them more extensively.

Key challenges

- Position heavy-duty vehicle maintenance centred on energy efficiency to complement existing road safety measures (SAAQ) and regulated gas emissions (MDDELCC).
- Determine the efficiency, profitability and social acceptability of:
 - o maintenance centred on energy efficiency bearing in mind the difficulty of establishing direct links between specific components and fuel consumption;
 - o the type of tire chosen and the management of tire pressure.
- Develop an energy efficiency culture in the heavy-duty vehicle maintenance and repair industry.

8.2.5 - An integrated vehicle energy efficiency approach

Other measures have a broader impact, i.e. both on the purchase of the vehicle, the choice of energy, the use of the vehicle and its maintenance.

The SmartWay Initiative: This Natural Resources Canada program follows the American model. It seeks to recognize all initiatives that a business undertakes to monitor and make more efficient the fuel consumption of its vehicles. It encourages fleet operators to pursue their enhancements.

Fuel management: This measure primarily targets vehicle fleet managers to encourage them to more efficiently manage all of the factors that affect fuel consumption.

9 - THE CONTRIBUTION TO QUÉBEC'S DEVELOPMENT OF THE DECARBONIZATION OF ROAD TRANSPORT

This background document describes six key approaches to reducing GHG emissions stemming from road travel:

- the reduction of the need to travel using a motor vehicle;
- the shift by motorists to mass transit;
- the enhancement of freight transportation logistics and cross-model transfer;
- the enhancement of the energy and environmental performance of vehicles that run on liquid fossil fuels by means of improved energy efficiency or reliance of biofuel;
- the enhanced environmental performance or conversion of fossil-fuel-powered vehicles with lower carbon intensity such as propane and compressed or liquefied natural gas;
- the abandonment of fossil-fuel-powered vehicles in favour of vehicles with electric motors powered by fossil fuels or a hydrogen battery.

Such approaches, which are sometimes exclusive and sometimes complementary, give rise to an array of economic, social and environmental consequences that inevitably have repercussions on Québec's development. The United Nations Environment Program (UNEP) defines seven key transportation-related challenges,⁶⁴ which are briefly described below, with a cursory illustration of the economic, social and environmental consequences, where applicable.

Fuel and vehicles: Direct costs, social repercussions and environmental impact of production

GHG emissions: The long-term costs of climate change, the forced change of ways of life, and climate change

Pollution and health: Health care costs, loss of quality of life and the degradation of ecosystems

Human safety and accidents: The cost of care and human injuries

Congestion: Loss of productivity and loss of quality of life

Accessibility of goods and services: Missed economic opportunities, limited personal development

Use of the territory and biodiversity: Replacement costs and ecological services affected, loss of recreational use, loss of biodiversity

⁶⁴ UNEP (2011), *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*, Chapter 8 Transport, Nairobi, United Nations Environmental Programme.

Without claiming to present a full assessment of each option contemplated in this background document on the decarbonization of road transport, it is possible to describe the main repercussions that they might have on the seven challenges from an economic, social and environmental standpoint. Accordingly, each of the options displays strengths and weaknesses, reveals possibilities or is developing under threats that are hampering the options and making them more or less attractive.

This chapter seeks to propose a general description of the impacts of the solutions on different facets of Québec's development and to analyze them, in order to sustain reflection on the choices that Québec will have to make in connection with energy and transportation.

9.1 - THE REDUCTION OF MOTORIZED TRANSPORT NEEDS

The importance of the “avoid” component, which land-use planning underpins, is recognized in Québec's *2013-2020 Climate Change Action Plan*.

The reduction of the frequency and distance of trips between the home and the workplace is the most important factor in the energy consumption of households. A reduction in motorized transport needs reduces the automobile ownership rate per household, perpetuates the reduction in distances travelled by car, limits traffic congestion and the cost of building and maintaining infrastructure and the energy costs linked to such infrastructure stemming from urban sprawl.

While initial investments are necessary to reduce needs, this option should eliminate numerous recurring costs. Such investments would revitalize the economy in the short term and reduce the expenditures linked to each challenge.

