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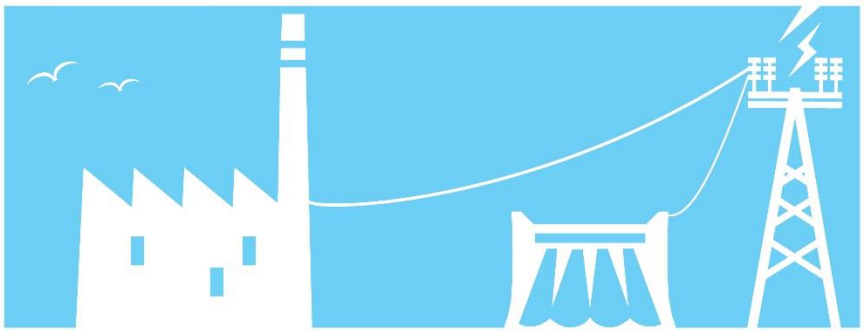

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TRANSPORT SECTOR IN CANADA – SPECIAL FOCUS ON THE PROVINCE OF QUEBEC

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Juillet, 2014

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Summary

This document is a general overview of the transport sector in Canada and more precisely in the province of Québec, within the context of global warming.

Firstly, we stress the environmental stakes of this issue: global warming effects have already an impact on Canada's average temperature and ecosystem. Short-term and long-term financial stakes are also present: regarding the long term global warming changes our ecosystem and puts into question our way of production. Thus, it has long-term economic effects. Regarding the short-term Canada signed in 2009 the Copenhagen Accord, which quantifies the economy-wide greenhouse gases (GHG) emissions target for 2020 to a 17% reduction in emissions compared to 2005. We then cast the light on transport sector which is directly responsible for 20% of Canada's GHG emissions, but more than 40% in the case of Quebec. Transport-related GHG emissions have been increasing these last years, turning thus the question of transportation into a central issue today for the Canadian community.

In a second part, we describe the general transportation trends in Canada. Transport covers both passengers and goods. Regarding passenger transportation in developed countries, we notice a decline in the growth rate of the vehicle fleet, a change in the use of cars as well as higher fuel prices. Regarding good transportation, we notice a strong correlation to the economic activities (and thus a huge slowdown from 2009 to 2011 because of the crisis). Eventually in developed countries funds are mostly dedicated to the maintenance of infrastructures than to the development of infrastructures. We highlight the importance of road transportation in Canada regarding passenger transportation or good transportation (in terms of quantity of goods or passengers transported, in terms of GHG emissions as well). We eventually focus on Québec to describe precisely each mean of transportation: road transportation (type of vehicles, fuel consumption, user cost …), train transportation, sea transportation, air transportation. As road transportation is the mean of transport the most used in Québec (in Canada as well) and as it is responsible for the main part of GHG emissions in transport sector, we really focus on this mean of transportation.

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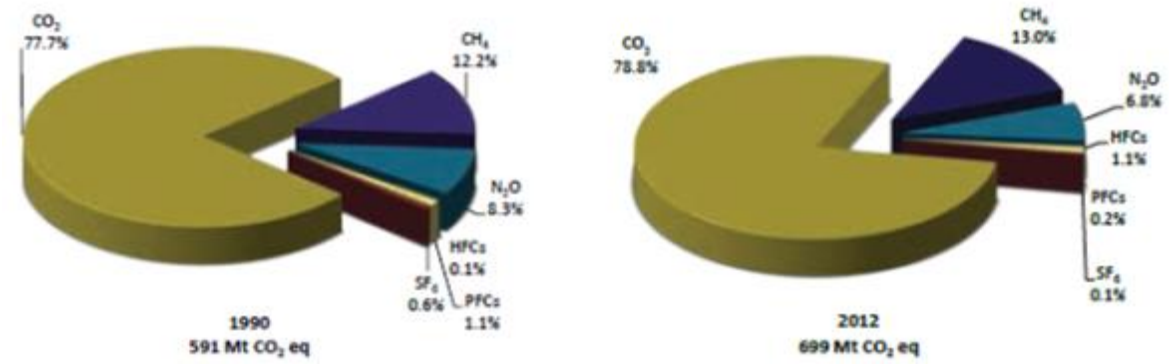
I- Environmental and Financial stakes: the growing impact of the transport sector

I A- Environmental and financial stakes

Reducing greenhouse gas (GHG) emissions in Canada is an urging issue. First we face growing concerns regarding climate change and its impact on our environment. In Canada, the impact of climate change may be felt in extreme weather events, the reduction of fresh water resources, increased risk and severity of forest fires and pest infestations, a reduction in arctic ice and an acceleration of glacial melting. Canada's national average temperature for 2012 was 1.9°C above normal. Annual temperatures in Canada have been at or above normal since 1993, with a warming trend of 1.7°C over the last 65 years (Environment Canada 2013). Scientists mostly agree on the huge role played by the rise in the concentration of GHG in the atmosphere on the global warming. We will focus on three GHGs: CO_2, CH_4, N_2O. They constitute indeed almost 99% of GHG emissions in the Canada (a figure more or less similar over the 22 past years).

Figure1: Relative contribution of GHGs to Canada's Total Emissions 1990 and 2012 (excluding LULUCF)



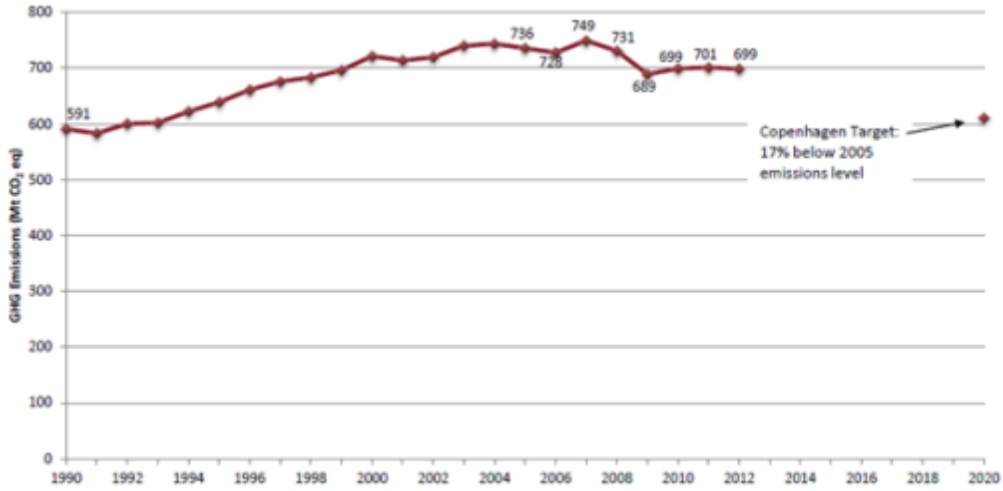
Source: NIR Canada 2014: Greenhouse Gas sources and sinks in Canada 1990-2012 figure 2-1

Those gases are naturally present in the atmosphere. However human activities have sensibly increased their concentration in the earth's atmosphere, jeopardizing natural balances. The point is even though the quantities released by human activities are low compared to the amount of gases naturally at stakes in their whole natural life cycles (for instance, human-caused releases of CO2 are relatively small -1/20- compared to the amounts that enter and leave the atmosphere due to the natural active flow of carbon -Hengeveld et al.2005-) there are evidence of a correlation between post-industrial human activities, an increase in the concentration of these gases and global warming. In 2011 the concentrations of CO_2, CH_4 and N_2O exceeded pre-industrial levels by about 40%, 150% and 20% respectively.

The international community has tried to tackle this issue by establishing in 1992 in Rio de Janeiro the United Nations Framework Convention on Climate Change (UNFCCC). The ultimate objective of the UNFCCC is to stabilize atmospheric GHG concentrations at a level that would prevent dangerous interference with the climate system. Canada ratified the UNFCCC in December 1992 and signed the

Copenhagen Accord in 2009, under which this country has committed to reducing its GHG emissions to 17% below the 2005 level by the year 2020.

Figure2: Canadian GHG Emissions Trend (1990-2012) and Copenhagen Target



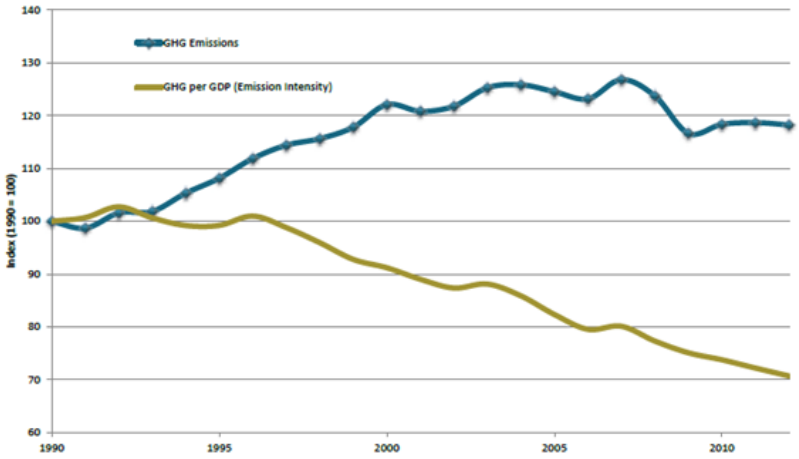
Source: NIRCanada 2014: Greenhouse Gas sources and sinks in Canada 1990-2012 figure S-3

In 2012 Canada's total GHG emissions were estimated to be 699 megatonne (NIR 1990-2012) of carbon dioxide equivalent (Mt CO2 eq). Since 1990, the net increase in total emissions has been 108 Mt (a rise by 18%).

While Canada represented less than 2% of total global GHG emissions in 2010 (CAIT 2013), it is one of the highest per capita emitters, largely as a result of its size, level of economic development, climate (i.e. energy demands due to climate), and resource-based economy. In 1990, Canadians released 21.3 tonnes (t) of GHGs per capita, in 2012, this had decreased to 20.1 t of GHGs per capita.

Though GHG emissions have risen by 18% since 1990, Canada's economy grew much more rapidly, with the Gross Domestic Product (GDP) rising by 67%. As a result, the emission intensity for the entire economy (GHG per GDP) has improved considerably, dropping by 29%. In 1995, GHG emissions started to decouple from economic growth, a shift that can be attributed to increases in efficiency, the modernization of industrial processes, and structural changes in the economy.

Figure3: Indexed trend in GHG Emissions and GHG Emissions Intensity (1990-2012)



Source: NIR Canada 2014: Greenhouse Gas sources and sinks in Canada 1990-2012 figure S-4

Thus the goal of the Canadian government is to reduce GHG emissions by 14% by 2020. Considering that since 2005, GHG emissions have decreased by only 5% (37 Mt), the 2020 target seems hard to reach. However because of the decoupling of GHG emissions and GDP, it seems to be possible to reduce GHG emissions without significantly damaging the Canadian economy. Then the drop in the emissions since 2005 was due to a drop in every emissions sector except the emissions from the transport subsector which has increased by 2 Mt. Thus we may question the part of Transport sector in Canadian GHG emissions.

I B - Transportation: a key sector to control GHG emissions

How we consider transport sector and what do we exactly count in it, is an important specification. There are two approaches to account for GHG emissions in the transport sector:

- The first one follows the Intergovernmental Panel on Climate Change (IPCC) recommendations. The IPCC define a sector: Energy[1] (). Transport appears in the energy sector through emissions due to fuel combustion.
- The other one defines transportation as an economic sector, which represents emissions arising from the mobility requirements of people driving cars, trucks, trains, aircraft and ships, and which also includes the mobility service emissions from heavy-duty trucks and other commercial vehicles. However, unlike the IPCC categorization, the transportation economic sector does not contain off road transportation emissions related to farming, mining, construction, forestry, pipelines or other industrial activities. Excluding off-road in the transportation economic sector ensures that emissions related to industrial activities do not appear as trends associated with on-road passenger and freight transportation requirements. For example, if there were any upward trend in farming or mining activity, emissions arising from the increased use in mobile farming machinery or mining trucks would be reflected in the economic sector estimates for agriculture or mining.

We will first use figures from the second approach, as transportation emissions in Canada follow this approach.

Canada's transportation economic sector is the second-largest contributor to Canada's GHG emissions, representing 24% of total emissions in 2012. Emissions rose by 39 Mt between 1990 and 2005, an increase of around 30% over the period. *Explanatory factors may include changing demographics, changes in personal travel demand, higher gasoline prices, and government policies.*

We can see in the figure below the evolution of the transport sector according to the economic definition. The results are in Mt CO_2 equivalent.

Figure 4: GHG emissions in Canada

	1990	2000	2005	2008	2009	2010	2011	2012
National GHG total	591	721	736	731	689	699	701	699
Transportation	128	155	168	166	163	167	166	165
Passenger transport	78	91	96	96	96	97	93	94
Cars, trucks and motorcycles	***69***	***83***	***87***	***87***	***87***	***88***	***85***	***85***
Bus, rail and domestic aviation	*8*	*9*	*9*	*9*	*8*	*8*	*8*	*8*
Freight transport	39	48	57	59	57	60	61	61
Heavy-duty trucks, rail	***32***	***41***	***49***	***52***	***49***	***52***	***54***	***54***
Domestic aviation and marine	*6*	*7*	*8*	*7*	*7*	*8*	*7*	*7*
Other (recreational)	12	16	14	10	10	11	12	11

Source: Source: NIR 2014: Greenhouse Gas sources and sinks in Canada 1990-2012

[1] For more detail see : http://www.ipcc.ch/meetings/session25/doc4a4b/vol2.pdf

The raise in the passenger transportation is due to a raise in the categories of lights vehicles: cars, trucks and motorcycles.

The raise in the emissions from freight-transport comes from the heavy-duty trucks and rail activity.

The analysis based on IPCC recommendation gives more details about those two categories.

The majority of transportation emissions in Canada are related to the Road Transportation category, which dominated the GHG growth trend in this area. Emissions from Road Transportation rose by 35.8 Mt (37%) between 1990 and 2012, accounting for almost one half of Canada's emission growth for the same period. The primary source of this net trend of rising emissions is the increase in the number of passenger-kilometres travelled (more people drove further) (NRCan 2013).

