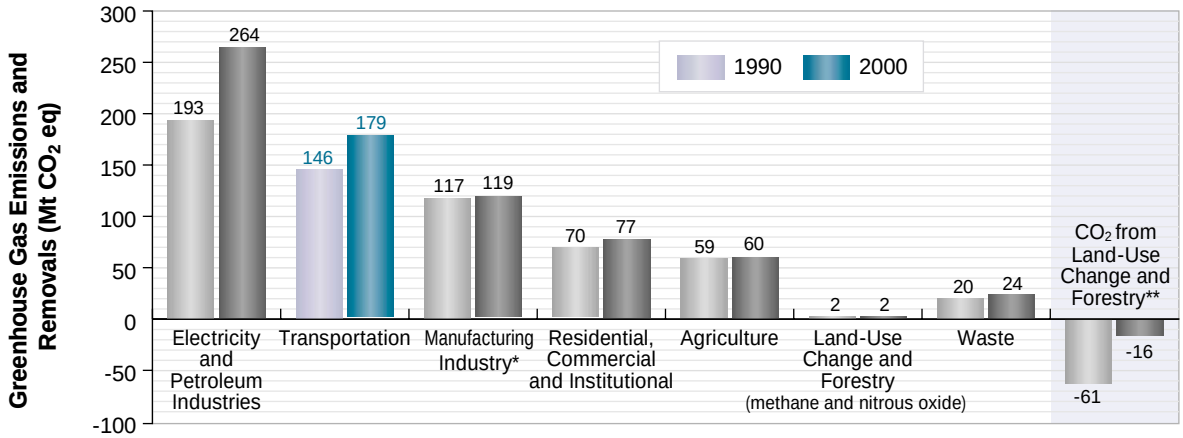
Transportation: 1990-2000

The Transportation sector includes estimates of all human induced greenhouse gases (GHG) resulting from the consumption of fossil fuels to move passengers, freight and bulk commodities throughout Canada. This category may be broken into five distinct sub-categories: on-road, air, marine, rail, and off-road. Emissions of carbon dioxide (CO_2: 94.7%) dominate this sector, although combustion processes also generate nitrous oxide (N_2O: 5.1%) and methane (CH_4: 0.3%).

- *In 2000,* the Transportation sector accounted for 179 megatonnes of carbon dioxide equivalent* (Mt CO_2 eq) emissions. This sector represents one of the largest sources of emissions, and was responsible for 24.7% of Canada's total emissions of 726 Mt.
- *Between 1990 and 2000,* this sector contributed 27.9% to Canada's emissions growth of 119 Mt. In 1990, Transportation is estimated to have emitted 146 Mt; in 2000, this had risen 22.7%. Almost all of the growth in emissions since 1990 can be attributed to 3 sub-sectors. Light-Duty Gasoline Trucks (LDGT), the category including Sport Utility Vehicles (SUVs) and Minivans, contributed 44.2% or 14.7 Mt of this sector's growth, Heavy-duty Diesel Vehicles (HDDV) contributed 40.1% or 13.3 Mt and Off-Road Diesel Vehicles were responsible for 20.6% or 6.8 Mt of the overall sectoral growth. Offsetting this growth has been the continued steady decline of emissions from Light Duty Gasoline Vehicles (LDGV a.k.a. "Cars") equal to –16.3% or –5.4 Mt of the same total.

*Unless otherwise indicated, all emissions are reported in Mt CO_2 eq. For brevity, this has been shortened to Mt. This concept provides a relative measure of the impacts of different greenhouse gases on global warming, with the effect of carbon dioxide being equal to one.

Figure 1 Canadian Greenhouse Gas Emissions and Removals, 1990 and 2000



*Value illustrated includes emissions due to Solvent and Other Product Use

**Carbon dioxide emissions from the Land-Use Change and Forestry sector are not included in the national inventory totals.

