TRANSPORTATION AND CLIMATE CHANGE:

OPTIONS FOR ACTION

OPTIONS PAPER

OF THE

TRANSPORTATION CLIMATE CHANGE TABLE

NOVEMBER 1999

This report is dedicated to the memory of

John Hartman

Transportation Association of Canada

A passionate advocate of sustainable transportation.

TRANSPORTATION AND CLIMATE CHANGE: *OPTIONS FOR ACTION*

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In December 1997, Canada, along with other developed countries, negotiated the Kyoto Protocol under the United Nations Framework Convention on Climate Change. If the Protocol were ratified, Canada would agree to reduce its emissions of greenhouse gases (GHGs) by six per cent over 1990 levels during the five-year period from 2008 to 2012.

In May 1998, the federal, provincial and territorial ministers of transportation established the Transportation Climate Change Table as part of a national process to develop a climate change strategy in response to Kyoto. Under this process, the Table's analysis will be integrated with that of 14 other issue tables in order to assess the most effective options across the economy, including the potential of instruments such as emissions trading.

The Table's membership reflects a broad range of interests in transportation (see Appendix 1). The Table was mandated to analyze options that achieve progressively greater reductions within transportation until reaching or, if possible, going beyond a six per cent reduction from 1990 levels. This report presents the results of the Table's analysis and deliberations on potential options to reduce GHG emissions from transportation.

TRANSPORTATION AND CLIMATE CHANGE

Transportation is the single largest source of GHG in Canada, accounting for 25 per cent of the total in 1997. GHG emissions from transportation are expected to exceed 1990 levels by 32 per cent in 2010 and 53 per cent by 2020, if current trends continue.

Although targets have not been allocated for each sector, emissions from transportation would have to be reduced by 28 per cent in 2010 in order to achieve a reduction of six per cent from 1990 levels, or about 54 megatonnes (Mt) from the forecasted level of 193 Mt in 2010.

Road vehicles account for almost 70 per cent of the GHG emissions from transportation, with 45 per cent from cars and light trucks, and 27 per cent from commercial heavy duty vehicles, primarily trucks. Off-road sources, such as construction, agricultural and household equipment, and recreational vehicles, such as power boats and snowmobiles, account for 13 per cent. About 8 per cent of emissions are due to international marine and aviation activities that, under the Kyoto Protocol, are to be addressed by international organizations rather than individual countries. The remaining 7 per cent of emissions come from domestic aviation, shipping and railways.

The sources of emissions expected to grow most quickly between 1990 and 2020 are aviation (forecast to increase by 99 per cent), off-road uses (diesel by 66 per cent and gasoline by 57 per cent) and on-road diesel (74 per cent). On-road gasoline is expected to increase by 44 per cent between 1990 and 2020.

THE TABLE'S ANALYSIS

The Transportation Table commissioned 24 research studies to identify potential measures to reduce GHG emissions. The Table developed an analytical framework based on the guidelines produced for the national climate change process. The costs and benefits of different options are expressed in dollars per tonne of GHG reduced (net present value). As part of that framework, non-monetary costs and benefits, such as time savings, activity restrictions or loss of consumer choice, have been included where possible. However, the financial, or strictly monetary, costs of the measures are also identified, where different.

Certain taxes and charges are not included in the costs of measures if they are not payments for goods or services, but are introduced as policy measures to influence user choices. They remain important for policy decisions, nevertheless. They represent real costs or revenues for consumers and governments, and are identified as resource transfers in the report.

In reviewing the measures, it is important to understand the limitations of the data used in the analysis. Assumptions were made where data were limited or non-existent. In some cases, there is no actual experience with specific measures (for example large scale increases in fuel prices or "feebates" for automobiles), so it has been necessary to estimate the effects and success of some measures. The basis for these assumptions and the limitations of the data used are important considerations and are explained in this paper and in each of the Table's studies.

The Table analyzed more than 100 different measures to reduce emissions from transportation. While cost-effectiveness is very important, there are other key social and economic criteria that must also be considered in determining the best measures for reducing emissions.

CRITERIA FOR ASSESSING TRANSPORTATION GHG MEASURES	
• GHG impact	• Cost-effectiveness
• Public support	• Economic impacts
• Complementarity to other measures	• Ease of implementation
• Certainty/risk	• Equity effects
• Ancillary impacts (e.g. safety, health, environment)	• Other financial factors (e.g. taxes, costs to government)

It was not possible, given the Table's budget and schedule, to complete a detailed assessment of all of these factors, or to examine in sufficient detail the range of issues related to implementation. The criteria were used as general guidelines to assess the measures as falling into one of four categories, as follows:

1. ***Most Promising Measures***: Measures that are cost-effective (generally have positive benefits or cost less than $10/tonne), are easier to implement, or do not involve significant resource transfers. They may require some additional analysis and design.

2. ***Promising Measures:*** Measures that have potential for various levels of GHG reductions at low to modest cost, or which are included to complement other measures in the package. They may need some additional analysis or development.

3. ***Less Promising Measures:*** Generally, higher cost measures that may have GHG reduction potential in the medium to longer term and/or require significant additional analysis, much greater public acceptance, or considerable technological development.

4. ***Unlikely Measures:*** Measures that Table members believe do not warrant active consideration at this time due to high cost (over $200 per tonne of GHG), limited potential to reduce emissions, or extreme difficulty in implementation. Also included are variations of measures made redundant by those in the first three categories.

The Table did not propose a single set of measures to achieve a six per cent reduction from 1990 levels. However, the various measures analyzed are sufficient to reach or go beyond the Kyoto target in transportation, as required by the Table's mandate.

THE OPTIONS FOR TRANSPORTATION

The transportation measures have been grouped into five themes or packages. These packages provide a useful framework for grouping measures that work well together, are aimed at a particular end use, or provide a focus for action in the transportation sector.

1. Passenger Package

Passenger travel represents a particularly important area in which to reduce emissions from transportation. It accounts for the bulk of transportation GHG emissions, but also presents a challenge in changing the travel, commuting and living habits of Canadians. The ***most promising*** measures are largely voluntary and aimed at increasing public awareness and changing travel behaviour, primarily in urban areas. Combined, they would reduce emissions by 3.7 Mt, or about seven per cent of the Kyoto target in transportation, at a benefit of $100 per tonne.

Telecommuting and car-sharing programs would reduce the number of automobile trips, whereas enhanced driver education would increase the energy efficiency of driving practices. Changing the tax treatment of employer provided transit benefits would remove an unintended bias that favours parking over transit. Combined, these measures would form an effective strategy for employers to implement voluntary trip-reduction programs in their organizations.

Two intercity measures are included in the *most promising* package: a range of actions in the aviation sector, such as improving flight routes and ground operations; and a code of practice for ferries to improve operating efficiencies.

PASSENGER: MOST PROMISING

GHG 2010:	**3.7 Mt**
Cost per tonne:	**-$100**
Range ($/tonne):	**-$941 to +$9**
Financial cost/tonne:	**-$97**

- Tax-exempt transit pass[1]
- Transit smart card
- Telecommuting
- Driver education
- Car sharing
- Aviation efficiency measures
- Code of practice for ferries

Fundamental to reducing single-occupancy commuter trips in urban areas is a strategy to significantly enhance urban transit services. Thus, the ***promising*** measures combine strong incentives for alternatives, such as transit and biking, while discouraging car use through charges on parking, starting with the three largest urban centres. Taken together, the *promising* measures could achieve an estimated GHG reduction of 10.1 Mt, or 19 per cent of the transportation target, at a cost of $49 per tonne.

PASSENGER: PROMISING

GHG 2010:	**10.1 Mt**
Cost per tonne:	**$49**
Range ($/tonne):	**$16 to $202**
Financial cost/tonne:	**$46**

- Enhanced transit (e.g. pricing, service, infrastructure, intelligent transportation systems)
- Pedestrian and bicycle
- Ride sharing
- Parking pricing (Montreal, Toronto, Vancouver)
- Natural gas ferries

Further reductions would require more aggressive pricing mechanisms for roads and parking, large costs for the purchase of more efficient planes and ferries, or measures to restrict travel, particularly air travel.

[1] The transit pass measure generates a large net benefit of $941 per tonne; excluding this from the total, the remaining measures produce reductions of 3.5 Mt at a net benefit of $54 per tonne.

2. Road Infrastructure Package

ROAD: MOST PROMISING	
GHG 2010:	**5.0 Mt**
Cost per tonne:	**$2**
Range ($/tonne):	**-$278 to $14**
Financial cost/tonne:	**-$38**

- Enforce existing speed limits
- ITS
- Synchronize traffic signals

Changes in the way we build, maintain and use our roads and highways could also play a role in reducing GHG emissions from transportation. The ***most promising*** road measures focus on two areas. The first is enforcing existing speed limits, which would generate significant GHG reductions at a low cost (4.2 Mt in 2010 at $10 per tonne) and improve public safety. The second is the use of intelligent transportation systems (ITS) and synchronized traffic signals to improve traffic flow. They would not generate significant reductions in terms of the Kyoto target, but would produce net benefits as a result of time savings. However, they would require government investments of $2.4 billion over 20 years.