Figure 5: Canada's GHG Emissions, the IPCC sector of transportation (1990-2012) in Mt CO_2 eq

	1990	2000	2005	2008	2009	2010	2011	2012
Transport	147	180	194	196	188	198	198	195
Civil aviation (domestic aviation)	7	8	8	7	6	6	6	6
Road transportation	97	118	130	132	132	134	132	132
Railways	7	7	7	8	5	7	8	8
Navigation (domestic navigation)	5	5	7	7	7	7	6	6
Other transportation	31	43	42	42	38	44	46	43

Source: Source: NIR 2014: Greenhouse Gas sources and sinks in Canada 1990-2012

We have to detail more road transportation sector to understand the raise in the emissions related to this sector.

Figure 6: GHG Emissions from Transport, Selected years (Mt CO_2 eq)

	1990	2000	2005	2008	2009	2010	2011	2012
Transport(total)	147	180	194	196	188	198	198	195
Civil aviation (domestic aviation)	7.1	7.6	7.6	7.3	6.4	6.4	6.2	6.1
Light-Duty Gasoline Vehicles	**45.5**	**42.0**	**40.2**	**39.5**	**39.7**	**40.0**	**38.5**	**38.3**
Light-Duty Gasoline Trucks	**20.3**	**36.4**	**42.7**	**42.3**	**42.5**	**42.9**	**41.2**	**41.4**
Heavy-Duty Gasoline Vehicle	7.44	5.47	6.54	6.80	6.91	7.02	6.71	6.91
Motorcycles	0.152	0.162	0.254	0.263	0.266	0.271	0.264	0.268

Light-Duty Diesel vehicles	0.469	0.466	0.574	0.652	0.699	0.750	0.788	0.824
Heavy Duty Diesel Vehicles	**20.0**	**30.8**	**37.6**	**39.2**	**39.0**	**40.2**	**42.0**	**41.7**
Propane & Natural gas vehicles	2.20	1.10	0.72	0.88	0.78	0.78	0.82	0.88
Railways	7	7	7	8	5	7	8	8
Navigation (Domestic Marine)	5.0	5.2	6.7	6.5	6.7	7.0	5.8	5.8
Off-road Gasoline	7.8	8.7	8.3	7.3	7.3	7.9	8.1	7.6
Off-road Diesel	16	23	24	28	25	30	32	30
pipelines	6.85	11.20	10.10	7.46	6.31	5.67	5.60	5.70

Source: NIR 2014: Greenhouse Gas sources and sinks in Canada 1990-2012

Note: the total 195 Mt CO_2 equivalent different from precedent results giving 165 MT CO2 equivalent for the year 2012 is directly due to two different definitions of the transport sector, as explained p 3.

Thanks to this former table, we understand the rise in transport-related emissions was driven primarily by energy used for personal transportation and heavy duty trucking.

- Emissions from light-duty gasoline trucks (LDGTs), the subcategory that includes sport utility vehicles (SUVs), pickups and minivans, increased 104% between 1990 and 2012 (from 20.3 Mt in 1990 to 41.4 Mt in 2012), while emissions from cars (light-duty gasoline vehicles or LDGVs) decreased 16% (from 45.5 Mt in 1990 to 38.3 Mt in 2012). The growth in road transport emissions is due not only to the 52% increase in the total vehicle fleet since 1990 (14% since 2005, see the table below), but also to a shift in light-duty vehicle purchases from cars to trucks, which, on average, emit 45% more GHGs per kilometre (NRCan 2013).

Figure 7: Trends in Vehicle Numbers (*1000) for Canada 1990-2012

	Gasoline Vehicles				Diesel Vehicles			
year	LDGVs	LDGTs	HDGVs	MCs	LDDVs	LDDTs	HDDVs	Total
1990	10646	3308	518	261	109	112	402	15356
2000	10863	6065	376	288	123	224	649	18587
2005	10961	7386	435	437	159	277	856	20510
2008	10663	7879	465	465	170	298	918	21858
2009	11897	8043	476	475	173	305	939	22308
2010	12130	8208	486	484	177	312	960	22757
2011	12267	8304	491	490	179	318	975	23025
2012	12405	8401	497	495	182	323	990	23293

Change since 1990	17%	154%	-4%	89%	67%	190%	146%	52%

Source: NIR 2014: Greenhouse Gas sources and sinks in Canada 1990-2012

- In 2012, emissions from heavy-duty diesel vehicles (HDDVs) contributed 42 Mt to Canada's total GHG emissions (an increase by about 108% from 1990 and 11% from 2005). This reflects the trend towards the increasing use of heavy-duty trucks for freight transports. Growth in emissions reflected a 137% increase in tonne-kilometres shipped by for-hire trucking between 1990 and 2003 (Statistics Canada 2013b), however this growth of the tonne-kilometer has been stopped during the past seven years (Statistics Canada 2013c). Emissions from heavy-duty gasoline vehicles (HDGVs) have remained relatively unchanged since 2004, at 7 Mt, which is 7% below the 1990 level.

  While there are difficulties in obtaining accurate and complete data for the freight transport mode, the trends in data from major for-hire truck haulers in Canada show conclusively that freight hauling by truck has increased substantially and that this activity is the primary task performed by HDGVs and HDDVs (Statistics Canada 2013a).

Figures highlights huge differences among the means of transport chosen: propane and natural gas vehicles are the cleanest way to circulate; diesel light-duty vehicles/trucks are cleaner than gasoline light-duty vehicles/trucks. However it is the reverse trend regarding heavy- duty vehicles. A long term decrease in some transport categories has been registered: specifically, reductions in emissions from light-duty-gasoline vehicles (i.e. cars), propane and natural gas vehicles, domestic aviation, heavy-duty gasoline vehicles. This long term decrease offers hope for a future decreasing part of transport-related emissions in the future. To conclude on an optimistic note, this table stresses that the rate of growth in emissions from Road Transportation has slowed, and emissions from this category have remained stable since 2008, as vehicles are becoming more efficient. Still, we need not only stabilization but decrease in the rate of transport-related emissions.

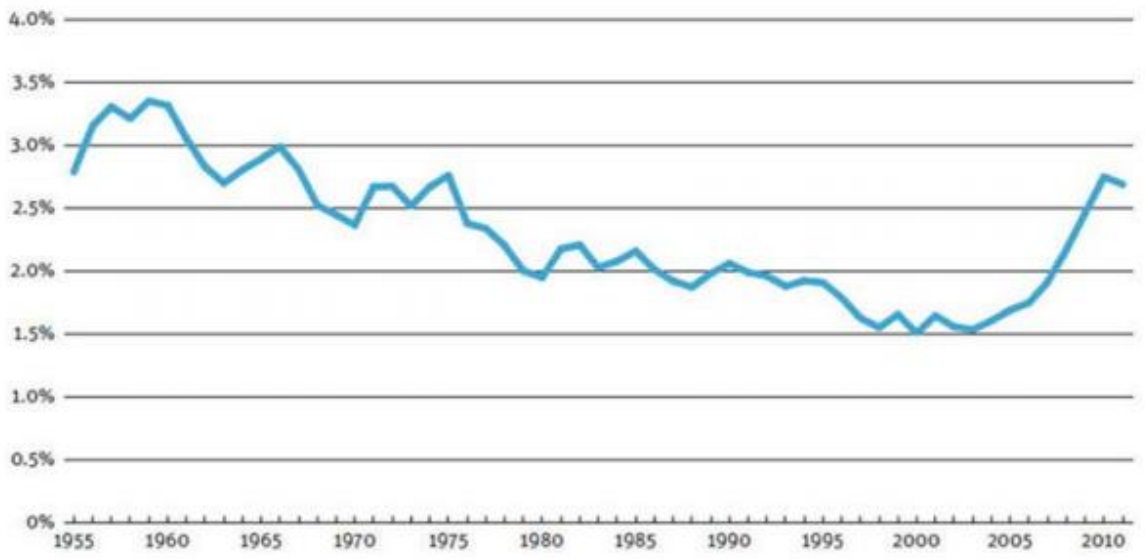
In order to evaluate the different options leading to such a decrease in the rate of transport-related emissions we need first to understand the current structure of the transport sector and to evaluate the further need in the development of this sector. Thus we will be able to assess the cost of present system of transport in terms of financial and social cost, then to evaluate the cost of each option: diesel-powered, electric-powered, natural gas- powered, bio fuel- powered, and hybrid vehicles. Given the context of the UNFCCC treaty, we will focus on the short-term: 5 years. However, given what we expect about the structure of the transport sector, we will have to work also on the medium term (15 years) to see greater impact of each option. As the task seems to be too long to be treated in 15 weeks for the whole Canada, we chose to focus on the province of Québec.

II- Trends of transport sector in Canada

IIA-Transport sector in Canada: Financial stakes

Because of its gigantic size: 9 984 670 km², transport has a special status in Canada. First transport infrastructures are essential for the development of the Canadian economy according to the chamber of commerce (décembre 2013): *Les bases d'un Canada compétitif : la nécessité d'investir de façon stratégique dans les infrastructure*. Canada is well known for its very expensive infrastructures such as the transcanadian road built from 1950 to 1971 and which cost more than 1 billion. Public investment in infrastructure set for 3% of the PIB in 1950. They then were strongly reduced up to 2005. Since 2005, many new projects have been launched aiming at a raise in the public investments in this country.

Figure 8: Net investment of Canada in public infrastructure (% PIB)



source: Les bases d'un Canada compétitif : la nécessité d'investir de façon stratégique dans les infrastructures, La chambre de commerce du Canada décembre 2013

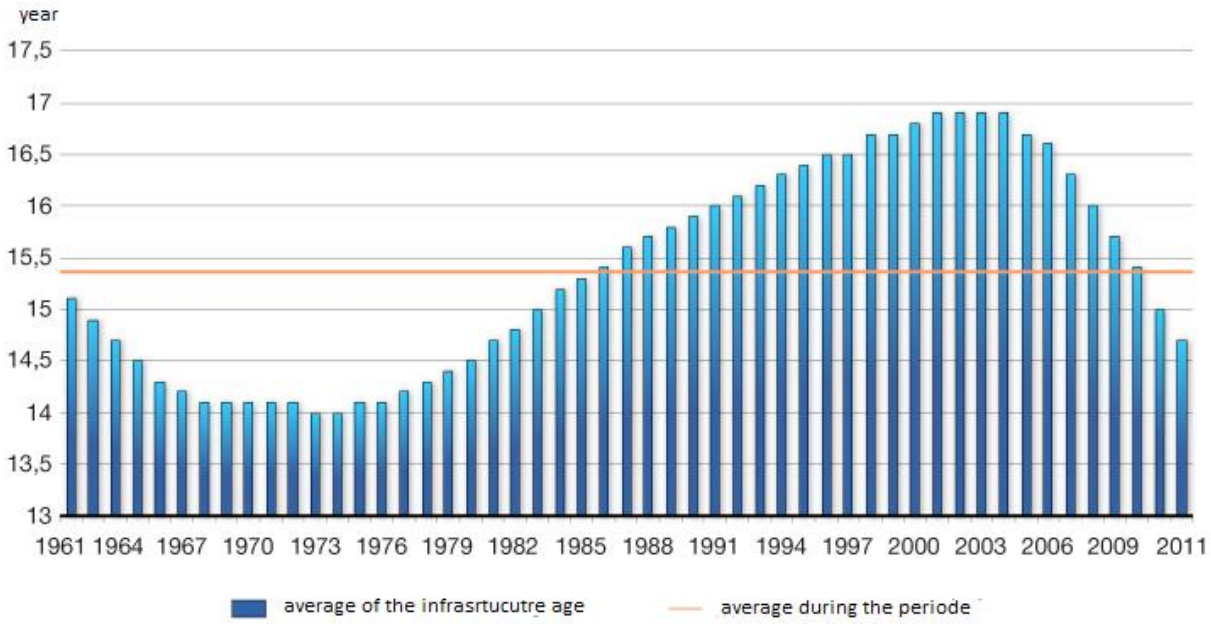
First we have to precise two ideas about this graph:

- the unit is % PIB. Thus an increase in the investment on the figure may result from a decrease in the PIB. This may be the case for the slight increase in 1980.
- This figure represent the public investment. Transport is not the only purpose of these investments, here we also deal with education, health, state infrastructure (such as institutional buildings) and so on. However, investments in transport follow the same curve.

We observe thus that first Canada invested a lot in its infrastructures (in the 1950s). This part set for the building of many infrastructures. Then we observe a huge decrease. This is because most of the infrastructures have been built and the country needs only to finance the maintenance. This scheme: first huge investments then decrease of the investment is a common trend to all the developed countries. Developing countries are in the first phase of expansion.

However, Canada may have impose a too intense decrease for budget constraint reasons. This intense decrease resulted in premature ageing infrastructures, as showed in figure 9:

Figure 9: Age of the Canadian infrastructures



source: Les bases d'un Canada compétitif : la nécessité d'investir de façon stratégique dans les infrastructures, La chambre de commerce du Canada décembre 2013

We can see on the figure 9 that the first effects of the projects launched in 2005 are the decrease in the average age of Canadian infrastructures.

To conclude, transport infrastructures are essential for the economic development of Canada. This key sector requires high investments, especially during the phase of expansion and the building of infrastructures. Today Canada is trying to solve the issue of its ageing infrastructures and has launched many projects to support its economic growth.

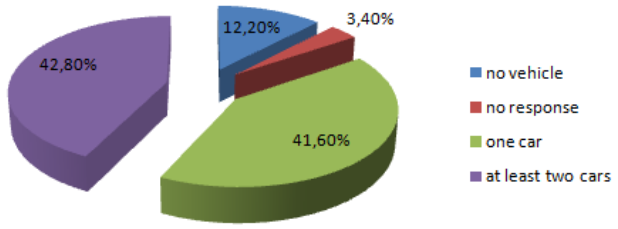
II B- Transport of passengers

People essentially move using cars, light trucks or other road-linked means of transport. As we only want to stress the main evolutions at the scale of the country, we will only talk about road transportation. We can roughly study the Canadian fleet of vehicles this way:

- Light vehicles: cars, familial cars, van, Sport Utility Vehicle and small truck. They weigh less than 4,5 t they are used for passengers transportation
- Medium and heavy trucks: vehicles that weigh 4.5t or more, essentially used to transport goods.

We will focus here on the light fleet as it is deserved to passenger transportation. 84% of Canadian households possessed at least one car in 2007, out of 12.9 million households.

