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IBI Group and Management of Technology Services
Sustainable Transportation

NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

BACKGROUNDER ON GREENHOUSE GAS EMISSIONS FROM URBAN TRANSPORTATION

FINAL REPORT

DRAFT

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GROUP
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Backgrounder on Greenhouse Gas Emissions From Urban Transportation - Executive Summary

This summary of the report content and findings follows the chapter structure of the main report.

1. INTRODUCTION

Recognizing growing concerns regarding climate change resulting from greenhouse gas (GHG) emissions, in particular carbon dioxide (CO₂), the National Round Table on the Environment and the Economy (NRTEE) has established a two phase program entitled "The First Step in Creating a Canadian Strategy to Reduce GHG Emissions from Urban Transportation". The program has three objectives: to maintain and build momentum on the transportation GHG subject generated by earlier reports and the Kyoto Protocol; to initiate a national debate on the critical issue of GHG reduction in the urban transportation sector; and to identify and rank possible options for a Canadian strategy, which would then be developed by others.

The NRTEE is currently coordinating its activities with the National Implementation Process of the Kyoto Protocol by participating in the National Transportation Issue Table. This body's mandate is to identify specific measures to reduce greenhouse gas reduction measures in the transportation sector, including costs, benefits and impacts. This Backgrounder Report will assist in this process by presenting information on GHG emissions by urban transportation and analyses of possible methods to reduce these emissions.

2. THE CLIMATE CHANGE CHALLENGE

As widely reported in the literature and summarized in Chapter 2 of this report, there is increasing evidence that increasing concentrations of greenhouse gases – of which the most important is carbon dioxide – have contributed to a measured increase in the global average temperature of approximately 0.5°C over the past century and that continuing warming can be expected if increases in atmospheric concentration of GHGs - much of which is due to the burning of fossil fuels and other human activities such as deforestation and industrial processes - is allowed to continue unabated. Climate trends during the past few decades, and climate modelling studies, indicate that ongoing global warming is causing increasing frequency and intensity of extreme weather events, droughts and dessertification in currently inhabited areas, and will lead to increases in sea levels and flooding in coastal and other areas if warming continues over the next 50-100 years and beyond.

Increasing national concerns have led to a number of international meetings aimed at limiting GHG emissions and emissions of other harmful substances. The most recent of these was the Kyoto Protocol of December, 1997, under which Canada agreed to reduce its GHG emissions to 6% below 1990 levels in the 2008 to 2012 period. While Canada has not yet ratified the Kyoto Protocol, there is an implied national commitment. Since the Kyoto Conference, Canadian Ministers of Energy and Environment have approved a process to examine the impacts, costs and benefits of implementing the Kyoto Protocol, as well as the various options for implementing the Protocol that are open to Canada. This process will lead to the development of a national implementation strategy on climate change. The NRTEE and other government and non-government agencies are integrated into this and are working to identify and help implement initiatives to achieve the Kyoto target.

3. ROLE OF URBAN TRANSPORTATION IN THE PRODUCTION OF GREENHOUSE GASES

Chapter 3 of this report summarizes and presents information on GHG emissions in Canada from all sources, from various types of transportation and from urban transportation, which is the focus of this report.

As summarized in Exhibit 3.5 in the body of the report, in 1995 total Canadian GHG emissions were some 619 megatonnes (MT) of CO₂ equivalent¹. Of this, 26% or 163.5 MT is attributed to transportation. Of that amount, approximately 50% is attributed to urban transportation and about 37% (60 mt) is attributed to urban transportation in the country's 13 top CMAs which are the subject of analysis in this report. About 78% of this urban transportation emission total is attributed to passenger transportation and about 22% is attributed to urban freight transportation. In Canada's top 13 CMAs, urban transportation produces about 9.7% of total Canadian GHG emissions.

Approximately 7.4% of the total Canadian GHG emissions are due to personal urban transportation in Canada's 13 largest CMAs, of which 97% is attributed to private automobiles and light trucks in personal use. This suggests that passenger transportation and the private automobile should be the highest priority in actions to reduce urban transportation CO₂ emissions, although urban trucking also deserves attention and is more challenging because of the essential nature of much of it and the difficulty of reducing freight volumes, substituting other modes or introducing vehicles which produce lower emissions.

4. DEVELOPMENT ASSESSMENT OF OPTIONS TO REDUCE CO₂ EMISSIONS

Chapter 4 presents an extensive discussion of 11 types of initiatives (referred to as options) which can be taken to reduce urban transportation CO₂ emissions. The chapter presents information from the literature on the elasticities of demand in relation to most of the options and provides estimates of CO₂ reductions likely to be achieved by 2010 if each option were introduced singly during the next few years in the 13 CMAs studied. Comments are also provided on the momentum provided by these initiatives for significant additional reductions beyond 2010. Some of these initiatives are intended to reduce GHG emissions by changing **behaviour**, by reducing the number of kilometres driven, while others are intended to improve efficiency by stimulating the development and implementation of improved **technology**. Others, such as increased fuel taxes, can be expected to do both.

The results of these analyses are summarized in Exhibit ES1 (Exhibit 4.14 as presented in Chapter 4). The exhibit presents results for seven of the 11 options, for which demand elasticity information is felt to be sufficiently reliable as a basis for estimating CO₂ reductions.

As shown in the exhibit, no single measure has the potential to offset the 22% increase in CO₂ emissions from urban transportation by 2010 relative to 1990 or to achieve the Kyoto target. Increased gasoline taxes are estimated to have the greatest potential for reductions. If applied throughout North America, an increase of 3¢ per litre in the gasoline tax each year starting in 2000 is estimated to lead to CO₂ emissions levels about 14% lower than the 2010 "business as usual" trend. If the same gasoline tax increase were applied in Canada only CO₂ levels would be 9% lower than 2010 baseline trend. Application of such taxes in Canada only is expected to result in lesser impacts because there will not be the same degree of investment in and development of fuel saving technologies if taxes are not applied on a North America-wide basis. Each of the other initiatives shown in Exhibit ES1, if applied individually, would also reduce CO₂ emissions by 2010 relative to the "business as usual" trend. These reductions are estimated to be in the range of 1-11%.

¹ CO₂ accounts for approximately 90% of greenhouse gases. The other portion is largely due to methane and nitrous oxide. The CO₂ equivalent is 21 tonnes for one tonne of methane and 310 tonnes for one tonne of nitrous oxide.

Backgrounder on Greenhouse Gas Emissions From Urban Transportation - Executive Summary

EXHIBIT ES1: Summary of Estimated CO₂ Emissions Reduction Impacts of Policy Options (Top 13 CMA in Canada)

Baseline Emissions (1990)	Passenger 39,589	Freight 8,390	Total 47,979
Business-as-Usual Emissions (2010)	45,581	12,887	58,468
% Change From 1990	15%	54%	22%

Policy	Reduction in 2010 (MT)	% Change from 2010 Business-as-Usual	% Change from 1990 Level
GASOLINE TAX ⁽²⁾			
Scenario 1A - Gasoline Tax (\$0.03/L annually - Canada Only)	-5.3	-9%	11%
Scenario 2A - Gasoline Tax (\$0.054/L - annually Canada Only) ⁽¹⁾	-9.4	-16%	2%
Scenario 1B - Gasoline Tax (\$0.03/L annually - North America Wide)	-8.0	-14%	5%
Scenario 2B - Gasoline Tax (\$0.036/L annually - North America Wide) ⁽¹⁾	-9.5	-16%	2%
DIESEL TAX			
Diesel Tax (\$0.03/L annually - North America Wide)	-1.0	-2%	20%
CAFE AND CAFC			
Canada Only - 1% annual improvement taking effect in 2005 (new veh only)	-0.7	-1.2%	20%
North America wide 2% annual improvement taking effect in 2005 (new vehicles only)	-1.2	-2.1%	19%
FEEBATES ⁽²⁾			
<i>Feebates Implemented in Canada Only</i>			
\$CAN 350/litre/100km	-0.7	-1%	20%
\$CAN 700/litre/100km	-1.1	-2%	20%
\$CAN 1400/litre/100km	-2.2	-4%	17%
\$CAN 2800/litre/100km	-4.0	-7%	14%
<i>Feebates Implemented North America-Wide</i>			
\$CAN 350/litre/100km	-2.2	-4%	17%
\$CAN 700/litre/100km	-3.1	-5%	15%
\$CAN 1400/litre/100km	-4.4	-8%	13%
\$CAN 2800/litre/100km	-6.2	-11%	9%
VEHICLE MAINTENANCE AND INSPECTION PROGRAMS			
Impacts assuming 1% reduction in fleet emissions	-0.6	-1%	21%
Impacts assuming 3% reduction in fleet emissions	-1.8	-3%	18%
PARKING PRICING			
Impacts of 5% annual parking price increase	-4.6	-8%	12%
ROAD PRICING			
\$0.10 peak/\$0.05 off-peak	-1.5	-2%	19%
\$0.20 peak/\$0.10 off-peak	-2.9	-5%	16%

Notes: ⁽¹⁾ These are the price increases that would be required to achieve a 6% reduction in CO₂ from 1990 levels by 2010 for gasoline vehicles only.

⁽²⁾ Estimated emission reductions from Distance Based Insurance and Vehicle Registration fees are assumed to be similar to those of Gasoline Taxes and Feebates respectively.

5. DEVELOPMENT AND ASSESSMENT OF INTEGRATED PACKAGES OF OPTIONS

Advantages of Integrated Packages

A number of studies have demonstrated that **integrated packages** of initiatives will be substantially more effective in reducing CO₂ emissions than will any single initiative such as the seven options shown in Exhibit ES1. This is because of mutually-reinforcing interactions among the various types of initiatives. For example, if user prices are increased for auto drivers in urban areas, the impact in terms of reducing vehicle kilometres of travel (vkt) by automobiles will be significantly greater if, at the same time, significantly improved public transit is provided. Another example relates to a regulatory option, Corporate Average Fuel Efficiency/Consumption (CAFE/CAFC) measures; analogous to earlier regulations of this type applied in the United States and Canada, this study defines the CAFE/CAFC options as a regulated CO₂ reduction for new vehicles of 2% per year, starting in 2005, North America-wide or in Canada only, as shown in Exhibit ES1. If this type of regulation were introduced, its impact would be reduced over time by what is known as the “take-back effect” which describes drivers’ tendency to take advantage of the lower fuel costs they experience (because they are driving a more fuel-efficient vehicle as required by the CAFE/CAFC regulations) and, as a result, travel farther and generate more vehicle-km of travel (vkt) per year per vehicle. The “take-back effect” can be reduced or eliminated if higher fuel taxes are introduced at the same time as the CAFE/CAFC regulations, so that the fuel cost per vkt remains stable or even increases in spite of the CAFE/CAFC regulations. Other synergistic effects of this type are also important; for example, if transportation demand management measures are taken (to encourage travel in off-peak periods, increase vehicle occupancy and more use of environmentally benign modes) combined with enhanced public transit services and transit-supportive, compact, mixed-use urban development (which reduces auto dependency and also tends to shorten average trip lengths required to achieve accessibility requirements) these supporting packages can be expected to enhance the CO₂ reduction impacts of each other and of the other options shown in Exhibit ES1.

Bearing in mind these synergistic interactions, three integrated packages of combined initiatives were identified for further analysis, as summarized in Exhibit ES2 which is also Exhibit 5.1 in Chapter 5.

EXHIBIT ES2: Summary of Integrated Packages

Individual Initiatives		COMBINATIONS					
		Package A		Package B		Package C	
		Road Vehicles - Basic		Road Vehicles - Alternative		Comprehensive Package	
		Canada Only	North America Wide	Canada Only	North America Wide	Canada Only	North America Wide
1	Fuel Taxes (Gas)	✓	✓			✓	✓
	Fuel Taxes (Diesel)		✓				✓
2	CAFE/CAFC	✓	✓			✓	✓
3	Feebates	✓	✓			✓	✓
4	Vehicle I&M			✓	✓	✓	✓
5	Vehicle Charges & Taxes			✓	✓		
6	Parking Pricing/Supply			✓	✓	✓	✓
7	Road Pricing			✓	✓	✓	✓
8	Alternative Fuels			✓	✓		
9	TDM					✓	✓
10	Enhanced Transit					✓	✓
11	Land Use/urban Design					✓	✓

Backgrounder on Greenhouse Gas Emissions From Urban Transportation - Executive Summary

GHG Emissions Reductions

As shown, **Package A: Road Vehicles – Basic** includes the first three of the options (increased fuel taxes, CAFE regulations, feebates) which are analyzed if applied in Canada only or North America-wide.

Increased taxes on diesel fuels are not included in the Canada only package because of concerns regarding economic competitiveness of Canada's trucking industry if the tax were applied to this country only.

Package B: Road Vehicles – Alternative includes five of the options (vehicle inspection and maintenance, vehicle charges and taxes based on distance travelled or fuel consumption, parking pricing and supply, road pricing, alternative fuels) and the package is also examined if applied in Canada only or North America-wide. Finally, **Package C: Comprehensive Package** includes the options in Package A and Package B (with the exception of vehicle charges and taxes and alternative fuels) plus the three supporting measures (transportation demand management, enhanced transit, land use/urban design). The body of the report presents more information defining the individual initiatives and explaining the reasons that the three combined packages have been defined as shown in Exhibit ES2.

As summarized in Exhibit ES3 (derived from Exhibits 5.2, 5.3 and 5.4 of Chapter 5) most of the three combined packages are estimated to meet the Kyoto target by 2010 if implemented as defined in the report. The exceptions are Package A and Package B if applied in Canada only. If implemented in Canada only, Package A would result in an estimated 5% **increase** in Canada urban transportation CO₂ emissions over 1990 levels. Package B, implemented in Canada only, is estimated to reduce emissions relative to 1990 levels, but falls just short of the 6% target. If applied North America-wide, however, both packages are estimated to **reduce** Canada's urban transportation CO₂ emissions relative to 1990 levels, in 2010. Package C, the Comprehensive Package, is estimated to achieve the greatest reductions in CO₂ emissions relative to 1990 levels: by 11% if applied in Canada only and by 20% if applied North America-wide.

EXHIBIT ES3: Summary of Estimated CO₂ Emissions Reduction Impacts of Integrated Packages (Top 13 CMAs in Canada)

	Passenger	Freight	Total
Baseline Emissions (1990)	39,589	8,390	47,979
Business-as-Usual Emissions (2010)	45,581	12,887	58,468
% Change From 1990	15%	54%	22%

Package	CO ₂ Emissions Reduction in 2010 (MT)	% Change from 2010 Business-as-Usual	% Change from 1990 Level
PACKAGE A - Road Vehicles - Basic			
Canada Only	-8.0	-14%	5%
North America Wide	-13.9	-24%	-7%
PACKAGE B - Road Vehicles - Alternative			
Canada Only	-12.8	-27%	-5%
North America Wide	-15.5	-27%	-11%
PACKAGE C - Comprehensive Package			
Canada Only	-15.8	-27%	-11%
North America Wide	-20.1	-34%	-20%

Economic Efficiency Impacts

Chapter 5 also discusses in broad terms the anticipated economic efficiency impacts of the three combined packages and their likely implications for Canada's economic competitiveness. Based on the evidence available from a variety of studies, primarily in Canada, the United States and Europe, it is broadly concluded that Canada's economic efficiency is unlikely to be reduced by any of the combined packages although there is some chance of a reduction if Package A or Package B were applied in Canada only. Packages A and B and Package C if applied in Canada only are anticipated to have a neutral or slightly positive impact on Canada's economic efficiency, while Package C if applied North America-wide is estimated to have a positive impact on Canada's economic efficiency. These conclusions are, of necessity, broad and qualitative since there was insufficient time or resources for new analyses as part of the assignment to prepare this report and there is considerable uncertainty in the literature on economic impacts of CO₂ reduction initiatives.

Assessment of Integrated Packages

Finally, Exhibit ES4 (Exhibit 5.5 from Chapter 5) summarizes the assessment of integrated options showing the extent to which Package A, Package B and Package C, respectively (if applied in Canada only or North America-wide) would meet the following five objectives (labelled evaluation criteria in the exhibit):

- **greenhouse gas reduction:** to meet or exceed the Kyoto target reductions;
- **public sector costs:** to be implemented without significantly increased costs to the public sector;
- **economic efficiency:** to be implemented without reducing Canada's economic efficiency;
- **case of early implementation:** to be implemented such that impacts are realized by 2010; and
- **social impacts:** to be implemented while improving social equity.

As indicated graphically in the exhibit, the overall assessment is that Package C would best meet the above five objectives, followed by Package A and Package B. If the primary objective, greenhouse gas reduction, is given more weight then Package B would be superior to Package A.

Backgrounder on Greenhouse Gas Emissions From Urban Transportation - Executive Summary

Exhibit ES4: Assessment of Integrated Options

		Package A Road Vehicles - Primary		Package B Road Vehicles - Alternative		Package C Comprehensive Package	
		Canada Only	N.A.wide	Canada Only	N.A.wide	Canada Only	N.A.wide
GHG Impacts - Summary							
% reduction from 2010 baseline		-14%	-24%	-22%	-27%	-27%	-34%
% reduction from 1990 baseline		5%	-7%	-5%	-11%	-11%	-20%
Evaluation Criteria	Objective						
Greenhouse Gas Reduction	To meet or exceed Kyoto target reductions	●	●	●	●	●	●
Public Sector Cost	To be implemented without significantly increased net costs to the public sector	●	●	●	●	●	●
Economic Impacts	To be implemented without reducing Canada's economic efficiency	●	●	●	●	●	●
Ease of Early Implementation	To be implemented such that impacts are realized by 2010	●	●	●	●	●	●
Social Impacts	To be implemented while improving social equity	●	●	●	●	●	●
Overall Assessment		●	●	●	●	●	●

Extent to which objectives are satisfied:

- (1) low
- (2) medium
- (3) high

6. CONCLUSIONS

Based upon the findings of this study as summarized above, the following conclusions are drawn.

- Policy options to reduce urban transportation GHG emissions which involve a single initiative only are unlikely to achieve the Kyoto target (see Exhibit ES1).
- Combinations of the individual initiatives show more promise, and three such combination packages were developed for analysis (see Exhibit ES2).
- Any one of the three combination packages, with the exception of Packages A and B if applied in Canada only, is estimated to meet the Kyoto target with Package C, the Comprehensive Package, likely to achieve the greatest reductions (see Exhibit ES3). Any of the packages would also build momentum for substantial CO₂ reduction trends beyond 2010, with Package C again as the most effective in this regard.
- When other objectives such as reasonable public sector costs, economic efficiency, ease of early implementation and reasonable social impacts, are taken into account as well as greenhouse gas reduction, the Comprehensive Package achieves the highest rating in a comparative evaluation. Package A is slightly better than Package B when all criteria are taken into account, but Package A achieves a smaller reduction in CO₂ than Package B (see Exhibit ES4).
- Based on the above, we conclude that it would be feasible for Canada, acting alone, to achieve its Kyoto target for greenhouse gas reductions as applied to urban transportation in the country's 13 largest CMAs, which account for some 80% of urban transportation GHG emissions in this country. This conclusion is significantly strengthened if any one of the three combined packages could be implemented North America-wide, and the likelihood of success is also increased if more initiatives are added to the package.

Clearly, the complexity and challenges of achieving cooperation as required for combined approaches increase as the field of actions moves from Package A to Package B and onward to Package C, but the rewards of accepting these challenges make the effort worthwhile in terms of meeting and exceeding the Kyoto target while also achieving other objectives (e.g. financial, economic, social). Similarly, the benefits from achieving a harmonized approach across North America warrant the additional effort of attempting to achieve a cooperative approach by the three national governments of Canada, the United States and Mexico. Based on the findings of this study, there is excellent promise that the Kyoto target can be reached for urban transportation greenhouse gas emissions in Canada through largely federal initiatives, so that there is good reason to act on these initiatives as soon as possible while initiating discussions with other jurisdictions in hopes of achieving broadened, cooperative approaches.

Backgrounder on Greenhouse Gas Emissions From Urban Transportation

1 INTRODUCTION

The overwhelming body of opinion in the scientific and environmental communities is that climate change resulting from the emission of greenhouse gases (GHG) due to human activity poses a serious threat. There is also a growing international consensus that action will have to be taken. The Kyoto Protocol resulted in GHG reduction targets being adopted by a number of countries, including Canada. However, this growing interest in "taking action" to date has not been matched by an agreement or consensus on what actions should be taken and how they should be implemented.

Transportation is a significant source of greenhouse gases, directly responsible for 26% of Canada's total emissions; urban transportation in particular is responsible for over 50% of all transport emissions. It is critically important to plan and initiate co-ordinated actions to reduce GHG emissions so that Canada can meet its current international obligations and perhaps more extensive future obligations.

1.1 THE NRTEE PROGRAM ON SUSTAINABLE TRANSPORTATION

In 1996, the National Round Table on the Environment and the Economy (NRTEE) convened a series of national workshops where stakeholders from all parts of the transportation sector discussed the issues and the barriers associated with making the Canadian transportation sector more sustainable. Over the course of these workshops, energy producers, carriers, shippers, transportation system users, suppliers and government representatives discussed areas of consensus and of disagreement. The results are reflected in the NRTEE's *State of the Debate Report: The Road to Sustainable Transportation in Canada*, which also offers recommendations on how to advance sustainable transportation principles in Canada.

1.2 PURPOSE OF THIS REPORT

The challenges presented by some of these conclusions led the NRTEE to focus on the greenhouse gas reduction potential in Canada's main urban areas of various sustainable transportation policies. The objectives of this report, therefore, are to:

- maintain and build momentum on action in the transportation greenhouse gas issue which were generated by the Kyoto Protocol, and the *NRTEE State of the Debate Report: The Road to Sustainable Transportation in Canada*, among others; and
- determine the greenhouse gas reduction contribution that can be expected from various urban sustainable transportation policies.

The NRTEE is currently co-ordinating its activities with the National Implementation Process of the Kyoto Protocol by participating in the National Transportation Issue Table. This body's mandate is to identify specific measures to reduce greenhouse gas reduction measures in the transportation sector, including costs, benefits and impacts. This Backgrounder Report will assist in this process by presenting information on GHG emissions by urban transportation and analyses of possible methods to reduce these emissions.

1.3 STRUCTURE OF REPORT

The following chapters of this report are structured as follows:

- Chapter 2 is a description of the problem, entitled the "Climate Change Challenge".

Backgrounder on Greenhouse Gas Emissions From Urban Transportation

- Chapter 3 describes the role of urban transportation in the production of greenhouse gases;
- Chapter 4 outlines a number of options to reduce greenhouse gas emissions from urban transportation and estimates their impacts;
- Chapter 5 outlines the development of three integrated packages of options and provides an assessment of the options, both in terms of CO₂ reduction potential and in terms of their broad economic and social implications. Chapter 5 also provides an overall assessment of the integrated packages.
- Chapter 6 summarizes the conclusions reached.