ROAD: PROMISING	
GHG 2010:	**1.5 Mt**
Cost per tonne:	**-$496**
Range ($/tonne):	**-$1,000 to $133**
Financial cost/tonne:	**-$4**

- High-occupancy vehicle (HOV) lanes[2]
- Expanded ITS
- More frequent road surfacing

The ***promising*** measures add two additional ITS measures to help travelers avoid congested areas. However, there is concern that ITS, by improving traffic congestion, could induce more traffic, thereby increasing emissions. More frequent resurfacing of the national highway system (moving to a 15-year cycle from a 20-year cycle) would generate energy efficiency improvements, but at a government cost of $1.8 billion over 20 years. High-occupancy vehicle (HOV) lanes could reduce emissions by almost 1 Mt, and at a significant net benefit of $1,000 per tonne. Much of this benefit is due to the time savings for users of the lanes. This measure would be enhanced when combined with actions to promote ride sharing and transit, which would benefit from dedicated lanes. However, additional work is needed to examine the feasibility of such lanes in congested urban areas and to further assess the costs to government of $1.5 billion over 20 years.

Further reductions, seen as more difficult, involve road pricing systems, changing pavements from asphalt to concrete, and reducing speed limits to 90 kilometres (km) per hour.

[2] The HOV- lane measure generates a large net benefit of $1,000 per tonne; excluding this from the total, the remaining measures produce reductions of 0.6 Mt at a total cost of $68 per tonne.

3. Road Vehicles and Fuels Package

Adopting less carbon-intensive vehicles and fuels is critical to reducing GHG emissions from transportation. However, measures to improve vehicle technologies and increase the use of alternate fuels are complex and can raise significant economic issues. As a result, the Table is not proposing a group of ***most promising*** measures. Several measures have potential, but would require further development and/or harmonization with the United States (U.S.).

The ***promising*** measures, combined, could generate reductions of 8.9 Mt of GHG at a cost of $64 per tonne, rising to 26 Mt by 2020. The largest reduction would come from setting a harmonized target with the U.S. to achieve a 25 per cent reduction in GHG emissions from new cars and light trucks by 2010. Due to the integrated nature of automobile manufacturing, where cars and trucks are made for a single market, this measure would require agreement with the U.S. on such a target. The cost of a Canada-only target would be double. Many of the new vehicle technologies also depend on improved fuel quality, such as lower sulphur levels in gasoline.

VEHICLES AND FUELS: PROMISING

GHG 2010:	**8.9 Mt**
Cost per tonne:	**$64**
Range ($/tonne):	**$6 to $120**
Financial cost/tonne:	**$52**

- Truck efficiency improvements
- Bus efficiency improvements
- Alternative fuel vehicle incentives for fleets, trucks and buses
- Harmonized vehicle target: 25 per cent by 2010
- Expand alternative fuel infrastructure
- Ethanol production for 10 per cent blend with gasoline

Several measures were assessed that would expand the use of alternate fuels, particularly in niche markets. Combined, the *promising* alternative fuel measures could reduce emissions by up to 3.2 Mt, at an average cost of $77 per tonne. The most cost-effective measure expands the production of ethanol for blending in gasoline at 10 per cent, focusing initially on grain ethanol and adding cellulose-based ethanol as the technology becomes commercialized. Other measures would expand the infrastructure for alternative fuels, such as propane and natural gas, in the three largest cities. and would increase their use in niche markets by mandating targets for government fleets, adopting voluntary targets for industry, and promoting their use in buses and heavy-duty trucks.

More difficult measures include purchase incentives for fuel-efficient cars and “feebates”. Feebates offer rebates for more fuel efficient vehicles and levy extra charges on less fuel-efficient models. Further work is needed, as there is no actual experience with feebates at the proposed level and scale by which to judge their effectiveness.

4. Freight Package

The ***most promising*** freight measures represent cost-effective, voluntary efforts, such as codes of practice and improved training and operating practices for truck drivers. Combined, they could reduce emissions by 2.0 Mt in 2010, at a cost of $6 per tonne.

FREIGHT: MOST PROMISING

GHG 2010:	**2.0 Mt**
Cost per tonne:	**$6**
Range ($/tonne):	**$6 to $9**
Financial cost/tonne:	**$6**

- Truck driver training
- Codes of practice, marine

A range of ***promising*** measures could generate reductions of 7.0 Mt at a net benefit of $3 per tonne of GHG. In trucking, these include load matching to reduce empty or partial trips, the use of new technologies such as improved lubricants, scrappage programs to remove older, inefficient trucks from the road, reducing speed limits to 90 kilometres per hour, and allowing longer trucks in three provinces where they are not currently permitted. Some of these measures need additional analysis to ensure that public safety is maintained and to better understand competitiveness impacts for both trucking and railways. Two measures encourage the greater use of more efficient rail cars and engines by increasing the capital cost allowance on rail.

FREIGHT: PROMISING

GHG 2010:	**7.0 Mt**
Cost per tonne:	**-$3**
Range ($/tonne):	**-$1278 to $156**
Financial cost/tonne:	**-$3**

- More efficient rail equipment (increase capital cost allowance)
- Long trucks in three provinces[3]
- Truck scrappage
- Truck lubricants
- Limit truck speeds to 90 km/hr
- Truck load matching

More difficult options include the use of alternative fuels and fuel cells for railways, which would be difficult to introduce for the Kyoto time-period, and additional truck technology measures, which have higher costs. Opportunities to shift freight from truck to rail or marine in the five corridors studied generated small GHG reductions at considerable cost. Electric railways and accelerated ship replacements also proved to be costly options.

[3] The two long-truck measures generate a large net benefit of $1,110 and $1,278 per tonne; excluding these from the total, the remaining measures produce reductions of 6.9 Mt at a total cost of $6 per tonne.

5. Off-Road Package

OFF-ROAD: PROMISING	
GHG 2010:	**4.3 Mt**
Cost per tonne:	**n/a**

- Fuel-efficiency standards
- Public awareness campaign
- Voluntary program with manufacturers

Off-road sources account for 13 per cent of transportation GHG emissions. The Table was not able to identify any ***most promising*** measures, as very little is known about this extremely diverse mix of equipment, which includes forestry, mining, agricultural, construction, lawn and garden equipment, fishing boats and recreational vehicles, such as snowmobiles. The Table identified three possible measures as ***promising*** that could achieve reductions of up to 4 Mt from recreational vehicles (snowmobiles and personal water craft) and some construction, mining and agricultural equipment. However, these estimates are preliminary, and it was not possible to estimate their cost-effectiveness.

6. Fuel Taxes

A number of the measures studied by the Table include the use of market mechanisms such as prices and fees—including parking charges, road pricing and fuel taxes. Prices play a role in determining the overall demand for transportation, the development and take-up of new more efficient technologies, and the choice of transportation services. Charges and fees could be used to better reflect the full cost of different transportation services, thereby ensuring their most efficient use.

The Table analyzed several models of fuel taxes, but did not reach a consensus on using fuel taxes as a measure to reduce greenhouse gas emissions (the different views are summarized in the accompanying chart). The analysis indicated that fuel taxes could be used as a single, stand-alone measure to achieve the Kyoto target if the level is set high enough (fuel prices would have to more than double). Higher fuel prices create an incentive for producers and consumers to take many of the actions stimulated by the other measures described in this report. However, the tax levels required turn out to be very high: unacceptably so in the Table's view. The magnitude of the fuel tax required, if it were the only measure used to reach the Kyoto target in transportation, illustrates the value that Canadians place on the convenience, necessity and pleasure of transportation, and indicates that the incentives required to induce them to reduce transportation activity could be complex and costly. This finding may be at odds with some of the lower costs estimated for specific measures.

RATIONALE FOR FUEL TAX

- Real gas prices are at late 1970s levels, limiting significant use of alternative fuels.
- No economic incentive for consumers; fuel efficiency is a low priority for vehicles.
- Prices reinforce technology. No price signal means little take up; manufacturers won't produce.
- Sustained higher prices reduce travel distance and promote shifts to other modes.
- Supports a move to full-cost pricing and targets GHG emissions.
- Source of funding for transit, incentives, or more efficient infrastructure.