Figure 10: Share of Canadian households according to the number of cars owned or rented, 2007



Source: RN Canada Enquête sur les véhicules au Canada, 2011

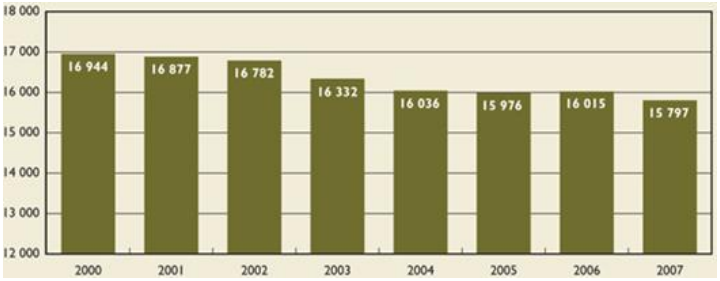
Figure 11: Evolution of the light fleet in Canada

	Light fleet
2000	16 642 140
2009	19 755 945
Growth rate in %	18.7
Annual total growth rate in %	1.9

Source: RN Canada Enquête sur les véhicules au Canada, 2011

From 2000 to 2009 light fleet grew by almost 19% with an annual composed growth: 1.9%, which is significantly higher than the population growth: 1.1 % on average during the same period (source: http://www4.rhdcc.gc.ca/.3ndic.1t.4r@-fra.jsp?iid=35). So the population growth cannot be the only explanation of this high growth rate for the light fleet. The number of cars per household has indeed increased from 1.43 cars in 2000 to 1.47 cars in 2009. The vehicle per driven kilometer growth rate is about 0.8% in Canada, far below the growth rate of the Canadian light vehicle fleet: 1.9%. The vehicle-kilometer has decreased since 2000, though the number of vehicle has increased:

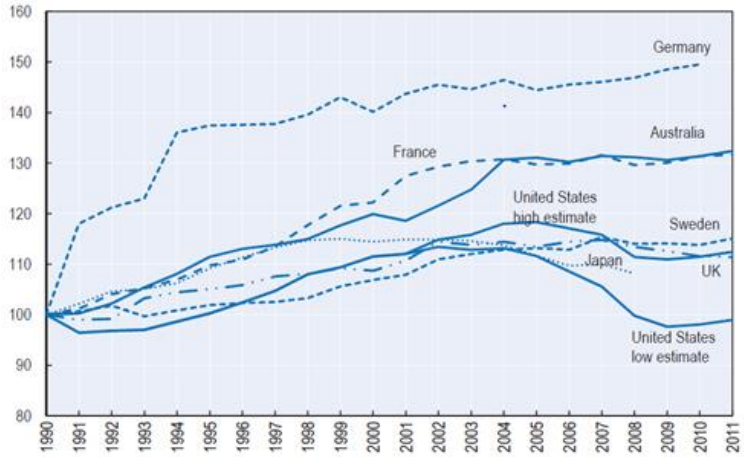
Figure 12: Vehicle-kilometer driven by light vehicles from 2000 to 2007:



Source: http://oee.nrcan.gc.ca/publications/statistiques/evc07/chapitre1.cfm?attr=0

Those three observations mean that people have bought more vehicles, but **each vehicle has been used less intensively** (leading to a fall in the occupancy rate from 1.68 in 2000 to 1.62 in 2009). This is a common trend among developed countries. Research has indeed revealed remarkable **changes in the intensity of car use** within some socio-demographic subgroups. Car use per capita among young adults (men in particular) has declined in several countries in recent years. Over the past 10 to 15 years, the growth of passenger-vehicle-travel-volumes has decelerated in several high-income economies and stopped or even turned negatively in some countries. Explanations are numerous: high fuel prices, increasing urbanisation, slowdown in population growth, population ageing, economic recession, and policy interventions (particularly in urban areas and sometimes at the national level).

Figure 13: Passenger-kilometer by private car (1990=100)



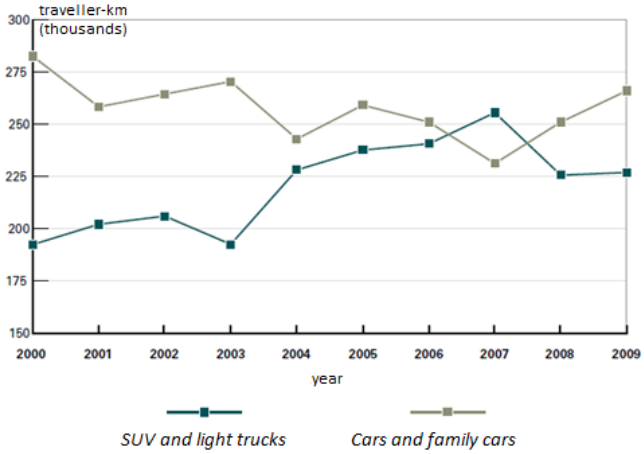
Source: OCDE-ITF, Transport Outlook 2013

Light fleet is divided in two huge groups:

- Light trucks (van, Sport Utility Vehicle and small truck)
- Cars (compact cars and familial cars).

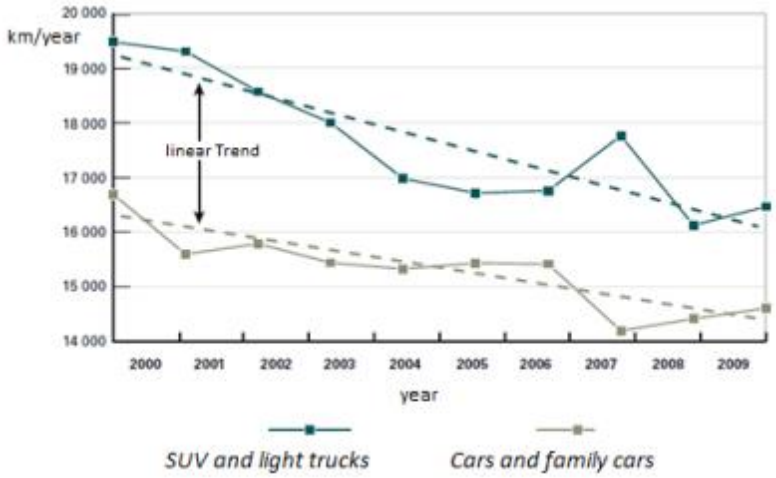
Light trucks and cars are not exactly used in the same situation, though differences tend to disappear:

Figure 14: Number of traveller-kilometer driven in Canada by light vehicles according to their types from 2000 to 2009



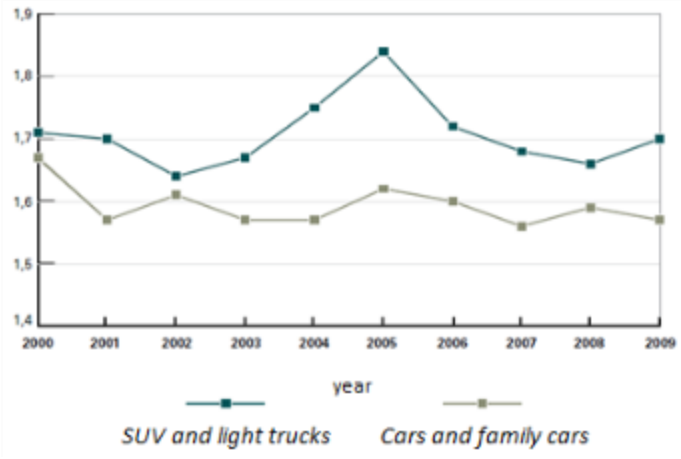
Source: RN Canada Enquête sur les véhicules au Canada, 2011

Figure 15: Average distance driven by light vehicles according to their types from 2000 to 2009



Source: RN Canada Enquête sur les véhicules au Canada, 2011

Figure 16: occupancy rate of light vehicles in Canada from 2000 to 2009

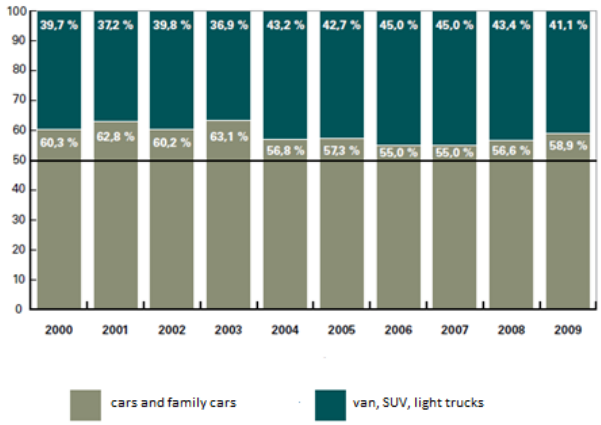


Source: RN Canada Enquête sur les véhicules au Canada, 2011

Those three figures show that initially cars and light trucks had different use. As we can see on the second graph, light trucks were used for longer trip than cars. Furthermore the average occupancy rate was higher for light trucks than for cars. Thus light trucks were used by groups of people (for instance family) to make long trip (for instance during the week-end or the holidays not for daily commuting), whereas cars were mostly used by one person for daily small trips. This difference in the use of those vehicles is stressed by the evolution of the number of passengers-km (equal to: *the number of vehicles* times *average-driven kilometer* times *average number of passengers per vehicle*) which was higher for cars than for light trucks (this order: bigger figure for cars than for light trucks is explained by the number of cars, which is far bigger than the number of light trucks). However, those three graphs stress that the distance per trip diminishes more for the light trucks than for cars so both trends come closer and closer, as we will stress later, the part of VUS in the light fleet has doubled these former years. As a result we observe on the first graph closer number of passenger-kilometer today than ten years ago. So we can conclude that the use of light trucks has changed to come closer to the use of cars. Thus light trucks have become true concurrent of

cars, used more and more the same way. That may be the conclusion of the following graph showing the evolution of the percentage of each type of light vehicles in the Canadian light fleet:

Figure 17: Light Fleet according to the type of vehicles

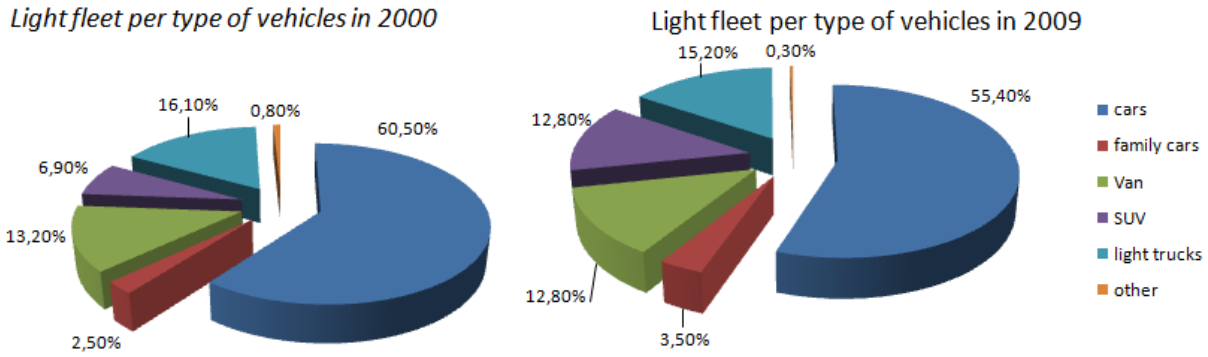


Source: RN Canada Enquête sur les véhicules au Canada, 2011

The use of light trucks tended to spread, but this trend was stopped by the crisis in 2008 maybe because of an increasing fuel price (light trucks consume more than cars).

This close use of cars and light trucks has structural consequences on the repartition of the Canadian light fleet. From 2000 to 2009, the number of light trucks rose, especially the number of SUV (6.9% in 2005 to 12.8% in 2009). The number of cars fell from 60.5% to 55.4%. The number of familial cars rose to reach 3.5% in 2009. Thus, Canadian seems to prefer bigger cars or light trucks than compact cars. We will see later the environmental impact of such a change.

Figure 18: Light fleet per type of vehicle, 2000 and 2009



16,642,140 vehicles 19,755,945 vehicles

Source: RN Canada Enquête sur les véhicules au Canada, 2011

The first point is the **growing mobility of people**, whatever the economic conditions. This is highlighted by the evolution of the surface passenger transport volumes measured in vehicle-kilometer (vehicle-kilometer = (number of vehicles)*(average driven kilometer)). This indicator has gone on rising in spite of the crisis, these former years.

Financial cost for the user:

Rising inequality and unfavourable economic conditions, including low wages and high unemployment, restrain budgets for increasing numbers of households. Rising costs of getting a driving license and of car insurance exacerbate these constraints, perhaps most for young adults. The affordability of mobility may become a concern. Transport was the second post of expenses for Canadian households in 2013. Prices are partly determined in markets and partly depend on transport policies broadly defined, where the latter now often are less favourable to car use than before. Together with ageing and saturation of access to cars, these changes contribute to slower growth of car use. They also reflect increasing heterogeneity among potential car users. Whereas car ownership and use was a common aspiration for most, and an aspiration that was satisfied for increasingly many, it has become a somewhat less universal goal, and perhaps one that is more difficult to reach for some. Mentalities have changed. Providing public transport services tends to slow down the increase in car ownership and use as incomes grow. Cities hence have the potential to embark on less private ownership-oriented pathway and rely more on other modes to meet growing mobility demands

The price-elasticity in the choice of the mean of transport is highly important. That is what shows in a way the punctual fall of kilometers made in 2008: the use of cars is very sensitive to the user cost (especially fuel prices and purchase cost), when prices are too high, people adapt their habits to move. We have to stress this idea to understand after the potential effects of transportation policies on the structure of the light fleet, and its speed to change.

For instance the population would strongly disagree on a massive rise in fuel taxes, without improving public transport efficiency at a low cost for the users. The same way, people would be reluctant to buy natural-gas powered vehicle if their prices is higher than gasoline- powered vehicles so incentive policies would have to be implemented if the government chooses to favour natural-gas powered vehicles.

The question opened here is so: how much does it cost to drive in a compact car, a familial car or a light truck/ VUS? The Canadian Driver Association produced a report in 2012 to answer this question. It chooses three vehicles: Civic LX setting for compact cars, Camry LE setting for familial cars, Equinox LT setting for VUS. Then the cost per kilometer was calculated for each car regarding some variables (for more details please report to the document Association Canadienne des Automobilistes (2013): *Coût d'utilisation d'une automobile*).