Table 1 Canadian Transportation GHG Emissions by Sub-Sector 1990 to 2000

Vehicular Transportation Total	GHG Emissions (Mt)		Change 1990-2000		Contribution to 2000 Total	Contribution to 1990-2000 Growth	Functional Subcategories			
	1990	2000	(Mt)	(%)			On-Road	Off-Road	Passenger	Freight
Light-Duty Gas Vehicles (cars)	53.7	48.3	-5.4	-10.1%	27%	-16%	*		*	
Light-Duty Gas Trucks	21.7	36.4	14.7	67.5%	20%	44%	*		*	
Heavy-Duty Gas Vehicles	3.1	5.8	2.7	86.5%	3%	8%	*			*
Motorcycles	0.2	0.2	0.0	4.0%	0%	0%	*		*	
Off-Road Gas Vehicles	5.0	5.3	0.3	5.2%	3%	1%		*		*
Light-Duty Diesel Vehicles (cars)	0.7	0.4	-0.3	-39.0%	0%	-1%	*		*	
Light-Duty Diesel Trucks	0.6	0.1	-0.5	-77.0%	0%	-1%	*			*
Heavy-Duty Diesel Trucks	24.6	37.8	13.3	54.2%	21%	40%	*			*
Off-Road Diesel Vehicles	11.3	18.1	6.8	60.6%	10%	21%		*		*
Propane and Natural Gas Vehicles	2.2	1.1	-1.1	-50.0%	1%	-3%	*			*
Domestic Air	10.7	13.7	3.0	28.1%	8%	9%			81%	19%
Domestic Marine	5.0	5.1	0.1	1.2%	3%	0%			0%	100%
Rail	7.1	6.7	-0.4	-6.2%	4%	-1%			3%	97%
Vehicles Subtotal	**146**	**179**	**33.2**	**22.7%**	**100%**	**100%**				

The Canadian Greenhouse Gas Inventory (CGHGI)

The Canadian Greenhouse Gas Inventory is developed, compiled, and reported annually by the Greenhouse Gas Division of Environment Canada, and utilizes methods and models developed in-house by engineering and scientific staff, as well as published data, data developed by industry, or methods developed by the Intergovernmental Panel on Climate Change (IPCC, 1997).

The greenhouse gases that have been estimated in the national inventory are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs).

The inventory uses an internationally agreed to reporting format that groups emissions and removals into the following six sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land-Use Change and Forestry, and Waste. The 2000 Trends Fact Sheet Series, while presenting the latest information on Canadian greenhouse gas emissions and removals derived from the latest national inventory, uses a modified sector approach to facilitate the use of information by the public.

Canada's Transportation Sector

In Canada, transportation activities involve over 17 million On-Road vehicles alone. This sector also includes the largest of sea going vessels to the smallest gas powered lawn trimmer. It includes a variety of vehicle types, using various fuels with properties that constantly change depending on the season, geographic location or specific vehicle configuration. Furthermore, individual vehicles operating under different conditions greatly affect the rate at which they generate emissions. As a consequence, developing estimates of greenhouse gas emissions within this diverse sector is complicated at best. Methods rely on a combination of practices incorporating internationally accepted estimation protocols and measured emission data derived from emission testing undertaken in the United States and Canada. A complete description of the methods and principles used to generate the estimates are described elsewhere (Environment Canada, 2002).

Under the United Nations Framework Convention on Climate Change (UNFCCC) guidelines and the

international reporting protocol, pipeline emissions are reported within the Transportation sector (IPCC, 1997). These emissions are typically compressor emissions and fugitive leaks resulting from the bulk transport of fuels in oil and/or natural gas pipelines.

Pipeline emissions are the only non-vehicular transport mode and for the purposes of this Fact Sheet Series, these emissions and their trends are reported within the Oil and Gas industry (see Fact Sheet #2 - Electricity and Petroleum Industries: 1990-2000).

General Trends

Vehicular Transportation emissions, henceforth referred to collectively as Transportation, increased 22.7% from 146 to 179 Mt over the period 1990-2000. Of the 33.2 Mt increase in emissions, 10.6 Mt can be attributed to passenger use, while 22.5 Mt may be attributed to freight purposes.