CONCERNS ABOUT FUEL TAX

- Diesel taxes would cause competitiveness issues for trucking.
- Response based on elasticity assumptions. Some feel overly optimistic at lower levels.
- Impacts on transportation costs throughout the economy and on competitiveness with U.S.
- Impacts on tourism.
- Equity issues. Rural areas have fewer options. Harder on lower income earners.
- Cross-border shopping if price difference is too large.
- Lack of public support unless dedicated to improvements in transportation

Some Table members believe that fuel taxes, at substantially lower levels, are a necessary complement to other measures aimed at reducing distances travelled or introducing more efficient vehicle technologies or alternative fuels. The use of more moderate fuel taxes as a means of funding improvements in transportation, particularly in urban areas as a source of funding for transit, generated the most, but not unanimous, support. In particular, the Table's discussions focused largely on two options:

- an additional 1 cent per litre per year for 10 years (total of 10 cents per litre by 2010), which is estimated to generate GHG reductions of about 7.5 Mt; and,

- an urban gas tax of 4 cents per litre (1 cent per litre per year for 4 years) which is estimated to produce GHG reductions of about 1.4 Mt.

Some Table members support the U.S. approach, whereby revenues from gasoline taxes are collected in a trust fund that funds transportation improvements (TEA-21; see Appendix 6). Others expressed interest in the practice of a local or provincial fuel tax being used to fund municipal transportation, as is now done in Montreal, Vancouver and Victoria. In this case, municipalities receive some or all of the revenue, thereby providing a much-needed source of funding for investments in urban transportation, including roads and transit. For example, the Table's transit measures would require government funding of $5.5 billion over 20 years, and the 4-cents-per-litre urban gas tax would generate $4.4-5 billion.

CONCLUSIONS AND RECOMMENDATIONS

As an input to the production process of almost every sector of the economy, an efficient transportation system is critical for Canada's competitiveness, trade and tourism. The transportation sector itself is a significant employer and contributor to Canada's economy and exports. Transportation also plays a key role in Canadians' quality of life, as people make billions of trips each year for work, recreation, medical care, and personal and family reasons.

At the same time, transportation is the single largest source of GHG in Canada, accounting for 25 per cent of the total in 1997. GHG emissions from transportation are expected to exceed 1990 levels by 32 per cent in 2010 and 53 per cent by 2020, if current growth patterns continue. For many countries, transportation is a large and growing source of GHG emissions, and one of the most complex sectors to address.

There is no single approach that will meet the Kyoto target. Technology has great potential, but technology alone will not meet the time frames of the Kyoto commitment. A balanced GHG strategy for transportation will have to address the various parts of Canada's transportation system, including vehicles, fuels, infrastructure and carriers, and will have to deal with consumer behaviour.

The Table has identified a range of ***most promising*** measures that are cost-effective, easier or would likely meet with public support. This set of measures could generate 10.8 Mt of GHG reductions in 2010, at a net benefit of $32 per tonne. This represents about 20 per cent of the Kyoto target in transportation. The cost to governments would be $3.5 billion over 20 years. These measures may still require further work before implementation.

MOST PROMISING MEASURES[4]			
	GHG Reduction (Mt)		
Measures Package	**2010**	**2020**	**Cost/tonne**
Passenger	3.7	4.3	-$100
Road infrastructure	5.0	5.8	$2
Road vehicles and fuels	0	0	-
Freight	2.0	2.3	$6
Off-road	0	0	-
TOTAL MOST PROMISING	**10.8**	**12.4**	**-$32**

A second category of ***promising*** measures have potential and could reduce emissions by a further 32 Mt in 2010, at a net cost of $5 per tonne. These measures move beyond strict voluntary measures, relying on financial incentives, infrastructure improvements and targets to encourage new technologies, improve energy and transportation efficiency, and change practices and behaviour. However, these measures may require significant government or private-sector investment or additional analysis, design, consultation or international discussions before implementation.

[4] As noted earlier, if the large net benefit of the transit pass measure is excluded, the remaining *most promising measures* produce reductions of 10.6 Mt at a total cost of -$16 per tonne and a financial cost of -$35 per tonne.

PROMISING MEASURES[5]			
	GHG Reduction (Mt)		
Measures Package	**2010**	**2020**	**Cost/tonne**
Passenger	10.1	11.4	$49
Road infrastructure	1.5	2.1	-$496
Road vehicles and fuels	8.9	26.3	$64
Freight	7.0	8.1	-$3
Off-road	4.3	n/a	n/a
TOTAL PROMISING	**31.8**	**47.9**	**$5**

To further reduce emissions in transportation, ***less promising*** measures have been identified that are more difficult and expensive, and generally involve restricting activity or introducing pricing mechanisms, such as road and parking pricing. The Table did not reach agreement on the use of fuel taxes as a possible measure. Some view fuel taxes as a complement to other measures, while others have concerns about the economic and social impacts of higher fuel prices. The use of fuel tax revenues as a means of funding improvements in transportation, particularly for transit in urban centres, generated the most, but not unanimous, support.

The work of the Table represents a comprehensive but initial look at the potential for reducing GHG emissions from transportation in Canada. Whereas previous climate change analyses focused on specific elements of transportation, this is the first time that a holistic analysis has been undertaken to analyze the costs and benefits of options across the entire transportation system. However, the Table's analysis covered a large and complex area of study in a relatively short period of time. Thus, this report is not intended to provide a prescription for implementing different measures. This may require more detailed analysis, design and consultation, including analysis by individual jurisdictions.

Rather, the report is intended to identify the costs and benefits of different options, highlight areas of potential, and identify issues and concerns to be addressed. It represents an important but initial step. Further work will be needed in the following areas:

1. ***Data Issues***
   The Table identified a number of areas where the data on transportation is limited. Given that climate change is a long-term issue, it is recommended that a national strategy be implemented to improve the quality of transportation data in Canada.

2. ***Analytical Issues***
   The Table has identified a number of areas where additional analytical work is needed as a result of its work. These include:

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[5] As noted earlier, if the large net benefit of the HOV lanes and the long-truck measures are excluded, the remaining *promising measures* produce reductions of 30.8 Mt at a total and financial cost of $44 per tonne.

i) **Gaps in the Table's studies**: Due to budget and time constraints, a number of areas were not adequately reviewed by the Table and require additional analysis, such as the regional impacts of the proposed transportation measures and further work on intercity rail and bus transportation. Further, the Table's work provides an initial but only qualitative assessment of some of the key competitiveness concerns, which require more quantitative analysis.

ii) **Measures**: The Table has highlighted a number of measures, particularly in the *most promising* and *promising* categories, that have potential for cost-effective GHG reductions, but require additional analysis, design and consultations. Active follow-up work on these measures is needed.

3. ***Mechanisms for Taking Action***

New practices and analytical tools are needed to incorporate GHG considerations into transportation policies, programs, plans and infrastructure investments. A number of Table members believe that Canada would benefit from a national mechanism similar to the U.S. Transportation Equity Act for the 21st Century (TEA-21-See Appendix 6) that would enable it to move forward on transportation issues such as climate change.

TRANSPORTATION AND CLIMATE CHANGE:
OPTIONS FOR ACTION

I. INTRODUCTION

In December 1997, Canada, along with other developed countries, negotiated the Kyoto Protocol under the United Nations Framework Convention on Climate Change. If the Protocol were ratified, Canada would agree to reduce its emissions of greenhouse gases (GHGs) by six per cent over 1990 levels during the five-year period from 2008 to 2012.

Shortly after the Kyoto meeting, the Prime Minister and First Ministers tasked the federal, provincial and territorial ministers of energy and environment with leading a national process to develop a climate change strategy. They established a series of 15 issue tables to engage stakeholders in analyzing options for reducing GHG emissions.

In May 1998, the federal, provincial and territorial ministers of transportation established the Transportation Climate Change Table as part of the national process. Transportation is the single largest source of GHG in Canada, accounting for 25 per cent of the total in 1997. GHG emissions from transportation are expected to exceed 1990 levels by 32 per cent by 2010 and 53 per cent by 2020, if current growth patterns continue.[6]

Specifically, the mandate of the Table was:[7]

- to identify and analyze a range of potential measures to reduce GHG emissions from transportation. The analysis of these measures was to include their GHG impacts during the Kyoto budget period of 2008-2012 and beyond to 2020, as well as their costs and benefits; and,

- to build an incremental package of measures that achieve progressively greater reductions within transportation until reaching or, if possible, going beyond a six per cent reduction from 1990 levels. This package would begin with easier and cheaper options and move on to more difficult and expensive measures.

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[6] These figures differ from those used in the Table's *Foundation Paper on Climate Change—Transportation Sector*, December 1998. They reflect new 1997 data from a July 1999 unpublished update of *the Energy Outlook 2020* by Natural Resources Canada.

[7] Mandate of the Transportation Climate Change Table. Council of Ministers Responsible for Transportation and Highway Safety. July 1998.

It is recognized that the national climate change strategy may or may not require Canada to reach the Kyoto target in the transportation sector. The opportunities, costs and benefits of different actions will be assessed across different sectors of the economy.

The Transportation Table was mandated to address all aspects of Canada's transportation system, including all freight modes (road, rail, marine, air), transportation fuels, passenger transport (intercity and urban), vehicles and equipment, infrastructure, inter-modal transportation, and transportation demand management.