Civic LX

Camry LE

Equinoxe LT

The results are presented below:

Figure 19: Annual cost of the use of a Civic LX ($)

Driven kilometer (km)	User cost per year	Owner costs per year	Total cost	Cost per kilometer
12000	1743.6	6214.2	7957.8	0.66
16000	2324.8	6482.16	8806.96	0.55
18000	2615.4	6482.16	9097.56	0.51

24000	3487.2	6737.88	10225.08	0.43
32000	4649.6	7225.08	11874.68	0.37

Source: CAA coût d'utilisation d'une automobile 2013

Figure 20: Annual cost of the use of a Camry LE ($)

Driven kilometer (km)	User cost per year	Owner costs per year	Total cost	Cost per kilometer
12000	1975.2	7179.84	9155.04	0.76
16000	2633.6	7494.00	10127.6	0.63
18000	2962.8	7494.00	10456.8	0.58
24000	3950.4	7801.08	11751.48	0.49
32000	5267.2	8373.48	13640.68	0.43

Source: CAA coût d'utilisation d'une automobile 2013

Figure 21: Annual Cost of the use of an Equinoxe LT

Driven kilometer (km)	User cost per year	Owner costs per year	Total cost	Cost per kilometer
12000	2000.4	8550.24	10550.64	0.88
16000	2667.2	8854.90	11522.10	0.72
18000	3000.6	8854.80	11855.4	0.66
24000	4000.8	9134.88	13135.68	0.55
32000	5334.4	9658.68	14993.08	0.47

Source: CAA coût d'utilisation d'une automobile 2013

The user cost is more or less the same for the Camry LE or the Equinoxe LT. Driving a Civic LX is cheaper. The owner cost depends strongly on the vehicle: owning a Civic LX is cheaper than owning a Camry LE, which is still cheaper than owning an Equinoxe LT. Thus, the appeal for VUS has a true financial cost for households.

Technical evolution of the fleet:

Technical evolutions have two main axes: security and fuel efficiency. Though some of innovations aiming at improving the security increase the consumption, on average fuel efficiency has well improved those last years. Vehicles are today heavier; they have more powerful engine and 4 driven wheels or with full transmission. Those transformations improve security but damage fuel efficiency. So vehicles tend also to have an electric injection system and more gears (up to 7 on some vehicles). These transformations make the vehicle more eco-friendly than it used to.

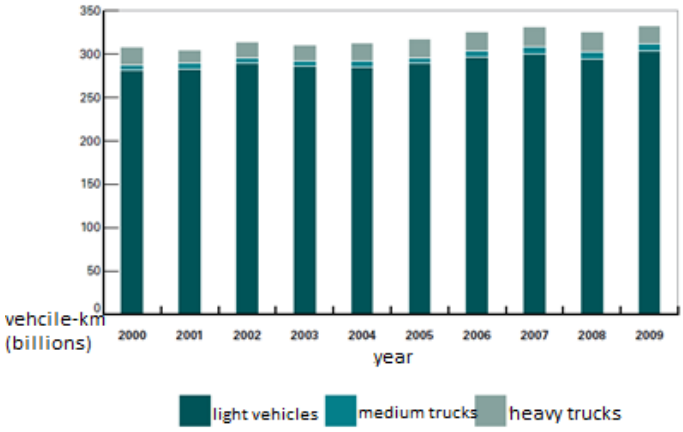
II C- Transport of goods in Canada

IIC1- Road transport: Medium and heavy trucks

At the opposite from the transport of passengers, surface freight volumes are strongly correlated with the economic activity of a country. Thus this sector has suffered a lot from the crisis.

The significant number of vehicle-kilometers made by trucks (8,9%) though they constitute only 4 % of the Canadian vehicle fleet indicate that their average trip are far longer than those of light vehicles.

Figure22: Driven Vehicle-kilometer according to the type of vehicles from 2000 to 2009



Source: RN Canada Enquête sur les véhicules au Canada, 2011

The fleet dedicated to the transport of goods can be segmented as follows:

- Medium trucks: : vehicle which weighs from 4,5 to 15 t
- Heavy trucks: vehicles which weighs 15 t or more

Both, medium and heavy trucks can be described by two types of vehicles:

- tractor trucks (only the driver cabin and the engine, can circulate alone, with one trailer or even two. Mostly used for long-haul trip)
- straight trucks (in one piece).

The following describtion of heavy and medium trucks aims at grasping the differences in the use of those two means of transport.

Figure 23: Evolution of the number of trucks used in Canada from 2000 to 2009

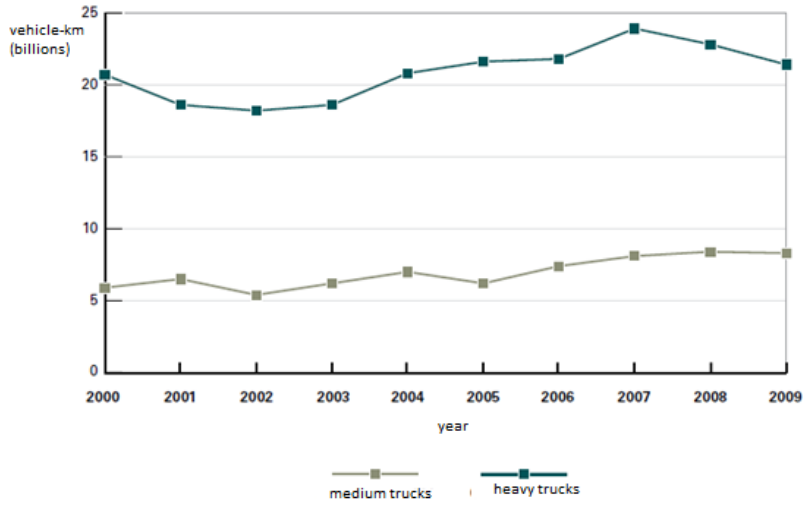
	Medium truck	Heavy truck
Number in 2000	319 500 A	255 503 A
Number in 2009	437 997 B	317 219 B
Growth rate in %	37.1	24.2
Annual composed growth rate in %	3.6	2.4

Source: RN Canada Enquête sur les véhicules au Canada, 2011

This table stresses that the medium-truck fleet is more important than the heavy-truck fleet by 27% in 2009. The gap between those two fleets has increased these years, as the annual composed growth rate related to medium trucks is bigger than the one related to heavy trucks: respectively 3.6 and 2.4.

The average number of vehicle-kilometer is far bigger regarding heavy trucks than medium trucks. Knowing that the medium-truck fleet is bigger than the heavy-truck fleet, this means that heavy trucks are used for far longer trip than heavy trucks. From 2000 to 2009, the vehicle-kilometer compound annual growth rate for medium trucks was high: 3.8% compare to heavy trucks: 0.4%. This is due to first the fact that the number of medium trucks grow faster than the number of heavy trucks, and then to a growing average distance driven by heavy trucks these years.

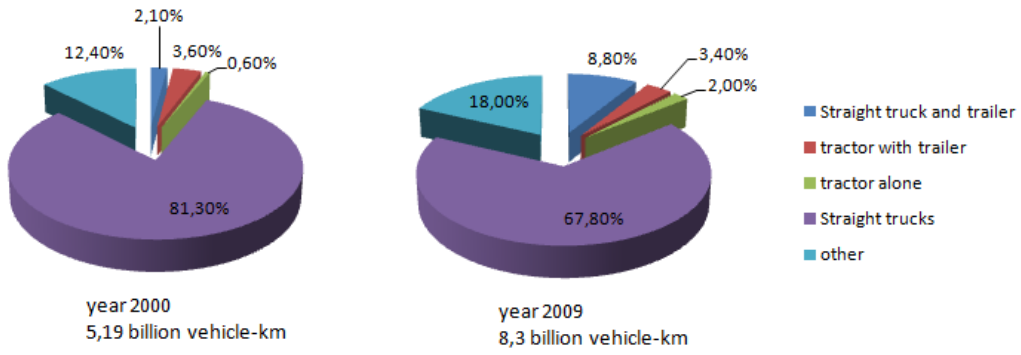
Figure 24: Vehicle-kilometer driven by heavy and medium trucks from 2000 to 2009



Source: RN Canada Enquête sur les véhicules au Canada, 2011

Main of on-the-road medium trucks are straight trucks. However, we notice a huge increase in the use of medium tractor trucks.

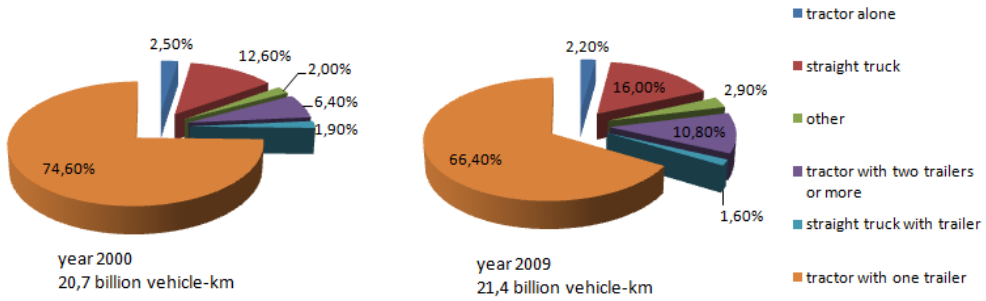
Figure 25: Average distance driven by trucks according to their types



Source: RN Canada Enquête sur les véhicules au Canada, 2011

We face the opposite trend for heavy trucks. Most of heavy-trucks are tractor trucks. The part of straight trucks rose from 2000 to 2009.

Figure 26: distance driven by heavy trucks according to their types

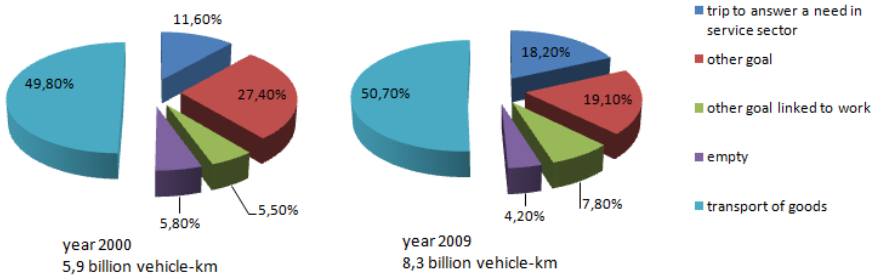


Source: RN Canada Enquête sur les véhicules au Canada, 2011

Those structural differences regarding the length of trips as well as the type of vehicles reveal different uses: heavy trucks are essentially used to transport goods on long-haul. Medium trucks are used to transport goods but also for many other reasons: their uses are more diverse.

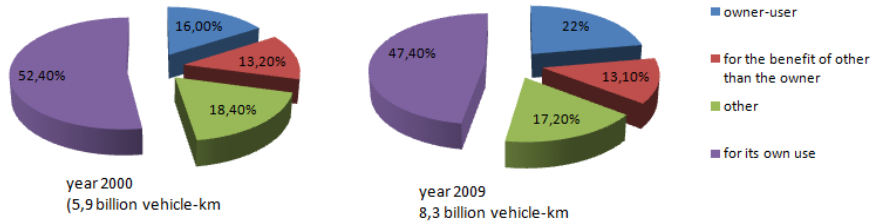
Use of medium trucks:

Figure 27: Distance driven by medium trucks according to their uses



Source: RN Canada Enquête sur les véhicules au Canada, 2011

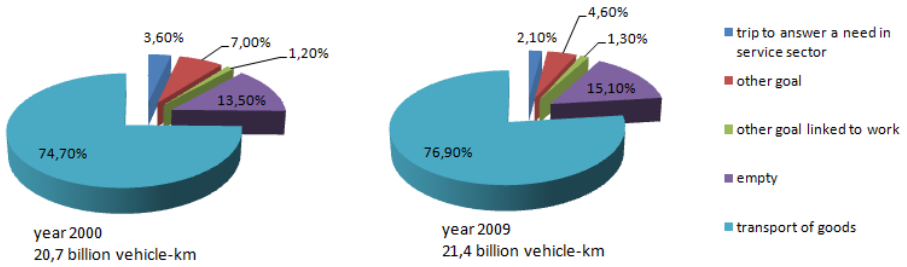
Figure 28: Distance driven by medium trucks according to their activities



Source: RN Canada Enquête sur les véhicules au Canada, 2011

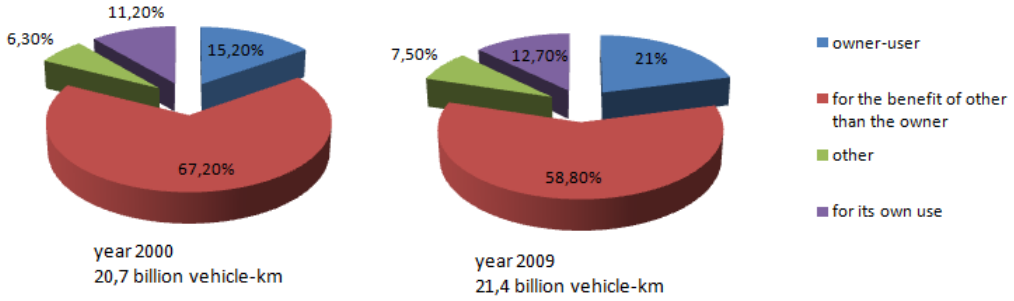
Use of heavy trucks:

Figure 29: Distance driven by heavy trucks according to their uses



Source: RN Canada Enquête sur les véhicules au Canada, 2011

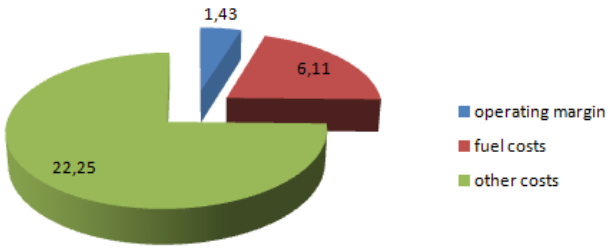
Figure 30: Distance driven by heavy trucks according to their activities



Source: RN Canada Enquête sur les véhicules au Canada, 2011

Thus, while medium trucks have diverse uses (transport of goods, services, other) and are mostly used by their owners, heavy trucks are essentially used to transport goods on long-haul; the user and the owner are not generally the same entity. Consequently, the transport of goods on long haul using heavy-trucks has generated a for-hire trucking industry, while the transport of goods on shorter distance proceeds through an owner-roader organisation. This for-hire trucking industry had generated an operating revenues of $29,8 billion in 2008 (to compare: rail: $11,2 billion or airline $13,6 billion). However this apparently high figure hides a low-entry-barrier industry, intense competition and thus thin margins, which lead to many bankruptcies each year (6% of all the business bankruptcies in Canada in 2008) and limit the possibility of investments by the actors of this sector.