From a social standpoint, the gains would be numerous: the direct transportation expenses of households would be reduced and the amounts saved could be used for other purposes and social damage would be directly reduced (better health, fewer accidents, reduced congestion, and so on).

Reduced use of vehicles, energy, natural resources and space would, what is more, help better preserve the natural environment.

Strengths: Reduced needs for motorized transport hinge on a greater diversity of solutions at the community and individual levels, whose benefits in respect of the quality of life are readily apparent to individuals.

Weaknesses: The modern North American and Québec lifestyle is closely tied to the feeling a freedom associated with cars. This solution therefore tackles an intangible, perceptual and cultural factor rooted in the configuration of physical space.

Opportunities: This solution genuinely offers the prospect of gains in the realm of health with equivalent reductions in the cost of the healthcare system. There is thus an opportunity for this option to converge with other of Québec's priorities.

Threats: This solution implies investments in the living environment without necessarily generating as many direct jobs as automakers and energy sector manufacturers do, making the approach politically difficult to advocate.

9.2 - THE TRANSITION BY MOTORISTS TO MASS TRANSIT AND OTHER MODES OF TRANSPORTATION

The transition by motorists to mass transit offers significant economic benefits as does the approach to reduce needs.

Mass transit is important for many individuals. It has a structuring effect on the urban fabric and increases the value of properties located near the main public transport routes. However, the benefits could be less extensive in relation to certain challenges because land occupancy is not designed to reduce transportation. Additional expenditures could, therefore, be necessary, compared with planning that minimizes transportation needs.

The additional expenditures could also limit certain social benefits. For example, increased public transit spending could put a strain on certain budgets and have less positive social repercussions than a reduction in needs even though GHG emissions, pollution and congestion were changing in a very positive manner. Moreover, the cost per tonne of GHG avoided by public transportation is higher than that of other solutions.

Strengths: Through a transportation package that combines mass transit, active transportation, carpooling, carsharing and taxis, this solution may prove to be not only financially attractive but also more efficient in terms of time and trouble than the ownership of a personal vehicle. Travel management centres are offering consulting services in the realm of sustainable mobility in the main regions of Québec.

Weaknesses: To be attractive, this transportation package solution must be fully integrated and easy to understand. The fragmented governance of urban planning, mass transit and school transportation and resistance from the municipalities and professional groups such as taxi owners to the new carpooling services could hamper the introduction of such an offering.

Opportunities: The new communications technologies, in particular smartphones, are facilitating instantaneous access to carpooling opportunities, which makes them much more attractive. In the same way, GPS can make information on the movements of mass transit vehicles much more accessible, which fosters more widespread use of this mode of transportation.

What is more, aside from public transit companies already established in urban areas, a substantial school bus fleet already exists. Its role could change to quickly develop a broader mass transit system throughout Québec.

Public support for mass transit also engenders economic spinoff in Québec by offering opportunities to collaborate to develop innovative products with manufacturing enterprises such as Novabus and Bombardier.

Threats: Individuals' attachment to their privately-owned motor vehicles is an obstacle to the implementation of collective solutions. This threat is exacerbated by the growing availability of cleaner, more efficient personal vehicles, such as zero-emission vehicles. The enhancement of the efficiency of privately-owned motor vehicles satisfies the challenge to reduce GHG emissions but does not respond to the other negative impacts of transportation such as the loss of agricultural and natural land, dependence on motorized transport, the loss of time, and so on.

A second threat stems from the introduction of low- or zero-emission technologies that are still not mature, which exacerbates risks concerning the reliability of mass transit and its operating costs in this market segment. Indeed, the first challenge that this solution poses is to encourage potential users to abandon their cars. A single bad experience caused by a technological or other flaw can lead to a loss of confidence whose consequences will, among unconvinced users, be irreversible.