Under the Kyoto Protocol, emissions from international transportation are the responsibility of international organisations–namely the International Civil Aviation Organization for aviation and the International Marine Organization for shipping—and were therefore not addressed by the Table.

Emissions from pipelines, the manufacturing of transportation equipment, and refineries were assigned to the Industry Table; issues related to urban land-use and design were to be addressed by the Municipalities Table; and public awareness was left to the Public Education and Outreach Table. Emissions from energy consumed in off-road uses, such as agricultural, construction, mining, recreational, and lawn-and-garden equipment, are included in the Transportation Table's work.

The Transportation Table comprised 25 members drawn from across the sector, including federal, provincial and municipal governments, industries, shippers, consumers, and environmental and non-government organizations.

The Table created four subgroups—Consultations, Road Vehicle Technology and Fuels, Freight Transportation, and Passenger Transportation—to engage additional stakeholders and undertake the analysis required. The Freight and Passenger subgroups were further sub-divided into modal groups in the case of Freight (rail, air, marine and trucking), and intercity and urban groups for Passenger. A list of Table and subgroup members is included in Appendix 1.

In December 1998, the Table produced a background paper entitled *Foundation Paper on Climate Change—Transportation Sector*. It provides an overview of transportation emissions, a summary of existing transportation climate change initiatives in Canada and other countries, and existing analyses of various options to reduce emissions.

The Table's subgroups commissioned a number of studies to identify and analyze potential measures to reduce GHG emissions, the results of which were reviewed by the Transportation Table as a whole. In all, 24 analytical studies were completed by the Transportation Table (a complete list is included in Appendix 2).

This report represents the Table's Options Paper. Its purpose is to summarize the analysis undertaken, and to present options to reduce GHG emissions from the transportation sector. The Table recognizes the challenge posed by its mandate. This is the first time that such a holistic analysis has been undertaken to analyze and cost options for GHG reductions across the entire transportation sector in Canada or elsewhere. This report presents an important step forward, but identifies a number of areas where further work is needed.

Section II briefly describes the transportation sector and summarizes the sources and trends of GHG emissions (please refer to the Table's Foundation Paper for more information). Section III provides an overview of the broad approaches to reducing emissions and some key considerations for decision makers in understanding the complex challenges in transportation.

Section IV is more technical, and summarizes the analysis of all of the specific measures, studied by the Table, including their GHG reductions and cost per tonne of emissions reduced (additional detail can be found in the various studies listed in Appendix 2). The core of the report is Section V entitled "The Options for Transportation." This section assesses the measures and provides a framework for grouping measures into synergistic packages. Section VI summarizes the results of the Table's deliberations and provides recommendations for further work.

II. TRANSPORTATION AND CLIMATE CHANGE

2.1 THE TRANSPORTATION SECTOR

In a country as vast as Canada, transportation has an impact on every aspect of life and business. Every piece of raw material and every finished good moves through the transportation system, often by more than one mode. People make billions of trips each year travelling for work, recreation, medical care and many other diverse reasons.

Transportation accounted for $27.8 billion of Canada's Gross Domestic Product (3.9 per cent of total GDP of $718 billion) in 1998.[8] As the Table's foundation paper suggests, a value of $135.2 billion might be more indicative of the extent of the sector's economic activity.[9]

Table 2.1
Economic Importance of Transportation, 1998[10]

Sector	GDP ($billion)	Employment (000)
Air	$4.3	110.2
Marine	$1.9	29.0
Rail	$4.0	45.9
Road	$11.0	369.7
Bus, urban transit and other	$6.6	176.7
Total	$27.8	731.5

Transportation plays a vital role in maintaining Canada's position as a trading nation. With the signing of the North American Free Trade Agreement (NAFTA), trade with the U.S. has grown considerably. Canada and the U.S. exchange nearly $1.5 billion per day in goods and services (Chart 2.1).[11] All of this trade moves over some part of Canada's transportation system, making north-south transportation links increasingly important.

Transportation is also fundamental to Canada's tourism industry. In 1997, tourism spending reached $44 billion, 70 per cent of which was spent by Canadians themselves and 30 per cent by visitors. Transportation accounted for 40 per cent of all tourism

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8 Transport Canada. *Transportation in Canada 1998: Annual Report*. 1999.

9 A full derivation of this calculation is included in Appendix C in *Foundation Paper on Climate Change—Transportation Sector*. Transportation Climate Change Table. December 1998.

10 Transport Canada. *Transportation in Canada 1998: Annual Report*. TP 13198E. 1999. GDP figures from Table 2-1, employment figures from Table 8-1. Bus/urban transit/other includes local services, government employment. The economic contribution in the road mode is entirely from trucking.

11 Department of Foreign Affairs and International Trade. *The NAFTA at Five Years: a partnership at work*. April 1999.

expenditures, or $17.6 billion, of which 55 per cent went toward air travel, followed by road travel at 37 per cent, with the balance toward rail, bus, taxis, etc.

Chart 2.1
Canada's Trade with the USA

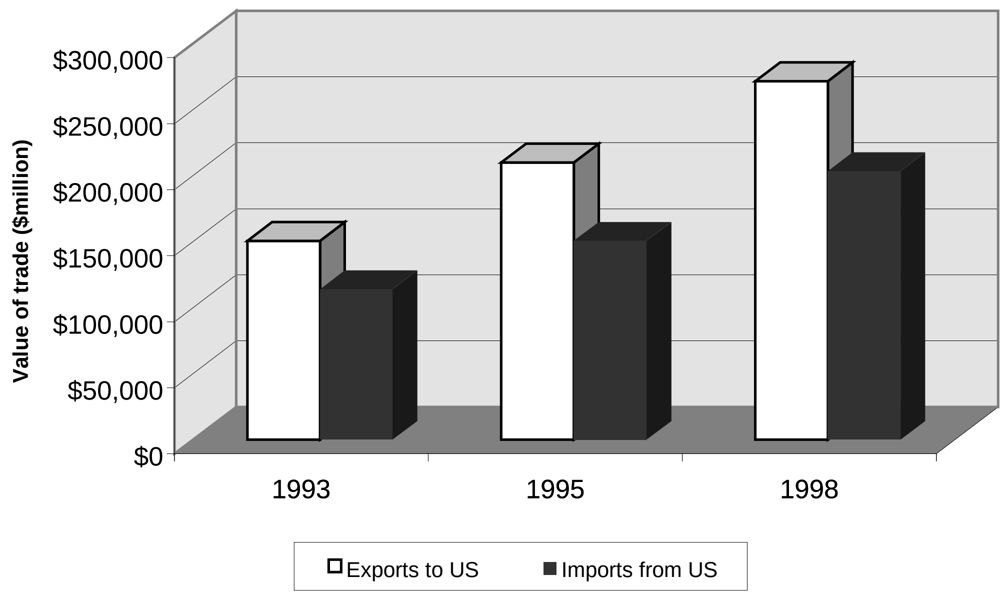


Table 2.2
Canada's Transportation Infrastructure[12]

Physical Infrastructure
1800 aerodromes/airports, including 83 flight service stations 44 air traffic control towers 7 control centres
901 903 kilometres (km) of road, including 24 239 km in the National Highway System 15 080 km operated by the federal government 229 486 km operated by provincial governments 655 892 km operated by municipal governments
18 gasoline refineries
16 000 service stations, including 13 300 gasoline and/or diesel stations 3000 vehicle refuelling appliances (VRA) 1500 propane stations 975 E10 fuel stations 200 natural gas stations 3 methanol fuel stations 1 E85 fuel station

[12] Transport Canada. *Transportation in Canada 1998: Annual Report*. 1999, plus Table research.

Canada has a well-developed transportation system (Tables 2.2 and 2.3), representing a large investment in existing infrastructure, vehicles and fuel distribution networks. New technologies that could reduce GHG emissions may require new infrastructure. This presents an additional hurdle for technologies that can not utilise the existing infrastructure built during the last century .