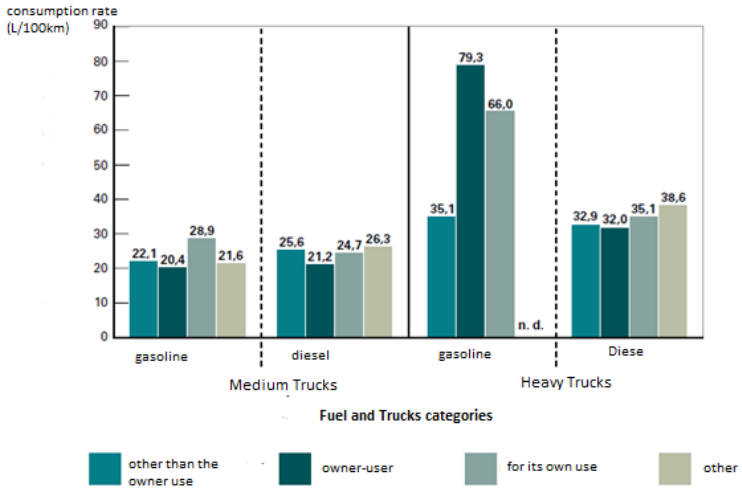
Figure 31: For hire trucking cost structure, 2008 ($ billions)



source: Transport Canada, Statistics Canada, The conference board of Canada

Operating costs (as opposed to capital costs) dominate total costs. The result is a more volatile costs structure. The for-hire trucking industry consumed over 5 billion liter of diesel fuel in 2008. At a unit price of $1.2/L, this would amount to more than 20 per cent of industry revenues. A 30-cent increase in the price of diesel fuel without a corresponding rise in freight charges would wipe out the operating margin. Thus this for-hire trucking industry is highly sensitive to the volatility of fuel prices (especially diesel prices as most of heavy trucks are diesel-powered). The following figures explain why most of the heavy trucks are diesel-powered, while medium trucks are more diverse: gasoline-powered or diesel-powered.

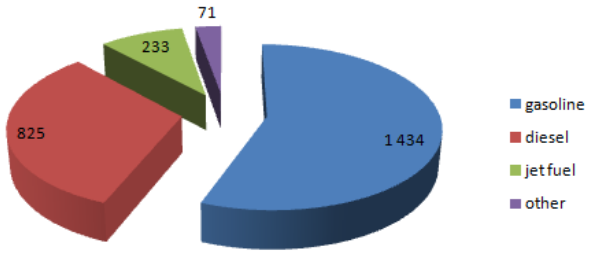
Figure 32: fuel consumption rate of medium and heavy trucks



Source: RN Canada Enquête sur les véhicules au Canada, 2011

Thus, 86% of the diesel used in transportation is used by trucking industry (24% remaining are used for rail and marine transportation). This accounts also for 28% of the whole energy used in transportation.

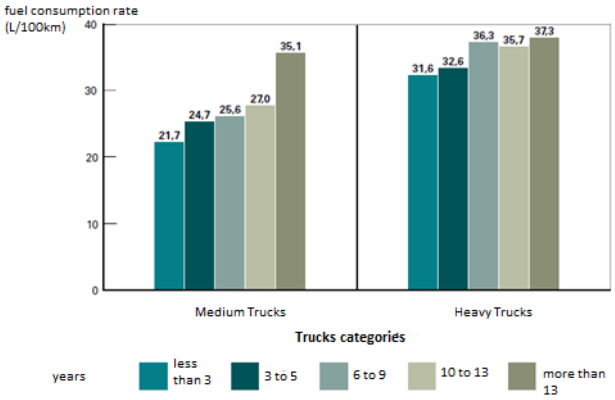
Figure 33: Relative Shares of Transportation Fuels in Canada, 2009 (energy content, PJ)



Sources: Transport Canada, Statistics Canada, The conference board of Canada

Technological improvement and time effects result in the following consumption rate:

Figure 34: Consumption rate of medium and heavy trucks according to their ages



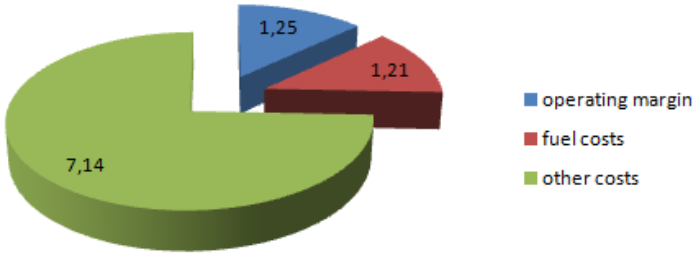
Source: RN Canada Enquête sur les véhicules au Canada, 2011

IIC2-Railway Industry

Two actors (94% of the rail freight traffic in Canada): Canada National Railways: CN, Canadian Pacific Railways CP. CN is the larger carrier, both by volume and by revenue.

Figure 35: Rail Industry Cost Structure 2009 ($ billions)

note: includes intercity and commuter passenger rail operations.



Source Statistic Canada the conference board of Canada 2011

Note: it is not meaningful to compare operating ratios between trucking and railway industries, as the railway industry is far more capital-intensive.

As a result, operating margins must be significantly higher in order to finance ongoing reinvestment. Thus the railway industry has greater access to capital and may discount future cash flows at a lower rate when making capital expenditure decisions. This fact is important to understand why rail industry can more easily finance new source of energy for the transportation sector than the trucking industry, which has to rely on consumer charges or public financial support.

To put it in a nutshell, we face today structural change in the transport sector. Regarding the transport of passengers, we noticed a trend to choose bigger cars in Canada, though those cars are more expensive. Furthermore, cars are used less intensively. We can explain it by many factors: the spread of urban area and the role of public transport, the price of private mobility, change in the mentality… Regarding goods transportation, we have observed its strong correlation to the economic growth (so figures observed since 2008 must always be interpreted in this way) whereas transport of passengers was slightly impacted by the economic growth. Transport sector is dominated by road transportation, which causes growing environmental concerns. Eventually, most of the transport-related funds are turned to the maintenance of the infrastructures in Canada, as well as in developed countries in general. As infrastructures are ageing, there will be growing needs in investments, which stresses the dramatic issue raised by excessive debts. Transport investment is indeed funded from general tax revenue or from charging users or indirect beneficiaries of transport infrastructure. The solution may be the spread of public-private partnership.

III- Transport sector overview in the province of Québec:

subsector	2008	2009	2010	2011	2012	AAVR 2012/2008 %
Québec	152 944	148 509	148 252	150 878	151 007	–0,3
Air transport	14 906	12 632	12 384	12 233	13 043	–3,3
Rail transport	6 912	6 532	6 544	6 912	6 888	–0,1
Truck transport	41 967	38 559	38 613	38 193	38 422	–2,2
Public transport and ground passenger transportation	33 857	34 632	35 242	36 112	35 865	1,5
Activities supporting transportation	22 642	23 277	23 184	24 567	24 726	2,2
Mail services	9 598	9 318	x	x	x	..
other	23 062	23 559	..	..	..	..
Canada	689 948	676 667	670 675	682 564	702 024	0,4
Air transport	65 959	68 033	66 793	67 560	71 160	1,9
Rail transport	37 783	36 767	34 844	35 854	37 193	–0,4
Truck transport	182 424	168 241	166 932	170 770	175 785	–0,9
Public transport and ground passenger transportation	118 881	119 209	119 400	121 634	124 831	1,2
Activities supporting transportation	97 992	97 307	98 705	102 303	106 067	2

Mail services	46 912	47 098	46 604	46 781	48 582	0,9
other	139 997	140 012	137 397	137 662	138 406	–0,3

Québec is the largest province of Canada in terms of area: 1 667 712 km^2. 25% of the Canadians so 8 155,3 thousands of people live in the province of Québec. 33% of the population of Québec live in one of the three biggest cities of the province: Montreal (1 717,8 thousands inhabitants, so 21% of the population of Québec live in Montreal), Québec (532,4 thousands inhabitants) and Laval (417,3 thousands inhabitants). In 2012, 151 007 people were working in the transport sector. A quarter (25,4%) of which was working in truck freight, which is thus the biggest subsector regarding employment though the number of jobs has decreased by 2,2% per year since 2008. Another quarter (23,8%) was working in public transport or on-road-passenger transport sector. This rate is high compare to the Canadian average of 17,8%. Regarding the economic activity of this sector, air transport has been strongly pushed down in Québec (AAVR = -3.3%) while it was a branch in full development if we consider Canada as a whole (AAVR: +1.9%). Truck transportation was stroke by the crisis. The consequences are sensitive on the regional scale (in Québec: AAVR= -2.2%) as well as on the country scale (in Canada AAVR= -1.9%). The biggest growth in the province of Québec was the sector of activities supporting transportation.

Figure 36: Number of transportation industry workers by subsector according to the NAICS (North American Industry Classification System), Québec and Canada, 2008–2012

TVAM : Annual Average Variation Rate

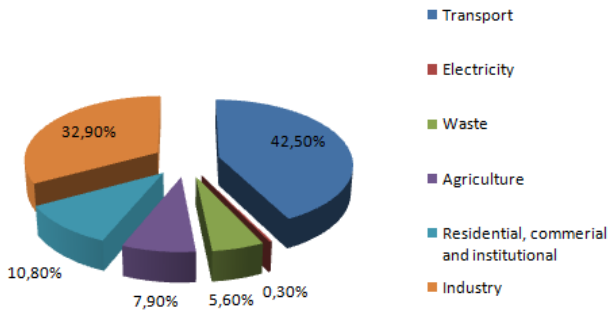
Source : Statistique Canada, Enquête sur l'emploi, la rémunération et les heures de travail, CANSIM, tableau 281–0024, novembre 2013

Many trends exposed above regarding the whole Canada are true regarding the province of Québec. Some specialities will be though stressed when they exist. We will first expose some generalities, then detail passenger transportation and eventually good transportation.

III A- Transportation in Québec: general trends:

Same point as for the whole Canada, transport sector raises great concern regarding GHG emissions. In 2010, Transport sector was responsible for 42,5% of the 82,5Mt CO_2 eq emitted in Quebec (10,4 t CO_2 eq per inhabitant).

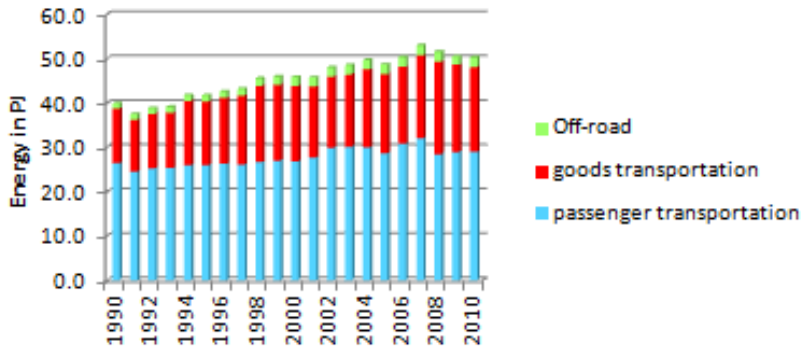
Figure 37: GHG emissions by sectors of activities, 2010



Source: Ministry of sustainable development, of environment, of fauna and parks. Political Management of the atmosphere quality.

This huge part of transport sector is explained by the weight of road transportation to transport people or goods in the province of Québec (as it was the case for the whole Canada).

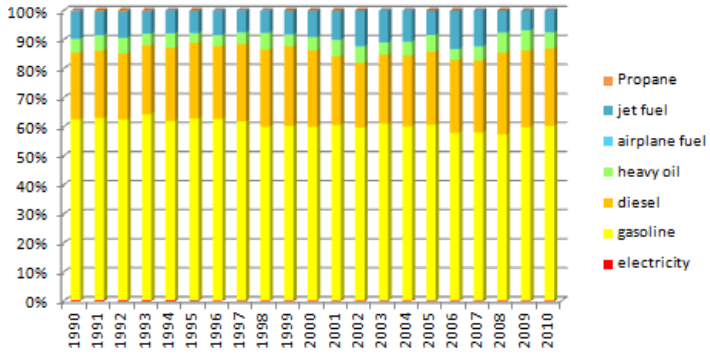
Figure 38: Secondary energy consumption of the transport sector in Quebec



Source: RNC Quebec transport sector table 1

The energy consumed by the transport sector has been rising since 1990, reaching a top in 2007. Figure 36 stresses first the importance of passenger transportation regarding the energy consumption and then the growing part of goods transportation.

Figure 39: Energy consumption by energy sector in Quebec (%)

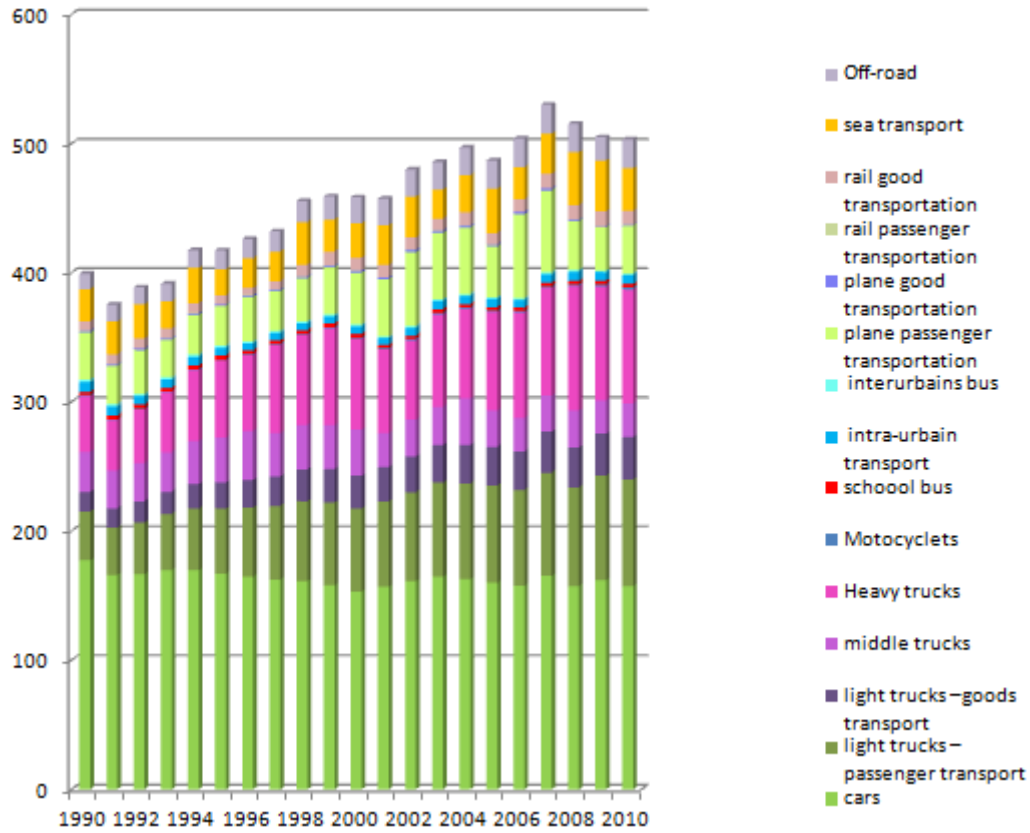


Source: RNC Quebec transport sector table 1

Figure 37 shows how transport sector has depended on gasoline since the 1990's. The structure of the energy sources has been the same for 20 years: the domination of gasoline is appalling. We may see a growing part of diesel-powered vehicles. This may be due to many factors: growth of good transport sectors (with diesel-powered heavy trucks), to a slight change in the light fleet (more light trucks are used, some of them are diesel powered)…

We notice the absence of the spread of the use of electricity, bio-diesel or ethanol-powered vehicle.