In order to distinguish trends in the use of vehicles as well as by type of vehicle, the following trend analysis has been undertaken and presented by both Form and Function. That is, what are the trends when observed according to the different types of transport vehicles - described by their Form, and what are the trends when we consider how we use these vehicles, distinguished by their Function, for either passenger or freight purposes. Furthermore, most transport modes include a component of both passenger and freight but for the purposes of the trend evaluations, Marine and Off-Road are assumed to be predominantly non-passenger and, therefore, their emissions are allocated to Freight.

Trends in Transportation Emissions by Vehicle Type (Form)

In Canada, Transportation can be divided into 5 distinct sub-sectors:

- Domestic Air (80% Passenger);
- Rail (3% Passenger);
- Domestic Marine (0% Passenger);
- Off-Road (0% Passenger); and
- On-Road (67% Passenger).

Domestic Air

Air transport in Canada includes both domestic and international flights. For accounting purposes, only those fuels sold to Canadian registered carriers in Canada are reported within the inventory. This principle complies with the established international guidelines governing bunker fuels.

Emissions associated with Domestic Air transportation increased 28.1% while through the same period their total activity, measured in total tonne-kilometres shipped, increased 52.5% and contributed to a 16.0% reduction in GHG intensity.

Rail

Rail transport boasts the lowest GHG intensity of all the freight modes. Total emissions actually declined 6.2% since 1990 while their annual shipping activity increased 35.9% over the same period, further reducing (improving) their GHG shipping intensity by 31%.

Domestic Marine

Marine Transport, like Air, has a substantial international component and similarly only the emissions resulting from fuel sold in Canada to Canadian registered vessels are considered here.

Although this sector's emissions have fluctuated over the period, overall emissions rose by only 1.2% from 1990 to 2000. Their activity, however, based on tonne-kilometres shipped, shows a reduction of almost 27.5%.

Off-Road

This sector, sometimes referred to as "Non-Road", includes the use of heavy mobile equipment in the construction, mining, and logging sectors, recreational vehicles such as snowmobiles, and lawn and garden devices including lawnmowers and trimmers. The estimates are calculated using data on volumes of fuel sold that are reported as being exclusive of road tax.

In 2000, the Off-Road sector contributed an estimated 23.4 Mt or 3.2% of the national total, up from 16.3 Mt in 1990. Although this sector includes both gasoline powered equipment (snowmobiles, all-terrain vehicles, etc.) and diesel powered equipment (excavating, construction, generator sets, etc.), 96.3% of the period's growth resulted from the 60.6% increase in the diesel component (11.3 to 18.1 Mt). Emissions from Off-Road gasoline sources rose 5.2% from 5.0 to 5.3 Mt.

On-Road

With greenhouse gas emissions of 130.3 Mt in 2000, this category contributed 17.9% of Canada's total emissions and 72.7% of the total emissions from transportation.

For the purposes of calculating estimates, the entire On-Road component is divided into 8 categories:

- Light-Duty Gasoline Vehicles (LDGV);
- Light-Duty Diesel Vehicles (LDDV);
- Light-Duty Gasoline Trucks (LDGT);
- Light-Duty Diesel Trucks (LDDT);
- Heavy-duty Gasoline Vehicles (HDGV);
- Heavy-duty Diesel Vehicles (HDDV);
- Motorcycles (MC); and
- Alternative Fueled Vehicles (Alt Fuel).

Factors influencing the quantity of greenhouse gases produced and emitted are mainly dependent upon:

- vehicle population;
- vehicle kilometres traveled (Vkmt);
- fuel consumption ratio (FCR), and
- emission control technology.

Since 1990, each of the 8 sub-categories has experienced changes in the above factors; yet these factors, sometimes moving in opposite directions for different vehicle sub-categories, indicate shifts in preference and utility for the Canadian vehicle operator (Table 2).