Table 2.3
Transportation Vehicles and Operators[13]

Mode	Vehicles	Operators
Air	27 988 fixed wing aircraft, including 21 577 private aircraft 6132 commercial aircraft 279 state aircraft 1689 helicopters 1400 electronic navigation aids	27 891 private pilots 9274 commercial pilots 10 629 passenger pilots 3769 helicopter pilots
Marine	174 merchant vessels 239 tugs and offshore supply vessels	
Rail	3259 locomotives 112 000 freight cars 428 passenger cars	
Road	11 900 000 cars (gasoline) 3 950 000 light trucks (gas) 150 000 heavy-duty vehicles (gas) 348 000 motorcycles 120 000 cars (diesel) 91 000 light trucks (diesel) 373 000 heavy-duty trucks (diesel) 254 000 alternative fuel vehicles	19 744 000 licensed drivers

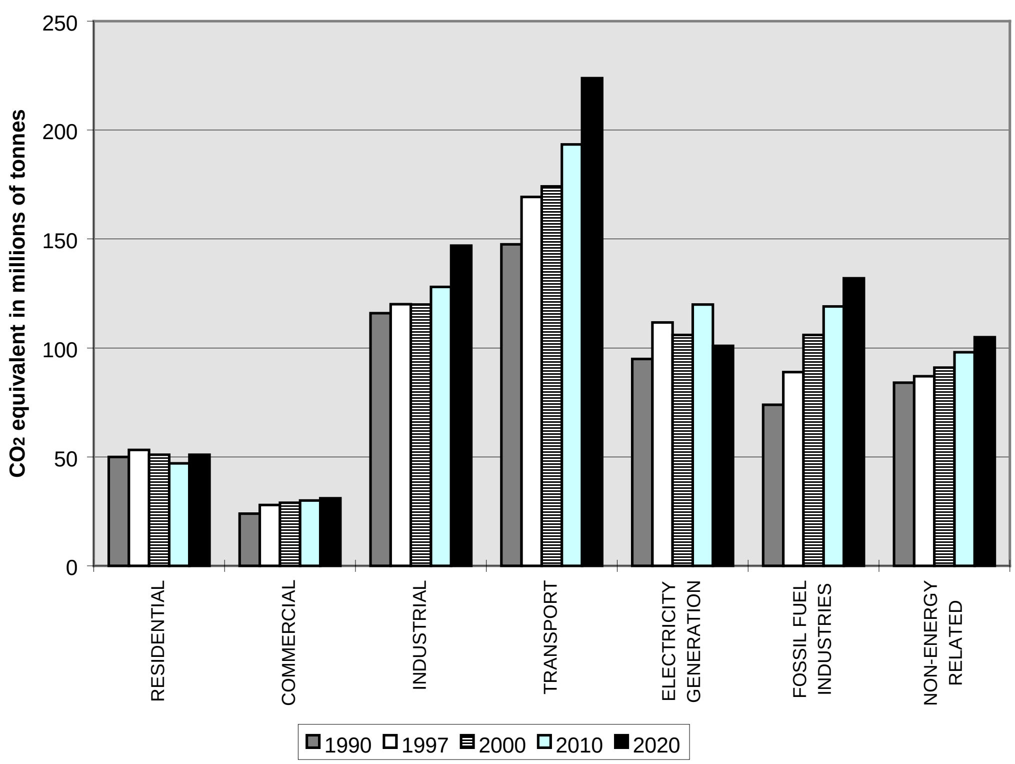
13 Data drawn from various sources, including Transport Canada Civil Aircraft Register (accessed via the Internet), May 1999, for aircraft population and licensed pilots; Transport Canada. *Transportation in Canada 1998: Annual Report*. 1999, for marine and rail vehicles; NRCan. Energy Outlook 1990 – 2020. April 1997 and Transportation Climate Change Table *Foundation Paper* for road statistics. The numbers are drawn from various years between 1995 and 1999, and so aren't strictly comparable, but show relative size.

2.2 CLIMATE CHANGE: CHALLENGES AND TRENDS

2.2.1 The Challenge of Climate Change

The Kyoto Protocol seeks to limit the growth of GHG emissions from human activity. Most of these gases occur naturally in the atmosphere. Their heat-trapping properties, known as the greenhouse effect, trap the sun's heat near the earth's surface and keep the planet warm. The main gases are water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and halocarbons (CFCs, HFCs). Different gases have different impacts; however, in this paper all emissions are converted to CO_2 equivalents. Most scientists agree that if humans continue to add GHGs to the atmosphere through the burning of fossil fuels and clearing of forests, the greenhouse effect will be enhanced, causing temperatures to rise.

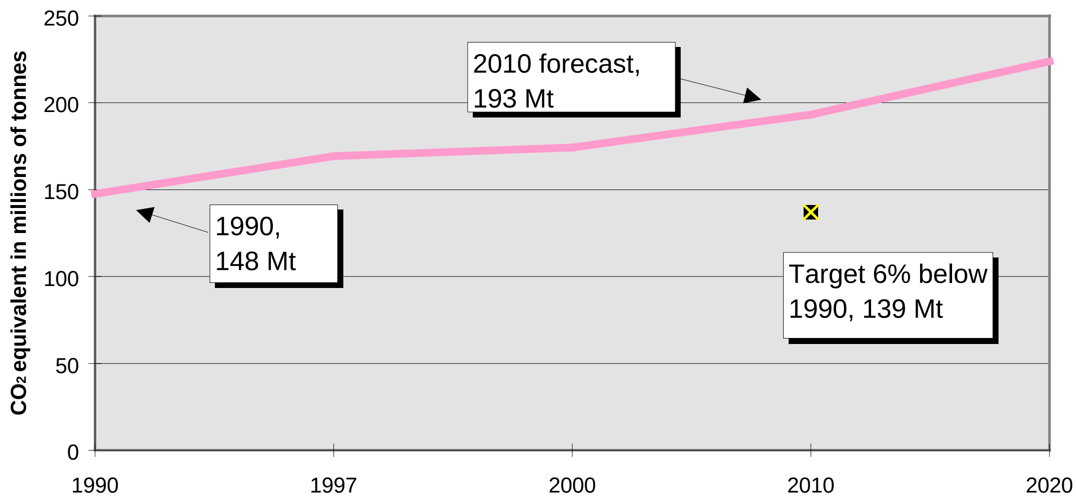
Chart 2.2
Canada's Greenhouse Gas Emissions



The Kyoto target for Canada is to reduce GHG emissions by six per cent over 1990 levels, averaged from 2008 to 2012 (this report uses 2010 as the horizon year, but has analyzed costs and impacts to 2020). Based on population and economic growth forecasts to 2010, this would require Canada to reduce its total GHG emissions by 20-25 per cent. Transportation is the single largest source of Canada's GHG emissions. In 1997, transportation accounted for about 25 per cent of Canada's total emissions (Chart 2.2)[14], virtually all of which resulted from the burning of fossil fuels.

Current forecasts are that, in the absence of any new policies or pricing changes, transportation GHG emissions in 2010 will increase to 193.0 megatonnes (Mt) compared to 146 Mt in 1990.[15] Targets have not been allocated for each sector of the economy. However, to reach 6 per cent below 1990 levels in transportation, GHG emissions would have to be reduced by 28 per cent (about 54 Mt) by 2010 from the 'business as usual' case (Chart 2.3).[16]

Chart 2.3
Kyoto Protocol Implications Transport Sector GHG Emission Projections, 1990-2020



The sources of transportation emissions are presented in Chart 2.4.[17] Road transport accounts for roughly 70 per cent of transportation GHG emissions, with 45 per cent from cars and light-duty trucks and 27 per cent from heavy duty commercial vehicles (primarily trucks). The next largest single source is off-road use, which includes a mixture of industrial equipment (agriculture, forestry, mining and construction), recreational vehicles, boats, and lawn-and-garden equipment.

The three sources of emissions expected to grow most quickly between 1990 and 2020 are aviation by Canadian carriers (forecast to increase by 99 per cent), off-road uses (diesel by 66 per cent and gasoline by 57 per cent) and on-road diesel (74 per cent). The largest source of transportation emissions—on-road gasoline—is expected to increase by 44 per cent between 1990 and 2020.

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14 Adapted by Transport Canada, Economic Analysis Directorate from unpublished update of *Canada's Energy Outlook: 1996 – 2020*. July 1999. Natural Resources Canada.