Figure 40: Energy consumption by means of transport in Quebec (PJ)



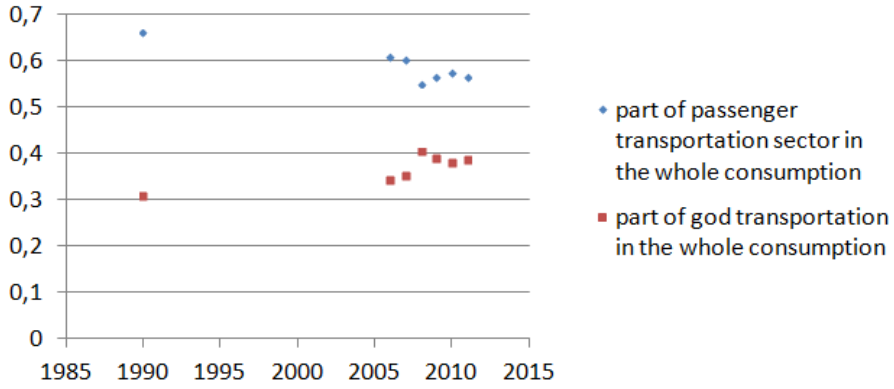
Source: RNC Quebec transport sector table 6

As said before, we observe that road transportation dominates the transportation sector in Québec: it represents 84.6% of the whole sector in 2012, 86.2% of passenger transportation, and 80.2% of good transportation. This domination explains why gasoline and diesel are that important when we study the energy-mix of Québec.

Two means of transport have widely increased these years: light trucks regarding passenger transportation and heavy trucks regarding good transport. This raises huge environmental concerns as those two means of transport are known as great polluters.

Since 1990, the part of the consumption due to passenger transportation has been decreasing whereas the part of energy consumption due to good transportation has been increasing:

Figure 41: Consumption of passenger and good transportation (%)



We observe that the consumption of passenger-transport sector plunged in 2008, certainly because of the economic crisis (we observe that this decrease happened one year later in good transportation. This delay may be due to a run-on-time of the economy). Since 2008, this consumption rate has gone on increasing.

We observe that the consumption of cars has been decreasing since 1990, when the consumption of light trucks has been increasing.

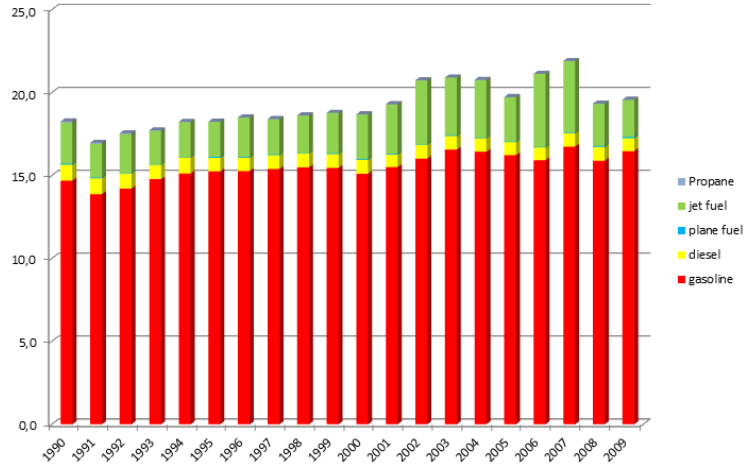
We observe that after having known a huge increase since 1990, energy consumption from good transportation sector plunged in 2009, undergoing the consequences of the 2008 economic crisis (this plunge in the consumption should reveal a slow-down of the economic activity). The most significant trend in this sector is the growing part of heavy trucks in the activity of this sector.

III B- Passenger transportation in Québec:

Households in Québec spent $10 393 in the transport sector in 2011. Thus transport represents 21,1% of an average household budget in Québec. This rate is slightly above the Canadian average: 20,4% (figures from statistic Canada website).

The energy consumption related to passenger transportation has been decreasing since 1990. However, this global trend hides two parts: First the consumption declined up to 2008 reaching 284.7 PJ. The consumption rate raised then to reach 294.1 PJ in 2011. Cars consumption declined from 2009 to 2011, when light truck consumption was rising. We may assume that this evolution is mostly due to a growing part of light trucks in the light fleet these last years. The energy consumed is mostly gasoline for cars (82.2% in 2011) and diesel for cars as well (4%). Jet fuel comes in 2nd position with 13.2%.

Figure 42: GES Emission in Mt CO2 eq passenger transportation, Quebec



Source: RNC Quebec sector of transport table 5

As expected, gasoline set for 82.2% of the energy consumption for passenger transport; it represents also 82.1% of GHG emissions. Jet fuel appears in second position with 13.4% of the emissions in 2012 and diesel comes at the end with 4.2%.

IIB1- Road transportation

Figure 43: Road transportation summarize

year	Passenger-kilometer (million)	Tonne-kilometer	Energetic intensity of passenger road transportation (MJ/Vkm))	Energetic intensity of good-related road transportation
1990	98999	21 038	2,30	4,26
1991	95 526	19 555	2,25	4,26
1992	99439	20 647	2,20	4,24
1993	102782	23 355	2,19	4,05
1994	106298	28 383	2,16	3,78
1995	107188	29 326	2,14	3,91
1996	106682	30 493	2,14	3,88
1997	108787	32 784	2,12	3,80
1998	109702	35 035	2,13	3,68
1999	110195	39 447	2,12	3,42
2000	108678	37 089	2,10	3,55
2001	111119	35 937	2,10	3,28
2002	116141	35 354	2,08	3,33
2003	120697	38 754	2,06	3,36
2004	120910	44 348	2,05	3,04
2005	120907	45 301	2,04	2,97
2006	121356	47 290	2,00	2,90
2007	127141	46 552	2,02	3,08
2008	123102	51 073	2,00	3,05
2009	128947	43 723	1,98	3,35
2010	128562	44 697	1,96	3,29

Source RNC Quebec transport sector table 20

The energetic intensity has drooped since 1990 by 17 % for passenger transportation and 30% for good transportation. On the contrary, the activity (so the number of passenger-kilometer) has increased by 30% since 1990. Thus the road-transportation efficiency seems to have increased since 1990, this progress may be not enough though to significantly reverse the trend of GHG emissions. The energetic intensity and the GHG emission rates seem to be uncorrelated: the energetic intensity has been decreasing since 2007, whereas the transport-related GHG emission rate has known strong variations during the same period. Those two variables are obviously linked but not as much as what could be thought at a first sight. We may explain it through the variable traveler-kilometer: number of traveler*number of driven kilometers. GHG emissions are directly linked to the fuel consumed, which is strongly correlated to the number of driven kilometer. However, the vehicle-occupancy rate may have risen from 2007 to 2011 (for instance because of the growing part of transport sector in households 'budgets), increasing thus a lot the number of

passenger-kilometer but not that much GHG emissions leading so to a "de-correlation" of the two variables.

- Car fleet overview:

Figure 44: car fleet overview

Year*1000	car (sold)	Cars (fleet)	Annual average driven kilometer (km)	Fuel(gasoline) average consumption on road: compact cars (L/100 km)	Fuel(diesel) average consumption on road: compact cars (L/100 km)
1990	254	2 804	17 444	10,5	7,8
1991	259	2 831	16 466	10,3	7,6
1992	243	2 824	16 858	10,1	7,5
1993	215	2 873	17 012	10,0	7,5
1994	213	2 836	17 404	9,9	7,5
1995	185	2 848	17 274	9,8	7,5
1996	198	2 779	17 467	9,8	7,4
1997	219	2 781	17 432	9,7	7,3
1998	225	2 815	17 030	9,6	7,2
1999	235	2 819	16 763	9,6	7,1
2000	249	2 814	16 411	9,5	7,0
2001	258	2 819	16 868	9,4	7,0
2002	279	2 901	16 943	9,4	7,0
2003	274	2 951	17 159	9,3	7,0
2004	262	2 996	16 800	9,2	7,0
2005	264	3 017	16 498	9,2	7,0
2006	263	3 076	16 022	9,2	6,9
2007	263	3 112	16 764	9,1	6,9
2008	284	3 171	15 786	9,0	6,9
2009	252	3 197	16 278	8,9	6,9
2010	239	3 227	15785	8,8	7,0

Data: statistic Canada, Table 21

After having known a constant growth-rate from 2006 to 2010 (38 700 new cars each year), car fleet growth-rate seems to flat. This should reflect the reverse trend: a decreasing number of cars bought since 2009. We observe also that the average driven distance per year, as well as the consumption rate of small cars has been decreasing all the time since 1990 (we may eventually note diesel is more fuel efficient than gasoline).

- Light trucks

  Figure 45: Energy consumption by source of energy (PJ):

year	1990	2000	2005	2008	2009	2010	2011
Gasoline	35,5	73,7	79,2	76,1	79,5	81,8	85,5
Diesel	2,0	0,5	0,5	0,5	0,6	0,7	0,6

We stress the absence of the following fuel: natural gas, ethanol, biodiesel-fuel, propane.

Figure 46: Activity of trucks used to transport people.

	1990	2000	2005	2008	2009	2010	2011
Traveller-kilometer	13 880	30 514	32 968	32 020	33 894	33 316	37 238
Energetic Intensity (MJ/Vkm)	2,71	2,43	2,42	2,39	2,36	2,34	2,31
GHG Emissions (Mt CO_2 eq)	2,6	5,1	5,5	5,2	5,4	5,6	5,8
GHG Intensity (tonnes/TJ)	69,7	69,0	68,7	68,2	67,9	67,5	67,2

GHG are emitted 99% by gasoline-powered truck and 0,1% by diesel-powered truck. This is explained by the huge greater number of gasoline-powered truck compare to the number of diesel-powered-truck.

We make the same observations as for cars: most of light trucks are gasoline-powered. The energetic intensity and the GHG emission rate are not strongly correlated.

- Motocyclette activity overview

  Even though we face a strong raise in motocyclette activity and GHG emissions, the figures are negligible compare to car and truck linked activity and emissions. Thus we briefly summarized them in the following table.

Figure 47: Motocyclette overview

	Energetic consumption (PJ)	Passenger-kilometer(million) (millions)	Energetic intensity (MJ/Vkm)	GHG emissions (Mt éq CO_2)	Average driven distance per year (km)	Average fuel consumption on road (L/100 km)	Park (*1000)

1990	0,7	441	1,48	0,0	4 723	4,7	85
2010	1,7	946	1,76	0,1	4 584	5,4	192
Increase since 1990 (%)	142%	115%	19%		-3%	15%	126%

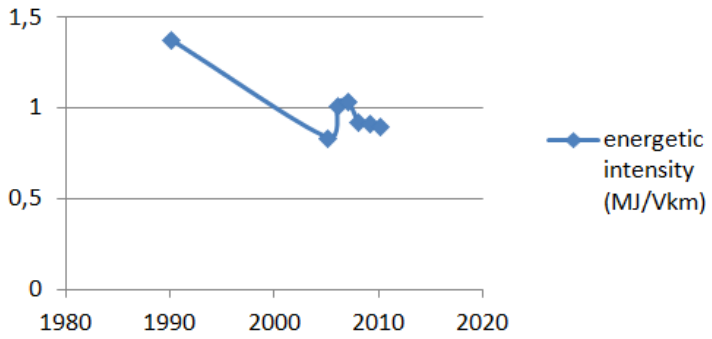
Source: RNC Quebec transport sector table 32

- Public transport

  Bus activity overview

  Bus activity measured in passenger-kilometer has increased by 39 % since 1990 reaching 12 252 million in 2010. The energetic intensity has decreased since 1990:

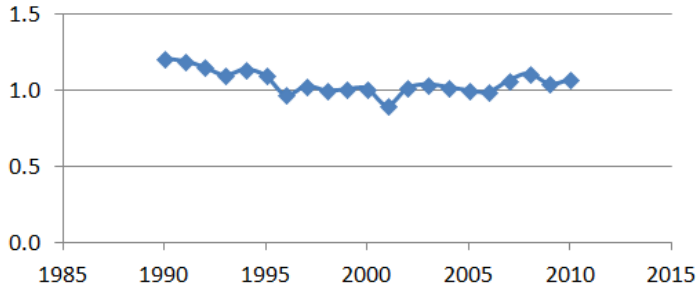
Figure 48: Energetic Intensity of Buses (MJ/Vkm)



Source: RNC Quebec transport sector table 12

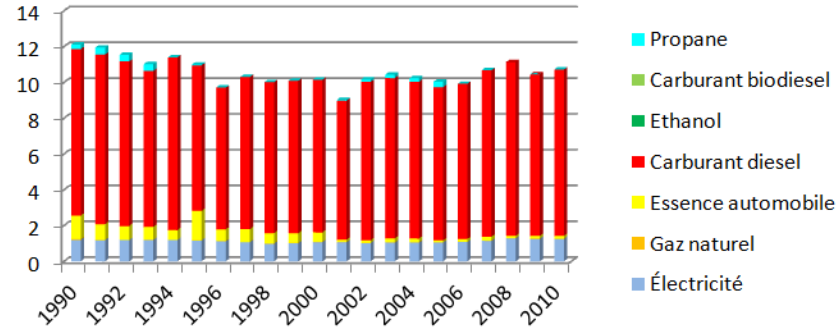
Thus bus transport seems to become more and more efficient. As the energy consumption has only slightly decreased since 1990, the decrease in the energetic intensity is due to an increase in the number of passengers transported and kilometer driven. In 2010, public transport made more than 569 million movements (source: Ministère des Transports du Québec, Direction du transport terrestre des personnes)