Backgrounder on Greenhouse Gas Emissions From Urban Transportation

2 THE CLIMATE CHANGE CHALLENGE

2.1 THE SOLAR HEAT BALANCE

Life on earth is based upon solar energy received in the form of sunlight. Sunlight warms the earth as well as providing the basic energy source for life by powering the photosynthesis process in plants. Solar energy also drives the hydrological cycle, causing evaporation of water which forms clouds and then drops back to earth, providing continuously renewed fresh water without which widespread terrestrial life as we know it would be impossible.

The stability of these processes is based upon a balance as illustrated on Exhibit 2.1. Approximately 30% of the solar energy that reaches the earth is scattered back into space by clouds, land and water. The remaining 70% reaches the lower atmosphere and the surface of the earth. Ultimately, this energy is converted to heat. This heat radiates upward in the form of infrared radiation. This energy would be radiated into space except for the presence of certain molecules in the atmosphere called greenhouse gases which retain some of the radiating energy, keeping the heat in the lower atmosphere and on the surface of the earth. These greenhouse gases include water vapour (H₂O) carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and ozone (O₃). These are all naturally occurring substances.

2.2 IMPACTS OF HUMAN ACTIVITY

In the last two centuries the level of human activity has reached a point that human-caused (anthropogenic) emissions are contributing significantly to the levels of greenhouse gases present in the atmosphere. The following table, Exhibit 2.2, shows the sources of both natural and anthropogenic gases.

Exhibit 2.2: Some Sources of Natural and Anthropogenic GHGs

Greenhouse Gas	Natural Sources	Anthropogenic Sources
Water Vapour (H ₂ O)	Evaporation, respiration and transpiration	(Negligible)
Carbon Dioxide (CO ₂)	Decaying plants, animal respiration, natural burning, volcanoes	Burning fossil fuels (oil, coal, natural gas), deforestation, industrial processes
Methane (CH ₄)	Decaying plants, animal digestion, volcanoes	Landfill, oil and gas production, domestic livestock
Nitrous Oxide (N ₂ O)	Released from soils and oceans	Burning fossil fuels, chemical production, nitrogen fertilizers
Halocarbons	NONE	Wide variety of industrial and consumer products

Source: Transportation Association of Canada: *A Primer on Urban Transportation and Global Climate Change*, May 1998

Exhibit 2.1: The Earth's Energy Balance

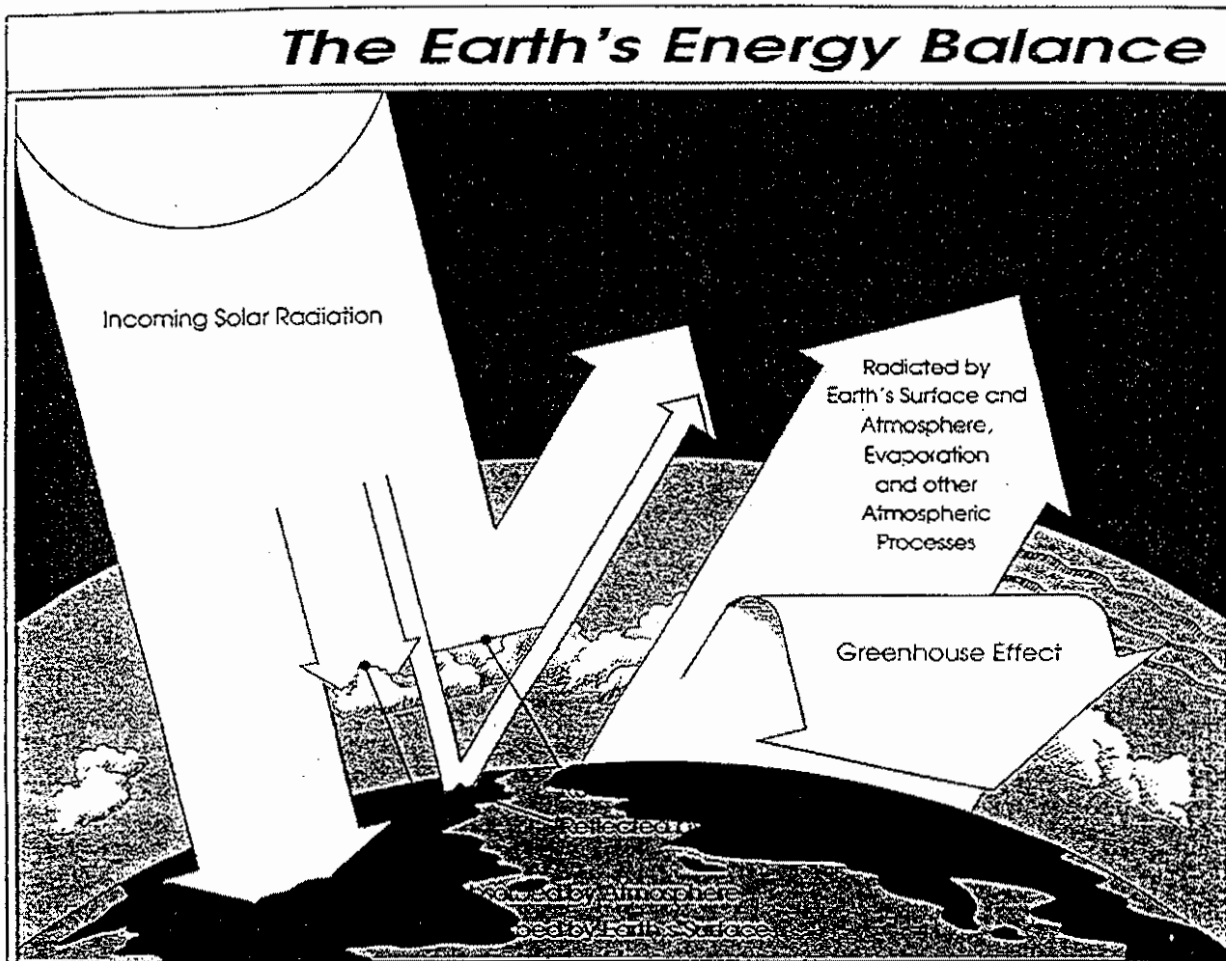


Figure 8

The sun's energy travels through nearly 150 million kilometres of space before arriving at the outer edge of the Earth's atmosphere. However, only about half of that energy actually reaches the Earth's surface. The rest is reflected back to space by clouds, scattered by dust and water vapour, or absorbed by the atmosphere and re-radiated.

At the surface still more of the incoming radiation is reflected back to the atmosphere and space, but part of it is absorbed by the land and oceans. The colour of a surface affects how much energy it will reflect or absorb - the lighter its colour, the more energy it will reflect; the darker its colour, the more it will absorb.

When it is absorbed, the solar energy is converted to heat to warm the Earth and the overlying air, to evaporate water, or to melt snow. Some of this heat escapes to outer space, but most is absorbed by water vapour, carbon dioxide, and other gases in the atmosphere and radiated back to Earth. The atmosphere actually works like a greenhouse window, letting in lots of energy from the sun but allowing only a portion of it to escape immediately back to space.

Eventually, however, all of the energy that the Earth receives from the sun returns to outer space. As a result, the Earth neither gains nor loses energy, and thus, over the long run, it neither heats up nor cools down.

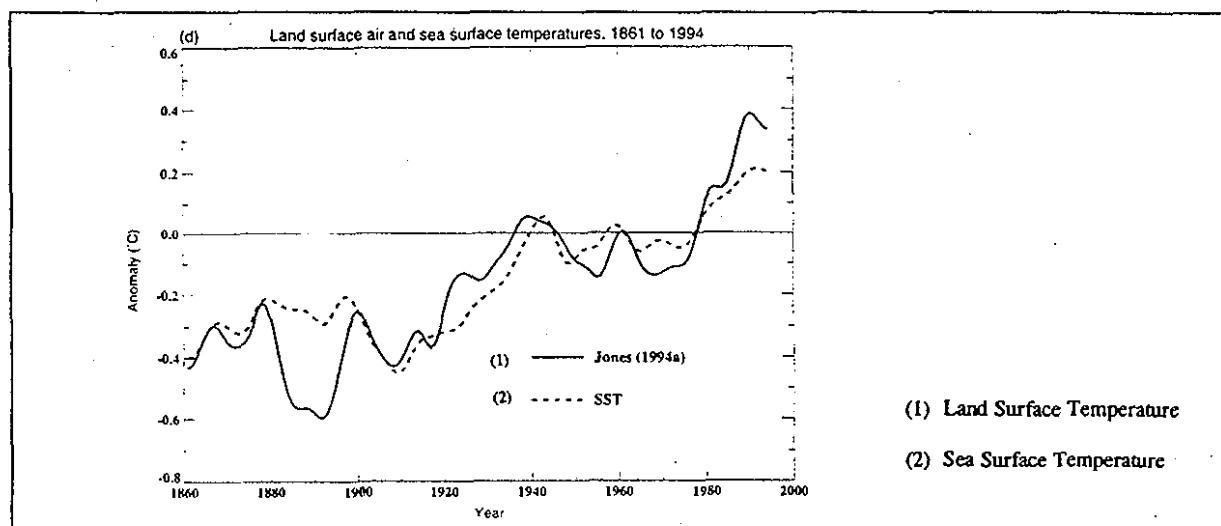
Source: Figure 8 from *A Primer on Climate Change*, Draft Report, Environment Canada, 1993, updated 1997.

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The most important of the anthropogenic sources is CO₂ which accounts for 81% of the impact of the anthropogenic GHG emissions. "Over the past 200 years, atmospheric concentrations of carbon dioxide have increased by 30%, methane by 145% and nitrous oxide by 15%. Continued increases are predicted both worldwide and in Canada."¹

At the same time, as illustrated in Exhibit 2.3, the global average temperature has increased by 0.5°C over the past century, with most of that change occurring in the past 40 years. Average temperature increases have been greater in higher latitudes, for example, the average temperature in Canada has increased by 0.8°C during the past 80 years.

Exhibit 2.3: Land Surface and Sea Surface Temperatures, 1861 - 1994



Source: Intergovernmental Panel on Climate Change, *Climate Change 1995* (Fig. 3.3)

There seems to be very little doubt about the causal relationships. Scientists have been able to model the relationships between CO₂ concentrations and their climate effects.

Climate change is not simply global warming. Global warming leads to other types of climate change including:

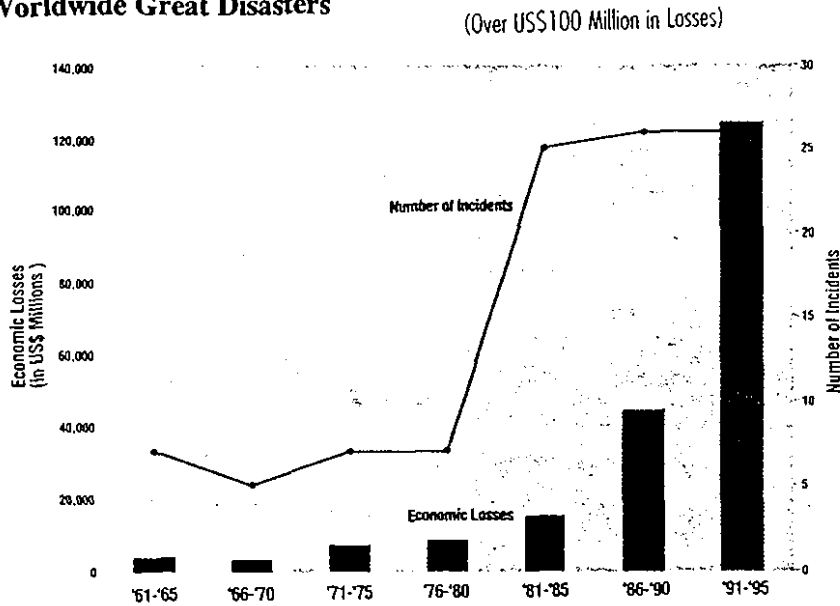
- rises in sea levels and flooding in coastal areas;
- droughts and desertification in currently inhabited areas;
- increasing frequency and intensity of extreme weather events such as hurricanes, tornadoes, and other types of storms. For example, "some studies suggest that since the late 1980's, north Atlantic winter storm activity has been more extreme than it ever was in the previous century"².

Exhibit 2.4 indicates how the number of natural disasters has been increasing.

¹ Transportation Association of Canada: *A Primer on Urban Transportation and Global Climate Change*, May 1998

² Carl, Nichols and Gregory, *Scientific American*, May 1997

Exhibit 2.4: Worldwide Great Disasters



Source: Munich Re, "Topics: An annual review of natural catastrophes" (1997).

2.3 THE FEASIBILITY OF REDUCING EMISSIONS

The international consensus on the problems of climate change have led to several agreements. In 1992, Canada signed the Framework Convention on Climate Change, agreeing to stabilize its GHG emissions at 1990 levels by the year 2000. Unfortunately, since 1990, GHG emissions in Canada have risen by some 13%. In 1997, Canada signed the Kyoto Protocol and agreed to reduce its emissions 6% below 1990 levels by the year 2012. Although Canada has not yet ratified the Kyoto Protocol, its signature implies a national commitment.

Attacking emissions through societal action can be successful. The best example is the international effort to phase out the production and consumption of ozone-depleting substances. Since the Montreal Protocol which came into effect in 1989, many countries have completely phased out the use of the worst offending substances and have agreed to a total phase-out by the year 2015.

This experience confirms that we can affect the amount of greenhouse gases that are emitted by human activity, but the challenge will be great to achieve the agreed targets.

In the remainder of this document, we describe the contribution of urban transportation to GHG emissions and then analyze various possible initiatives to reduce GHG emissions from urban transportation in Canada.

Backgrounder on Greenhouse Gas Emissions From Urban Transportation

3 ROLE OF URBAN TRANSPORTATION IN THE PRODUCTION OF GREENHOUSE GASES

The purpose of this section of the report is to provide the most accurate description possible, from available information, of the role and importance of urban transportation in the production of greenhouse gases (GHG's) in Canada today and to describe future emissions.

3.1 TRANSPORTATION ACCOUNTS FOR 26% OF ALL GREENHOUSE GAS EMISSIONS

In 1995, the total level of greenhouse gas emissions was estimated to be approximately 619 megatonnes (Mt), expressed on a CO₂ equivalent basis. Exhibit 3.1 provides a breakdown of the sources of GHG emissions in Canada. The emissions are shown in CO₂ equivalents, which takes into account the combined impact of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). The CO₂ equivalent is 21 tonnes for one tonne of methane and 310 tonnes for one tonne of nitrous oxide. CO₂ is by far the largest component of greenhouse gas emissions from transportation accounting for about 92% of the total GHG emissions. As shown on Exhibit 3.1, transportation is the single largest source of greenhouse gas emissions accounting for 26% of all greenhouse gas emissions.

According to Natural Resources Canada (NRCan) projections, which form the basis of the table below, total GHG emissions from all sectors in Canada are expected to rise from 619 MT in 1990 to 669 MT in the year 2010 if no initiatives to reverse current trends are taken. This represents an increase of about 8%, or an average annual growth rate of 0.5% per year. GHG emissions from transport sources are expected to rise from 163.5 MT in 1995 to 188 MT in 2010, an increase of 15%. Compared to 1990 levels, emissions from all transport sources are forecast to increase by 26%.

Exhibit 3.1: Transportation's Contribution to GHG Emissions (million tonnes CO₂ equivalent)

End use Sector	1990	1995	2010	1995 Share	Avg. grth rate 1995 - 2010
Residential	44.10	47.10	38.40	8%	-1.4%
Commercial	26.20	28.70	33.00	5%	0.9%
Industrial	90.10	98.00	117.30	16%	1.2%
Transport	149.20	163.50	188.00	26%	0.9%
<i>Sub-total</i>	<i>309.60</i>	<i>337.30</i>	<i>376.70</i>	<i>55%</i>	<i>0.7%</i>
Electricity Generation	95.10	103.10	110.10	17%	0.4%
Fossil Fuel Production	83.40	101.60	96.20	16%	-0.4%
<i>Total Energy Related</i>	<i>488.10</i>	<i>542.00</i>	<i>583.00</i>	<i>88%</i>	<i>0.5%</i>
Total Non-Energy Related	75.90	76.60	85.70	12%	0.8%
Grand Total	564.00	618.60	668.70	100%	0.5%

Source: Reproduced from *Foundation Paper on Climate Change – Transportation Sector Initial Draft*, prepared by Transport Canada, Environment Canada, Natural Resources Canada, Department of Finance Canada and Industry Canada with the assistance of Marbek Resource Consultants, June 1998.

Backgrounder on Greenhouse Gas Emissions From Urban Transportation

3.2 OVER 60% OF GHG'S FROM TRANSPORT ARE ATTRIBUTABLE TO PASSENGER TRANSPORTATION

It is not surprising that the largest single source of GHG emissions from transportation is the automobile. As shown on Exhibit 3.2, in 1995, automobiles and light trucks accounted for 54% of all GHG emissions from transportation sources. When transit, air and marine modes are taken into account, passenger transportation accounts for approximately 63% of all GHG emissions. The remaining 37% of GHG emissions are due to the movement of freight, with diesel trucks making up the largest component.

Exhibit 3.2: Total GHG Emissions by Mode (million tonnes CO₂ equivalent)

Mode	GHG ⁽¹⁾ Megatonnes (1995)	1995 Share (%)
Passenger Transportation		
Cars and Light Trucks	81.6	54%
Urban and Intercity Bus and Rail	2.0	1%
Air ⁽²⁾	10.3	7%
Marine	0.7	0%
Total Passenger	94.5	63%
Freight Transportation		
Diesel Trucks	26.6	18%
Gas Trucks	13.7	9%
Rail	5.7	4%
Air ⁽²⁾	2.6	2%
Marine	6.8	5%
Total Freight	55.4	37%
Total On-Road Transportation	150.0	100%
Other/Off-road (Non-Rail) Transportation	14.0	
All Transportation	164.0	

NOTES:

- (1) From Lawson, J., CTRF Paper, 1998. (see footnote ⁴ for complete reference)
- (2) Assumes 80% of air travel is due to passenger transportation

3.3 THE TOP 13 CMAs ACCOUNT FOR MORE THAN HALF OF ALL TRAVEL ACTIVITY IN CANADA

In 1996, 62% of the population of Canada lived in one of the 25 Census Metropolitan Areas (CMAs) and 54% resided in the top 13 CMAs³. About one-third of the population resided in one of the three largest

³ The top 13 CMAs in declining order of population are Toronto, Montréal, Vancouver, Ottawa - Hull, Edmonton, Calgary, Québec, Winnipeg, Hamilton, London, Kitchener, St. Catharines - Niagara, Halifax

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CMA's: Montreal, Toronto and Vancouver. It is clear that Canada's urban population represents the most significant market to target in terms of achieving GHG emission reductions from the transportation sector.

Urban transportation has been defined in many different ways in the past. Since the focus of this study is on urban transportation, it is necessary to develop a fairly strict definition of urban travel. For transit modes, it is quite easy to distinguish between urban and intercity travel based on the statistics for the individual carriers. The difficulty lies in defining urban travel for autos (e.g. light vehicles) and freight modes. For the auto modes, a general definition has been developed which includes all auto travel made by residents living in urban areas. For the purposes of this study, urban areas include the 13 most populated CMA's in Canada. By this definition, urban travel would include intercity auto trips made by urban dwellers. This definition was chosen on the basis that many of the policies (e.g. fuel pricing) examined in this report would impact all travel made by an urban resident.

For freight transportation, all activity by non-road modes (e.g. rail, marine and plane) has been assumed to be non-urban. For road freight, an informed estimate of transportation activity and emissions according to urban and non-urban sources was made. Based on information from urban cordon counts, it can be estimated that roughly 20% of all vehicle km driven by diesel trucks are in urban areas (e.g. the 13 largest CMA's). For heavy duty gasoline trucks, it was assumed that the ratio of urban to non-urban would be similar to automobiles and closely related to population and economic activity.

Exhibit 3.3 provides a summary of passenger transportation activity by mode based on estimates developed for this study. As shown, the 13 largest CMA's in Canada (based on 1996 population) account for 57% of all passenger transportation activity (excluding aviation and marine modes). The remaining 12 CMA's account for 7% while the rest of Canada, considered here to be non-urban, accounts for 36%. Automobiles and light trucks account for the largest portion of both urban and non-urban activity.

Exhibit 3.3: Passenger Transportation Activity in Canada - 1995 (billions of passenger-km)

Geographic Definition	Automobiles and Light Trucks		Surface Bus		Rapid Transit		Passenger Rail		Total	
	billion pkm	%	billion pkm	%	billion pkm	%	billion pkm	%	billion pkm	%
Top 13 CMA's	228.8	56%	9.3	71%	4.8	100%	2.6	63%	245.4	57%
Remaining 12 CMA's	29.4	7%	0.7	5%	0.0	0%	0.0	0%	30.0	7%
Rest of Canada ⁽¹⁾	148.1	36%	3.2	24%	-	-	1.5	37%	152.8	36%
All of Canada	406	100%	13.1	100%	4.8	100%	4.1	100%	428	100%
Modal Share	95%		3%		1%		1%		100%	

Notes:

⁽¹⁾ Transit and rail modes include intercity trips

NOTES: pkm = passenger-kilometres

⁽¹⁾ Transit and rail modes include intercity trips.

Similar to passenger transport, Exhibit 3.4 provides a breakdown of freight tonne-km by mode. Since most air and marine freight cargo is international, these modes are not shown in the comparison. Also, marine and air modes do not enter into the analysis of policy options.

Backgrounder on Greenhouse Gas Emissions From Urban Transportation

When compared on a tonne-km basis, rail freight accounts for the largest portion of all freight movement in Canada. This is consistent with results presented elsewhere⁴. Heavy-duty diesel vehicles dominate the road freight modes accounting for about 41% of all freight tonne-km on a national basis. As shown previously, diesel trucks; most of which are heavy-duty vehicles, are responsible for the majority of GHG emissions from freight movement. Therefore, improving the efficiency of freight movement by diesel trucks represents a potential source for achieving significant GHG reductions.