9.3 - THE ENHANCEMENT OF THE CARBON DIOXIDE FOOTPRINT OF FOSSIL-ENERGY-POWERED VEHICLES

The enhancement of motor vehicles is the only option that we have been able to observe on a wide scale over the past two decades. Indeed, vehicle consumption has improved considerably, which leads to fuel savings for consumers, who have continued to own their vehicles and maintained their driving habits. What is more, given such improvements, vehicle buyers sometimes opt for bigger vehicles, a striking example of the rebound effect. The Québec car fleet is thus growing faster than the population and the proportion of light trucks—sport utility vehicles and pickup trucks—is rising. From an economic standpoint, possible gains are thus not being achieved because individual behaviour is sometimes moving in opposite directions. Losses can actually occur since the improvements are indirectly increasing congestion.

From an environmental standpoint, we might expect problems to stagnate given that the enhancements will likely be reversed by greater use of increasingly big vehicles. Biodiversity would, on the other hand, suffer from increasing urban sprawl. Biofuels are a partial solution whose environmental impact varies enormously depending on the nature of the raw materials used to produce them. The outcome is better when residual matter is used, as Enerkem is proposing.

From a social standpoint, if the lessons of recent years proved to be accurate, this solution would represent stagnation or a decline. By perpetuating a model of use of the territory that we know is problematical, the solution engenders a greater loss of quality of life linked to congestion. This is true of all solutions that rely on the enhancement of vehicles. Furthermore, first-generation biofuels are posing a threat to access to staple agricultural products, especially for less privileged populations.

Strengths: This option does not require any adaptation by the public and therefore benefits from high social acceptability. It also gives a warranted impression of enhancement since a genuine improvement in the individual efficiency of vehicles is occurring.

Weaknesses: Québec does not have any means to intervene directly with respect to this situation. Given extended vehicle life, the solution does not satisfy the short-term GHG emission reduction targets (2020) that Québec has adopted and does not reposition the province to attain its long-term objectives. Biofuels are helping to perpetuate public acceptance of this type of vehicle.

Opportunities: This option presents possibilities linked to innovation as revealed by the sound outcomes that Québec universities are often achieving in competitions aimed at maximizing the distance travelled on one litre of gasoline. The regulation governing the fuel consumption and GHG emissions of light-duty vehicles is generating notable, durable gains and compelling automakers to innovate. Broader recourse to aluminium offers Québec a source of expansion. However, the automotive industry's limited presence in Québec is making it harder to tap this potential. The production of biofuels represents sound markets for the bioeconomy centred on forest and agricultural biomass.

Threats: The diversion of the resources that the automotive industry has allocated to research and development devoted to other types of motorization and fuels has necessarily affected the pace of development of technological innovation pertaining to the energy efficiency of petroleum-fuel-powered vehicles.

9.4 - THE ELECTRIFICATION OF VEHICLES

The option to electrify vehicles still poses an economic challenge since the solution is still not competitive in relation to internal combustion engine vehicles of equivalent size. However, in the medium and long term, there is every reason to believe that such vehicles will represent an economic gain, above all because of their energy efficiency, i.e. the limited amount of energy required to travel one kilometre. Economic gains through GHG and pollution reduction would also be achieved but neutral or adverse impacts should be expected in respect of other challenges, such as traffic congestion. Accordingly, the latter will continue to be problematical since the owners of zero-emission vehicles will be less inclined to leave their electric vehicle at home and take the bus or ride a bicycle.

From a social standpoint, the solution would have positive repercussions in relation to the current situation but mitigated impacts as regards factors such as congestion, accessibility, and use of the territory. By failing to make more accessible goods and services to individuals without personal vehicles, such social groups are denied a number of economic and social integration levers.

Excluding air emissions, the environmental impacts of electric vehicles are usually deemed to be equivalent to those of internal combustion engine vehicles. Indeed, over their life cycle from construction to dismantling, their production requires, overall, as many if not more resources. The impacts linked to GHG and air pollution are nonetheless highly positive, insofar as 99% of Québec's electricity is generated from renewable sources.

Strengths: The efficiency of electric motors and the absence of emissions in a context of electricity from renewable sources makes this option very attractive. The option's compatibility with our current habits increases its social acceptability. Québec possesses some expertise in research on electric mobility and the electric transportation industry.