Figure 49: Energy consumption of buses (PJ)



Source: RNC Quebec transport sector table 12

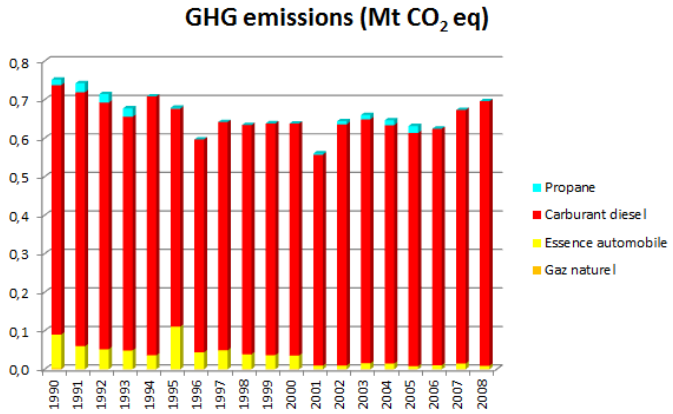
Figure 50: Energy consumption by sources of energy (PJ)



Source: RNC Quebec transport sector table 12

Buses are essentially diesel powered. The consumption of gasoline has crushed since1996. Electricity consumption seems to stay constant over the years. Biodiesel, ethanol or natural gas consumptions are not significant enough to appear on the graph. Thus, the structure of bus consumption does not present any dramatic change over the last twenty years, except gasoline, which has almost vanished from this energetic-mix. Even though bus-related fuel consumption and GHG emissions have nothing to do with car figures or truck figures, we may question this missing change: if public transport are the key to solve congestion issues and a driven factor to reduce the use of cars, it may urge to adopt new sources of energy more eco-friendly than diesel.

Figure 51: GHG Emissions (Mt CO_2 eq)

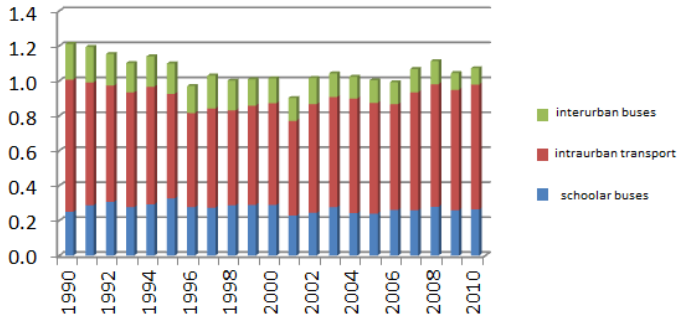


Source: RNC Quebec transport sector table 22

Emissions are directly linked to fuel consumption: Diesel is the fuel the most used so it is responsible for the main part of GHG emissions.

We observe three kinds of buses: intra-urban buses to move inside a city, interurban buses to move from a city to another, school buses.

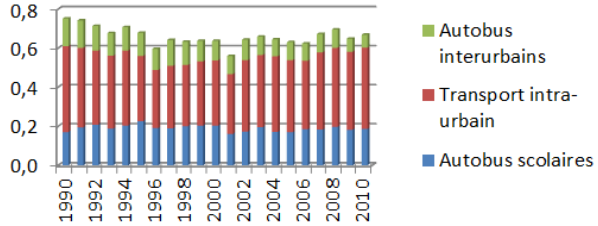
Figure 52: Energy consumption by type of buses (PJ)



Source: RNC Quebec transport sector table 12

Intra-urban buses are the more used, that is why they represent more than half of bus energy consumption.

Figure 53: GHG by type of buses (Mt CO_2 eq)



Source: RNC Quebec transport sector table 12

GHG emissions are linked to the consumption. We cannot conclude from these graphs that one kind of bus is more polluting than the other.

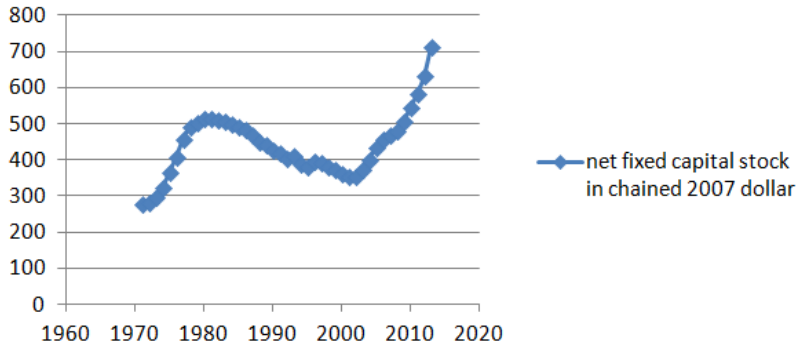
In 2010, expenses reached $2,4 billion; two third of which are paid by users (34%), transport ministry (22%), car user taxes (7%), other subventions such as the federal State (5%), the last third is paid by the local town.

Figure 54: Public transport expenses

	Number of trips made by public transport users	Total business income	Car user charges (k$)	Ministry of Quebec charges (k$)	Other subsidies (k$)	Municipalities charges (k$)	Total expenses (k$)
Common transport society	523 344 165	700 627	110 499	290 238	110 719	631 027	1 843 111
Metropolitan transport agency	16 876 300	56 180	42 508	120 996		86 510	306 194
Municipal transport organisation	21 994 210	50 332	13 229	37 331	1 941	29 433	132 266
Adapted transport	7 404 183	19 486		83 892	820	35 142	139 340
total	569 618 858	826 625	166 236	532 457	113 480	782 113	2 420 911

source: statistique Québec
Details:
Car user charges come from 30$ taken from the registration right and 3 cents per liter of fuel.
Ministry of Québec charges count also the debt from the metropolitan.
Municipalities assume the deficit from public transport use.

Figure 55: Net fixed capital stock in chained 2007 k$



Sources: Statistic Canada, Flux et Stock de capital fixes 2011, adapté par l'institut de statistique du Québec (ISQ). Prochaines données : 2014.

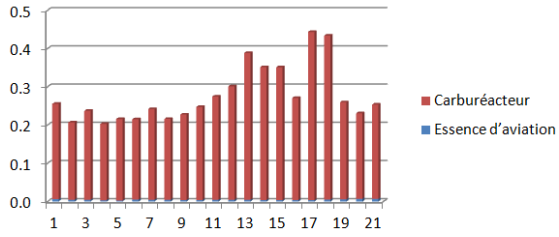
In 2013 the net stock of fixed assets in public transport per inhabitant reached a historical top: $ 712/inhabitant, for a total value of the assets of $5,8 billion. The first increase in the 1970's is partly due to the building of metropolitan infrastructure in Montreal. Since 2002, the asset value per inhabitant has increased every year. This increase may be explained by the extension of the metro to Laval, and by the

Public transport policy lead by the government of the province. Given the steady population growth-rate, those variations are mostly due to variations in the net stock value of fixed assets in public transport.

IIIB2- Air transportation

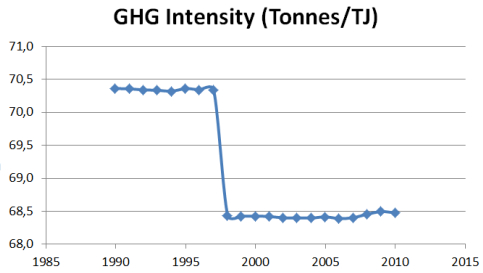
Air transportation mostly relies on jet fuel as source of energy (between 97 and 99 % according to the year - *Source RNC Quebec transport sector table 14*-), thus jet fuel represents also most of the source of GHG emitted by this subsector.

Figure 56: GHG Emission, air transportation ($MtCO_2eq$)



Source RNC Quebec transport sector table 14

Figure 57: GHG Intensity (T/TJ)

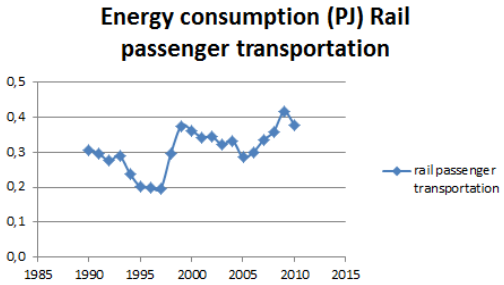


Source RNC Quebec transport sector table 14

The GHG intensity has not really changed since 1990, the decrease observed in 1997 represents only a drop by 3%.

IIIB3-Rail transportation

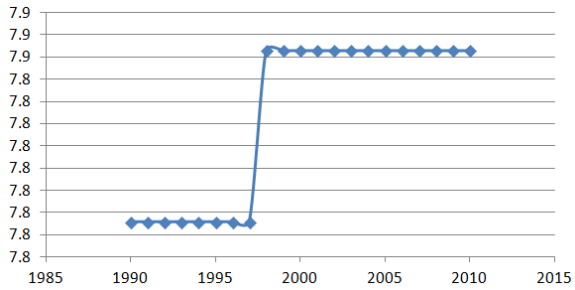
Figure 58: Energy consumption, passenger rail transportation (PJ)



source: RNC Quebec transport sector table 7

The energy consumed by rail sector knew first a drop from 1992 to 1999 then a huge increase up to 2000. Mostly stable since then, the energy consumption reveals the economic situation: increase from 2005 to 2008, drop in 2008 and 2009.

Figure 59: GHG Intensity (tonnes/TJ)

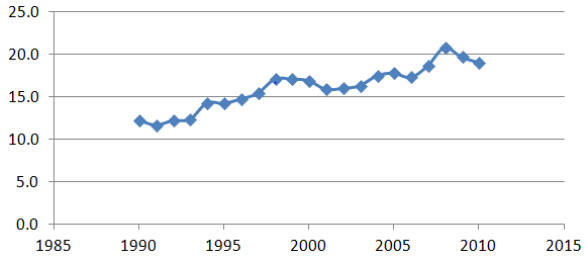


Source: RNC Quebec transport sector table 8

III C- Good transportation in Québec:

IIIC1- Energy consumption:

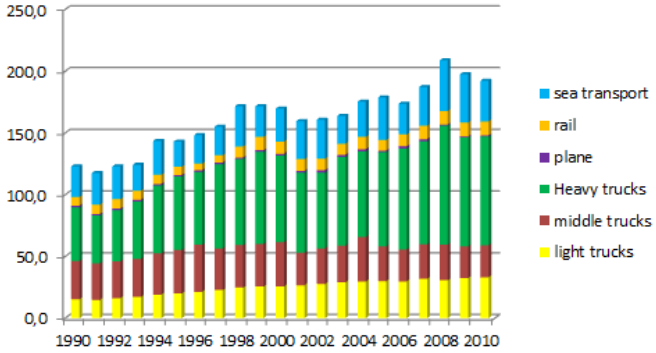
Figure 60: Good-transportation related energy consumption (PJ)



Source: RNC Quebec transport sector table 3

The energy consumption of good transportation has mostly known an increasing trend since 1990. We notice a decrease in the years 2009 and 2010 because of the economic crisis, which impacted a lot the sector. However, this trend has been reversed in 2011 and the consumption rate started increasing again.

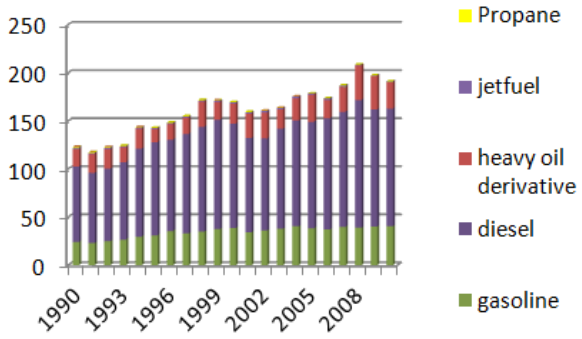
Figure 61: Energy consumption by sort of transport (PJ)



Source: RNC Quebec transport sector table 7

Heavy truck consumption represents almost 20% of the whole consumption of the transport sector. What is more the weight of heavy truck in good-transportation-related energy consumption has been growing these last years. If we add light and medium truck, road transportation for goods represents 31.1% of the whole transport sector energy consumption.

Figure 62: Energy consumption by source of energy (PJ)

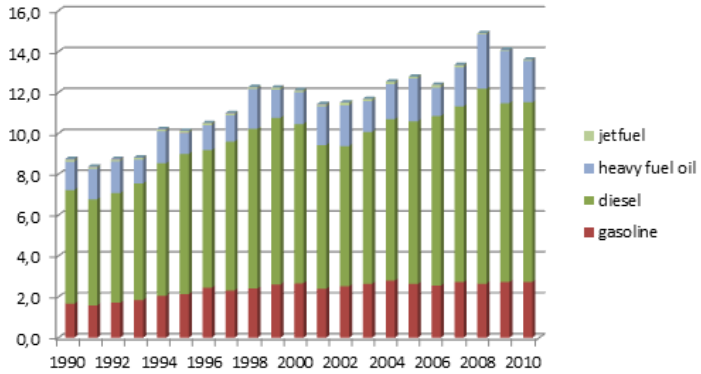


Source: RNC Quebec transport sector table 3

68.2% of the energy used in good-transportation is consumed through diesel (used in heavy trucks), 20.8% through gasoline and 10.5% through heavy oil derivatives.

Greenhouse gas emissions:

Figure 63: Good-transportation related GHG Emissions (Mt CO_2 eq)

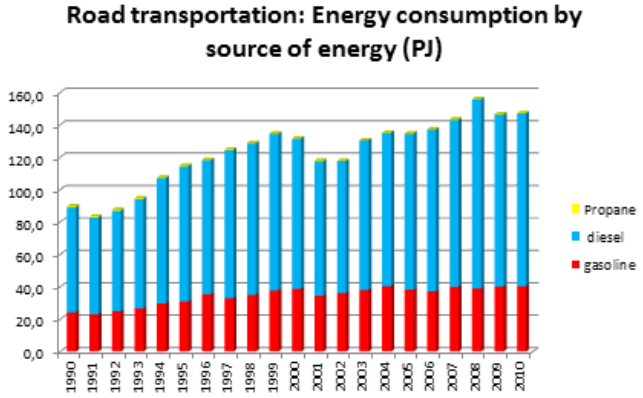


Source: RNC Quebec sector of transport table6

In 2012, most of GHG emissions were due to diesel combustion (68.9% of the emissions), since it is the type of energy the most used in good transportation. Gasoline is then responsible for 19.6% of the emissions and heavy oil derivatives of 11%.