Exhibit 3.4: Freight Transportation Activity in Canada (billions of veh-km and tonne-km)

Geographic Definition	HDDV	HDTV	LDDT	LDGT ⁽²⁾	Rail	Total
All of Canada						
Vehicle-km (billions)	26.9	2.0	2.1	13.4	-	44.3
Tonne-km (billions)	214.8	15.6	2.1	6.7	282.2	521.5
Urban Canada ⁽¹⁾						
Tonne-km (billions)	43.0	8.7	1.2	3.8	-	-
Modal Share of Tonne-km (All Canada)						
	41.2%	3%	0.4%	1.3%	54.1%	100%

DEFINITIONS:

HDDV = Heavy-Duty Diesel Truck; HDTV = Heavy-Duty Gas Truck;
LDDT = Light-Duty Diesel Truck; LDGT = Light-Duty Gas Truck

NOTES:

- (1) 20% of all diesel tonne-km and 56% of all gas tonne-km estimated to be urban.
- (2) 20% of LDGT veh-km are assumed to be for commercial or freight purposes.

SOURCES:

Primarily based on information from Environment Canada, Trends in Canada's Greenhouse Gas Emissions, 1997. Rail tonne-km were obtained from Transport Canada reports.

3.4 CONCLUSION - URBAN TRANSPORTATION IS RESPONSIBLE FOR ABOUT 10% OF ALL GHG EMISSIONS

Exhibit 3.5 provides a breakdown of the total GHG emissions in Canada from all sources, ending with the total GHG emissions from urban transportation. As discussed previously, it is estimated that about 619 Megatonnes tonnes (MT) of GHG's were produced in Canada in 1995. Of this, transportation is directly responsible for 26%, or about 163.5 MT. About 91% of the emissions from transportation are attributable to road, rail, marine and aviation modes. The remaining 8% is due to other transportation sources, which comprise off-road ground (non-rail) mobile sources.

⁴ *Foundation Paper on Climate Change – Transportation Sector Initial Draft*, prepared by Transport Canada, Environment Canada, Natural Resources Canada, Department of Finance Canada and Industry Canada with the assistance of Marbek Resource Consultants, June 1998.

Backgrounder on Greenhouse Gas Emissions From Urban Transportation

Based on figures developed by Transport Canada staff, it is estimated that passenger transportation is responsible for 63% of the GHG emissions and freight transportation is responsible for 37%⁵. Of the passenger transportation emissions, auto is by far the largest contributor. For freight modes, diesel trucks, which are primarily used for heavy duty freight movement, are the primary contributor, although rail, marine and aviation modes comprise a significant portion.

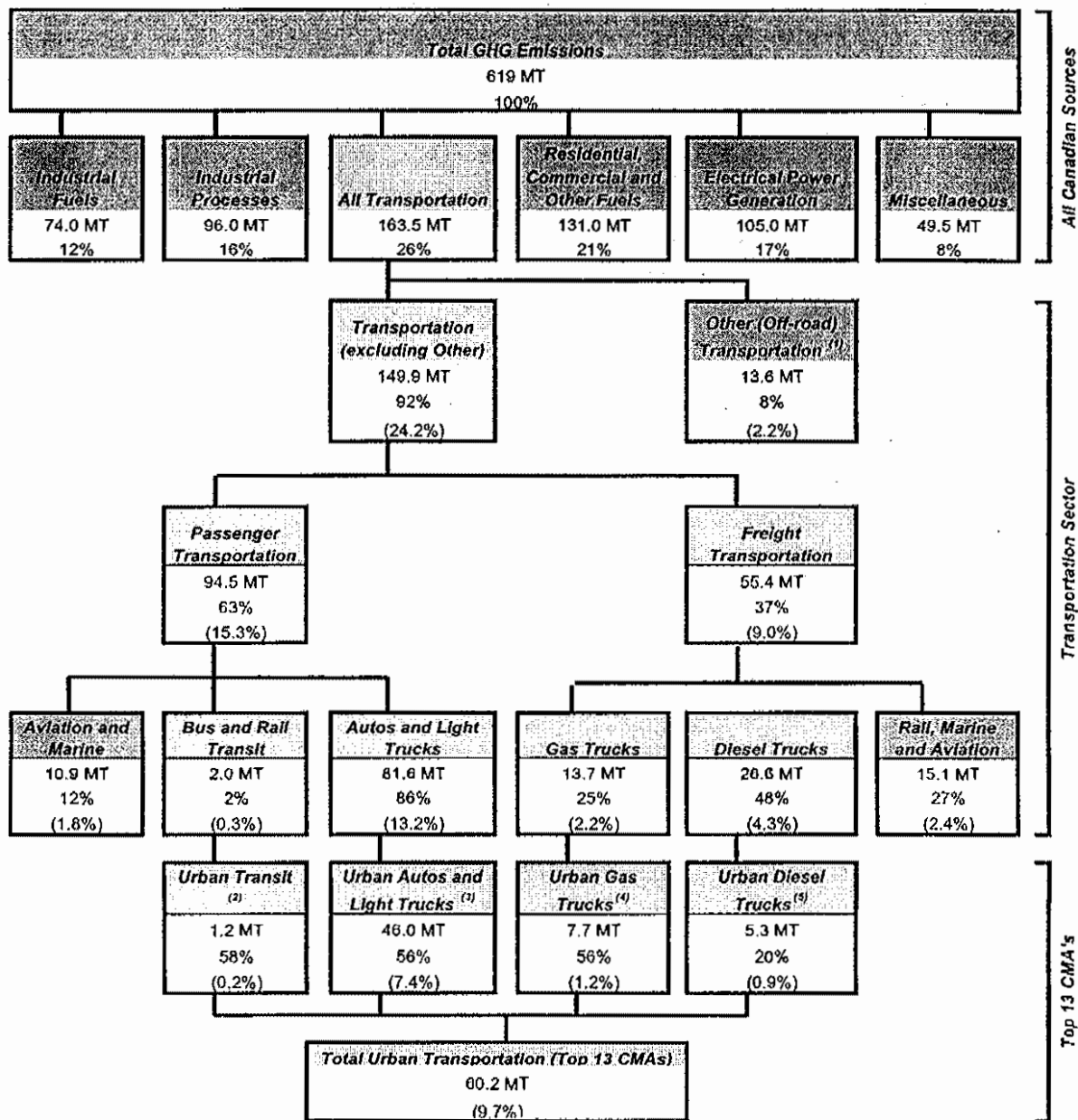
A number of assumptions described above were required in order to estimate the percentage of activity, and subsequently GHG emissions, that can be attributable to urban transportation. Of primary importance, is the fact that this study has defined urban transportation on the basis of the 13 most populated CMAs in Canada. For the bus and passenger rail modes, it is estimated that about 58% of all transportation-related GHG emissions are from urban sources. For auto modes, about 56% of the GHG emissions come from urban use.

Based on all of the assumptions, it can be concluded that transportation in the top 13 CMAs in Canada is responsible for nearly 10% of all GHG emissions in Canada. If all 25 CMAs were included, as well as smaller cities and towns, the total would be greater.

⁵ Lawson, J., *Canada's Commitment on Greenhouse Gas Emissions under the Kyoto Protocol and the Potential for Reductions in Transport*, presented at the Canadian Transportation Research Forum 33rd Annual Conference, Edmonton Alberta, May 25-28, 1998. (Note: In developing Exhibit 3.5, 20% of the emissions from international aviation and 100% from marine modes were estimated to be from freight transportation).

Backgrounder on Greenhouse Gas Emissions From Urban Transportation

Exhibit 3.5: Urban Transportation and GHG emissions - 1995 (million tonnes CO₂ equivalent)



Urban GHG emissions in 13 CMA's as percent of total transportation = 37%
 Urban GHG emissions as percent of total transportation (excluding other) = 40%
 Urban GHG emissions as percent of total transportation (excluding other, rail, aviation and marine) = 49%

(XX%) - Percent of total GHG Emissions

Notes:

- (1) Includes off-road ground (non-rail) mobile sources such as farm tractors which are not pure transportation.
- (2) Based on figures from Transport Canada, representative of emissions for 13 CMA's
- (3) Based on emissions for top 13 most populated CMA's (54% of Canada's population)
- (4) Urban ratio for gas trucks assumed to be similar to autos and light trucks
- (5) Subjective estimate based on professional judgement.

4 DEVELOPMENT AND ASSESSMENT OF OPTIONS TO REDUCE CO₂ EMISSIONS

There are literally hundreds of measures that individuals, businesses and governments can take to reduce CO₂ emissions from urban transportation. On the other hand, the transportation sector presents a formidable challenge precisely because decisions that affect carbon emissions are diffused so thoroughly in the daily activities of all Canadians.

In many cases, measures originally aimed at achieving other social, economic and environmental goals result in carbon emissions reductions as a collateral benefit. Vehicle *Inspection & Maintenance* programs designed to reduce emissions of smog precursor and particulate pollutants are examples.

The *Walking School Bus* movement, in which parents organize themselves to supervise groups of children walking to school, is another example. The initial motivation was the safety and security of children, as well as physical exercise and social contact within the neighbourhood. Reducing the need for children to be driven to school also reduces CO₂ emissions, congestion and air pollution by removing cars from the streets.

Policies that encourage mixed use more compact urban development, where they are applied, are the result of regional or municipal desires to increase consumer choice, improve quality of life, and reduce congestion and public infrastructure costs. Such policies can reduce automobile dependency by reducing the need for mechanized transportation and making public transit, walking or cycling more attractive.

Some key themes are emerging from the international research on sustainable transportation, including the 1997 NRTEE *State-of-the-Debate Report: The Road to Sustainable Transportation in Canada*, and from political events such as the Kyoto Protocol on climate change:

- Strong measures will be required if the transportation sector is called upon to proportionally contribute to Canada meeting its Kyoto emissions reduction of 6 percent relative to 1990 levels by the 2008 to 2012 period, and more challenging targets anticipated beyond 2012.
- No single policy, level or department of government or sector of society can solve the problem alone. Many integrated, co-ordinated and mutually reinforcing actions will be required. Options should be considered in a framework of four elements of an emerging strategy for sustainable transportation:
 - public education and awareness;
 - co-operation among all major players – governments, private sector and the public;
 - technology; and
 - institutional and social change. These include, for example, changes in land use, transportation facilities, services and pricing, other forms of demand management, providing more choice of urban transportation modes and creating more services within neighbourhoods.
- The use of economic instruments to fully cover external costs or to meet specific greenhouse gas targets, will be necessary if targets are to be met;
- Canadians can take many unilateral actions to reduce CO₂ emissions from urban transportation. However for certain of the stronger measures such as gasoline taxes or regulation of fuel economy standards, joint action with the United States will be highly desirable.

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- Policy options that appear to be the most effective in reducing carbon emissions from urban transportation are thought by many to be among the most politically difficult to implement in both Canada and the U.S.
- “Three forces are at work in Canadian cities:
 - The threat of climate change;
 - Urban air quality as a public health issue;
 - Shrinking municipal budgets.

These forces can reinforce each other and provide a unique opportunity to introduce change in the way Canadians perceive, develop and use urban transportation”⁶.

From Exhibit 3.5 in the previous section, it can be seen that urban automobiles and light trucks are responsible for a large portion (76%) of total urban transportation emissions in Canadian urban areas. Even more overwhelming is the fact that automobiles and light trucks are responsible for 97% of GHG emissions for personal travel. Urban transit, despite substantial, long-term public financial support, has been losing market share to the automobile for many years.

It seems clear, therefore, that any strategy or plan for meeting the Kyoto target in the 2008 to 2012 period must start with strong policy measures aimed directly at motivating consumers and businesses to reduce fossil fuel consumption from light duty road vehicles. As this section will show, the strongest individual policy options available are economic instruments. Improved technology will be a major way of achieving reductions in GHG emissions; many of the economic measures described are intended to stimulate and/or accelerate the development and implementation of improved technology.

Policy options that facilitate the expansion of public transit and other more sustainable urban transportation options, should be considered supporting policies to the main objective of more responsible, constrained use of road vehicles. Provision of such alternatives, as road vehicle use is reduced, will be essential to the future economic and social, as well as the environmental health of urban Canada.

This report draws on many Canadian, European, OECD and U.S. literature sources. There is a rich body of work in the industrialized world on the policy options discussed in this report. In particular, U.S. literature is relevant to development of a Canadian strategy for urban transportation because of the tight integration that already exists in road transportation manufacturing and operating sectors in the two countries. The success of a Canadian urban transportation strategy can be strongly influenced by the Kyoto strategy of the United States and the product and marketing decisions of automobile and truck manufacturers selling in the North American market.

The policy options chosen for reducing CO₂ emissions from urban transportation to meet the Kyoto target will require dramatic reductions from road vehicles. In Section 4.1, policy options that directly influence road vehicle use and emissions characteristics, are assessed. Section 4.2 reviews policy options that indirectly influence road vehicle use by encouraging expansion of alternative means of social and economic exchange within urban regions. The latter are discussed under the categories of Enhancing Public Transit, Land Use and Urban Design and Other Transportation Demand Management policies.

⁶ John Hartman, Transportation Association of Canada, *Presentation to National Air Issues Co-ordination Committee Conference on Transportation and Climate Change*, Toronto, April 2, 1998

The projections of vehicle emissions prepared by NRCan and used as the base line scenario include assumptions about the relationship between overall fuel consumption and GDP/personal income over the horizon period of this study. No additional analyses of these relationships were undertaken in this study.

4.1 REDUCING CO₂ EMISSIONS FROM ROAD VEHICLES

4.1.1 Fuel Taxes

Gasoline Taxes

Gasoline price has a direct impact on fuel consumption. In North America, there was strong market reaction to the oil shocks of the 1970's, as consumers reduced automobile use and moved to more fuel efficient vehicles.⁷ Today in Europe and Japan, with much higher gasoline prices, per capita fuel consumption is approximately one third that of Canada and the U.S. Higher population densities in Europe and Japan reduce per capita vehicle use. In addition, average or fleet-wide fuel economy ratings of North American vehicles are lower than those of offshore competitors, reflecting historically lower fuel prices relative to Europe and Japan.

Gasoline taxes are considered by many to be among the strongest and most economically efficient policy options that can be applied to reduce fuel consumption and CO₂ emissions. Because gasoline price directly impacts the cost of driving, it can impact a broader range of consumer and business decisions than most other policy options.

Research suggests that consumers constrain their decisions about transportation within a total budget for acquisition and operation that is a fixed percentage of their total incomes.⁸ The short term response to fuel price increase is reduced vehicle use (Vehicle Kilometres Travelled - vkt). In the longer term, fuel taxes impact consumer choices of where to live and work, as well as vehicle manufacturers' decisions on fuel economy of their products through vehicle design, cost-effective technology uptake, and marketing strategies.

The Canadian market for light duty vehicles represents approximately 8 percent of the total North American market. Decisions by vehicle manufactures to incorporate cost effective technologies for improving fuel economy of their products would be much more sensitive to a harmonized, North America-wide gasoline tax policy initiative than they would for a gasoline tax policy applied only in Canada.

For a "Canada only" gasoline tax, the impact on CO₂ emissions, even over the long term, would likely be limited to reducing vkt and to vehicle downsizing. Both vehicle size and average vehicle fuel economy rating (vehicle size) are already lower in Canada than in the U.S. as shown on Exhibit 4.1. This data suggests that Canada would have limited room to manoeuvre in unilaterally further shifting the fleet mix to even smaller vehicles. On the other hand, North America-wide tax increases should stimulate manufacturers to invest in development of new technologies in order to meet anticipated market demand.

⁷ Nivola and Crandall, *The Extra Mile: Rethinking Energy Policy for Automotive Transportation*, The Brookings Institute, Washington, 1995, page 28

⁸ Ibid

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Exhibit 4.1: Passenger Car Segment Share - 1994 (Canada vs U.S.)⁹.

Segment	Canada Share (percent)	U.S. Share (percent)
Economy	7.3	3.2
Small	34.9	24.6
Compact	16.6	14.1
Midsize	24.5	30.0
Large	5.0	7.4
Luxury	5.9	11.9
Sport	5.8	8.9

In order for a gasoline tax policy to be effective, the research literature indicates that very significant price increases would be required to achieve the Kyoto targets for carbon dioxide reduction. This assumes proportional reductions from the urban transportation sector will be required, and that there will be a need to establish momentum for greater reductions beyond 2012.

Mitigating economic disruption and allowing consumers and industry time to adjust to strong, new market price signals, suggests that tax increases would need to be gradual and sustained over a period of many years. Given the underlying uncertainties about the impacts of such a tax policy, an additional benefit of the gradual approach is that it provides opportunities for program modification in response to experience gained with the policy over time.

A current example of a national commitment to a gradual annual gasoline tax increase is the U.K. In 1993, the British government announced a policy of increasing gasoline prices by 5% each year for the indefinite future. This has now been raised to 6% per year.

Many studies have examined the elasticity of demand between fuel price and fuel consumption. Short term elasticities relate to the impact of fuel price on vkt by the fleet on the road, and have been found to be in the range of - 0.1 to -0.3¹⁰. (i.e. If gasoline prices rise by 10 percent, vkt will drop between 1 and 3 percent in the short term.)

In a recent University of Toronto study of the impact of fuel price increases on peak period (mostly work related) automobile travel in the Greater Toronto Area, found that short term elasticities were much lower than indicated above¹¹. This may reflect modelling method limitations, as discussed by the authors. It may also relate to the inelasticity of work trip origins and destinations and the lack of acceptable transportation alternatives for such trips in the short term. The GTA case study did not address off-peak, personal travel, which is a growing percentage of total trips. Personal travel would be expected to exhibit more elastic response to fuel price increases.

For purposes of this Backgrounder the following scenarios for light duty vehicles were assumed:

⁹ The Osborne Group, DesRosiers Automotive Consultants and Piorusso Research and Consulting, *Reducing Greenhouse Gas Emissions from the Ontario Automotive Sector*, for the Transportation and Climate Change Collaborative, May, 1995.

¹⁰ *A Review of New Demand Elasticities with Specific Reference to Short and Long Run Effect on Price Changes*, P.B. Goodwin, Journal of Transport Economics and Policy, Volume 26, No. 2, May 1992.

¹¹ *Full Cost Pricing and Sustainable Urban Transportation: A Case Study of the Greater Toronto Area*, R. Soberman, E. Miller, University of Toronto, November 1997.

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- CO₂ emission reductions have been estimated for two different tax programs, from 2000 to 2010:
 - Scenario 1: gasoline price increases 3 cents/litre annually. This represents an annual increase of about 5.5% relative to current gasoline prices in Canada and is comparable to the annual increases in the U.K. that started in 1993 as a long term measure to reduce CO₂ emissions.
 - Scenario 2: gasoline price increases X cents/litre annually, where X is the increase necessary, as a single measure, to reduce gasoline consumption to meet the Kyoto target (6% below 1990 levels for gasoline vehicles only).

The new vehicle fleet replacement rate (new vehicle sales) is estimated to be 8 percent per year, with fleet turnover of about 12 years.

Long term elasticities of demand to fuel price increases are assumed to be:

- vkt = - 0.15
- Fuel economy of new vehicles
 - vehicle design, technology = - 0.25
 - shift in vehicle fleet mix = - 0.15¹²

Case A. *Canada Only Gasoline Tax*

For a Canada only gasoline tax, the total long term elasticity of fleet fuel consumption to gasoline price would be the sum of elasticities of vkt and shift in fleet mix. It is assumed that manufacturers would not make vehicle design and technology decisions for the Canadian market only. The long term, Canada only elasticity is therefore assumed to be - 0.15 with respect to vkt and -0.15 with respect to the fuel economy of new vehicles.

For Case A, the annual fuel price increase required to meet the Kyoto target (for gasoline vehicles only) would be 5.4 cents per litre

Case B. *North America-Wide Gasoline Tax*

For a North America-Wide gasoline tax, the total long-term elasticity would be - 0.15 with respect to vkt and $(-0.25 + - 0.15) = - 0.40$ with respect to the fuel economy of new vehicles. This reflects the long term influence of tax policy on vkt, manufacturers' vehicle design and fuel efficiency technology decisions, and shifts in consumer vehicle purchase decisions. There is some uncertainty about whether the impacts of these three effects are simply additive but the impact of this uncertainty is considered to be small.

For Case B, the annual fuel price increase required to meet the Kyoto target (for gasoline vehicles only) would be 3.6 cents per litre.

¹² Michaelis, OECD

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Exhibit 4.2 illustrates the impacts of the scenarios for gasoline tax increases based on the assumptions about the long term elasticities of vehicle-km and fuel efficiency.

Exhibit 4.2: Impacts of Gasoline Taxes

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-	-	-	-
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenarios									
Scenario 1A - Gasoline Tax (\$0.03/L annually - Canada Only)	40,809	12,332	53,141	-10%	-4%	-9%	3%	47%	11%
Scenario 2A - Gasoline Tax (\$0.054/L annually - Canada Only) ⁽¹⁾	37,179	11,909	49,087	-18%	-8%	-16%	-6%	42%	2%
Scenario 1B - Gasoline Tax (\$0.03/L annually - North America Wide)	38,385	12,066	50,452	-16%	-6%	-14%	-3%	44%	5%
Scenario 2B - Gasoline Tax (\$0.036/L annually - North America Wide) ⁽¹⁾	37,029	11,911	48,940	-19%	-8%	-16%	-6%	42%	2%

Note: ⁽¹⁾ These are the price increases that would be required to achieve a 6% reduction in CO₂ from 1990 levels by 2010 for gasoline vehicles only. Most emissions from gasoline vehicles are due to passenger transportation.

If gasoline prices were increased in Canada only, the major impacts would be on vkt and vehicle fleet mix. It is assumed that technology improvements would not proceed as swiftly compared to a harmonized, North America-wide tax initiative. The resulting reductions in CO₂ for a 3 cent/litre per year increase would be in the order of 10% compared to the 2010 baseline CO₂ for passenger transportation only. If the Kyoto target reduction of 6% from the 1990 levels by 2010 were to be achieved for gasoline vehicles only, a 5.4 cents/litre per year increase would be required.

Emissions reductions for a North-America wide increase of 3 cents/litre per year would be significant. Compared to the baseline 2010 scenario, annual CO₂ could be reduced by as much as 16% for passenger transportation. Compared to the 1990 CO₂ levels, the reduction was estimated to be in the order of 3% for passenger vehicles. If the Kyoto target reduction of 6% from the 1990 levels by 2010 were to be achieved for gasoline vehicles only, a 3.6 cents/litre per year increase would be required.

It is assumed that a new gasoline tax policy aimed at reducing CO₂ emissions would be the subject of joint federal/provincial negotiations. The need for federal/provincial co-operation for such a policy option stems from the fact that both federal and provincial governments currently have gasoline taxation powers, and from the need to ensure a level playing field throughout Canada.

As single occupancy vehicle use is reduced through increased fuel taxes, more sustainable transportation alternatives such as urban transit and infrastructure for walking, cycling, and other measures for reducing transportation demand, must be developed in parallel. Dedicated investment of a portion of revenues from a new gasoline tax policy has often been suggested as a funding mechanism for the latter. Indeed, the way in which such funds are re-invested could have an impact on long term emissions reductions.