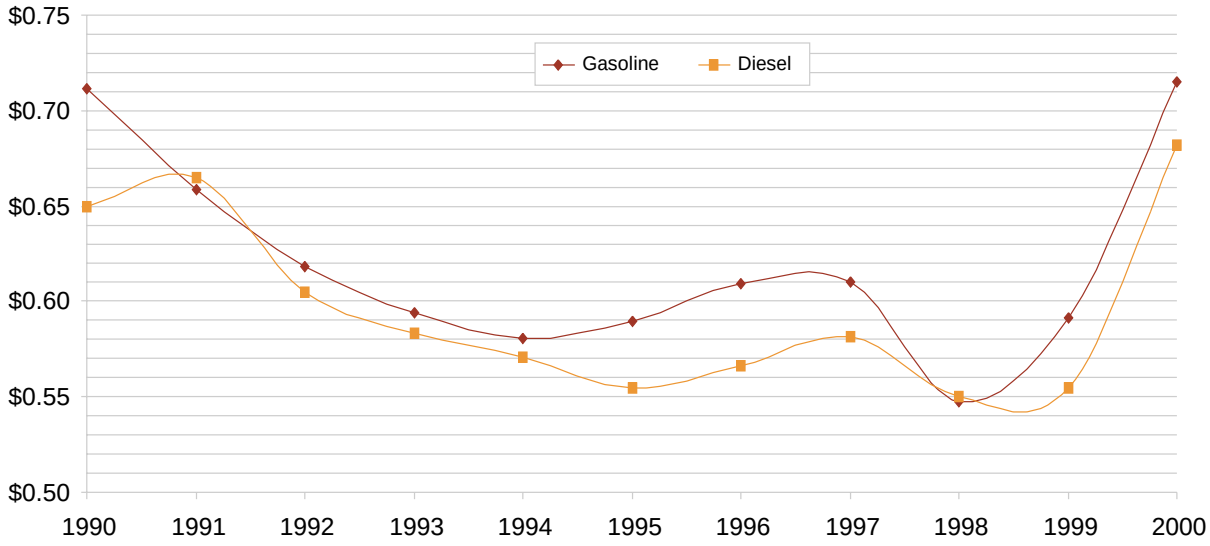
From 1990-2000, Gross Domestic Product (GDP) and population grew 32.5% and 11.0%, respectively, while the total number of On-Road vehicles increased 15.3%. Most of the vehicle population increase has occurred in the light-duty gasoline truck, heavy-duty gasoline and heavy-duty diesel truck categories, which have shown individual growth rates over the period of 68.7%, 75.3%, and 126.5%, respectively. Evidence of a shift towards bigger, less efficient (more GHG intense) vehicles is indicated when one considers that the number of light-duty gasoline cars has declined 4.3% while the number of light-duty diesel vehicles (including cars and trucks) has decreased 52.9%. One contributing factor is likely to be the almost steady decline in the real price of fuel through most of the 90's (Figure 2).

With the exception of LDDT and HDDV, each showing vehicle-kilometres-traveled declines of about 30% since 1990, vehicle kilometres traveled in all other categories show growth of about 4-7% from 1990 to 2000.

Table 2 Factors Contributing to Trends in Emissions Between 1990 and 2000

	Vehicle Population	FCR	Vehicle km Travelled	Combined Effect	Change Since 1990	
					Kt	%
LDGV	-4%	-12%	6%	-11%	-5,399	-10%
LDGT	69%	-9%	7%	65%	14,666	67%
HDGV	75%	0%	6%	86%	2,712	87%
MC	-1%	0%	6%	4%	9	4%
LDDV	-42%	0%	4%	-39%	-262	-39%
LDDT	-72%	0%	-18%	-77%	-455	-77%
HDDV	127%	0%	-32%	54%	13,295	54%

Figure 2 Trends in Canadian Fuel Prices (2000$)



Over 90% of Canada's fleet of vehicles has benefited from improved efficiencies over the ten-year period. Since the 1990 model year, the LDGV component of the fleet has become 12% more fuel-efficient while the similar LDGT component improved 9%.

Improvements in the emission control technology incorporated into new vehicles have been less progressive through the 1990's. The largest gains in emission reductions through technological improvements occurred in the 1980's when computer control, electronic fuel injection and new generation catalytic converters were introduced. As these technologies penetrate the market place, and as older vehicles are retired and replaced with vehicles incorporating more advanced emission and engine control devices, the benefits of these advances are realized.