IIIC2-Road transportation

Figure 64: road transportation Energy consumption by source of energy (PJ)



Source RNC Quebec transport sector table 11

The energy consumed by road transportation has known an appalling increase since 1990. If the use of gasoline seems to have been stabilized around 40 PJ per year, the use of gasoline knows strong variations, and an increasing trend.

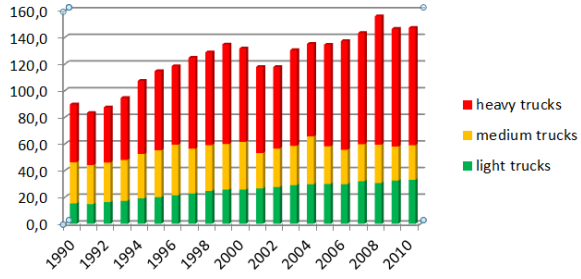
Figure 65: Road transportation activity

year	Energetic intensity of good-related road transportation (MJ/Tkm)	GHG intensity of good-related road trasportation (tonnes/TJ)	GHG emissions-except electricity good-related transportation (Mt éq CO2).
1990	4,26	69,2	6,2
1991	4,26	69,3	5,8
1992	4,24	69,3	6,1
1993	4,05	69,4	6,6
1994	3,78	69,4	7,5
1995	3,91	69,5	8,0
1996	3,88	69,5	8,2
1997	3,80	69,7	8,7
1998	3,68	70,1	9,0
1999	3,42	70,1	9,4
2000	3,55	70,1	9,2
2001	3,28	70,3	8,3
2002	3,33	70,3	8,3
2003	3,37	70,3	9,2
2004	3,05	70,2	9,5
2005	2,97	70,2	9,4
2006	2,90	70,1	9,6
2007	3,08	70,0	10,0
2008	3,05	70,0	10,9
2009	3,35	69,9	10,2

Source: Natural resources Canada sector of transport Quebec table 9

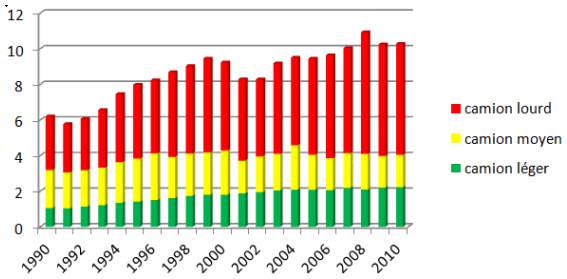
The energetic intensity has decreased by only 3% since 1990, the GHG intensity has remained almost constant during the same period, GHG emissions have dramatically increased by 40%.

Figure 66: Energy consumption (PJ)



Source: RNC Quebec transport sector table 12

Figure 67: GHG Emissions (Mt CO_2 eq)



Source: RNC Quebec transport sector table 12

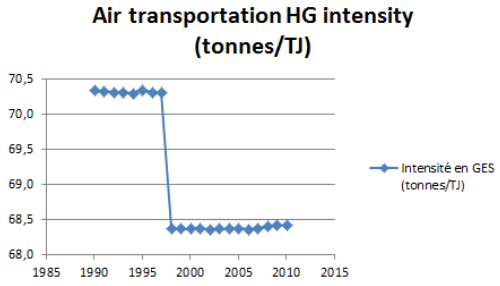
The large use of heavy truck is the driving factor that explains the energy consumed by road transportation to transport goods and thus the GHG emissions of this sector. The use of medium trucks has remained mostly stable since 1990, and seems even to follow a decreasing trend since 2002. On the contrary light trucks are following an increasing trend.

It may be a concern to see that the energy-mix of road transportation has not changed since 1990. This remark should more accurate for passenger transportation, but we do master some new technologies: natural-gas powered truck, electricity-powered car, bio-fuel…. And no change has been observed since 1990 except the increasing use of heavy trucks to transport goods.

IIIC3-Air transportation

The fuel used to transport good by airplane is almost exclusively jet fuel. Thus the consumption of this fuel is responsible for 99% of GHG emissions by air transportation for what good transportation concerns.

Figure 68: Air transportation GHG Intensity (tonnes/TJ)

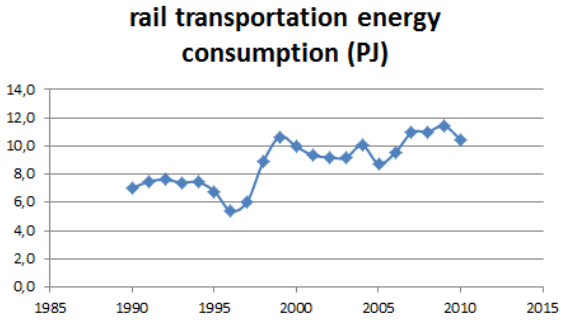


Source: RNC quebec transport sector table 15

IIIC4-Rail transportation

Rail transportation only consumes diesel fuel.

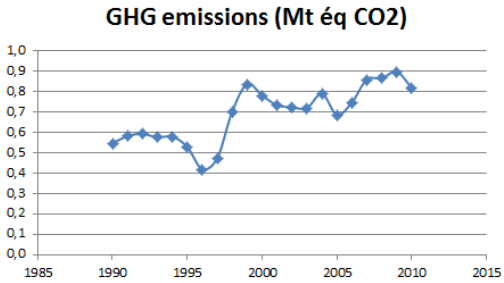
Figure 69 : rail transportation energy consumption (PJ)



Source RNC Quebec transport sector table 18

Rail transportation has known an increasing trend since 1990. This should reflect a larger use of rail transportation.

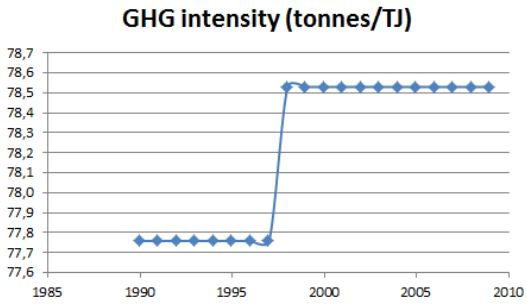
Figure 70: Rail transportation GHG Emissions (Mt CO_2 eq)



Source RNC Quebec transport sector table 18

The similarity between figure 67 and figure 68 results from the direct link between energy consumption and GHG emissions in the absence of improvement in the yield of GHG emissions: the more rail transportation consumes, the more it emits GHG. To reverse this trend solutions could be: use more intensively trains, rethink the size of trains (to improve the efficiency), new technologies to reduce the emissions per liter of fuel consumed.

Figure 71: GHG Intensity (tonnes/TJ)

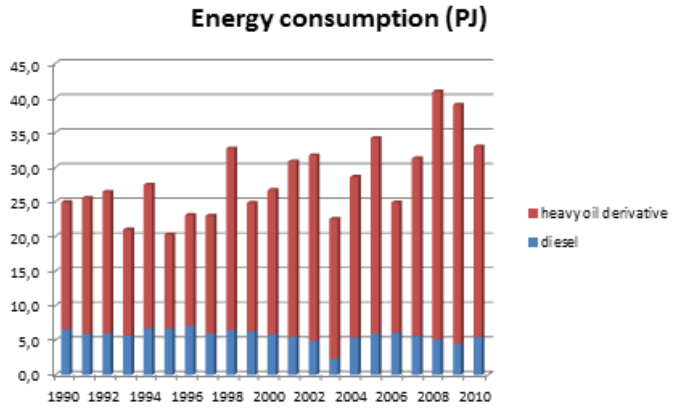


Source RNC Quebec transport sector table 18

The GHG intensity has remained constant since 1990. The increase we can see on the figure 69 is in fact only a jump by less than 1%. So there has been no real improvement regarding the efficiency of train transportation since 1990, if we consider the GHG intensity.

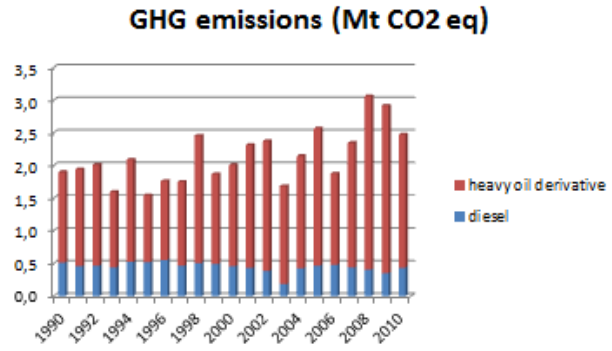
IIIC5-Sea transportation

Figure 72: Energy consumption of sea transportation (PJ)



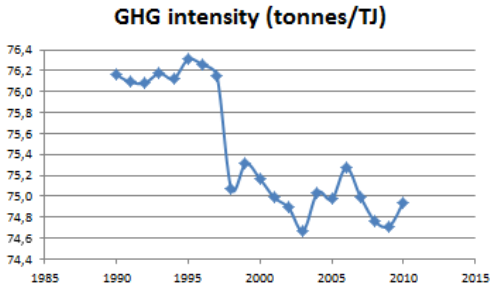
Source: RNC Quebec transport sector table 19

Figure 73: GHG Emissions (Mt CO_2 eq)



Source: RNC Quebec transport sector table 19

Figure 74: GHG Intensity (tonnes/TJ)



Source: RNC Quebec transport sector table 19

Sea transportation is not a very used mean of transport that is why it does not produce much of GHG. However, we may stress the drop in GHG intensity since 1995. This drop is due to an optimisation of cargo-vessels size. This improvement regarding the environmental impact of this mean of transport let us hope that there is a huge work to do in optimizing the size of trucks, and the occupancy rates of light fleet: transport sector has not been yet optimized regarding its use, meaning that many improvements can be obtained with few changes in our habits.

Conclusion

In the first part we first stress on how urgent environment concern regarding transportation sector was: Canada's transportation economic sector is the second-largest contributor to Canada's GHG emissions, representing 24% of total emissions in 2012. Emissions rose by 39 Mt between 1990 and 2005, an increase of around 30% over the period. We then insist on the two driving factors regarding transport-related GHG emissions: the constitution of the light fleet: mostly gasoline-powered for passenger transportation, the use of medium and heavy trucks for good transportation.

In a second part we saw that Canada shares many features in common with all the other developed countries regarding the development of transport sector. During their developments, countries invest a lot to build new infrastructures. Then the transport-related expenses diminish to focus on the maintenance of the infrastructures. The driving factor of the development of the transport sector is the growing division in space of our society: there is a place where people work, a place where they live, a place to produce goods, a place to sell goods. This situation implies a growing number of trips and explains the development of this sector.

The third part focuses on the province of Québec. It shows first that most of the Canadian issues are true as well at the provincial scale: transport-related GHG emissions are mostly due to gasoline-powered vehicles and the use of medium and heavy trucks. However, as emphasized the transformation in the sea-transportation, a better optimization of the trips (higher occupancy rate, more fuel-efficient cars, use of alternative way of moving especially for the intra-city trips) should lead to a significant drop in the GHG emissions. However, political decisions taken up to now seem to be not efficient enough to meet 2020 targets.

Bibliography

Direction des études et des stratégies en sécurité routière société de l'assurance automobile du Québec (juin 2013): *Dossier statistique Bilan 2012-accidents, parc automobile, permis de conduire*

Direction des études et des stratégies en sécurité routière société de l'assurance automobile du Québec (juin 2013): *Dossier statistique Bilan 2012-taxis, autobus, camions lourds et tracteurs routiers*

Perreault M. and Bourque G.L. (2014) *Evolution du transport routier au Québec la crise s'un paradigme*, Montréal : Institut de recherche en économie contemporaine.

OCDE (2013): *Transport Outlook*

OCDE (2005): *Making cars efficient*

Natural Resource Canada Office of Energy Efficiency (2010): *The addition of freight emissions to GHGenius*

Natural Resource Canada Office of Energy Efficiency (2009): *Enquête sur les véhicules au Canada*

Direction générale de l'analyse économique de Transports Canada en collaboration avec le Groupe de travail de l'examen de la totalité des coûts Comité de soutien aux politiques et à la planification du Conseil des sous-ministres responsables des transports et de la sécurité routière (Août 2008): *Estimation de la totalité des coûts du transport au Canada Rapport de synthèse*

The conference board of Canada (2009): *Cheap Enough making the switch from diesel fuel to natural gas?*

Association Canadienne des Automobilistes (2013): *Coût d'utilisation d'une automobile*

Environnement Canada (2014): National Inventory Report (NIR).

Jean Dumont (2013): *Le marché du carbone au Québec Analyse et enjeux*

Bangqiao Jiang (2001): *Revue des études sur la relation entre les investissements dans l'infrastructure des transports et la croissance économique*

La chambre de commerce du Canada (décembre 2013): *Les bases d'un Canada compétitif : la nécessité d'investir de façon stratégique dans les infrastructures*.

Jacques B. (2011) *Estimates of the Full Cost of Transportation in Canada: An overview*, presentation made at the Mobility Pricing Conference, Toronto, Ontario, February 3rd, 2011, Ottawa: Transport Canada.

Web sites

Statistique Canada (mai 2014) : http://www5.statcan.gc.ca/subject-sujet/theme-theme.action?pid=4006&lang=fra&more=1, http://www.stat.gouv.qc.ca/statistiques/quebec_statistique/eco_tra/eco_tra_1.htm

Ministère des ressources naturelles Canada (mai 2014): http://oee.rncan.gc.ca/organisme/statistiques/bnce/apd/guide_tran_ca.cfm?attr=0

Ministère des transports au Canada (mai 2014): http://www.tc.gc.ca/fra/politique/rapport-aca-anre2011-index-3010.htm

Statistique Québec(mai 2014) http://www.stat.gouv.qc.ca/statistiques/quebec_statistique/eco_tra/eco_tra_6.htm

Ressource naturelle Canada- RNC- (mai 2014) :
http://oee.nrcan.gc.ca/organisme/statistiques/bnce/apd/evolution_tran_ca.cfm