Gasoline taxes increases on the scale necessary to provide strong incentives for reduced fleet fuel consumption would generate very large amounts of tax revenue. The gross revenues (in 1998 dollars) in the year 2010 generated from increased gasoline taxes for each of the four scenarios are shown below.

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For both the Canada only and North America wide scenarios, the revenues are from gasoline sold in the 13 CMAs in Canada only.

- Scenario 1A - Gasoline Tax (\$0.03/L annually - Canada only) - \$5.49 billion
- Scenario 2A - Gasoline Tax (\$0.054/L annually - Canada only) - \$8.91 billion
- Scenario 1B - Gasoline Tax (\$0.03/L annually - N.A. Wide) - \$5.15 billion
- Scenario 2B - Gasoline Tax (\$0.036/L annually - N.A. Wide) - \$6.05 billion

Such revenue increases could be used to reduce other tax rates such as personal or corporate income taxes to deal with social equity and competitiveness issues. Many commentators have suggested that the cause of economic efficiency would be better served by taxing consumption to reflect true external costs, than by taxing income and other wealth generating activities. Such a fundamental change in the structure of tax policies would require dialogue among all levels of government in Canada.

Diesel Fuel Taxes

There is limited research reported in the literature on elasticities of diesel fuel consumption to fuel price. For purposes of this study, we have used a figure of - 0.2 reported in Michaelis (1996) to project CO₂ emissions reduction in 2010 from a 3 cents per litre annual fuel price increase, starting in 2000.

Unilateral imposition of a large annual diesel fuel tax, in Canada, for trucking could have major impacts on the international competitiveness of Canadian trucking firms. For this Backgrounder, it has been assumed that such a tax would only be introduced as a harmonized tax in co-operation with the United States. At present, there is no indication that such a tax is being seriously considered in the U.S.

The estimated reductions for a 3 cents per litre annual diesel fuel price increase are shown on Exhibit 4.3. It is important to note that the reductions shown are for the urban portion of road freight transport only. For a North American-wide diesel fuel tax, the potential emissions reduction would be much more significant, given that most road freight movement takes place outside of urban areas. If only road freight modes are considered, the CO₂ reduction would be 8% compared to the 2010 baseline. This estimate is based on an elasticity that does not take into account modal shifts in freight tonne-km and the possible emissions implications of this.

Exhibit 4.3 Impacts of Diesel Fuel Tax

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-	-	-	-
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenario									
Diesel Tax (\$0.03/L annually - North America Wide)	45,522	11,920	57,443	-0.1%	-8%	-2%	15%	42%	20%

4.1.2 Corporate Average Fuel Economy

Corporate Average Fuel Economy (CAFE – U.S.) and Corporate Average Fuel Consumption (CAFC – Canada) are regulatory instruments under which each automobile manufacturer is required to meet a common fuel efficiency standard, averaged over all of the vehicles sold by that manufacturer in a model

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year. The U.S. Government introduced legislation imposing CAFE standards in 1975, in response to the OPEC oil shock of the previous year. The standards were set to move new passenger car fuel economy from a standard of 18.0 mpg (13.11 l / 100 km) starting in 1978, to 27.5 mpg (8.7 l / 100 km) in 1985. The latter standard remains in effect today.

Separate, less aggressive standards were set for two-wheel drive and four-wheel drive light duty trucks, including minivans and sport utility vehicles. The current average CAFE standard for all light duty trucks is 20.2 mpg (11.8 l / 100 km). When these standards were set, the majority of light trucks were used for commercial purposes. Light trucks then represented about 15 percent of the total light duty vehicle fleet on the road. At that time, the lower standard for this class of vehicle was not seen as a major barrier to the overall success of the CAFE program.

Today, however, light duty trucks represent approximately 50 percent of new vehicle sales. This growth, compared with relatively flat sales of cars, reflects increased use of trucks as personal vehicles. The lower fuel efficiency standard for light trucks has tended to offset the gains in fuel consumption expected from CAFE for the overall vehicle fleet.

Since 1980, the Canadian Government, under a Memorandum of Understanding with automobile manufacturers, has had a voluntary Corporate Average Fuel Consumption (CAFC) program in place. CAFC mirrors the U.S. CAFE standards. Because of higher fuel prices and lower disposable income in Canada, the Canadian light duty vehicle fleet mix is biased towards smaller, more fuel efficient vehicles. As a result, fuel efficiency of the Canadian fleet has been slightly higher than the U.S. since the early 1980's¹³. In 1993, the average Canadian passenger car fleet fuel efficiency was 29.4 mpg (8.0 l / 100 km) compared with the U.S. average of 28.3 mpg (8.4 l / 100 km).

Experience with CAFE/CAFC

Overall fuel consumption by the light duty vehicle fleet is a function of both average fuel efficiency and the amount vehicles are used. CAFE/CAFC places responsibility for increased fleet fuel efficiency on vehicle manufactures. Manufacturers, acting rationally, may respond by reducing the weight of the new vehicles, incorporating fuel efficiency technologies within cost constraints of the discounted value of fuel savings to the consumer, or by increasing prices of larger vehicles and lowering the prices of smaller, more fuel efficient products. Experience reported in the U.S. literature indicates that all of these strategies have been used.

Many commentators have credited CAFE standards with having improved fuel efficiency from 19.9 mpg in 1978 to 28.8 mpg in 1988. However, in the years prior to 1981, it has been shown that fleet fuel efficiency improved as a result of market demand, as consumers reacted to higher gasoline prices, following the first oil shock of 1974, and the expectation that fuel prices would remain high.¹⁴ After 1981, manufacturers did respond to CAFE standards as gasoline prices in the U.S. fell to the post-WW2 levels that persist today. It has been estimated that fuel efficiency gains from CAFE offset the increases in vehicle use (vkt) caused by the drop in fuel prices in the years following 1981.

It has also been established that manufacturers did raise prices of larger vehicles and lower those of smaller vehicles in this period as a strategy for compliance with CAFE¹⁵. In the 1983 to 1993 period,

¹³ *Reducing Greenhouse Gas Emissions from the Ontario Automotive Sector*, The Osborne Group et al, for the Transportation and Climate Change Collaborative, May 1995, page 8

¹⁴ Nivola & Crandall, p. 24

¹⁵ *Ibid*, p. 40

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analysis has shown that the price charged for additional weight doubled after 1983 and the price for acceleration more than tripled.

There is some controversy about the relationship between the rate of application of new technology by manufacturers and real and expected changes in fuel prices. Some argue that CAFE seems not to have been a major factor in the fuel efficiency technology decisions of the car makers. Nivola and Crandall state that "the decided slowdown in technical progress in achieving efficiency, evident in the 1990's, is strongly correlated with declining (fuel) prices (in the U.S.) over the 1980's. Apparently vehicle producers are unwilling to commit to expensive new technology to save fuel in an environment of falling gasoline prices"¹⁶. The counter argument is that "there have been very significant technological changes to cars in the past decade in spite of falling fuel prices, and these changes have essentially allowed fuel economy to stay flat as consumers have shifted to larger, more luxurious vehicles"¹⁷.

In summary, it appears that CAFE/CAFC affects the weight of vehicles sold, while fuel efficiency technology application is more sensitive to fuel price.

CAFE/CAFC standards have a number of other characteristics that affect their overall effectiveness:

- In a period of stable or falling gasoline prices there is a "take-back" effect, in which consumers respond to lower gasoline costs by driving more. This effect is estimated to be in the range of 15 to 30 percent, meaning that a one percent improvement in fuel efficiency results in increased vkt of 0.15 to 0.30 percent.
- As vehicle manufacturers reduce the price of smaller vehicles under CAFE/CAFC, some analysts suggest that the number of new vehicles sold increases. Others argue that raising prices of new vehicles to meet CAFE/CAFC regulations causes some consumers to delay replacement of older, less fuel efficient vehicles, thus further undermining the intent of the regulation.
- The experience of CAFE/CAFC in the 1980's, has generated strong opposition to new or extended standards by the Big Three automobile manufacturers and U.S. autoworker unions. The reason for this opposition is straightforward. The products of North American automobile companies have historically been larger and less fuel efficient than Japanese competitors. Under CAFE each manufacturer was required to meet the same standard for each major class of light duty vehicle in a given model year. This had a negative effect on the competitiveness of domestic manufacturers in their home markets. When CAFE was first imposed, North American manufacturers' average fleet fuel efficiency for cars was 18.7 mpg compared with the Japanese average of 27.9 mpg. By 1993, the gap had narrowed with the U.S. domestic average for cars close to the standard of 27.5 mpg, compared with the import average of 29.4 mpg, still 2 mpg better than the Big Three.
- Because of its economic inefficiencies, and specifically its inability to contribute to reduced vkt, some analysts have concluded that CAFE/CAFC standards have larger economic cost

¹⁶ Ibid, p. 39

¹⁷ K.G. Duleep, Energy and Environmental Analysis Inc., personal communication, August 1998

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than a gasoline tax designed to produce the same reduction in energy use¹⁸. The issues of economic efficiency and impacts are will be discussed later in this report.

For this Backgrounder, estimates of the CO₂ emissions for urban transportation in Canada, from a new CAFE/CAFC standard applied in the U.S. and Canada, were made for the two cases of "Canada only" and "North America-wide" under the following assumptions:

- New standards are set in 2002 in both countries for all classes of light duty vehicles, with the first annual increment taking effect in the model year 2005. New vehicle fuel efficiency for each major class of light duty vehicle improves 1 percent annually when applied in Canada only and 2 percent annually when applied North America-wide¹⁹. Again, the reason that North America measures are more effective is that they will stimulate technological innovation much more than measures that are applied in Canada only.
- Fuel efficiency of new vehicles improves at the base forecast rates adopted by Natural Resources Canada in the absence of new policy intervention by government²⁰, until the new CAFE/CAFC standards take effect in 2005. For automobiles, this rate is -0.66% per year.
- A take-back effect of one-third has been assumed to account for the fact that people may drive further as they are using less fuel.

Alternative forms of new CAFE/CAFC standards have been proposed in the literature:

- tradable CAFE permits;
- national new vehicle fuel economy standard to be met by manufacturers collectively, with individual manufacturers' targets determined through negotiation;
- CAFE combined with feebates, or with "gas guzzler" taxes;
- CAFE that depends on the type of car sold - for example, allowing higher average fuel consumption for the product mix of manufacturers that produce larger vehicles.

OECD suggests that the use of tradable CAFE permits would be the most economically efficient approach to imposing economy improvements on manufacturers²¹.

The impacts of CAFE and CAFC standards in the horizon year 2010 are shown in Exhibit 4.3. In estimating the impacts, the fact that the CAFE standards would apply to new vehicles only has been taken into account. Assuming a fleet replacement rate of 8% per year, roughly 48% of the vehicle fleet would

¹⁸ Annex I Expert Group on the UN FCCC, Working Paper 1, *Policies and Measures for Common Action – Sustainable Transport Policies: CO₂ Emissions from Road Vehicles*, Laurie Michaelis, OECD, July 1996, page 44

¹⁹ The assumption of 2% improvement in new vehicle fuel economy under a new CAFE/CAFC program reflects the fuel efficiency technology that can be applied by manufacturers within the discounted value of fuel savings. This rate is derived from *Annex I Expert Working Group on the UN FCCC, Policy measures for Common Action, Working Paper 1, Sustainable Transport Policies: CO₂ Emissions from Road Vehicles*, by Laurie Michaelis, OECD, July 1996, Figure 10, page 33

²⁰ NRCan Energy Outlook 1990 - 2020

²¹ Michaelis, OECD, p 35

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be replaced by 2010, all operating with varying degrees of CAFE standards, depending on the year they were built.

The impacts of CAFE/CAFC standards are relatively minor given that the standards do not start taking effect until 2005, and even then apply to new vehicles only. The estimated reduction in CO₂ levels due to CAFC for passenger vehicles is roughly 1.4% compared to the baseline 2010 projections. The impacts of CAFE standards would be about twice that at 2.5%.

Exhibit 4.4: Impacts of CAFE and CAFC in 2010

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight ⁽¹⁾	Total	Passenger	Freight ⁽¹⁾	Total	Passenger	Freight ⁽¹⁾	Total
1990	39,589	8,390	47,979	-	-	-			
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenarios									
Canada Only - 1% annual improvement taking effect in 2005 (new veh only)	44,930	12,840	57,770	-1.4%	-0.4%	-1.2%	13.5%	53%	20%
North America Wide 2% annual improvement taking effect in 2005 (new veh only)	44,433	12,792	57,225	-2.5%	-0.7%	-2.1%	12.2%	52%	19%

NOTES:

⁽¹⁾ Applied to light duty freight only.

Since the CAFE/CAFC standards would not be implemented until 2005, their ultimate potential is significantly underestimated when examined for a 2010 horizon. In order to demonstrate the longer term impacts of CAFE/CAFC, the effects have been extended to the year 2020. As shown on Exhibit 4.5, the impacts of CAFE and CAFC are much more significant after several years, based on the assumption that the 2% annual improvement would continue to take place as long as the standards were in place. Using 2020 as the comparison year, the impact of a Canada only CAFC standard would be roughly a 10% reduction in CO₂ from the baseline estimate for passenger transport. A North America-wide standard would result in a reduction of about 15% from the baseline. This is evidence that policy makers should think about implementing CAFE standards in the very near future.

Exhibit 4.5: Impacts of CAFE and CAFC in 2020

	Annual CO ₂ (kilotonnes)			% Change from 2020 Baseline			% Change from 1990		
	Passenger	Freight ⁽¹⁾	Total	Passenger	Freight ⁽¹⁾	Total	Passenger	Freight ⁽¹⁾	Total
1990	39,589	8,390	47,979	-	-	-			
2020 Baseline	48,640	15,388	64,028	-	-	-	23%	83%	33%
2020 New Scenarios									
Canada Only - 1% annual improvement taking effect in 2005 (new veh only)	40,928	12,509	53,436	-10.2%	-2.9%	-8.6%	3.4%	49%	11%
North America Wide 2% annual improvement taking effect in 2005 (new veh only)	38,742	12,298	51,041	-15.0%	-4.6%	-12.7%	-2.1%	47%	6%

NOTES:

⁽¹⁾ Applied to light duty freight vehicles only.

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4.1.3 Feebates

A feebate is an economic policy instrument under which vehicles are subject to taxes or rebates in proportion to how much they exceed or fall below a specified reference energy factor, typically the mean fuel economy rating for the vehicle fleet for a particular year. Feebates can be designed to be revenue neutral, or to generate sufficient revenue to cover their administrative costs.

Feebates have been extensively researched, especially in the U.S., but have not been implemented in a substantive way in any jurisdiction.

Feebates provide a strong market based incentive to consumers to purchase more fuel efficient vehicles. They provide no direct incentive to reduce vehicle use (vkt). In fact, by increasing the percentage of smaller, lower fuel consuming vehicles on the road, they could induce a "takeback" effect for the same reason as CAFE/CAFC standards.

In response to feebates, consumers who are not prepared to purchase smaller vehicles, can be expected to delay purchase decisions in the face of higher replacement costs for older less fuel efficient vehicles.

In theory, if applied across North America, feebates provide manufacturers incentives to incorporate fuel efficiency technologies into their products. As in the case of CAFE/CAFC, feebates can also influence the weight of new vehicles and the fleet mix. For a feebate applied only in Canada, the impact would be limited to changing the fleet mix through the downsizing effect on consumers' purchase choices. A North America-wide measure would be more effective in stimulating technological innovation.

Ontario's Tax for Fuel Conservation (TFFC), introduced in 1989, is considered a feebate scheme. However, it applies to a very small percentage of new vehicle purchases with highway fuel economy ratings better than 6.0 l/100 km, or worse than 9.0 l/100 km. For 90 percent of new vehicles with fuel economy ratings between these two thresholds, a flat tax of \$75 applies with no incentive for increased fuel efficiency. Since new vehicles represent only 8 percent of the road vehicle fleet, the TFFC program only impacts about 1 percent of the fleet in any one year. Exhibit 4.6 shows the schedule of taxes and rebates under the Ontario TFFC program. Note that the rebate of \$100 for cars rated at less than 6.0 l/100 km, is a nominal sum which likely has little influence on vehicle purchase decisions. With the exception of the \$100 rebate for the most fuel efficient cars, the Ontario TFFC is very similar to the U.S. "Gas Guzzler" tax. The latter has been shown to have a very small impact on the fleet mix since it applies to such a small percentage of new vehicle sales.

Exhibit 4.6: Tax Charges and Rebates - Ontario Tax for Fuel Conservation

Rated Fuel Economy- Highway (Litres/ 100km)	Feebates Taxes and (Rebates)	
	Passenger Cars	Sport Utility Vehicles
Less than 6.0	(\$100)	\$0
6.0 - 7.9	\$75	\$0
8.0 - 8.9	\$75	\$75
9.0 - 9.4	\$250	\$200
9.5 - 12.0	\$1,200	\$400
12.1 - 15.0	\$2,400	\$800
15.1 - 18.0	\$4,400	\$1,600
Over 18.00	\$7,000	\$3,200

The following are suggested features of an effective feebate program for Canada. The program would:

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- be nationwide.
- have high leverage in the middle of the rated fuel economy distribution of the fleet, where approximately 90 percent of vehicle sales occur. This can be achieved in the design of feebate rate schedule, expressed in \$ / litre/ 100 km
- set feebate rates high enough to change market behaviour and to meet CO₂ emissions targets
- include all classes of gasoline powered light duty vehicles including cars , light trucks, sport utility vehicles and minivans. Strong incentives are needed to improve light truck fuel efficiency, given the impact of lenient fuel economy regulation on truck sales since the 1970's. Separate feebate schedules by vehicle class could also be designed to mitigate the domestic vs import market distortion, since the Big Three have the largest share of the light truck market.

Feebates can be designed to be complementary or as alternatives to new CAFE/CAFC standards. They can also be integrated with gasoline taxes. These combinations of policies will be discussed in the next section.

Feebates applied across North America would likely have greater impact in Canada, than a program applied in Canada only, based on the widely held view that manufacturers are not likely to incorporate advances in fuel efficiency technology into their products for Canada's 8 percent of the North American market.

To illustrate the potential CO₂ emissions reduction potential of a national feebate program in Canada, estimates of impacts have been made on the following assumptions:

- Case A - Feebates are applied across Canada only.
- Case B - Feebates are applied on a harmonized basis in Canada and the U.S.
- The feebate program would be introduced in 2005 with five years notice to manufacturers, and extend to 2010 and beyond.
- Energy reference factor / baseline vehicle fuel economy is 9.0 litre/ 100 km.
- The following estimated effects, by 2010, of feebates of different levels were derived from the literature²².

²² Ibid, Table 6, page 41

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Exhibit 4.7: Feebate Options

Feebate Rate \$ CAN./Litre/ 100 km (Relative to 9 litres/100km)	Expected New Vehicle Fuel Economy Improvement (%)	
	North America	"Canada Only"
\$350	10	3
\$700	14	5
\$1400	20	10
\$2800	28	18

NOTE: The research on which the above figures are based presented the feebate scenarios in U.S. dollars. For this report, the \$U.S. feebate amounts were converted to Canadian Dollars using a multiplier of 1.4.

For "Canada only", it is assumed that feebates would affect only fleet mix through downsizing. The estimates for North America-wide application include estimated impacts of the feebate on vehicle redesign, additional technology uptake by manufacturers, and downsizing.

A range of feebate scenarios are presented in Exhibit 4.8 showing the impacts if implemented for Canada only as well as if implemented on a North America-wide basis. For the Canada-only feebate program, the reductions relative to the business-as-usual scenario for 2010 would range from 1% for a \$CAN 350/litre/100 km feebate to 9% for a \$CAN 2800/litre/100 km feebate. The impacts for the same feebates implemented on a North America wide basis would range from 5% to 14%. Under no scenario would the feebate program alone be able to reduce CO₂ below 1990 levels.

Exhibit 4.8: Impacts of Feebates

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-			
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenarios									
<i>Feebates Implemented in Canada Only</i>									
\$CAN 350/litre/100km	44,913	12,887	57,801	-1%	0%	-1%	13%	54%	20%
\$CAN 700/litre/100km	44,469	12,887	57,356	-2%	0%	-2%	12%	54%	20%
\$CAN 1400/litre/100km	43,357	12,887	56,244	-5%	0%	-4%	10%	54%	17%
\$CAN 2800/litre/100km	41,577	12,887	54,465	-9%	0%	-7%	5%	54%	14%
<i>Feebates Implemented North America-Wide</i>									
\$CAN 350/litre/100km	43,357	12,887	56,244	-5%	0%	-4%	10%	54%	17%
\$CAN 700/litre/100km	42,467	12,887	55,354	-7%	0%	-5%	7%	54%	15%
\$CAN 1400/litre/100km	41,133	12,887	54,020	-10%	0%	-8%	4%	54%	13%
\$CAN 2800/litre/100km	39,353	12,887	52,241	-14%	0%	-11%	-1%	54%	9%

As with CAFE standards, the feebates will not have reached their full potential by 2010, just five years after implementation. Assuming a replacement rate of 8% per year, less than half of the vehicle fleet would be purchased under the feebate program by 2010. However, by 2020, it is likely that most drivers would have purchased at least one vehicle under the feebate programs. Therefore, it is reasonable to assume that the impacts of feebates in 2020 would be at least twice as great as the impacts shown in Exhibit 4.8 above.

4.1.4 Inspection & Maintenance (I&M) Programs

Approximately 20 percent of vehicles on the road, including a distribution of vehicles from all model years, are operating at emissions and fuel consumption levels well below their rated performance. Annual or biennial I&M programs have demonstrated that it is possible, at reasonable cost, to identify gross polluters and cause owners to repair their vehicles.

In Canada, British Columbia is the only jurisdiction with an operational I&M program. The B.C. AirCare program, introduced in 1992, applies to approximately 1.0 million vehicles in the Lower Fraser Valley. Fuel economy of the cars repaired as a result of the program, has improved on average by 7%. As a consequence, gasoline consumption in the region was reduced by 0.73% in the third year of the program.²³ Based on experience in the U.S., it is expected that further reductions will be achieved in B.C. as the AirCare program is modified in future. The B.C. program has been extended to include light and heavy duty trucks.

Fuel savings to motorists in the third year of the program have been estimated at about \$7 million. Cost of repairs is estimated at \$8.7 million. Consumers realize a payback in a little over a year, with the expectation that fuel savings will continue for a number of years.²⁴

Ontario has announced that it will implement an I&M program beginning in 1999, starting in the Greater Toronto Area with subsequent extension to other regions of the province by 2002. The Ontario government estimates that when it is in full effect, the province-wide program will reduce annual CO₂ emissions by 0.9 Mt²⁵.