Trends in Transportation Emissions by Vehicle Use (Function)

Passenger Transportation

This functional category encompasses those greenhouse gas emissions from mobile sources primarily used for the movement of people. In 2000, 97.9 Mt or 54.6% of total vehicular emissions were allocated to this category, a rise from 87.2 Mt or 59.8% of the same total in 1990. On a national basis, 13.4% of Canada's total emissions are allocated here with 98.0% coming from LDGV, LDGT and the passenger portion of Domestic Air travel (49.3%, 37.2% and 11.5%, respectively).

While emissions from the passenger portion of Domestic Air travel increased 32.2% and those from LDGV have actually decreased 10.1%, the overall trend has been heavily influenced by an almost 67.5% increase in emissions from LDGT, the class of vehicle that includes Sport Utility Vehicles (SUVs) and Mini-Vans.

Freight Transportation

In 2000, the collection of sub-categories representing freight and bulk transport contributed 81.2 Mt or 11.2% of Canada's total greenhouse gas emissions, an increase of 38.4% over the 1990 value of 58.7 Mt.

Growth in these transport emissions is significantly higher than population growth over the same period and can be primarily attributed to increased fuel use in three sub-sectors:

- Heavy-Duty Diesel Vehicles - representing 59.0% of the total freight increase;
- Heavy-Duty Gasoline Vehicles - representing 12.0% of the total freight increase; and

- Off-Road Vehicles - representing 31.5% of the total ten-year increase.

Other modes of freight transport include Domestic Marine, and the freight portions of Domestic Air and Rail emissions. These are distinguished from their total emissions by considering data indicating their different fuel allocations to passenger versus freight lines in the case of Rail, and passenger tonne-km versus freight tonne-km, as reported by Canada's main air carriers. In comparison, LDDT's accounted for less then 1% of freight emissions in 2000.

Trucking: Heavy-duty Diesel and Gas Vehicles

Some of the growth in greenhouse gas emissions can be directly related to the growth of heavy-duty diesel and gasoline trucking primarily used for shipping freight. Difficulties arise, however, in obtaining accurate and complete data for this transport mode. Firstly, fuel consumption data, although primarily for freight, is mixed with several other uses (e.g. buses and emergency vehicles). Secondly, complete data are not available for freight shipments (often expressed in tonne-km) within the sector. Regardless, 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 activity attributed to Heavy-duty Gasoline and Diesel Vehicles.

The reported tonne-km of for-hire domestic and trans-border freight shipments by truck in Canada show significant growth from 1990 to 2000. Combined emissions from HDDVs and HDGVs increased steadily since 1992 in parallel with the reported domestic growth in trucking tonne-km. The rate of shipping growth has outpaced that of the emissions by almost 2:1, further reducing the industry GHG intensity by over 28.5%. Again, there is no indication of the value of those goods shipped and subsequently no trend in GHG/GDP intensity is evaluated.

Railways

Railways are heavily dependent on delivering bulk shipments of coal, potash, wheat, and lumber. As a result, fluctuating supply or demand for these products in particular affects railway freight activity and emissions. Year-to-year total activity, and therefore emissions, depend on foreign markets and Canadian crop harvests, in particular. Statistics Canada's report entitled Rail in Canada indicates 3% of the total fuel consumption was for VIA Rail, a passenger only service. As such, it was therefore assumed that freight contributed the remaining 97% of total Rail emissions.

In 2000, Rail was responsible for just below 8.0% of Canada's freight transport greenhouse gas emissions. Between 1990 and 2000, annual tonne-kilometers shipped by rail increased by 35.9% while reducing fuel consumption and producing 6.2% less GHG emissions.

Air

Transport by air moves a significant and growing percentage of freight traffic. Canadian air carriers report a 57.5% and 33.6% increase in passenger and freight related tonne-kilometres, respectively, contributing to an overall 52.5% increase in shipments while only generating an estimated 28.1% more emissions. Although air shipping of freight is the least efficient way to go with respect to GHG intensity, the trend illustrated is positive.