15 Ibid.

16 Ibid.

17 Ibid.

Chart 2.4
Source of Transportation GHG Emissions, 1997

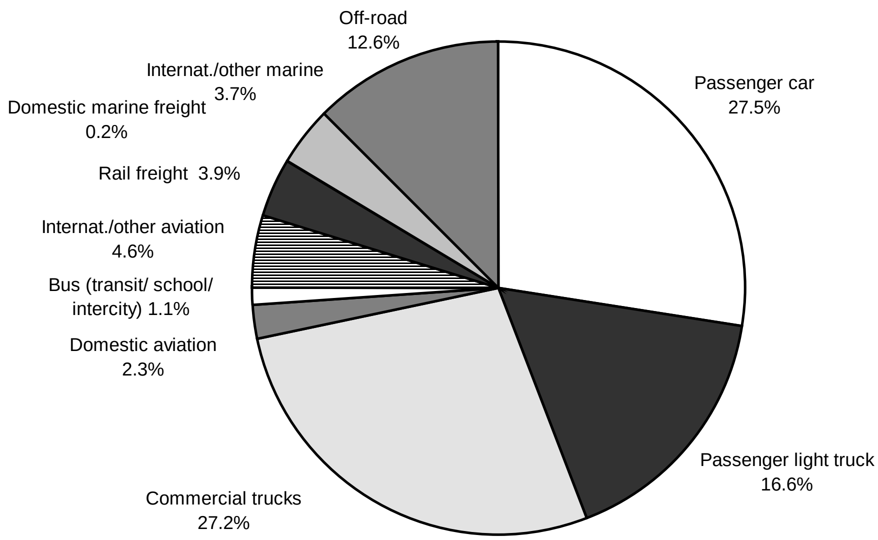


Table 2.4
Growth in Transportation GHG Emissions, 1990-2020[18]
(CO_2 equivalent in millions of tonnes)

Source of GHG emissions by fuel use	1990	1997	2010	2020	Total change (%)	Annual change 1990-2020	Annual change 1997-2020
Road gasoline, on network	80.1	87.0	99.7	115.2	43.81	1.22%	1.23%
Road gasoline, off network	4.0	4.6	5.6	6.5	56.69	1.57%	1.47%
Road diesel, on network	25.7	35.7	39.4	44.7	73.75	1.86%	0.97%
Road diesel, off network*	12.2	14.2	16.0	20.2	65.98	1.70%	1.53%
Road alternate fuels	1.7	2.0	0.9	1.4	-14.56	-0.52%	-1.51%
Subtotal, road transport	**123.7**	**143.6**	**161.6**	**188.0**	**51.94**	**1.40%**	**1.18%**
Rail	7.1	6.4	7.1	7.4	3.60	0.12%	0.62%
Aviation (Canadian carriers)	10.6	13.0	17.6	21.1	99.03	2.32%	2.13%
Marine	6.2	6.3	7.1	7.4	20.99	0.64%	0.76%
Total, transport sector	**147.5**	**169.2**	**193.3**	**223.8**	**51.71**	**1.40%**	**1.22%**

* in 2010 excludes 3 Mt increase from oil and gas production

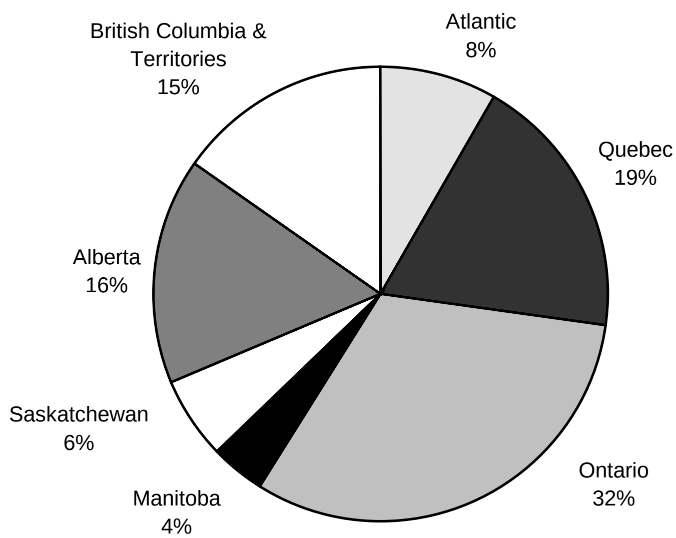
[18] Adapted by Transport Canada, Economic Analysis Directorate from unpublished update of *Canada's Energy Outlook: 1996 – 2020*. July 1999. Natural Resources Canada.

2.2.2 Regional Differences

The contribution of transportation to GHG emissions varies considerably across the country (Chart 2.5).[19] The proportion of GHG emissions from transportation varies from a low of 13 per cent in Alberta to a high of 41 per cent in British Columbia (BC) (Chart 2.6)[20]. This can be attributed partly to the differing structures of provincial economies, energy sources for electric power, and the prevalence of more or less GHG-intensive modes of transport. However, when population is considered, Alberta and Saskatchewan have the highest transportation emissions per capita, while Ontario and Quebec have the lowest (Chart 2.7).[21]

Overall, transportation energy demand is expected to grow by 0.66 per cent per year between 1997 and 2020. However, there are marked regional differences, with Alberta exhibiting the highest growth rate at 0.95 per cent, and Ontario next at 0.71 per cent. With the exception of the Atlantic provinces (0.68 per cent), all other regions are growing at less than the national rate (Table 2.5).[22]

Chart 2.5
Provincial Contributions to Transport GHG Emissions, 1997



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[19] Ibid.

[20] Ibid.

[21] Adapted by Transport Canada, Economic Analysis Directorate from unpublished update of *Canada's Energy Outlook: 1996 – 2020*. July 1999. Natural Resources Canada.

[22] Adapted by Transport Canada, Economic Analysis Directorate from unpublished update of *Canada's Energy Outlook: 1996 – 2020*. July 1999. Natural Resources Canada.

Chart 2.6
Transportation's Share of Regional GHG Emissions, 1997

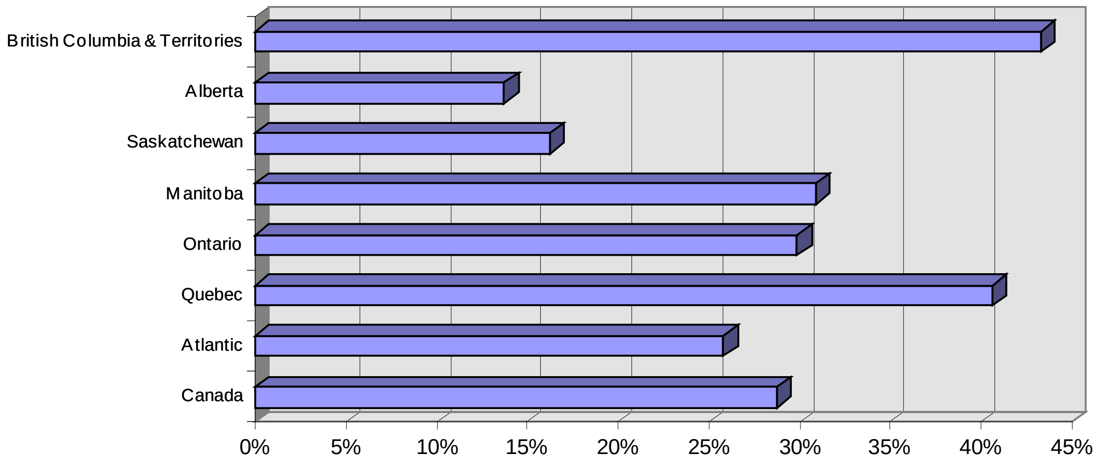


Chart 2.7
Transportation GHG Emissions Per Capita, 1997

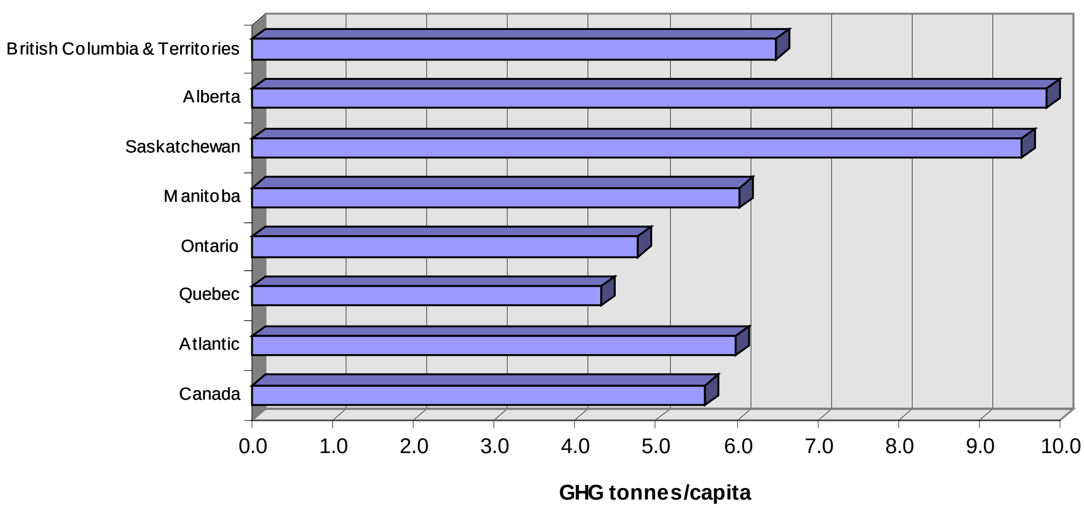


Table 2.5
Transportation Energy Demand by Region, 1997
(petajoules)

Region	1990	1997	2000	2010	2020	Annual change 1990 - 2020	Annual change 1997-2020
Atlantic	202	209	224	245	274	0.65%	0.68%
Quebec	424	450	454	500	573	0.55%	0.46%
Ontario	681	765	797	901	1058	0.94%	0.71%
Manitoba	89	93	97	106	117	0.57%	0.57%
Saskatchewan	108	132	132	144	161	0.98%	0.39%
Alberta	306	379	392	471	557	1.45%	0.95%
BC & Territories	290	374	379	426	481	1.29%	0.57%
Canada	2100	2402	2476	2794	3222	0.96%	0.66%

2.2.3 Passenger Transportation

Passenger transportation continues to grow rapidly. Total demand for travel, as measured in passenger-kilometres (one passenger travelling one kilometre) reached 542 billion in 1997, an increase of four per cent in the last two years. In terms of distance travelled, intercity travel accounts for 55 per cent of passenger travel. However, urban travel accounts for 60 per cent of the GHG emissions from passenger travel, because urban passenger travel produces twice the amount of GHG emissions per passenger-kilometre (as noted in Table 2.6).[23]

For intercity travel, air is the most GHG-intensive mode, followed by rail and auto, and then bus, which is the least GHG-intensive mode. However, air fuel-efficiency improves for longer trips. In urban areas, the automobile is the most GHG-intensive mode of transportation (Chart 2.8).[24] This reflects current technologies and operations, including current vehicle stock and load factors; it does not imply that different modes could not become more efficient.