The Government of Quebec has also embarked on a pilot I&M program. The province of Quebec announced a two year voluntary I&M program in 1997. The program operated from April to October 1997 with voluntary clinics held throughout the province. Voluntary clinics were also being held during the summer of 1998. A final report is to be submitted to government officials in the spring of 1999.

I&M programs are now being complemented by advanced on-board vehicle diagnostic systems that, starting in 1996, are being incorporated into new light duty vehicles. The new systems detect emissions or fuel control component or system failures, provide warning signals to the driver and, for some failures, put the vehicle into a "Limp Home" mode until repairs are made.

At present, I&M programs have air quality improvement as their primary objective. Greenhouse gas emissions reductions are a collateral benefit.

For purposes of this Backgrounder, it is assumed that:

- advanced on-board diagnostics systems are in virtually all light duty vehicles by 2010;
- I&M programs for all classes of light and heavy duty road vehicles are in full operation in each of the 13 CMAs covered by this study by 2010;

²³ *Reducing Greenhouse Gas Emissions in Canada, Success Stories and their Potential for Broader Replication*, Pembina Institute, Spring 1998

²⁴ *Ibid*, page 36

²⁵ *Ontario's Smog Plan*, Steering Committee Report, January, 1998, page vi

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- CO₂ emissions reduction from I&M programs is in the range of 1% to 3% of fleet emissions in 2010 compared to baseline emissions in that year.²⁶

As discussed above, the emissions reduction potential of vehicle I&M programs has been estimated to be in the order of 1% - 3%. Exhibit 4.9 quantifies the impacts of vehicle I&M programs on urban transportation CO₂ emissions for the lower and upper range. For the purpose of this study, it has been assumed that the reductions from vehicle I&M would encompass all urban transportation modes including urban transit and also road freight modes.

Exhibit 4.9: Impacts of Vehicle I&M Programs

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-			
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenarios									
Impacts assuming 1% reduction in fleet emissions	45,125	12,758	57,883	-1%	-1%	-1%	14%	52%	21%
Impacts assuming 3% reduction in fleet emissions	44,213	12,501	56,714	-3%	-3%	-3%	12%	49%	18%

4.1.5 Vehicle Charges and Taxes

There are a number of different vehicle related fees and taxes that can be used to influence road fleet fuel consumption. They are market-based instruments that can be used as alternative or complementary measures to gasoline taxes, fuel economy standards or feebates.

Annual Vehicle Registration Fees

Annual vehicle registration fees, tied to fuel economy rating or other reference energy factor, can be considered as an alternative to the one-time "gas guzzler" tax applied at time of purchase.

The advantage of the annual registration fee is that it provides a more continual market signal to the consumer throughout the life of the vehicle. The disadvantage is that it does not present the vehicle purchaser with the full financial impact of the "gas guzzler" tax at time of purchase. The annual registration fee does not provide the direct incentive of the feebate by providing rebates to the better fuel economy rated vehicles.

Annual registration fees tied to fuel economy and/or emissions, also referred to in the literature as road taxes, are used in Quebec and are also widely used in Europe. In Europe they vary by country and are based on vehicle weight, engine power, and fuel type (gasoline or diesel), either individually or in combinations²⁷. Combined with higher fuel prices, these road taxes can reasonably be credited with contributing to smaller average vehicle size and a more fuel-efficient fleet than in North America. France and Denmark levy taxes of 18% and 50% respectively on vehicle insurance premiums.

As with CAFE/CAFC, and feebates, vehicle registration fees could be expected to affect vehicle use and fleet mix, if used in Canada only.

²⁶ *Reducing Greenhouse Gas Emissions from the Ontario Automotive Sector*, The Osborne Group, DesRosiers Automotive Consultants Inc, Pilorosso Research & Consulting Inc, for the Transportation and Climate Change Collaborative, November 1995, page 48.

²⁷ Michaelis, OECD page 23

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For the purpose of this study, we have assumed that annual vehicle registration fees would be set so as to provide the equivalent emissions reduction impact of feebates. The feebates discussed in Section 4.1.3 ranged from \$CAN 350 /litre/100km to \$CAN 2800 /litre/100km. These feebates would be assessed on a one time basis at the time of sale of vehicles.

Because feebates would likely be revenue neutral; that is, some people would pay for being over the limit and some people would benefit for being under the limit, it is difficult to express feebates as a single average value. However, in order to provide a rough approximation of the equivalent annual value of the feebates (which could be administered as registration fees), the initial value was simply amortized over the average life of a vehicle (12 years). The annual values (calculated using an interest rate of 8%) are shown in Exhibit 4.10 below.

As shown on Exhibit 4.10, the average equivalent annual values for the feebates assumed previously range from \$CAN 46/yr/litre/100 km to roughly \$CAN. 372/yr/litre/100 km. These values can be interpreted as the annual amount a person would have to pay (or would receive) if they purchased a vehicle that had a fuel economy of 1 litre/100 km more or less than the average. For the lower end feebate rates, the annual fee would simply be a token amount. However, in the upper range of the feebate values, the annual equivalent values should have a very measurable impact.

Exhibit 4.10: Annual Registration Fees Required to Provide Equivalent CO₂ Reductions to Feebates

Scenario	% Improvement in New Car Fuel Economy	Amount of Feebate at Time of Purchase (for a 1 litre/100km deviation from the average)	Equivalent Annual Value (\$CAN)
\$CAN 350/litre/100km	10%	\$350	\$46
\$CAN 700/litre/100km	14%	\$700	\$93
\$CAN 1400/litre/100km	20%	\$1,400	\$186
\$CAN 2800/litre/100km	28%	\$2,800	\$372

4.1.5.1 Vkt Charge

An alternative to the gasoline tax instrument is a vkt charge based on odometer readings collected annually during vehicle registration, or automatically at the gas pump. It can impact the amount of vehicle use but provides no incentive for purchase and use of more fuel-efficient vehicles, or for manufacturers to offer more fuel efficient vehicles for sale. There are no known applications of vkt charges in any OECD country.

4.1.5.2 Distance Based Insurance

Insurance is the second largest motor vehicle operating expense. For a typical vehicle, fuel & oil costs represent about 16% of total annual costs of vehicle ownership and operation compared with 18% for insurance. However, insurance is usually perceived by the consumer as a fixed expense with respect to annual distance travelled. Insurance costs are not seen as a reason to drive less. However, the more a

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vehicle is driven, the higher are the risks of accidents and insurance claims. Conversely, lower mileage vehicles are subsidizing the insurance costs of those who drive longer distances.²⁸

If insurance premiums were tied to distance travelled, they could have a similar impact on vkt as an equivalent increase in fuel price through taxation, or could be used to complement a long term fuel tax strategy.

Distance pricing of vehicle insurance can have an impact equivalent to fuel taxes (similar elasticities), and would be cost-effective and more equitable than current annual insurance premiums.

Litman argues that the current insurance price structure of insurance is unfair and inefficient. It is "unfair in terms of horizontal equity because owners of vehicles driven less than average pay more per mile and therefore subsidize higher mileage vehicles. It is unfair to women, who as a class drive less than men and have fewer accidents... It also tends to be unfair in terms of vertical equity because low-income households drive much less than higher income households."²⁹

Co-operation of the insurance industry would be essential for this method of collecting premiums. It is likely that distance based insurance would have to be legislated, since no one company would take the business risk of unilateral action. It could be feasible if the industry saw merit in relating insurance premiums directly to actual vkt.

A practical implementation issue for such a scheme would be the need for an annual odometer audit.

For this Backgrounder, we have estimated the total additional charges that would be required to produce the equivalent CO₂ emissions reduction as a "Canada only" gasoline tax. It could be expected that Distance Based Insurance program would have somewhat different implications than the Canada only gasoline tax:

- consumers would receive an itemization of part of the variable costs of driving at the time of insurance premium payment;
- inclusion of insurance charges could possibly reduce the vkt tax component of charges required to achieve the equivalent CO₂ emissions reductions of a gasoline tax.

Distance Based Insurance has been researched but has not been implemented in any jurisdiction.

Distance Based Insurance "has been opposed by the automobile insurance industry because it reduces their marketing opportunities and potential profits. It has been proposed a few times, but has never received broad debate as a travel demand management strategy. Surveys and focus groups indicate that it is among the travel demand pricing options most acceptable by consumers, although high mileage drivers tended to raise minor objections"³⁰

²⁸ *Distance Based Vehicle Insurance as a TDM Strategy*, Todd Litman, Victoria Transport Policy Institute, published in *Transportation Quarterly*, Vol. 51, Summer 1997, pp 119 - 138

²⁹ *Ibid*

³⁰ *Ibid*. Cites *Transportation Demand Management; A Quantitative Analysis of Public Views*, BCTFA and Greater Vancouver Regional District (Burnaby), 1996

4.1.6 Parking Policies

There are three basic types of parking policy options that can be considered for reducing single occupancy vehicle use and CO₂ emissions:

- changes in parking pricing through tax measures;
- changes in parking supply through regulation, tax measures; or
- a combination of both of the above.

4.1.6.1 Parking Pricing Policy

Parking which is free or low in cost to the driver, for work related and personal trips, is a strong incentive for single occupancy vehicle use. A recent survey in the United States determined that 99 percent of all automobile trips had a free parking spot waiting at the destination and that 95 percent of all commuters had free parking at their place of employment.³¹

A study in Los Angeles³² showed that the average parking cost to the employer was \$3.87 a day. In comparison, the average operating cost for a 36 mile commuting round trip was \$2.35. Hence the cost borne by the employer to provide parking represented 62 percent of the total commuting cost. This suggests that, for work related trips, parking pricing could be similar in effectiveness to gasoline tax increases. While the specific costs in Canadian cities differ from those in the Los Angeles example, it is clear that free parking is a strong factor in road vehicle use, and a disincentive for public transit use.

The effectiveness of shifting responsibility for parking costs from employer to employee is illustrated in the results of five studies of parking – four for different parts of the greater Los Angeles region and one for Ottawa.³³ On average, these studies showed a reduction of 40 percent in SOV use when the costs of parking are shifted from employer to employee. In addition average vehicle occupancy increased from 1.43 to 1.96. In the specific case of Ottawa SOV use declined by 20 percent and average vehicle occupancy improved from 2.56 to 3.13.

One way that some employers have found to shift the burden of parking costs to employees is to provide a transportation allowance (say \$70 per month) to all employees. Employees who chose to drive vehicles and use company-supplied parking pay \$70 per month for the privilege. Others are free to use other means of getting to work and keep part or all of the monthly transportation allowance. Under current rules, such transportation allowances would be treated as taxable benefits in Canada. When the Canadian government imposed a \$23 monthly charge for federal government employees parking in Ottawa, demand dropped 18%. In Los Angeles, employees of Commuter Computer reduced their use of company supplied parking by 38% with a \$58 US monthly charge³⁴.

For this Backgrounder, elasticity of parking pricing to vkt is assumed to be - 0.15 for urban regions and - 1.0 for the downtown core of the largest cities, including Vancouver, Toronto and Montreal. The elasticity

³¹ Shoup, Donald, *An Opportunity to Reduce Minimum Parking Requirements*, APA Journal, Winter 1995, page 14

³² Ibid, page 15

³³ Regional Transportation Authority of Chicago, *An Assessment of Travel Pricing Strategies*, September 1994, page 14

³⁴ Urban Ecologist, Winter, 1993

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assumption for urban regions is the average derived from the Los Angeles and Ottawa studies.³⁵ The perfect elasticity of -1.0 for large city cores is derived from a University of Toronto study³⁶. This higher elasticity reflects the difference in auto use modal split (31 percent downtown vs 62 percent for the GTA), and the availability of better transit in the core.

It is also assumed that:

- a parking pricing policy is mandated by provincial legislation since it would have to be applied over entire urban regions to minimize inequity and market distortions;
- parking pricing policies are applied to all public and commercial parking in the 13 CMAs in Canada;
- parking prices increase 5 percent annually relative to the baseline from 2000 to 2010;
- tax revenues are collected by municipalities and dedicated to other measures that increase the supply and use of more sustainable transportation alternatives.

The impacts of parking pricing were assessed separately for trips to urban areas and for trips to the three largest downtown areas using the elasticities outlined above. Based on data from the Toronto Transportation Tomorrow Survey, it can be concluded that about 5% of all daily auto trips have destinations in the downtown Toronto Area and would be highly elastic to parking prices. For the purpose of this study, this ratio of 5% was applied to Montreal and Vancouver as well.

The net impacts of a 5% annual increase in urban parking prices are estimated to be in the order of a 10% reduction in CO₂ from the baseline scenario (passenger transport only). Based on these results, it would appear that parking pricing may have a significant potential as means for reducing urban GHG emissions.

Exhibit 4.11: Impacts of Parking Policies

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-			
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenario									
Impacts of 5% annual parking price increase	40,974	12,887	53,862	-10%	0%	-8%	3%	54%	12%

4.1.6.2 Parking Supply Policy

Parking supply policy relates to the ability of local governments to control the total number of parking spaces that are available in a given area, thereby influencing the number of vehicles that will be attracted to the area. In addition, local governments can control the availability of specialized parking such as park and ride lots or dedicated HOV spaces.

³⁵ Apogee Research, *Policy Instruments Working Paper on Reducing CO₂ Emissions from the Transport Sector in Ontario*, for Ontario Transportation and Climate Change Collaborative, 1995, page 74

³⁶ Eric Miller, *Modelling Central Area Work Trip Modal Choice and Parking Demand*, prepared for City of Toronto Planning & Development Department, June 1992, page 51

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There are many different parking supply measures that can be implemented to reduce the number of vehicles travelling in an area:

- preferential parking for high occupancy vehicles;
- peripheral parking with shuttles;
- on-street controls;
- reduced minimum parking requirements for new development;
- parking maximums; and
- area-wide parking caps.

These measures can influence mode shifting by:

- reducing the number of parking spaces available;
- reducing the time allowed for parking at designated places; and
- improving the availability and attractiveness of commuting by alternative means.

The Urban Council of the Transportation Association of Canada has called for one of the decision making principles in its New Vision of Urban Transportation to be:

“Plan parking supply and price to be in balance with walking cycling, transit and auto priorities.”³⁷

Commercial off-street parking is usually on sites pending redevelopment. Municipalities regulate parking supply for new development, usually by establishing minimum supply standards. They also regulate commercial off-street parking on redevelopment sites that:

- creates oversupply in the downtown core;
- destroys the regulated balance between supply and demand; and
- results in downward pressure on all-day prices and therefore encourages single occupancy vehicle (SOV) commuting.

Some U.S. cities, including Cleveland and Minneapolis/St. Paul, have moved to address this issue by:

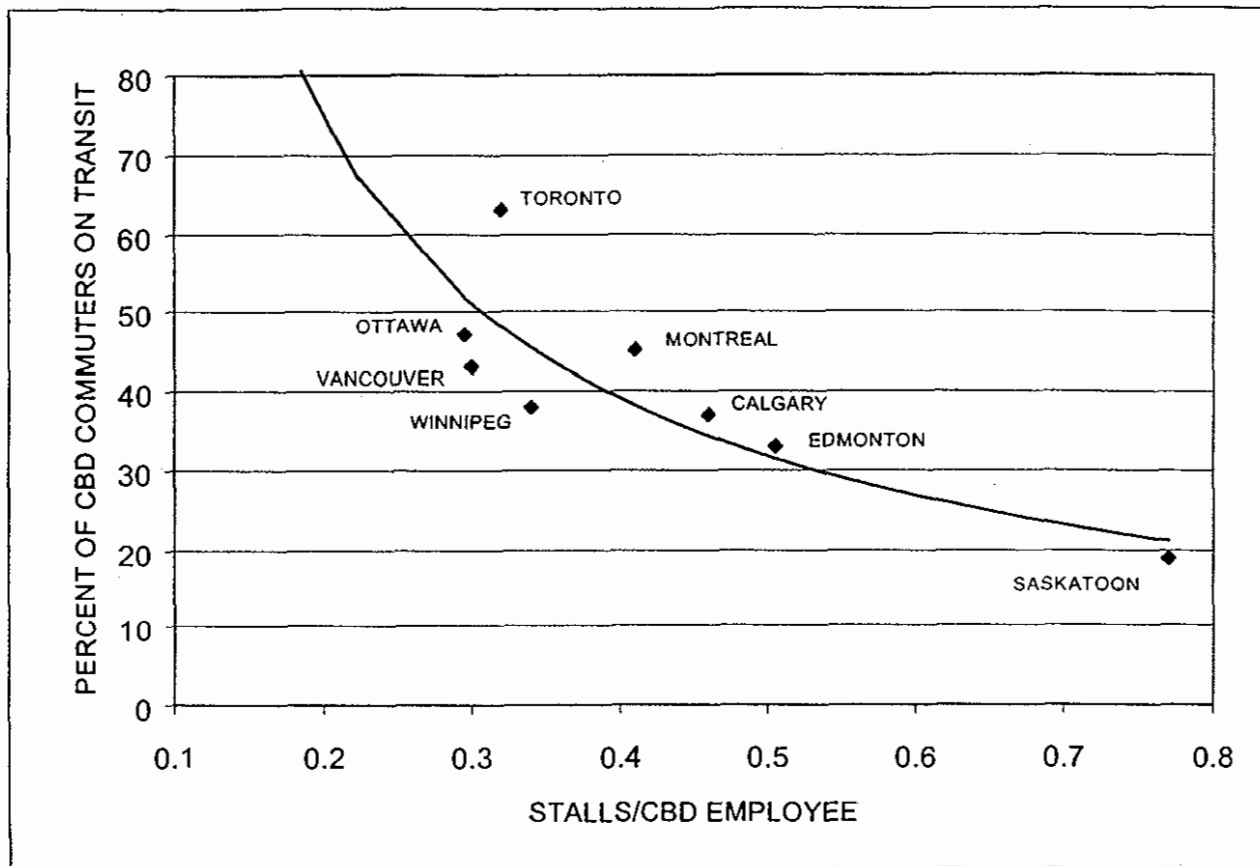
- permitting off-street surface parking on redevelopment sites where a parking deficiency exists;
- not renewing temporary off-street surface parking when a supply deficiency disappears;
- taxing the site at highest and best use if the site remains undeveloped after 2 years.

A City of Calgary study demonstrates that there is a direct correlation between the amount of downtown parking available and public transit ridership³⁸. Exhibit 4.12 shows the relationship between the percentage of commuters that use transit and the parking spaces per central business district (CBD) employee.

³⁷ *Financing Urban Transportation*, Transportation Association of Canada, February 1997, page 2.

³⁸ Calgary GOPlan, *Calgary Downtown Parking and Transit Study Summary Report*, March, 1994, page 5

Exhibit 4.12: Downtown Modal Split vs Parking Spaces per CBD Employee



Source: Re-created from Calgary Downtown Parking and Transit Study – Summary Report Calgary Go-Plan, December 1994, page 5, figure 3

Elasticity of parking supply to vkt has not been widely studied. Based on a parking study of Boston, it has been established that the elasticity of vkt to parking supply could be about -0.16 . As with parking supply, trips to downtown areas would likely be more elastic given the availability of alternative modes. Due to the high uncertainty of the elasticities of parking supply, for purposes of this Backgrounder, we simply assume that the impacts of parking supply reductions would be similar to equivalent increases in parking price.

4.1.7 Road Pricing

Road pricing is used in many countries as a means of generating revenues to pay for the capital, operations and maintenance of road infrastructure including bridges, tunnels and restricted access highways. Only recently, congestion pricing is also being used more frequently to influence demand in peak and off-peak periods.

Road pricing can also be used as a means of making users pay for the full societal cost of road use including “external” costs not currently reflected in market (monetary) terms, or as a means of contributing to specific vkt and CO₂ emissions reduction targets.

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Historically, road tolls have been collected manually at toll-booths. The latter have been sources of congestion and increased air pollution from vehicles idling in line-ups at road facility entry and exit points. Technological advances now make it possible to use automated means for determining toll charges and for revenue collection. Highway 407 in the GTA and the new Highway 104 in Nova Scotia are recent examples. As technology advances it will become increasingly feasible and cost effective to use road pricing on a wider basis.

In the first Kyoto period to 2010, it is assumed that it would be technically feasible to introduce automated road or congestion pricing on all limited access roads, as well as major tunnels and bridges in the 13 CMAs.

Road pricing also has the potential of being a revenue source for dedicated funding of sustainable transport alternatives such as public transit and other Transportation Demand Management options (as will be discussed later), in the urban region where they are collected.

There are two primary categories of road pricing programs:

- continuous facility pricing, with kilometre-based fees charged depending on vehicle class, for use of the facility at particular times of day. Variations can include peak-period pricing for all or selected routes in a system, or for all or selected lanes on a given highway;
- area-wide pricing, with fees charged for entry to a congested area, such as a downtown business district, during peak hours. It could be used to promote mode shifting away from SOV use in the designated area.

An area-wide implementation strategy using a downtown as a cordoned zone may have few environmental benefits at a regional level. Such a strategy could work in conflict with a strategy of more compact urban form by stimulating economic activity outside the congested core. If the size of the core is large, many trips will be unaffected by the charge.

Area-wide road pricing might have merit in certain CMAs, such as the Montreal Urban Community because of the unique constraints of bridge access to the Island of Montreal. It would not appear appropriate for a region such as the GTA, which is laid out on a grid with many access corridors for any part of the region, including the downtown core.

The major problem with continuous facility pricing is the potential for drivers to seek parallel, un-tolled routes such as arterials or local streets.

For purposes of this Backgrounder, vkt and CO₂ emissions reduction estimates have been made based on the following assumptions:

- congestion pricing is applied on all limited access highways in the 13 CMAs; and
- congestion pricing is in place on all routes by 2010, with implementation taking place throughout the intervening period.

Vkt and emissions reduction estimates have been made for two simple pricing scenarios - \$0.10 / km and \$0.20 / km in the peak hours with a 50 percent reduction in the off-peak hours. As with fuel taxes, an elasticity of -2 has been used to estimate the impacts of road tolls on vkt. The results of the two scenarios

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are presented below in Exhibit 4.12. These results should be considered broad estimates given the assumptions about the amount of vehicle-km on limited access highways in urban areas.