Weaknesses: Several short- and medium-term constraints burden this option: the cost of batteries and recharging infrastructure, charging time, and battery range, above all in cold weather, as is the case during the winter in Québec.

Opportunities: With extensive renewable energy production, a vast electricity transmission and distribution network, electricity transmission can be carried out under ideal conditions. Other regions of the world do not benefit from such advantages and thus do not have the same potential to electrify transportation. Québec also possesses an electric vehicle component industry that is developing rapidly.

Threats: Technologies that rely on other alternative fuels in a gaseous or liquid state such as natural gas or hydrogen and offer quick refill times are serious competitors for vehicles that run on electrochemical batteries.

9.5 - CONVERSION TO NATURAL GAS AND OTHER OIL GAS

Natural-gas-powered vehicle technology and other oil gases such as butane or propane is a mature technology, although the latter has not enjoyed widespread implementation in most countries because liquid fuels such as gasoline and diesel predominate. However, such vehicles have an important economic benefit as regards the cost of fuel: natural gas is now much cheaper than gasoline and diesel. What is more, with a developing market, the price of natural-gas-powered vehicles would be equivalent to that of gasoline- or diesel-powered vehicles. Economic gains would also stem from lower GHG emissions and pollutants in relation to the current situation in the transportation sector. As for the other challenges, the economic impacts would be similar to those offered by the electric solution and improved consumption. Since natural gas is a form of fossil energy it would serve more as a transitional energy or one that targets certain types of vehicles or situations.

The social repercussions of the approach to convert to natural gas are positive as regards the first three factors insofar as enhanced quality of life stemmed from the enhancements engendered by the use of natural in transportation. However, stagnation and regression would occur with regard to the other factors since transportation would continue to develop based on the current model.

In relation to the current situation, in which gasoline and diesel are the predominant fuels, the use of natural gas would be positive since the fuel-vehicle combination would be less problematical than in the case of oil.

Strengths: The technology's maturity and the cost of vehicles and fuel are attractive as is the similarity in constraints of use in relation to current habits.

Weaknesses: The general public's lack of awareness of this possibility makes it harder to grasp. Although a natural gas distribution network covers part of Québec, new refuelling infrastructure should be built, which poses a challenge in terms of investment and the business model. Bearing in mind the need to completely eliminate by the end of the century GHG emissions, natural gas is a transitional fossil fuel, which limits its prospects for more widespread use in the longer term.

Opportunities: Stakeholders in the Québec transportation sector have taken the lead in the adoption of liquefied and compressed natural gas in the sector. There is positive economic and environmental potential, above all in the realm of freight transportation. Renewable natural gas exists and is being developed in Québec in the organic matter conversion option. Non-renewable natural gas could also be developed in Québec.

Threats: The development of infrastructure to extensively develop natural gas in North America will exert significant additional pressure on this form of energy. Such pressure would lead to higher prices and sooner or later could make the use this fuel for transportation uncompetitive.

9.6 - CONVERSION TO HYDROGEN

The conversion of vehicles to hydrogen is not an option that is accessible in the short term given the cost of the vehicles and hydrogen distribution infrastructure. There is considerable uncertainty in the medium and long term about changes in such costs. What is more, if hydrogen is produced from natural gas, its production emits GHG. To help combat climate change, hydrogen must be produced through the electrolysis of water (H₂O). The key benefits in relation to reliance on electricity to power an electric vehicle are refuelling time and range, at the cost of production and distribution infrastructure that has yet to be built. Technological uncertainty aside, hydrogen would allow for significant gains from the standpoint of GHG and pollutants emitted by vehicles and would also be comparable to the transportation electrification option.

The social and environmental repercussions are also similar to those of electrification except in respect of human safety, where the risks related to handling hydrogen, which is highly explosive, might have a negative impact.

Strengths: Hydrogen-powered vehicles can have a considerable range and much shorter refuelling time than electric vehicles, which enables them to offer use equivalent to fossil-fuel-powered vehicles without emitting GHG or pollutants. The involvement of major automakers, in particular Toyota, is evidence of certain technological potential.