Also, while the passenger and freight activity levels increased over the period by varying rates, they remained in similar proportions; that is, of the total annual tonne-km reported by major Canadian air carriers since 1990, 20% is allocated to the transport of freight and 80% to that of passengers.

Marine

The emissions associated with domestic marine use of fuel in 2000 represented 6.3% of freight related greenhouse gas emissions. Since 1990, emissions have risen only 1.2% indicating low overall growth in marine shipments.

Data indicate that domestic shipping decreased 27.5% between 1990 and 2000 (measured in tonnes loaded and unloaded between Canadian ports), while international shipping increased 12.1%.

Table 3 Trends in Shipping/Freight-Related GHG Intensity

	1990	2000	Change Since 1990	
			Absolute	Relative
Rail				
GHG Emissions[1]	6.9	6.5	-0.4	-6.2%
Activity[2]	235.9	320.5	84.6	35.9%
GHG Intensity[3]	29.2	20.2	-9.1	-31.0%
Air				
GHG Emissions[1]	2.2	2.5	0.3	12.2%
Activity[2]	1.7	2.3	0.6	33.6%
GHG Intensity[3]	1274.9	1070.4	-204.5	-16.0%
Trucking				
GHG Emissions[1]	27.7	43.7	16.0	57.8%
Activity[2]	74.7	165.1	90.3	120.9%
GHG Intensity[3]	370.4	264.7	-105.8	-28.5%
Marine				
GHG Emissions[1]	5.0	5.1	0.1	1.2%
Activity[2]	53.4	38.7	-14.7	-27.5%

[1] Mt CO_2 eq
[2] Tonne Kilometre shipped (Billions)
[3] grams CO_2 eq per tonne-kilometre shipped

Glossary

Gross Vehicle Weight Rating (GVWR): The maximum allowable weight of a fully loaded vehicle, including liquids, passengers, cargo, and the tongue weight of any towed vehicle. This value is defined by the manufacturer and is based on vehicle design.

Heavy-Duty Vehicles: Any vehicle rated at more than 3900 kg GVWR or designed to carry more than 12 persons at a time. Typical icons in this category include tractor-trailers, city and highway buses and utility vehicles such as ambulances and fire trucks but also includes Light-Duty Trucks with GVWR greater than 3900 kg (such as some heavier full size pick-up trucks and work vans).

Light-Duty Trucks: This category includes pick-up trucks, mini-vans and SUVs with a GVWR of 3900 kg or less which are designated primarily for transportation of light-weight cargo or that are equipped with special features such as four-wheel drive for off-road operation. It includes both LDGT and LDDT.

Light-Duty Vehicles: This category contains what we would commonly refer to as "cars" and includes LDGV, LDDV and alternatively fuelled vehicles used primarily for passenger transport.

Tonne-Kilometre: An expression of weight (mass) multiplied by distance from origin to destination for each freight shipment. This is the standard output metric for the shipping industry.

References

Environment Canada, *Canada's Greenhouse Gas Inventory 1990-2000*, June 2002.

Intergovernmental Panel on Climate Change (IPCC), *Greenhouse Gas Inventory Reporting Instructions*, Vol. 1; and *Greenhouse Gas Inventory Reference Manual,* Vol. 3, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, 1997.

Statistics Canada. *Annual Demographic Statistics,* 2000, Catalogue #91-213.

Statistics Canada, CANSIM 9028.

Statistics Canada, *Rail in Canada 1990-1999,* Catalogue #62-001-XIB.

Statistics Canada, *The Consumer Price Index,* Catalogue #62-001-XIB.

Statistics Canada, *Trucking in Canada,* 1990-2000, Catalogue #52-216 -XIB.

Kochhar, P., Transport Canada, *Personal communication,* July 2002.

DiPietro, L., Statistics Canada, *Personal communication,* July 2002.

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Contact:
Art Jaques, P. Eng
Chief – GHG Division, Environment Canada
351 St. Joseph Boulevard, Hull, QC, K1A 0H3
(819) 994-3098, (819) 953-3006 (fax)
ghg@ec.gc.ca
http://www.ec.gc.ca/pdb/ghg

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