Exhibit 4.13: Impacts of Road Tolls

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-			
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenarios									
\$0.10 peak/\$0.05 off-peak	44,317	12,694	57,010	-3%	-1%	-2%	12%	51%	19%
\$0.20 peak/\$0.10 off-peak	43,052	12,501	55,553	-6%	-3%	-5%	9%	49%	16%

4.1.8 Alternative Fuels

Alternative fuels have the potential to reduce greenhouse gas emissions from transportation. Currently, compressed natural gas (CNG) and liquid propane gas (LPG) are relatively widely available in the Canadian market. The technologies for these gaseous fuels are maturing, vehicle manufacturers offer factory warranted alternative fuel vehicles, and significant investments in refuelling facilities have been made by fuel marketers. These lower carbon fuels can provide modest reductions of GHG emissions relative to gasoline. In recent years, ethanol as an additive to gasoline has entered the Canadian market. To date, this ethanol has been derived from corn. Research indicates that there may be greater potential for GHG emissions reductions with ethanol derived from cellulose.

Despite substantial continuing commitments of both the private and public sectors to the alternative fuel vehicle industry, however, market penetration has been limited, currently representing about 1 % of total light duty vehicle fuel consumption. There are at present no major market conditions or pending government policy interventions that are likely to materially change market penetration of these fuels in the short term. However, market penetration is the key to unlocking their emissions reduction potential.

A major barrier to market penetration is the low price of gasoline. If a gasoline tax policy is adopted as part of Canada's climate change strategy for transportation, and if additional taxes are not imposed on the alternative fuels, then market penetration of the latter could be expected to rise, with benefits in CO₂ emissions reductions in the timeframe of the Kyoto Protocol.

4.1.9 Summary of Impacts of Options to Reduce CO₂ Emissions From Road Vehicles

Exhibit 4.14 provides a summary of the estimated CO₂ emissions reduction impacts of the seven policy measures discussed above. The impacts are shown for the case where each of the measures would be implemented individually. The impacts of implementing the measures in integrated packages is the focus of Chapter 5.

On the basis of individual impacts, it would appear that fuel taxes, particularly when implemented on a North America wide basis, would have significant potential for reducing emissions. An added benefit is that fuel taxes would generate significant revenues, as discussed in Section 4.1.1.

Feebates also show good potential for reducing emissions, although there is a significant level of uncertainty in the literature surrounding the potential impacts.

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Exhibit 4.14: Summary of Estimated CO₂ Emissions reduction Impacts of Policy Options

(Top 13 CMAs in Canada)

Baseline Emissions (1990)	Passenger 39,589	Freight 8,390	Total 47,979
Business-as-Usual Emissions (2010)	45,581	12,887	58,468
% Change From 1990	15%	54%	22%

Policy	Reduction in 2010 (MT)	% Change from 2010 Business-as-Usual	% Change from 1990 Level
GASOLINE TAX ⁽²⁾			
Scenario 1A - Gasoline Tax (\$0.03/L annually - Canada Only)	-5.3	-9%	11%
Scenario 2A - Gasoline Tax (\$0.054/L - annually Canada Only) ⁽¹⁾	-9.4	-16%	2%
Scenario 1B - Gasoline Tax (\$0.03/L annually - North America Wide)	-8.0	-14%	5%
Scenario 2B - Gasoline Tax (\$0.036/L annually - North America Wide) ⁽¹⁾	-9.5	-16%	2%
DIESEL TAX			
Diesel Tax (\$0.03/L annually - North America Wide)	-1.0	-2%	20%
CAFE AND CAFC			
Canada Only - 1% annual improvement taking effect in 2005 (new veh only)	-0.7	-1.2%	20%
North America wide 2% annual improvement taking effect in 2005 (new vehicles only)	-1.2	-2.1%	19%
FEEBATES ⁽²⁾			
<i>Feebates Implemented in Canada Only</i>			
\$CAN 350/litre/100km	-0.7	-1%	20%
\$CAN 700/litre/100km	-1.1	-2%	20%
\$CAN 1400/litre/100km	-2.2	-4%	17%
\$CAN 2800/litre/100km	-4.0	-7%	14%
<i>Feebates Implemented North America-Wide</i>			
\$CAN 350/litre/100km	-2.2	-4%	17%
\$CAN 700/litre/100km	-3.1	-5%	15%
\$CAN 1400/litre/100km	-4.4	-8%	13%
\$CAN 2800/litre/100km	-6.2	-11%	9%
VEHICLE MAINTENANCE AND INSPECTION PROGRAMS			
Impacts assuming 1% reduction in fleet emissions	-0.6	-1%	21%
Impacts assuming 3% reduction in fleet emissions	-1.8	-3%	18%
PARKING PRICING			
Impacts of 5% annual parking price increase	-4.6	-8%	12%
ROAD PRICING			
\$0.10 peak/\$0.05 off-peak	-1.5	-2%	19%
\$0.20 peak/\$0.10 off-peak	-2.9	-5%	16%

Notes: ⁽¹⁾ These are the price increases that would be required to achieve a 6% reduction in CO₂ from 1990 levels by 2010 for gasoline vehicles only.

⁽²⁾ Estimated emission reductions from Distance Based Insurance and Vehicle Registration fees are assumed to be similar to those of Gasoline Taxes and Feebates respectively.

4.2 EXPANDING MODAL CHOICE

A practical CO₂ emissions reduction strategy must also expand the availability of attractive alternatives to road vehicles, if consumers and businesses are to be motivated by the above policies to constrain their use of high emitting vehicles. Policy options aimed at encouraging expanded choice for people to access personal and commercial activities are discussed in the remainder of this section under the headings of Enhancing Transit, Land Use/Urban Design, and Other Transportation Demand Management Policy Options.

Quantitative estimates of CO₂ emissions reductions from the latter categories of policy options have not been attempted in this report for two primary reasons:

- Each of the three categories comprises a large number of measures for which individual estimates would be impractical.
- It was the judgement of the consulting team that demand management, transit and land use policies can only be effective in the effort to meet the very challenging Kyoto target, if applied in support of the more direct policies for reducing road vehicle use. The issue of synergy among policy options is discussed more extensively in the next section.

4.2.1 Enhanced Transit

Many studies in recent years have recommended a wide range of measures for reversing the continuing decline in the modal share of public transit relative to personal road vehicle use. When operated close to design capacity, public transit systems, both bus and rail, show major energy efficiency advantages and lower emissions of air pollutants including CO₂ emissions. However, transit systems operated at low load factors produce greater emissions per passenger kilometre than road vehicles³⁹.

Mode shifting from personal road vehicles to public transit will only result in CO₂ emissions reductions where population densities support strong transit systems. At currently reported load factors for public transit in Canada, Transport Canada has estimated that a doubling of transit ridership would result from diversion of 12.5 billion passenger-km from personal vehicles, reduce fuel use by 1.74 percent and greenhouse gas emissions by 1.55 Mt⁴⁰. These figures should be used as broad indicators only since the reporting of passenger-km of transit usage in Canada does not separate bus and rail transit figures. In the case of the largest transit property in Canada, the Toronto Transit Commission does not report passenger-kilometre data.

From data collected by the Canadian Urban Transit Association⁴¹, the average number of persons per transit vehicle in Canadian cities is about 17. Assuming average occupancy of cars to be 1.5 persons, and average light duty fuel economy rating of about 10 litres/ 100 km, the literature suggests that emissions per passenger-kilometre for transit would be somewhat lower than that of personal vehicles⁴². This is a very crude estimate of the relative emissions of transit and cars. There is a need for a much more complete comparative analysis of actual per passenger-kilometre emissions of these modes in Canadian cities.

³⁹ *Sustainable Transportation Monitor, No. 1, March, 1998*, Centre for Sustainable Transportation, page 6.

⁴⁰ *Canada's Commitment on Greenhouse Gas Emissions under the Kyoto Protocol and the Potential for Reductions in Transport*, John Lawson, Transport Canada, paper for Canadian Transport Research Forum, 1998, page 9

⁴¹ *Transit Fact Book, 1996*, Canadian Urban Transit Association

⁴² *Transportation Quantification and Indicators in the Cities for Climate Protection Campaign*, Ralph Torrie for ICLEI, presentation to Moving the Economy conference, Toronto, July 11, 1998

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The potential for increasing overall average load factors in Canadian transit, is unknown. A key factor in achieving such gains would be long term shifts toward more compact urban development in all cities, including the municipalities outside of the core cities in the Vancouver, Toronto and Montreal urban regions.

By comparison, in the U.S. cars now use less energy per passenger kilometre than urban buses⁴³. This is explained partly because fuel efficiency of cars has advanced more rapidly than for buses since the 1970's. However, the major cause in this historic reversal is the decline in average occupancy of transit buses in the U.S.

It is possible that through a combination of policy measures and technology advances that fuel efficiencies of passenger vehicles on the road could double over the next twenty years. Comparable improvement in fuel consumption per passenger-kilometre in transit will be required if transit is to maintain its energy efficiency competitiveness. Improvements in buses can come from both technology advances and from increasing load factors. The former can be encouraged through regulation and standards, the latter through transit service innovations and investments and policies that are disincentives for personal vehicle use.

Increasing the mode share of public transit will require two fundamental changes in policy direction by governments:

- policies that directly reduce Single Occupancy Vehicle (SOV) demand; and
- policies that increase the availability and attractiveness of public transit as alternatives to road vehicle use.

One recent report, *Trans-Action '98*⁴⁴, summarizes the priority measures that transportation professionals consider to be the "most achievable, politically acceptable and have the highest potential to bring about modal shift to transit". All of the proposed actions, if implemented, could be contributing to CO₂ emissions reductions in the 2010 time period.

The *Trans-Action '98* report is the outcome of a Transit Summit held in Toronto in December of 1997, as well as a review of the extensive recent national literature on the subject. Seven of the top ten recommendations in this Action Plan, presented in summary form as Exhibit 4.15, are not specific to the GTA. They could facilitate mode shift to transit in any Canadian CMA. The remaining three recommendations could be readily adapted to the institutional arrangements existing in other cities and city-regions. In some jurisdictions such as B.C. and Quebec, certain of the recommendation are already being implemented. But there is no jurisdiction in Canada where the majority of these proposals has been adopted.

⁴³ *National Transportation Statistics*, U.S. Bureau of Transportation Statistics, 1997

⁴⁴ *Trans-Action 98*, Pollution Probe, Canadian Urban Transit Association, Toronto Transit Commission, May 1998

Exhibit 4.15

**Summary List of Actions from
Trans-Action '98 – An Action Plan for a
Modal Shift to Transit in the Greater Toronto Area⁴⁵**

Federal Government Action

- 1** *Tax Treatment of Transit Passes – make employer-provided transit passes a non-taxable employee benefit to encourage increased use of transit as an option for getting to work (in Canada currently only 10 percent of employees use transit to get to work, whereas 80 percent use a car, truck, or van.*

Joint Federal/Provincial/Municipal Government Action

- 2** *Overall Taxation and Subsidy Strategies for Transit and Transportation Funding and Modal Choice Incentives – Develop an overall taxation and user-pay strategy, and evaluate and re-align subsidy programs, to support and encourage transit.*

Provincial Government Action

- 3** *Greater Toronto Services Board (GTSB) – Establish the GTSB with the mandate and authority to administer cross-boundary transit service integration, overall Greater Toronto Area transit planning, GTA-wide fare policies and municipal funding levels, including GO Transit. An overall Modal Shift Action Plan should also be prepared on a GTA-wide basis, and the GTSB can play an instrumental role in developing this plan. (Ed. Note. Moves in this direction have already been made in B.C. with respect to the GVRD and in Quebec with the new Metropolitan Transportation Agency for the Montreal region.)*
- 4** *Access to Alternative Funding Sources – Amend the Municipal Act to allow municipalities to use alternatives to property tax to fund transit, such as fuel taxes, road pricing revenues (tolls), vehicle registrations or sales tax, etc. (Ed. Note: Action in this area is being taken by the Government of British Columbia)*

Provincial and Municipal Government Actions

- 5** *Transit Supportive Land Use Planning Guidelines as Policy – The Provincial Government should amend the planning process to provide means of ensuring that municipal and regional plans are consistent with transit-supportive planning principles. Municipalities should incorporate specific measures included in the Ontario Ministry of Transportation (MTO)/ Ontario Ministry of Municipal Affairs and Housing (MMAH) Transit Supportive Land use Guidelines into Official Plans and municipal policies on land use planning and development.*

⁴⁵ *TransAction 98 - An Action Plan for Modal Shift to Transit in the Greater Toronto Area*, Dave Roberts for Pollution Probe, 1998. This report is the outcome of a Transit Summit in December 1997 co-sponsored by the Canadian Urban Transit Association, Pollution Probe and the Toronto transit Commission.

Exhibit 4.15 (Cont.)

Municipal Government Actions

- 6 ***Transportation Demand Management Plans and Strategies*** – Each municipality should develop and adopt an overall Transportation Demand Management plan and specific strategies to meet the demand management objectives. These should include specific targets and timetables for modal shifts as well as strategies and actions to achieve targets, especially in the areas of transit improvements, managing the supply and pricing of parking and better managing the supply of road capacity.

Transit System Actions

- 7 ***Modal Shift Action Plans*** – Each transit system should adopt its own Action Plan (e.g. percent modal shift targets over a certain time frame) for a modal shift to transit and make it the basis for transit service plans and annual transit budgets. An overall Modal Shift Action Plan should be prepared on a GTA-wide basis, and transit systems can play an instrumental role in developing this plan.

Corporate Actions

- 8 ***Employee Transit Programs*** – Implement employer-based education, transit co-ordination and transit programs for employees. (The authors of Trans-Action 98 acknowledge the such actions can be incorporated into broader employee transportation plans that address other measures such as cycling, walking, van pooling and ridesharing.)

Advocacy Organization Actions

- 9 ***Public Education Programs*** – Advocacy organizations should take the lead in an ongoing effort to better educate the public on the costs and dangers of increased private vehicle use and the benefits of a modal shift to transit, including getting this type of material into school curricula. (Ed. Note: The Centre for Sustainable Transportation has adopted similar recommendations made by the NRTEE and has begun developing programs targeted at primary, secondary and post secondary levels.)

Actions for Pollution Probe and/or CUTA

- 10 ***Building Support and Getting Commitment*** – Make presentations on the Transit Action Plan and build broad based coalitions to develop stakeholder support for specific actions noted in this Action Plan

4.2.2 Land Use/Urban Design

“Cities were invented to facilitate exchange of information, friendship, material goods, culture, knowledge, insight, skills, and also the exchange of emotional, psychological, and spiritual support....That is why we build cities. Cities are concentrations of people, and structures that enable mutual exchange to take place while minimising the travel needed....But even though the city’s basic function is to maximise access to exchange opportunities while minimising the need to travel, a certain amount of travel or movement is still necessary within the city to facilitate mutual exchange. Hence the need for transport systems as a means to an end, to facilitate exchange.”⁴⁶

Many observers have suggested that the current phenomenon of urban sprawl had its origins in the Industrial Revolution when cities became crowded, filthy and disease ridden and focussed on industrial output. The concept of suburban Garden Cities was born in the Victorian age as a means for the wealthy to escape the then despised city. The concept has been very widely embraced in the twentieth century, particularly in North America, with the growing wealth of the middle class and mobility provided by the automobile. Societies moved away from the sometimes chaotic compact, mixed use form of urban development to the current model of separation of the activities of life, with the vast majority of face-to-face connections being made through automobile travel.

The mobility provided by road transportation has become so pervasive that the lines are blurred for many between its role as a means for human exchange or as an end in itself.

There is now evidence that reurbanisation is going on in many parts of the world, as polluting industries have been cleaned up or moved away from heavily built up areas. In many respects cities, at least in the developed world, are being revitalized as places of human exchange. But the problem of transportation remains.

Research on urban regions around the world shows that “car use does not necessarily increase with increasing wealth but tends to fall in the most wealthy cities. Where wealth is accompanied by land use and transport policies which do not facilitate car travel, car use will be lower.”⁴⁷

Urban population density has been shown to relate strongly to road vehicle use. The data from worldwide research confirms that cities with densities below 30 persons/ha have a high dependence on the automobile for most urban travel.⁴⁸ Population densities in Canadian cities average 25 to 30 persons/ha, higher than in U.S. cities, but lower than in European cities. The City of Toronto has a population density of 41 persons/ha, comparable to European cities. Its transit system recovers 80 percent of operating expenses from the fare box. Population density in the urbanised areas of the other municipalities in the GTA averages 26 persons/ha. and the modal shares of transit are dramatically lower. Transit systems in these suburban communities are more heavily subsidized than the Toronto Transit Commission.

It can be concluded that in higher density cities above 30 persons/ha, transit:

- can achieve higher mode share relative to personal vehicles;

⁴⁶ *Reclaiming our Cities and Towns*, David Engwicht, New Society Publishers, Philadelphia, PA, Gabriola Island, BC, page 17

⁴⁷ *Indicators of Transport Efficiency in 37 Global Cities*, Kenworthy et al, Murdoch University, Australia, for the World Bank, February, 1997, page 5.

⁴⁸ *Ibid*, page 12

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- is more cost-effective and requires less subsidy per passenger-kilometre;
- can generate lower CO₂ emissions;

than are achievable in lower density cities.

It has also been shown that auto-dependent urban sprawl is expensive in terms of the capital and maintenance costs of public infrastructure such as water mains, sewers, and other utilities, as well as roads. For example, it has been estimated that \$1 billion annually could be saved by constraining urban sprawl in the Greater Toronto Area, reducing the financial burden on municipalities and increasing the region's competitiveness⁴⁹.

The Transportation Association of Canada and others, have pointed out that current limits on governments' ability to fund investments in expanded infrastructure including transportation, provide governments with the motivation to consider more cost-effective urban settlement patterns. Governments are beginning to use least-cost evaluation techniques which examine transportation modal alternatives and incorporate the external costs of congestion, accidents, health and environmental impacts in making transportation investment decisions.

A wide range of measures have been proposed for intensification of settlement patterns in Canada's urban regions. In addition to reducing CO₂ emissions by reducing the need for motorised travel, these measures can be expected to bring many other social, economic and environmental benefits.

Some of the land use policy options that can make transportation more sustainable over the long term include:

- provincial policy guidelines to ensure that municipalities develop and implement transit supportive and TDM supportive land use and transportation policies in Official Plans. Key policies are those that enable more compact, mixed use urban form, residential and commercial intensification, including redevelopment of brownfield (abandoned industrial) sites and development around major transportation hubs;
- restricting vehicle access in urban cores, as is increasingly practised in European cities. Experience has shown that properly designed and implemented, such zones stimulate rather than constrain economic, social and cultural activity;
- improved cycling and pedestrian environment and facilities, including giving cycling and walking priority over personal vehicles;
- encouraging increased use of telework including telecommuting, teleconferencing, distance education. More research is required to identify the extent that such advanced communications techniques can reduce motorised travel. This is an extremely complex subject. One suggestion for study would be the impacts of teleconferencing on the per-employee travel of international consulting firms. Many such firms now routinely use teleconferencing as a mature business tool, and have the administrative capacity and corporate culture to support such research;
- creation of public/private collaborations to investigate new, more efficient options for goods movement within cities, including among others, freight transfer facility locations and new intracity freight consolidation service innovations;

⁴⁹Report of the Greater Toronto Task Force, January 1996, page 111

- building on the proceedings and outcome of the July 1998, International Moving the Economy Conference in Toronto, that showcased success stories and ideas about the economic benefits being achieved around the world in redesigning cities and transportation systems for sustainability. An Economic Action Plan/Agenda is expected to be developed in the coming months that could be used as a model by any city for economic development based on sustainable transportation initiatives. The interdependence of land use/urban design and transportation was strongly reinforced during this important international event.

4.2.3 Other Transportation Demand Management Policy Options

Transportation Demand Management is a term used to categorize a very broad range of policies and actions that can be applied to reduce the use of road vehicles and to encourage shifts to more sustainable modes of transportation. Many of the options discussed above are included as TDM measures in the literature. This section examines a range of other TDM measures that indirectly impact road use by encouraging use of other means of accessing activities. The following are selected examples of such other TDM measures drawn from a number of sources⁵⁰.

Intermodal Transfer Nodes - Passenger

The economic, social and environmental benefits of integrating and facilitating intermodal transfer for both passenger and freight are well known. Research shows that intermodal facilities for passengers can be important focal points for urban revitalization and intensification. There are notable examples in Canada including:

- integration of SeaBus, Skytrain, Vancouver Transit, and commuter rail in downtown Vancouver;
- Union Station in Toronto, currently the centre of intense study for redevelopment for expanded commuter rail and bus (GO Transit), Via Rail, and a downtown bus terminal, integrated with the new Air Canada Centre sports complex, the SkyDome, the expanded Toronto Convention Centre and new retail and tourism development. More than 100,000 people pass through this facility each week day. GO Transit forecasts a near doubling of passenger volumes through Union Station by the year 2021. To handle this traffic, extensive improvements to the facility, estimated to cost in the range of \$100M, will be required for GO Transit alone⁵¹;
- Place Bonaventure in Montreal which integrates hotel and retail facilities with Via Rail, commuter rail and bus transit services.

Many other smaller passenger transportation nodes in Canadian CMAs provide essential links among municipalities within each urban region and intermodal links within the municipalities.

⁵⁰ *Transportation Demand Management*, McCormick Rankin Corporation, January 1998.

TDM Working Group Report to Ontario's Smog Plan Steering Committee, Unpublished, May 21, 1997

Win-Win Transportation Management Strategies, Todd Litman, Victoria Transport Policy Institute, 1998

Trans-Action 98, Pollution Probe, Canadian Urban Transit Association, Toronto Transit Commission, May 1998

⁵¹ *GO Transit Year 2021 Plan*, February 1998, page 7

Development of transfer nodes is vital to the emergence of sustainable urban transportation in Canada. By making intermodal transfer easier, transfer nodes increase the availability of attractive transportation options for all citizens and encourage use of more energy efficient modes. They also create expanded opportunities for increased cultural, social and commercial exchange.

Senior levels of government have important roles to play in helping cities and business to realize the substantial economic, social and environmental benefits available from continued development of intermodal transfer nodes in Canadian cities. A critical priority for the federal and provincial governments should be to develop new and robust mechanisms for financing the (re)development of transportation transfer node facilities in the context of a broader policy shift towards the financing of sustainable transportation.