Passenger transportation, both intercity and urban, is dominated by the private light-duty vehicle (cars, vans, and light trucks), which accounts for 87 per cent of all passenger-kilometres travelled and 92 per cent of the GHGs attributed to passenger transportation.

23 Adapted by Transport Canada, Economic Analysis Directorate from unpublished update of *Canada's Energy Outlook: 1996 – 2020*. July 1999. Natural Resources Canada.

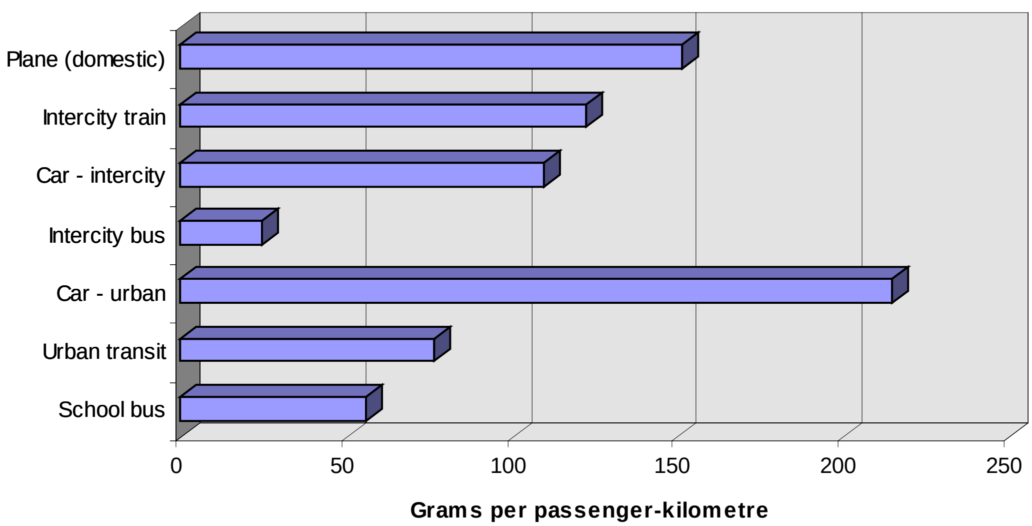
24 Ibid.

Table 2.6
Passenger Transportation Activity, Intercity and Urban, 1997

Mode		Activity		GHG emissions		GHG grams/ pass-km
		Billion pass-km	Percent	Kilotonnes	Percent	
Intercity	Car/light truck	250.2	46.2%	27 523	33.4%	110
	Bus	14.2	2.6%	364	0.4%	26
	Train	1.4	0.3%	175	0.2%	123
	Aircraft	30.5	5.6%	4562	5.5%	150
	Ferry	0.9	0.2%	531	0.6%	570*
	Subtotal	**297.3**	**54.8%**	**33 155**	**40.2%**	**112**
Urban	Car/light truck	223.0	41.1%	47 882	58.0%	215
	Transit	12.7	2.4%	978	1.2%	77
	School bus	9.1	1.7%	510	0.6%	56
	Subtotal	**244.8**	**45.2%**	**49 370**	**59.8%**	**202**
Subtotal for car/light truck		**473.2**	**87.3%**	**75 405**	**91.4%**	
Total passenger		**542.0**	**100.0%**	**82 526**	**100.0%**	**152**

* Assigns all fuel use to passengers, ignoring vehicles and freight.

Chart 2.8
GHG Emissions per Passenger-Kilometer by Mode, 1997



The challenge of reducing emissions from personal transportation is illustrated in Table 2.7. Canada is facing continued growth in the number of vehicles, and each vehicle is being driven farther. Although energy efficiency in transportation is forecast to improve by 0.7 per cent per year between 2000 and 2020, this is likely to be overwhelmed by the increased use and number of vehicles. Past improvements in vehicle fuel economy have also been eroded due to consumer preferences for vehicle performance and size, as well as regulated changes to improve air quality and safety, which add weight to the vehicle and reduce fuel efficiency.

Table 2.7
Growth in Number and Use of Light-Duty Vehicles[25]

	1990	1995	2000	2010	2020
Automobiles (millions)	11.10	10.31	9.37	9.72	12
Average distance per vehicle (kms)	16 738	18 786	19 817	19 839	19 584
Light trucks (millions)	3.45	4.34	5.16	6.81	8.61
Average distance per vehicle (kms)	23 167	22 166	22 209	21 612	21 181
Total vehicle-kms travelled (billions)	**265.72**	**289.78**	**300.20**	**339.92**	**407.86**

2.2.4 Freight Transportation

Any analysis of freight transport must consider that shippers make decisions in a complex business environment. The relative energy and GHG intensities of different modes are only a part of the picture. For example, although rail dominates in the amount of freight shipped based on tonne-kilometres (one tonne of freight being shipped one kilometre), trucking dominates on straight tonnage. Although tonne-km is a standard measurement of freight activity around the world, it does not reflect differences in the services and value of freight provided by the different modes.

Rail freight dominates in long-haul markets and in the transportation of bulk commodities such as coal, grain, iron ore and forest products. It is also a major carrier in the long-distance movement of high-value manufactured goods such as international containers, automobiles and auto parts. Trucks, buses and aircraft tend to carry high-value items across a wide range of product types, particularly when speed is a critical factor. Three other points worth mentioning are that:

- not all businesses have access to rail, although most have access to roads that will support heavy truck traffic;
- trucks offer speed and flexibility of service that many businesses have built into their competitive strategies (e.g. just-in-time inventory control) or require for the transport of perishable goods; and,
- a substantial portion of truck traffic (by some estimates 50 per cent) is in private trucking (i.e. the shipper owns his/her own fleet of vehicles).

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25 Natural Resources Canada, Transportation Energy “Champagne” model and unpublished update of *Canada’s Energy Outlook: 1996-2020*. April 1997. Natural Resources Canada. Automobiles in this table are gasoline and diesel powered. Gasoline trucks are assumed to be primarily personal use vehicles, i.e. vans and sport utilities.

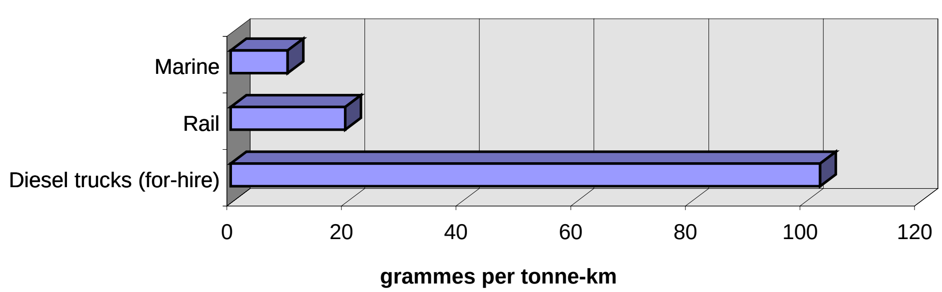
With these caveats in mind, in 1995 rail accounted for 56 per cent of tonne-kms of freight shipments and consumed 14 per cent of the energy used in freight transport. Trucking was the next largest, accounting for 36 per cent of tonne-kms and 82 per cent of the energy consumed in freight transport.