Weaknesses: The high cost of the fuel cell that equips hydrogen-powered vehicles and the need to establish a network of hydrogen fuelling stations makes this option hardly competitive in the short and medium term. The question of the source of the hydrogen remains open.

Opportunities: With a high volume of renewable energies, including a growing share from variable sources such as wind power, Québec could produce clean hydrogen through electrolysis and store electrical energy in the form of hydrogen. Accordingly, the natural gas distribution network can accommodate a proportion of between 5% and 10% hydrogen, which would afford the latter an additional outlet. However, these possibilities are limited by current production costs and their foreseeable development by 2050.⁶⁵

Threats: Direct competition from electrochemical batteries offering greater range is the biggest threat. On the other hand, since the two technologies rely on electric motors, synergy and emulation between them are fairly positive as regards the development of the two options.

⁶⁵ ADEME, GRTGaz and GrDF (2014). *Étude portant sur l'hydrogène et la méthanation comme procédé de valorisation de l'électricité excédentaire*, 238 pages. [online] [ademe.fr/etude-portant-lhydrogene-methanation-comme-procede-valorisation-lelectricite-excedentaire] (consulted on March 31, 2015).

Box 8: Energy, social and environmental challenges that must be clarified with respect to autonomous vehicles

Autonomous vehicles are being discussed increasingly in the automotive industry. Certain industry observers maintain that such vehicles appear to be the biggest technological revolution that automobiles have experienced since the internal combustion engine. The vehicles are an application of mobile robotics and intelligent transportation systems (ITS).

At the highest level of automation, the vehicle is entirely autonomous, i.e. capable of running automatically and autonomously in real traffic and using non-specific infrastructure without human intervention. The driver programs the route and can then go about his business such as working or sleeping, until he reaches his destination. The vehicle refuels and parks itself.

The concept of the communication-equipped vehicle implies systems that allow for communication between vehicles and communication between the vehicles and road infrastructure to exchange data to support the safe driving of different vehicles.

Fully autonomous vehicles are being tested and certain of their features will soon be incorporated into mass-production vehicles. Google announced the launching, in December 2014, of its autonomous car ready for testing on North American roads starting in 2015. Moreover, numerous automakers such as Audi, Toyota, Nissan, General Motors and Mercedes-Benz are carrying out autonomous car projects. In North America, the legislation and regulations of various authorities do not cover autonomous vehicles but do not prohibit them.

Studies conducted by the automotive industry suggest that the widespread use of autonomous vehicles could reduce accidents and congestion, eliminate constraints related to driving, reduce police controls and insurance costs, achieve greater energy efficiency, and reduce pollution.

The scope of such benefits has yet to be established but a certain optimism is apparent concerning the positive impacts that this emerging transportation niche can generate for the environment and society.

Source: Rand Corporation 2014. *Autonomous Vehicle Technology: A Guide for Policymakers*. [online] [rand.org/content/dam/rand/pubs/research_reports/RR400/RR443-1/RAND_RR443-1.pdf] (consulted on April 2, 2015).

10 - CONCLUSION

As we noted earlier, the transportation sector uses nearly 30% of the energy consumed in Québec and this share is growing over time. Road transport alone consumes 75% of the petroleum products sold and accounts for one-third of Québec's total GHG emissions, including non-energy emissions.

The current objective to reduce GHG emissions by 20% by 2020 implies stringent, structuring measures in the transportation sector. Ensuring that Québec is a leader in the realm of renewable energies, energy efficiency and energy innovation and the pursuit of the development of a low-carbon economy implies a review of its commitment and the radical reduction of the use of fossil fuels in transportation.

Because renewable energies already occupy a significant place in Québec's energy balance, it must, to appreciably reduce its GHG emissions, tackle as a matter of priority the road transport sector.

Although Québec stands out because of its intensive reliance on abundant, renewable electricity, in the realm of transportation and land-use planning, the same phenomena are apparent here as elsewhere in North America:

- constant suburban expansion and the desire of a large part of the population to live there and remain there after retirement;
- constantly increasing distances between the home and the place of work;
- an increase in the motorization rate of households;
- the predominance of solo car use;
- the enhancement of the energy efficiency of automobiles and trucks that is insufficient to offset higher energy consumption attributable to more frequent motorized trips.