4.2.3.1 *Manage Road Supply, including High Occupancy Vehicle (HOV) Lanes, and Sharing of Existing Road Space with Other Users*

The pace and modal/geographic balance of added capacity and related enhancements to the road, transit pedestrian and cycling networks can have an influence on transportation behaviour as well as transportation system performance and emissions. Some options for managing road supply and sharing of road space include:

- stabilize road supply in terms of kilometres or roads and numbers of lanes in a geographic area;
- provide restricted access lanes for high occupancy vehicles, alternative fuelled vehicles, zero emission vehicles or car sharing club vehicles. HOV lanes, reserved bus lanes or busways will be essential for high quality express bus services to serve a growing market between and among municipal centres outside the core city centre of each city-region. Such services are contemplated in the regional planning strategies in each of the GVRD, the GTA (GO Transit) and the Montreal Urban Community Transit Commission. Experience with HOV lanes in Canada has been mixed for several reasons. Compliance with HOV regulations is a known problem. In addition, HOV lanes have tended to be established on individual roads, and not as systems that would allow integration of bus services over a grid of intersecting bus routes for increased convenience to transit riders;
- with respect to freight transport, the trucking and shipping organizations have long advocated increased investment by the federal and provincial governments in upgrading and expanding the National Highway System, including portions within urban areas. In certain corridors, however, it may be cost-effective for both the public and private sectors to consider provision of state-of-the-art intermodal rail/truck services as an alternative to expanded highway capacity. The rail and trucking industries, along with shippers and federal and provincial governments should examine "least-cost" options for intercity freight movement. The first corridor for such study and decision-making should be the Windsor-Quebec corridor, the most heavily travelled freight corridor in the country. While the major CO₂ emissions impacts will relate to the non-urban portion of such movements, intercity trucking is both a major source of CO₂ emissions and a major consideration in urban highway investment as well as in the planning and investment in intermodal facilities within cities. (See *Mode Shifting to Intermodal Freight Movement*, below).

4.2.3.1 Traffic Calming and Street Reclaiming

The sustainable neighbourhood and the sustainable transportation system requires a different view of urban settlement than has been used in the past. " Instead of seeing themselves as "mechanics" planners would see themselves as "doctors". ... In listening to the heartbeat of neighbourhoods, these "doctors"... would be searching to understand what promotes life and what takes it away. They would become preoccupied with entirely different questions (than traditional planners). What makes this neighbourhood tick? Why is there a sense of togetherness in this street and not this one? Why does this park work as a people place and not this one? Why is crime high in this neighbourhood and not this one? Is there a connection between traffic flow and the quality of community life?"⁵²

"Traffic calming involves fundamental rethinking of metropolitan planning and organization, and a renewed emphasis upon quality rather than quantity of life."⁵³

The objective in a new approach to land use planning should be to maximize the opportunities for human exchange at minimum social cost. David Engwicht suggests the following ways to optimize exchange efficiency:⁵⁴

- Bring the destinations to the people;
- Increase density of housing, job opportunities and (commercial and social) exchange opportunities;
- Creatively mix housing, job and exchange opportunities;
- Charge the true costs of exchange opportunities;
- Promote exchange-friendly modes, such as walking, cycling and transit, that facilitate human exchange;
- Convert planned exchanges into home-based or spontaneous exchanges;
- Encourage diversity and expression of diversity;
- Build the "Commons";
- Give people and neighbourhoods greater control over decision making;
- Make those usually considered least, those considered most.

4.2.3.2 Location Efficient Mortgages (LEM)

A test of the LEM concept is scheduled in Chicago in the Fall of 1998. The program is sponsored by the Center for Neighbourhood Technology of Chicago, The Natural Resources Defense Council of California

⁵² *Reclaiming our Cities & Towns*, David Engwicht, New Society Publishers, Philadelphia, PA, Gabriola Island, BC, 1993, page 83

⁵³ *Traffic Calming*, Phil Day, Queensland Planner, vol.29, no. 1, Royal Australian Planning Institute, Brisbane, 1989, page 2

⁵⁴ Engwicht, page 129.

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and the Surface Transportation Policy Project of Washington, D.C. It provides for "stretch" in allowable income-to-expense ratios in mortgage applications for households. Eligibility is based on the number of vehicles owned and distances driven, for homes purchased in designated areas served by public transport. It is targeted at low and middle income families, giving recognition to the cost savings from lower automobile ownership and use.

4.2.3.4 Car Sharing Clubs

Conceptually, Car Sharing is time sharing of automobiles. It is a means of having access to a car when needed without the full burden of ownership, maintenance and insurance. Members pay a small monthly fee and a low hourly and kilometre charge based on vehicle use. Studies of car sharing programs in Europe indicate that members, including those who previously did not own a car, reduce their annual vehicle usage(vkt) by 30 percent after one year of participation.

A recent Canadian survey of prospective car sharing members, suggest that most (50 of 70) currently do not own a car, but drive on average about 6700 km per year in borrowed or rented cars⁵⁵. Assuming that on average cars driven before car sharing, were larger, older higher fuel consuming vehicles than the newer subcompacts of a car sharing fleet, per member reduction of CO₂ emissions from car sharing has been estimated to be about 50 percent⁵⁶.

Car sharing complements conventional car rental. The latter is more economical to the consumer for trips of longer length or duration. In both cases, the consumer is directly confronted with the full variable costs of the distance driven and motivated to reduce vkt.

Switzerland is now served by car sharing clubs in 600 locations throughout the country, serving 20,000 clients with about 1000 cars. Car Sharing clubs/businesses have been established in Quebec City (Auto Com), Montreal (CommunAuto), Vancouver (Co-operative Auto Network (CAN)), and Victoria (Victoria Car Share Co-op). The launch of a new club in Toronto is reported to be imminent.

Some of the ways that governments can support this fledgling industry include:

- They can fund Sustainable Transportation incubators. Car sharing clubs are small entrepreneurial businesses focussed in communities or neighbourhoods. They need financial and management help in the start-up phase. The Quebec government has provided grants for the start-up of car sharing clubs in that province. Environment Canada has provided money for a pilot program in Vancouver. In Toronto, efforts are under way within the community to establish a Sustainable Transportation Incubator.
- Municipal governments can support car sharing by providing car share vehicles with permits to park anywhere that permit parking is in effect. This has been done in Quebec City.
- Car sharing can support public transit use if appropriate incentives are in place. Discounts by transit authorities on monthly transit passes for car sharing members is one possible incentive.

⁵⁵ *Greenhouse Gas Impacts of Car Sharing*, Liz Reynolds, Auto Share, Toronto (personal communication), July 1998

⁵⁶ Ibid

4.2.3.5 *Mode Shifting and Consolidation of Freight Movement*

Measures that can reduce market distortions in freight movements originating or ending in urban centres include property tax exemptions for railway rights-of way, increased capital depreciation for railways, and banking of railway-rights-of-way.

Based on past and expected future trends, diesel fuel consumption in trucking is growing and will grow faster than gasoline consumption. A major, though unknown, percentage of fuel use is for intercity trucking in corridors where intermodal services have the potential to be competitive and to increase the rail modal share.

Intergovernmental co-operation in support of rail/truck intermodal/bi-modal infrastructure planning is essential to the expansion of commercially viable truck/rail services. For the larger cities in Canada, governments and private sector carriers and shippers need to carefully examine, together, how energy and economic efficiency of freight transport, in appropriate corridors, can be improved through expansion of intermodal/bi-modal services.

Cost-effective intermodal transfer of freight is also important to the economic vitality of urban regions and in facilitating CO₂ emissions reduction from intercity freight movement. The maturing of commercially viable intermodal rail/truck technologies such as Iron Highway (CP Rail/St Lawrence and Hudson Railway) and Eco-Rail (CN), present new opportunities for expanding intermodal market share in high density corridors. All levels of government have key roles to play, in partnership with rail and trucking industries, in planning and development of the necessary intermodal facilities in major urban centres.

Within CMAs, local distribution of goods is a major contributor of congestion and pollution. New concepts of local freight consolidation are emerging in Europe that should be examined for application in Canadian cities.

4.2.3.6 *Walking School Buses*

Based on an neighbourhood initiative originally started in Australia and now in Toronto as well, residents organize to walk groups of children to school as an alternative to the use of automobiles. This healthy, cost-effective idea, originally conceived to provide safety and security for children, takes cars off the streets, and reduces emissions of air pollutants. It also has a positive socializing impact on the both the children and the adults in a neighbourhood. The concept is spreading rapidly across Canada and internationally. The Walking School Bus requires limited full time staffing to promote and maintain program momentum, and to provide advice and support to neighbourhood volunteers who perform the service.

5 DEVELOPMENT AND ASSESSMENT OF INTEGRATED PACKAGES OF OPTIONS

5.1 DEVELOPMENT AND EMISSIONS IMPACTS OF INTEGRATED PACKAGES

There is near consensus among government, private sector and non-governmental organizations that emissions reductions from transportation to meet the Kyoto target cannot practically be achieved by:

- *Any one level of government* – no level or department of government has sufficient policy levers in its jurisdiction.
- *Governments acting alone* – meeting the Kyoto targets will require co-operation among all levels of government, industry and the public
- *Any single policy measure* – no single measure is likely to be sufficient. All effective measures have limitations. Conversely, many policy options have the potential to work synergistically to reinforce one another and to offset undesired economic, social and environmental side effects of other options.
- *Technology alone* – Extensive international research leads to the conclusion that advances in technology are unlikely to be sufficient to overcome the negative emissions impacts of projected growth in high energy intensive modes of transport in addition to improvements to technology. There is a high level of agreement that, in addition to improvements in technology, societal behaviour change will be required to reduce the per capita demand for transport. Recent research by an OECD project suggests that, to achieve greater GHG emission reductions than the Kyoto commitments will require more contribution from behaviour modification than from technological improvements. Work for Environment Canada for this project, however, has suggested that the practical ratio of technology changes to policies that impact transportation demand in Canada may be in the range of 50/50⁵⁷.

An effective strategy to meet the Kyoto targets will, therefore, require integrated packages of policy options involving all three levels of government and with broad business and public support. The question is “What should comprise such an integrated package?”

For this Backgrounder three possible packages are considered with various options within each package depending on whether it is implemented on a “Canada only” or “North America-wide” basis. In the main, North America-wide application of measures that encourage changes in technology are more effective because it is felt that manufacturers have much more incentive to invest in technology for the larger North American market. The components of the three options are shown in Exhibit 5.1. A discussion of each of the packages is provided in the following sections.

⁵⁷ Based on preliminary work carried out by IBI Group and A.K. Socio-Technical Consultants for Environment Canada as part of the OECD Environmentally Sustainable Transportation (EST) Study.

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Exhibit 5.1: Summary of Integrated Packages

Individual Initiatives		COMBINATIONS					
		Package A		Package B		Package C	
		Road Vehicles - Basic		Road Vehicles - Alternative		Comprehensive Package	
		Canada Only	North America Wide	Canada Only	North America Wide	Canada Only	North America Wide
1	Fuel Taxes (Gas)	✓	✓			✓	✓
	Fuel Taxes (Diesel)		✓				✓
2	CAFE/CAFC	✓	✓			✓	✓
3	Feebates	✓	✓			✓	✓
4	Vehicle I&M			✓	✓	✓	✓
5	Vehicle Charges & Taxes			✓	✓		
6	Parking Pricing/Supply			✓	✓	✓	✓
7	Road Pricing			✓	✓	✓	✓
8	Alternative Fuels			✓	✓		
9	TDM					✓	✓
10	Enhanced Transit					✓	✓
11	Land Use/urban Design					✓	✓

5.1.1 Package A – Road Vehicles – Basic

Light duty **gasoline** vehicles produce 82 percent of urban transport CO₂ emissions. The three policies included in this package are targeted directly at reducing light duty vehicle emissions. Each measure can contribute to improving total fleet fuel efficiency.

The Federal government has jurisdiction to implement policy change for each option and could take unilateral action on this package. Co-operation with the provinces could produce an even stronger package. The measures included in Package A are the strongest measures available to the federal government (except for fuel rationing or emissions trading which were outside the scope of this study). Package A is examined for two different cases, with and without harmonization with the United States.

The policy synergies or interactions among the options in this package are as follows:

- The package collectively impacts vkt, vehicle purchase choice and therefore new vehicle fleet mix (vehicle size and fuel economy), and manufacturers' product offerings including average vehicle weight and technology content (more so for the North America wide option). All of these variables can impact new vehicle and "fleet on the road" fuel consumption and CO₂ emissions.
- The gasoline tax is the strongest measure for reducing CO₂ emissions because it is the measure that directly or indirectly influences the broadest range of short and long term decisions by consumers, businesses and governments. It is considered to be among the most cost-effective measures available. Gasoline pricing also has a significant impact on vkt, affecting consumer behaviour over both the short and the long term. Over the long term, it can have similar impact on the technology decisions of manufacturers, particularly if fuel tax policy were to be used across North America. It can also affect vehicle purchase choice over the long term.
- Increasing gasoline price through taxation counters the demonstrated weaknesses in CAFE/CAFC standards including:

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- the “take-back” effect which results in increases in vkt of up to 30 percent of the gain from the standard, as a result of lower operating costs from improved fuel economy;
 - technology uptake by manufacturers. CAFE/CAFC has been shown to be relatively weak in motivating car makers to incorporate fuel efficiency technologies into vehicles, instead they have tended to focus on vehicle weight and marketing (pricing) strategies to achieve CAFE targets. Fuel taxes provide additional market incentive for technology uptake;
 - the fact that CAFE/CAFC provides no incentive to reduce vkt or to shift to more energy efficient modes.
- Feebates can have the most direct impact on consumers vehicle purchase decisions and reinforce the weaker effects of both the gasoline tax and CAFE in this regard. Addition of the feebate could strengthen the fleet mix shift to smaller vehicles.
 - CAFE/CAFC directly impacts manufacturers marketing decisions as they adjust sales approaches to meet their targets.
 - Gasoline taxes are preferred by North American vehicle manufacturers over CAFE and feebates because the latter tend to favour Asian manufacturers whose product offerings on average are smaller and more fuel efficient. A policy package that includes gasoline taxes is likely to be more acceptable to car manufacturers since it tends to level the competitive playing field.

The assumed level of intensity of the measures for Package A were as follows:

- gasoline tax increase of 3 cents per litre/yr starting in the year 2000;
- diesel Fuel Tax increase of 3 cents per litre/yr starting in the year 2000 (North America wide package);
- CAFE or CAFC standards announced in 2002 and effective starting in 2005:
- feebate program introduced in the year 2005 (assume a feebate rate of \$CAN 1,400/Litre/100 km).

There are a number of complex relationships between the individual measures of Package A that are difficult to quantify. To some extent, the measures in Package A enhance each other; however, there is also some overlap between the measures (e.g. CAFE and Feebates both impact vehicle technology). For the purpose of this study, it was assumed that the impacts of the combined package would be similar to the sum of the individual impacts. One exception is that the take-back effect for CAFE standards (assumed to be 1/3) would likely be reduced or eliminated as a result of higher fuel prices. The projected impacts of CAFE standards were therefore adjusted accordingly.

Exhibit 5.2 provides a broad indication of the combined impact of the three measures proposed as part of Package A. Based on the assumptions outlined above, the net impact of the three measures if implemented on a Canada-only basis, the impacts of the three measures would be a 16% reduction for passenger vehicles and a 5% impact for freight vehicles (gasoline only). In the Canada-only case, it was assumed that diesel fuel taxes would not be increased for reasons of international competitiveness. If implemented on a North American wide basis the impacts would be a reduction of 26% from the 2010

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baseline CO₂ for passenger transportation and a 14% reduction from the baseline for freight vehicles. In terms of meeting the Kyoto targets, the North America wide scenario would exceed a 6% reduction from 1990 levels by 2010 for both passenger vehicles, as well as on an overall basis. If implemented on a Canada-only basis only, the impacts of fuel prices (on vehicle technology), CAFC and Feebates are much reduced. With the level of fuel price increases assumed, the Kyoto target would not be met for the Canada-only case.

Exhibit 5.2: Impacts of Integrated Package A

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-			
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenarios									
Canada Only	38,143	12,287	50,430	-16%	-5%	-14%	-4%	46%	5%
North America Wide	33,526	11,043	44,569	-26%	-14%	-24%	-15%	32%	-7%

5.1.2 Package B – Road Vehicles – Alternative

This package is similar to Package A in that it targets road vehicles; however, more measures are combined to form the package. It is also targeted directly at road vehicle technologies and driver behaviour. Other market pricing measures such as parking policies, road pricing and vehicle charges are included which could either complement or be used in place of gasoline taxes. Mandatory road vehicle Inspection and Maintenance (I&M) programs are included in this package to address the issue of lifetime vehicle emissions.

Package B comprises measures that could be applied under provincial and/or municipal jurisdiction. The options, within limits, could be applied independent of the policy direction taken by the U.S.; however, in the case of vehicle charges (assumed to be similar in impact as fuel taxes), the impacts would be enhanced if implemented on a North America wide basis.

For the purpose of illustrating the impacts of the alternative road vehicle package, the following levels of intensity were assumed:

- vehicle Inspection and Maintenance with full implementation by the year 2000;
- vehicle charges (annual registration fees), with a fleet fuel economy impact equivalent to feebates;
- vkt charges and distance-based insurance, with a demand impact similar to fuel taxes;
- parking pricing (5% annual increase from 2000- 2010);
- road pricing (\$0.10 peak/\$0.05 off-peak on major expressways).

In Package B, vehicle charges and distance based fees are assumed to have similar impacts to the feebates and gasoline taxes of Package A.

As with Package A, there are a number of inter-relationships among the measures that cannot be quantified with certainty. For example, road pricing, parking pricing, and vkt charges would all have an impact on user behaviour, possibly impacting similar trips. Generally, it was assumed that the combined

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impact of the demand related measures (e.g. parking pricing, road pricing and vehicle charges) would be similar to the aggregate of the individual impacts. The impacts of the technology related measures (e.g. vehicle taxes and vehicle I&M) on CO₂ emissions were also assumed to be equivalent to the sum of the individual measures, but the impacts were applied to the CO₂ from the reduced demand estimates.

Exhibit 5.3 summarizes the results of Package B, showing the estimated impacts if implemented with and without harmonization with the U.S. The primary difference between these scenarios is that vehicle charges and taxes, if implemented North America wide, would have a more profound impact on auto manufacturers and vehicle technologies. Under the harmonization scenario with the U.S., the CO₂ reductions would be very significant. For passenger transportation CO₂ modes, emissions would be reduced by 30% from the baseline 2010 emissions. For freight transportation, emissions would be reduced by 15%. Overall, in comparison to the 1990 baseline emissions, the net impact of the measures would be in the order of an 11% reduction. Under the Canada only scenario, the combined impact of the measures would be reduced somewhat, but the net result would still be significant. In fact, under the Canada only scenario, Package B would nearly meet the Kyoto target when passenger and freight transportation is combined.

Exhibit 5.3: Impacts of Integrated Package B

	Annual CO ₂ (kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-	-	-	-
2010 Baseline	45,581	12,887	58,468	-	-	-	15%	54%	22%
2010 New Scenarios									
Canada Only	33,716	11,930	45,645	-26%	-7%	-22%	-15%	42%	-5%
North America Wide	31,962	10,977	42,940	-30%	-15%	-27%	-19%	31%	-11%

5.1.3 Package C – Comprehensive Package

This package includes the direct road vehicle measures of Package A and the complementary road vehicle measures of Package B. It is assumed that the gasoline tax policy, co-ordinated among levels of government would be used initially, without the use of other vehicle charge measures. Package C also includes policy options for enhancing transit, changing land use/urban design policies and other Transportation Demand Management (TDM) policies.

The Comprehensive Package will unquestionably produce the greatest momentum towards sustainable transportation in the Kyoto period to 2010. The Comprehensive package will also set the stage for further progress in following decades.

The major synergies in the Comprehensive Package over Packages A and B relate to the parallel development and expansion of choice for the public and for businesses to access opportunities for exchange in cities as personal vehicle use declines under the more direct policy initiatives. Options for expanding modal choice will clearly enhance the effectiveness of the measures targeted directly at personal vehicles.

The general approach for developing an estimate of the impacts of the Comprehensive Package was to assume that the regulatory measures would have the same impact as under the individual options. This is based on the premise that the impact of the individual options would be enhanced if implemented in a comprehensive package, thereby balancing out the overlap between some of the measures. The impacts of the measures to expand modal choice were taken into account by increasing the elasticity of demand

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due to fuel taxes. This is based on the assumption that the options to expand modal choice would enhance the impacts of fuel pricing by providing alternatives for people to reduce personal vehicle use. By increasing the elasticity of demand to fuel price from -0.15 to -0.2, the net impact is an approximate reduction in demand of 3.5% for the Canada-only case. This is a fairly moderate percentage reduction, however, it should be recognized that most of the options for expanding modal choice (e.g. land use and enhanced transit) will take a long time to take effect.

To illustrate the potential of a Comprehensive Package of options, the following assumptions were made regarding the intensity and implementation of the individual measures:

- gasoline tax increase of 3 cents per litre/year starting in the year 2000;
- diesel Fuel Tax increase of 3 cents per litre/year starting in the year 2000 (North America wide package);
- CAFE or CAFC standards introduced in the year 2005;
- feebate program introduced in the year 2005 (assume rate of \$CAN 1,400/Litre/100 km);
- vehicle Inspection and Maintenance with full implementation by the year 2000;
- parking pricing (5% annual increase from 2000- 2010);
- road pricing (\$0.10 peak/\$0.05 off-peak on major expressways);
- Transportation Demand Management initiatives;
- enhanced transit;
- land use/urban design;

Exhibit 5.4 summarizes the results of a comprehensive package of measures. Assuming the package is implemented in Canada only, CO₂ emissions from passenger transportation may be reduced by over 30% from the base case 2010 emissions and by about 22% from the 1990 levels. Taking both passenger and freight transportation into account, the net impact of the Comprehensive Package was estimated to be a 11% reduction from 1990 levels, which exceeds the Kyoto target of 6%. It should be recognized that this is an illustrative scenario only; however, and that different price increases or regulatory controls would result in different reductions.

For the North America-wide case, the Comprehensive Package of options presented would meet the Kyoto target level reductions achieving a 20% reduction from 1990 levels when both passenger and freight modes are combined. As with the Canada only scenario, freight transportation would not meet the targets on their own.

Exhibit 5.4: Impacts of Integrated Package C

	Annual CO ₂ (Kilotonnes)			% Change from 2010 Baseline			% Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	-	-	-			
2010 Baseline	45,581	12,897	58,468	-	-	-	15%	54%	22%
2010 New Scenarios									
Canada Only	31,060	11,604	42,663	-32%	-10%	-27%	-22%	38%	-11%
North America Wide	27,968	10,417	38,385	-39%	-19%	-34%	-29%	24%	-20%

5.2 ECONOMIC IMPLICATIONS OF INTEGRATED PACKAGES

5.2.1 Macroeconomic Considerations

A potential barrier to implementing changes in policy that could enable the Kyoto target to be met, is concern about possible negative effects on the national economy. There are, for example, specific concerns about the impacts on the automotive manufacturing and petroleum industries that are important to the economies of regions of Canada.

The international literature regarding the economic impact of climate change policies and strategies is extensive. Perhaps even more so than the science of climate change itself, it is also inconclusive. Major reasons for the uncertainty regarding economic outcomes include structural differences in the national economies studied, the differences in the economic models used to estimate impacts, data limitations and differences in the assumptions used as inputs to model simulations. Repetto and Duncan assert that⁵⁸:

- top-down models typically incorporate relatively little detail on energy consumption and technology change. Such models would not, for example predict the economic impact of increased use of renewable energy in transportation as a result of new energy technologies, including wind, solar and biomass, now rapidly moving down the engineering cost curve; whereas
- bottom-up models typically incorporate relatively little detail on nonenergy consumer behaviour and interactions with other sectors.

In its 1995 report on the *Economic and Social Dimensions of Climate Change*, Working Group III of the IPCC drew the following broad conclusions from its extensive review of the literature about the macroeconomic impacts of mitigation and adaptation policy packages⁵⁹:

- "...there is agreement that energy-efficiency gains of perhaps 10 to 30 percent above baseline trends over the next two to three decades can be realized at negative to zero net cost.

⁵⁸ *The Costs of Climate Protection, A Guide for the Perplexed*, R. Repetto, D. Austin, World Resources Institute, Washington, D.C., 1997

⁵⁹ *Climate Change 1995, Economic and Social Dimensions of Climate Change*, Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Summary for Policy makers. Co-editors, along with Hoesung Lee of Korea, were Canadians James Bruce of the Canadian Climate Program Board and Erik Haites of Margaree Consultants Inc.

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- *For OECD countries, top-down(macroeconomic) studies suggest that the costs of substantial reductions below 1990 levels could be as high as several percent of GDP. In the specific case of stabilizing emissions at 1990 levels, most top-down macroeconomic studies estimate the annual costs in the range of minus 0.5% of GDP to plus 2% of GDP could be reached over the next several decades. In other words the range is from an increase in GDP of 0.5% to a decrease of 2%.*
- *Bottom-up studies(based on detailed studies of engineering costs and energy consumption) are more optimistic about the potential for low or negative cost emissions reductions and the capacity to implement that potential. Such studies show that the costs of reducing emissions by 20% in developed countries within two to three decades are negligible to negative. Other bottom-up studies suggest that there exists a potential for absolute reductions in excess of 50% in the longer term, without increasing, and perhaps even reducing, total energy system costs.*
- *Despite its widespread use in economic policy evaluation, GDP is widely recognized to be an imperfect measure of a society's well-being, largely because it fails to account for the degradation of natural systems.*
- *At both the international and national levels, the economic literature indicates that instruments that provide economic incentives, such as taxes and tradable quotas/permits are likely to be more cost-effective than other approaches.”⁶⁰*

Use of economic instruments such as gasoline and diesel taxes, or other energy consumption related measures such as vehicle registration fees or vkt charges, have the potential to raise very large tax revenues. The IPCC concludes that “*how the revenue is distributed could dramatically affect the cost of mitigation. If the revenues are distributed by reducing distortionary taxes in the existing system, they will help reduce the tax burden of the existing tax system, potentially yielding an additional economic benefit (double dividend).*”⁶¹

A recent study called *Energy Innovations*, by a group of U.S. environmental organizations, found that U.S. carbon emissions could be reduced by 10 percent below the 1990 level by 2010, while reducing annual energy costs from all sectors by \$530US per household and creating approximately 800,000 jobs. For the transportation sector, the *Energy Innovations* study included many of the measures included in the Integrated Packages of this study of urban transportation in Canada. The U. S. study did not include a direct gasoline tax, but did include “transportation pricing reforms including parking subsidy reform, uniform commuter benefits; shifting hidden, fixed or indirect costs to road users; pay-as-you-drive (distance based) insurance; and more equitable and environmentally sound road use cost allocation.”⁶² *Energy Innovations* places heavy emphasis on renewable energy and technology advances in transportation as driving elements of a U.S. climate change strategy. It concludes that by 2010, for an investment of \$588B, cumulative savings would be \$1005B, for a cumulative benefit to cost ratio, over all sectors, of 1.7.

⁶⁰ Ibid, page 13, Box S.1 Top-Down and Bottom-up Models

⁶¹ Ibid, page 13

⁶² *Energy Innovations: A Prosperous Path to a Clean Environment* Alliance to Save Energy, American Council for an energy-Efficient Economy, Natural Resources Defense Council, Tellus Institute, and Union of Concerned Scientists, Washington, D.C., 1997, Executive Summary – A Greener Way to Go.

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The January 1998 update of the Rational Energy Program proposed by the Sierra Club of Canada, considered a similar range of measures for the transportation sector to those included in the Integrated Packages of this NRTEE study of urban transportation in Canada, though differing in the relative assumptions about specific measures. The Rational Energy Program, based on analyses by Natural Resources Canada, Informetrica and the Sierra Club of Canada, concludes that a National Transportation Strategy could reduce GHG emissions from transportation by 62.9 million tons by 2010 with, cumulative net savings to the economy of \$11.8B.

In a 1995 study, Informetrica concludes that *“in the period 1995 to 2010, the overall size of the Canadian economy, and its growth are unlikely to be significantly changed by initiatives designed to reduce emissions of Greenhouse Gases.”*⁶³ Despite wide variations in cumulative costs for households, governments and businesses for the scenarios analysed, *“the finding of small aggregate impact is invariant across the scenarios, since increased costs are matched by increased savings from reductions in energy use.”*

More recently, the Government of Canada commissioned Standard and Poor/DRI to prepare a report on the impacts of climate change mitigation activities on Canadian competitiveness⁶⁴. This report concluded that:

- “CO₂ abatement imposes transition costs on the Canadian economy; and
- policy choices matter.”

More specifically it concludes that:

“Reducing CO₂ emissions will impose short- to medium-term transition costs on the Canadian economy. After ten to fifteen years (post 2013) the Canadian economy is expected to produce about the same level of output, albeit at reduced level of CO₂ emissions as it would have under Business-as-Usual conditions. The transition costs vary by region and sector. Because of their carbon-based economy, Alberta and Saskatchewan are most adversely affected both in the short and long term. British Columbia, Ontario and Quebec also experience significant costs until 2013 when output is forecast to rise above Business-as-Usual levels. This study has not addressed the issue of the benefits associated with climate change mitigation. Measurement of the benefits is required to determine the overall cost-effectiveness of the policy.”

For Canada as a whole the DRI simulations suggest that the GDP would be 2-3% lower than the Business-as-Usual (BAU) level for seven or eight years (e.g. between 2002 and 2010), with a lesser differential earlier and later in the transition period, and a positive impact (about 0.3 – 0.8% above the BAU level) during the period 2014 – 2020. The positive impact shows an increasing trend, but the simulation period ended at 2020. The estimated provincial impacts remain negative for Alberta and Saskatchewan through 2020; Ontario would experience a greater decrease (about 3% below the BAU level) during the period 2003 – 2008, but would, along with Quebec and British Columbia,

⁶³ *Impact of GHG Initiatives on the National and Provincial Economies*, C.A. Sonnen, M.C. Justus, Informetrica, for The Forecast Working Group of the National Air Issues Co-ordinating Mechanism, April 1995

⁶⁴ *Impacts on Canadian Competitiveness of International Climate Change Mitigation: Phase II* by Standard and Poor's DRI, November, 1997, prepared for Environment Canada, Natural Resources Canada, Industry Canada, Department of Finance, International Affairs and International Trade.

experience a higher than average recovery after 2013 (a difference of 1 – 1.5% above BAU level and rising) in the period 2014 – 2020.

The above estimated impacts are based on a “tradable permit scenario” assuming that CO₂ emissions are reduced to 1990 levels by 2010; they are similar for a “carbon tax scenario” aimed at a 10% CO₂ reduction by 2010 relative to 1990, except that the reductions during the transition period are slightly greater (about 3 - 3.5% below the BAU level for the period 2003 through 2010) but the positive recovery subsequently is also greater (about 0.7 – 1.3% above the BAU level during the period 2015 – 2020, with a generally rising trend), at the national level.

This is an example of a top-down model approach.

5.2.2 The Cost-Effectiveness of Fuel Economy Standards

CAFE/CAFC standards have been shown to be less cost-effective than economic instruments that can be designed to target specific market behaviour. For example, Crandall reports that the midrange of comparative studies of CAFE and fuel taxes, shows that the gasoline tax assumed to match “CAFE’s conservation effect would have reduced producer and consumer welfare by 8 cents a gallon saved, while the regulatory alternative actually reduced welfare by around 60 cents a gallon saved.”⁶⁵ The cost-effectiveness of CAFE is also affected by the aggressiveness of the annual changes in the standards. For this study, we have assumed an annual improvement of 2%, suggested by the literature to be the close to the least-cost rate of technology uptake. For higher rates of improvement in fuel economy, manufacturers would incur higher costs to meet CAFE targets.

5.2.3 Wealth and Automobile Dependency

Recent research on the relationship between the Gross Regional Product of urban regions worldwide and the nature of their urban densities and transportation systems, has shown that “car use does not necessarily increase with increasing wealth, but tends to fall in the most wealthy cities. Where wealth is accompanied by land use and transport policies which do not facilitate car travel, car use (and energy cost) will be lower.”⁶⁶

Wealthy cities show strong use of public transit and especially rapid transit and commuter rail systems. “Rail transit systems, (for large urban regions) compared to all other motorised transport, appear to have the best energy efficiency and greatest ability to attract people out of cars, they are the most important factor in the recovery of transit operating costs, seem to be the catalyst for compact sub-centre development and make a major contribution to sustainability on all indicators. Transforming cities towards efficiency in both economic and environmental terms would appear to involve good rail systems.”⁶⁷

5.2.4 The Inefficiencies of Urban Sprawl

In addition to the energy cost inefficiencies of transportation in low density urban regions, it has been shown that the costs of capital expansion and maintenance of all urban infrastructure including water and sewer systems, roads and other utilities, resulting from urban sprawl are very high. The Report of the

⁶⁵ *The Extra Mile: Rethinking Energy Policy for Automotive Transportation*, Robert Crandall, Pietro Nivola, The Brookings Institute, Washington, D.C., 1995, page 33

⁶⁶ *Indicators of Transport Efficiency in 37 Global Cities*, Jeff Kenworthy et al, Murdoch University, Australia, for the World Bank, February, 1997, page 5

⁶⁷ *Ibid.*

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Greater Toronto Task Force estimated that continued urban sprawl in the GTA as the population of the region grows over the next two decades would result in annual costs of \$1B for capital and maintenance, compared with a strategy of more compact mixed use development throughout the region. Similar conclusions have been drawn from studies of the Greater Vancouver Region.

The work of the Australian researchers Peter Newman and Jeff Kenworthy has clearly shown that population densities in the range of 30 persons per hectare or more are required for financially viable public transit. Such densities are found in the core of some Canadian cities, but not in their suburban regions.

The American researcher, David Aschauer has found that "Within the broad category of transportation spending, the evidence indicates that public transit spending carries more potential to stimulate long run economic growth than does highway spending".⁶⁸

Although this Backgrounder is focussed on urban transportation in Canada, most of the literature on economic impacts of climate change policies for transportation does not distinguish between urban and non-urban segments. On the assumption that there are more opportunities for cost-effective alternatives to high energy intensive modes for passenger and freight movement in urban areas, it seems reasonable to expect policy measures to have somewhat larger positive economic and social impacts in cities than in rural areas. From the available data, however, this assumption cannot be confirmed.

5.2.5 Positions of the Auto and Petroleum Industries

Consensus among major stakeholders about sectoral economic impacts will be difficult to achieve. This is strikingly illustrated in a report to the President of the United States by the Policy Dialogue Committee (known as the Cartalk Group). The majority report of this multistakeholder body states that: "*The Committee...was unable to reconcile the following positions: Environmentalists favoured fuel economy standards, which the auto industry opposed. The automobile industry proposed gas taxes to which the oil industry representatives objected. Finally a consensus report stating the Committee's disagreement was unacceptable to the auto industry if it mentioned direct measures to increase fuel economy in a quantified way.*"⁶⁹ The positions of stakeholders to date in Canada have been similar.

Many studies have suggested that a portion of revenues from increased fuel taxes or other market-based economic measures can be dedicated to funding other initiatives, such as enhanced public transit and other Transportation Demand Management policies. The Transportation Association of Canada has proposed that *the majority of money collected from fuel taxes and license fees be identified as taxes and retained as general revenues, and an appropriate portion be identified as a transportation fee and dedicated to urban transportation in support of local visions. Any future increases to either the general revenue tax or the dedicated urban transportation fee would be identified as such at the time.*⁷⁰

5.2.6 Conclusions on Economic Impacts

The following broad conclusions can be drawn from the above discussion of the literature on the economic impacts of policy options for mitigating climate change impacts of rising GHG concentrations:

⁶⁸ *Transportation Spending and Economic Growth*, Aschauer, D.A. and Campbell, E.J. Bates College (1991), reported in *Earthword: The Journal of Environmental and Social Responsibility*, 4, 38

⁶⁹ *Majority Report to the President by the Policy Dialogue Advisory Committee to Recommend Options for Reducing Greenhouse Gas Emissions from Personal Motor Vehicles*, Washington D.C., 1997, Executive Summary

⁷⁰ *Financing Urban Transportation*, Briefing of the Transportation Association of Canada, February 1997, page 5.

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- there is uncertainty about estimates of economic impacts of GHG related policies. Such estimates are very sensitive to the econometric models and assumptions used;
- there is general agreement among economists that energy-efficiency gains of 10 to 30 percent above baseline trends over the next two to three decades can be achieved at negative to zero net cost;
- policy instruments such as taxes and tradable quotas/permits are likely to be more cost-effective than other approaches;
- tax revenues from GHG related policies can be used to reduce distortionary taxes in the existing system, potentially yielding additional economic benefit;
- the wealthiest global cities are not highly dependent on road vehicles;
- urban sprawl is costly; and
- effective policies for reducing GHG emissions will impact some industries and regions more than others. Impacts can be softened by implementation of policies over extended periods and by private and public sector strategies for adapting to the changing policies.

5.3 ASSESSMENT OF INTEGRATED PACKAGES

Five broad criteria have been selected as a means for discussing and assessing the integrated packages:

- greenhouse gas reduction;
- cost;
- economic impacts;
- ease of implementation; and
- social impacts.

Exhibit 5.5 on the following page presents a summary of the assessment of the integrated packages based on these five criteria.

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Exhibit 5.5: Assessment of Integrated Options

		Package A Road Vehicles - Primary		Package B Road Vehicles - Alternative		Package C Comprehensive Package	
		Canada Only	N.A.wide	Canada Only	N.A.wide	Canada Only	N.A.wide
GHG Impacts - Summary							
% reduction from 2010 baseline		-14%	-24%	-22%	-27%	-27%	-34%
% reduction from 1990 baseline		5%	-7%	-5%	-11%	-11%	-20%
Evaluation Criteria	Objective						
Greenhouse Gas Reduction	To meet or exceed Kyoto target reductions	●	●	●	●	●	●
Public Sector Cost	To be implemented without significantly increased net costs to the public sector	●	●	●	●	●	●
Economic Impacts	To be implemented without reducing Canada's economic efficiency	●	●	●	●	●	●
Ease of Early Implementation	To be implemented such that impacts are realized by 2010	●	●	●	●	●	●
Social Impacts	To be implemented while improving social equity	●	●	●	●	●	●
Overall Assessment		●	●	●	●	●	●

Extent to which objectives are satisfied:

- (1)
low
- (2)
medium
- (3)
high

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The assessment was largely subjective, drawing on the material presented in the previous two chapters. A discussion of the extent to which each of the options meets each criterion is provided below.

5.3.1 Greenhouse Gas Reduction

In terms of GHG reduction, the effectiveness of the options generally increases as more measures are added. In Package A, two of the three measures (CAFE and Feebates) would not have realized their full potential by the year 2010. Fuel taxes, the primary measure in this package, will also take some time to have an impact on technology, fleet efficiency and demand impacts. The lack of measures to expand modal choice limits the potential effectiveness of fuel taxes in Package A. The net effect of the integrated measures in Package A is a fairly moderate reduction in CO₂ emissions. This results in low and medium ratings for the Canada-only case and North American wide scenario respectively. The advantages of achieving harmonization with the U.S. are very apparent in Package A. If harmonization does occur, the integrated measures in Package A have the potential to result in reductions equal to or greater than the Kyoto Target.

Most of the options in Package B will have a more direct impact on the use of vehicles, compared to the options in Package A. The Canada-only case would fall just short of the Kyoto target while the North American wide case would exceed the target by a significant margin.

Of all the packages, Package C demonstrates the greatest potential to reduce CO₂ significantly. This is largely due to the synergistic effects that the options to expand modal choice have on the other measures and the large number of measures targeted at specific behavioural decisions. Package C is given high ratings for both the Canada-only and North American wide scenarios.

5.3.2 Public Sector Cost

There are several ways in which cost could be assessed. For the purpose of this assessment, the options have been assessed in terms of their ability to be implemented without significantly increasing costs to the public sector. As opposed to economic impacts, which is a separate criterion, the cost criterion relates more to the direct internalized costs to the public sector, excluding environmental costs and other external costs.

Based on our definition of cost, Package A would likely have the lowest cost to the public sector, and is therefore given the highest rating. In fact, the fuel tax measure under Package A would generate a significant revenue surplus which governments could use to adjust distribution impacts of existing tax systems. Package B may have somewhat more substantial costs than Package A, given that most of the measures would have non-trivial operating and capital costs. For example, road pricing (e.g. road tolls) would require a physical collection mechanism to be built, operated and maintained. Likewise, vehicle inspection and maintenance programs require initial investment to set-up the actual testing stations (which are to be privately owned in Ontario). Some or all of the costs to implement these measures would be recovered through user fees.

In terms of public sector costs, Package C would likely be the most expensive. The costs of Package C include capital and operating costs of the measures in Packages A and B plus substantial costs to expand options for modal choice, for example, investment in transit infrastructure. Package C has therefore been given a low rating in this regard although its net cost to the public sector could be quite low (while higher than those for Package B or A or even negative if user revenues; e.g. from gas tax revenues, parking surcharges or road tolls, are used to fund these investments).

5.3.3 Economic Impacts

Section 5.2 of this report provided a broad overview of the likely economic impacts of achieving reductions in CO₂ emissions. Our general conclusions based on the literature is that measures that reduce CO₂ can improve economic efficiency. Further, measures that reduce CO₂ also reduce the costs associated with environmental damage, accidents and other externalities. The three packages were therefore rated in terms of their ability to improve economic efficiency. Under this criterion, Packages A and B are given low to medium ratings and Package C medium to high rating. In all aspects, including improving economic efficiency, the Packages are enhanced if implemented on North America wide basis. There are clearly economic benefits associated with being able to share the costs of improving vehicle technology with United States.

5.3.4 Ease of Early Implementation

Several criteria could be used to reflect the ease of implementation of the various measures and packages. Perhaps the most relevant is the ability of the measures in each package to be implemented such that their impacts are felt by the 2010 horizon. In terms of ease of implementation, Package A and Package B both contain measures that are relatively easily implemented. The higher rating for the Canada-only case reflects the fact that potentially lengthy negotiations with the United States would not be required.

5.3.5 Social Impacts

Social impacts can be assessed based on a number of criteria including material wealth, social polarization, community relationships, health and safety and even cultural diversity. Of all the Packages, Package A would likely have the least negative social impacts. Under Package A, Feebates would reduce the purchase cost of economically efficient cars relative to more energy consuming, emission producing vehicles. In turn, this would reduce the cost of car ownership for people with lower incomes who require the use of a car for work or other purposes. Due to the fact that Package B contains a number of direct user pay initiatives, it may have more measurable social impacts than Package A. In particular, people with lower incomes may not be able to afford the costs of driving, whereas people with higher incomes could, thereby increasing social polarization. In Package C, the measures to expand modal choice should provide considerable benefit to individuals with lower incomes given that they would have more travel options. Another key advantage of Package C is that the restructuring of land use could serve to enhance community relationships. Unfortunately, some of the options to expand modal choice (e.g. expanding transit infrastructure) as well as land use measures are longer-term initiatives.

5.3.6 Overall Assessment

All of the integrated packages move in the right direction; however, some packages have obvious benefits over others. Exhibit 5.5 presents an attempt to assess the three packages in overall terms. This overall assessment is largely a subjective one taking into account the various advantages and disadvantages of each package.

Based on the five broad criteria, it would appear that Package C offers the greatest benefits with the least negative impacts. Package C has many other advantages besides GHG reduction alone. In particular, the individual measures in Package C represent a balance between regulatory measures and more passive measures to expand modal choice. Package C also generates the broadest momentum for greater emission reductions which may be required beyond the timeframe of the Kyoto Protocol.

6 CONCLUSIONS

Based upon the findings of this study as summarized above, the following conclusions are drawn.

- Policy options to reduce urban transportation GHG emissions which involve a single initiative only are unlikely to achieve the Kyoto target (see Exhibit 4.14).
- Combinations of the individual initiatives show more promise, and three such combination packages were developed for analysis (see Exhibit 5.1).
- Any one of the three combination packages, with the exception of Package A and Package B if applied in Canada only, is estimated to meet the Kyoto target with Package C, the Comprehensive Package, likely to achieve the greatest reductions (see Exhibit ES3). Any of the packages would also build momentum for substantial CO₂ reduction trends beyond 2010, with Package C again as the most effective in this regard.
- When other objectives such as reasonable public sector costs, economic efficiency, ease of early implementation and reasonable social impacts, are taken into account as well as greenhouse gas reduction, the Comprehensive Package achieves the highest rating in a comparative evaluation (see Exhibit 5.5).
- Based on the above, we conclude that it would be feasible for Canada, acting alone, to achieve its Kyoto target for greenhouse gas reductions as applied to urban transportation in the country's 13 largest CMAs, which account for some 80% of urban transportation GHG emissions in this country. This conclusion is significantly strengthened if any one of the three combined packages could be implemented North America-wide, and the likelihood of success is also increased if more initiatives are added to the package.

Clearly, the complexity and challenges of achieving co-operation as required for combined approaches increase as the field of actions moves from Package A to Package B and onward to Package C, but the rewards of accepting these challenges make the effort worthwhile in terms of meeting and exceeding the Kyoto target while also achieving other objectives (e.g. financial, economic, social). Similarly, the benefits from achieving a harmonized approach across North America warrant the additional effort of attempting to achieve a co-operative approach by the three national governments of Canada, the United States and Mexico. It is fortunate that, based on the findings of this study, there is excellent promise that the Kyoto target can be reached for urban transportation greenhouse gas emissions in Canada through largely federal initiatives, so that there is good reason to act on these initiatives as soon as possible while initiating discussions with other jurisdictions in hopes of achieving broadened, co-operative approaches.

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