Furthermore, factors specific to Québec are adding to the challenge of decarbonizing transport:

- the car fleet is more ecoenergetic than elsewhere in Canada although the gap is narrowing;
- the ageing of the population, which is more pronounced than in the rest of Canada, thus changing needs and both motorized and active travel patterns;
- the limited potential of intermodality in freight transportation;
- the climate.

The challenge that the decarbonization of road transport poses is, however, far from being insurmountable since the possibilities of improving energy efficiency in the transportation sector are huge.

The challenge is achievable because the requisite measures fall within the scope of an approach compatible with sustainable development and Québec society's ability to adapt. The avoid-shift-improve approach can guide the future orientations in the *Politique énergétique 2016-2025 en matière de transport routier*. Solutions that are applicable to decarbonization will inevitably hinge on a series of measures whose costs and benefits must be considered when choices are made.

The conditions to initiate this multi-approach transition process are present:

- concrete action of a regulatory nature has been taken to halt urban sprawl;
- investments in mass transit are producing results; and
- Québec is already a leader in experimenting with electric vehicles of all sorts in its territory.

On the strength of its expertise and abundant renewable resources, Québec can focus on other alternative fuels such as ethanol or hydrogen and convince individuals and businesses to choose vehicles that benefit them and society as a whole.

The avoid-shift-improve approach is the structure given to this background document to emphasize that each of the options to reduce fossil fuel consumption must be explored in order to decarbonize transportation in the coming decades. This is the key message of this document, which now invites stakeholders in Québec society to express their vision of the future and propose promising solutions for Québec.

11 - QUESTIONS

1. Given its specific context from the standpoint of climate, the availability of energy and economic potential, which energy sources should Québec favour by 2025 in respect of passenger and freight transportation?
2. In the realm of energy efficiency, how might Québec promote more widespread adoption by vehicle owners of the numerous possibilities for reducing fuel consumption and GHG emissions?
3. Should we reduce the cost of tolls on Québec's roads and bridges or offer discounts on parking meter rates for all-electric vehicles?
4. Should we encourage service station operators to install infrastructure that enables motorists to refuel regardless of the nature of the energy consumed, i.e. gasoline, natural gas, electricity, hydrogen, and so on, as is the norm in California?
5. By intensifying measures pertaining to mass transit, could Québec at the same time support the growth of its bus and subway car construction industry, create more jobs, reduce urban congestion and pollution and thus enhance the quality of living environments?
6. Should Québec implement an action plan to halt urban sprawl and thereby protect farmland, reduce energy consumption and optimize public investments?
7. What is the role of intermodality and freight transportation logistics bearing in mind that the best options imply trips from or to regions located outside Québec, i.e. Ontario and the United States?
8. Which measures would be likely to influence the behaviour of motorists and businesses and foster the efficient, economical use of energy for travel and freight transportation?
9. Given the positive spinoff from and high potential of mass transit and active transportation, should Québec broaden its support for mass transit and the development by the municipalities of utilitarian bicycle lanes in urban centres?
10. Should Québec draw inspiration from other jurisdictions and make compulsory the sale of zero-emission vehicles in its territory?
11. Following the example of Oregon and Minnesota in the United States, Switzerland and the Netherlands, which are testing deterrent pricing, should we impose the installation of an electronic chip that charges motorists according to the distance travelled within urban perimeters and the time of day?
12. Should Québec, following the example of other jurisdictions, seek to become carbon neutral by the middle of the century?
13. Should Québec include incentives or regulatory measures to guide the conversion of commercial and industrial road vehicles to gaseous fuels with low carbon footprints, biofuels, electricity or hydrogen?

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14. Should Québec compel its government corporations to use vehicles equipped with engines other than gasoline-powered engines?
 15. Should the Société du Plan Nord be involved in the decarbonization of transportation by reducing the use of fossil energies for its travel in the territory that the Northern Plan covers?

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