Table 2.8
Freight Transport Activity by Mode[26]
(million tonne-kms)

	1990	1995	2010	2020	Total Change 1990-2020
Truck	149 000.0	180 000.0	240 000.0	289 000.0	94%
Air	544.5	584.8	859.5	1111.0	104%
Rail	250 100.0	282 400.0	342 800.0	390 000.0	56%
Marine	50 900.0	42 500.0	42 500.0	42 500.0	-16.5%
Total	**450 544.5**	**505 484.8**	**626 159.5**	**722 611.0**	**60%**

The trends in freight pose a significant challenge in reducing GHG emissions. Freight movement, as measured in tonne-kilometres, is expected to increase by 60 per cent between 1990 and 2020, with the greatest growth in the air and trucking sectors, followed by rail. The marine sector is expected to remain stable from 1990 levels (Table 2.8). The two areas of most rapid growth, air and trucking, are also the two most GHG-intensive modes when measured on a tonne-km basis (Chart 2.9).[27] For example, while both rail and trucking will grow by about 110 million tonne-kms between 1995 and 2020, GHG emissions are expected to increase by 0.2 megatonnes for rail compared to 13.6 megatonnes for trucking.[28]

Chart 2.9
GHG Freight Emissions per Tonne-Kilometer by Mode, 1997



[26] Delcan Corp. with AK Socio-Technical Consultants. *Assessment of Freight Forecasts and Greenhouse Gas Emissions*. June 1999.

[27] Transportation Climate Change Table. *Foundation Paper on Climate Change – Transportation Sector*. December 1998.

[28] Assessment of Freight Forecasts and Emissions. Delcan Inc. Transportation Climate Change Table. July 1999.

III. CHALLENGES IN TRANSPORTATION

For almost all the industrialized nations that signed the Kyoto Protocol, transportation is a large and growing source of GHG emissions. It is also one of the more complex and challenging sectors to address. As noted in Section 2, the trend in Canada is one of continued growth in the number of people and volume of goods being moved, generally driven by increases in population, growth in the economy, and higher incomes. This section outlines four basic approaches for reducing emissions from transportation and highlights some key considerations that are important in assessing different options.

3.1 GENERAL APPROACHES TO REDUCING EMISSIONS

There are four basic ways to reduce emissions in transportation. Each one poses its own combination of economic, technological, social and political challenges. Essentially, the measures studied by the Table attempt to influence one or more of the four factors that determine GHG emission levels.

1. Level of Transport Activity
Since the level of GHG emissions is determined by the amount of transportation, one approach to reducing emissions is to limit the growth of transport activity. This could be achieved by raising prices, limiting the expansion of infrastructure, or through efforts to reduce people’s use of transportation. The Table studied a full range of options, but gave a general preference to those that would not restrict people’s mobility or the flow of goods in the economy.

2. Transportation System Efficiency
Emissions could be reduced by making the overall transportation system more efficient. This includes, for example, efforts to reduce congestion or integrate different modes, resulting in less energy consumed for the same amount of activity. Greater efficiencies could be achieved by shifting traffic to less energy-intensive modes of transportation, such as shifting urban commuters to public transit. These options pose a challenge in that they can be perceived as going against current economic trends or consumer travel preferences.

3. Energy Efficiency Within Each Mode
Reducing the energy intensity of different modes of transportation—that is, using less energy for the same activity—is another means by which to reduce emissions. This would require significant technological change, such as introducing new technologies to make vehicles more fuel efficient, or changing operating practices, such as reduced engine idling or reducing empty or partial loads in trucking.

4. Carbon Content of Fuels
The final approach to reducing emissions would be to reduce the GHG content of the fuels themselves. However, shifting to less carbon-intensive fuels could pose significant technological and economic challenges, depending on the fuel. Some alternative fuels, such as natural gas, propane and ethanol blends, are in limited use now. Others, such as ethanol made from biomass, will require new production technologies, changes in vehicles and engines, and new fuelling infrastructures.

3.2 KEY CHALLENGES IN TRANSPORTATION

Reducing GHG emissions from transportation represents a considerable challenge. However, given the size of and growth in emissions, it will be hard to ignore transportation if Canada is to meet its Kyoto commitments. In assessing various options, there are a number of important considerations that need to be stressed to decision makers.

Transportation Affects Our Quality of Life
Transportation directly affects people lives, from where they live to how they travel to work and enjoy recreation. Transportation assumes immense social importance in reducing isolation and providing access to health care, education, and other government services. It is a key element of a country's standard of living.

Choices with respect to land use, urban design, roads, and public transportation have a profound effect on urban communities and how well they function. In rural areas, transportation issues are different, but no less important. Distances to services are greater and there are fewer alternatives to the private automobile. Understanding how various options affect rural and urban communities differently is an important consideration in assessing climate change options.

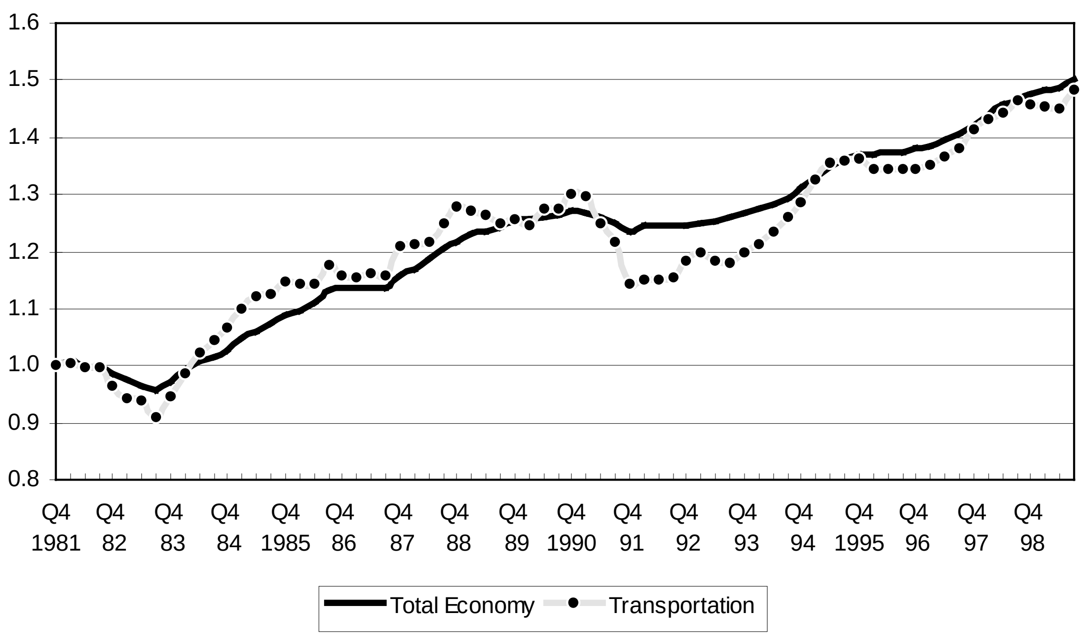
Changes to transportation require the participation of the public. Informing members of the public is not enough—they must be engaged and understand the issues and changes they are being asked to make. At present, the public's understanding of climate change and the impacts of their energy use is low. Transportation must be a key component of any public information strategy, and is currently being analyzed by the Public Education and Outreach Table.

To change public behaviour, it is critical that the public associate these changes with other benefits. In cases where transportation behaviour has been modified, the changes have been driven by benefits such as convenience or cost avoidance, and not just reduced fuel use. Other environmental benefits, such as reducing smog or congestion, will be important to encourage consumer action, and should be highlighted in awareness programs. Further, it is likely that the types of behavioural changes sought will not be achieved solely as a result of a general awareness campaign; targeted awareness efforts need to be integrated into the measure itself.

A Derived Demand

Transportation is a derived demand—as the economy grows, so too does the demand for transportation (Chart 3.1).[29] Because the sector is almost totally fossil-fuel based, GHG emissions rise accordingly. Canada's economy is forecast to grow at a rate of about 2.2 per cent per year between 1995 and 2010, and the population is expected to increase over the same time frame from 29.6 to 33.8 million.[30] In other words, by 2000, Canada's economy will be 12 per cent larger than it was in 1995, and 70 per cent larger by 2020. Reducing GHG emissions from transportation therefore requires breaking the traditional link between growth in the demand for transportation and GHG emissions.

Chart 3.1
Transportation and Economic Activity
Seasonally Adjusted Quarterly GDP, 1981 - 1988
(Index, 1Q/1981=100)



In and of its own right, transportation is also an important economic activity and generator of investment and employment. In 1996, spending from all sources on transportation added up to $135.2 billion—almost 17 per cent of total domestic demand.[31] Direct employment in transportation services exceeded 730 000 in 1998 (almost five per cent of Canada's total labour force of 15 million). Adding such industries as highway

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29 Transport Canada. *Transportation in Canada: 1998 Annual Report.* 1999.

30 Natural Resources Canada. *Canada's Energy Outlook 1996-2020.* April 1997.

31 Transportation Climate Change Table. *Foundation Paper on Climate Change—Transportation Sector.* December 1998. Transportation services comprise intermediate inputs in the production of goods and services, rather than economic outputs in the traditional economist's calculation of Gross Domestic Product. Determining the total value of transportation services in the economy is not a simple task, and Appendix C of the Foundation Paper describes this analytical process in depth.

construction, fuel marketing, and the manufacture, sale and service of transportation equipment brings the total direct employment to over 1.5 million.[32]

Competitiveness Impacts

There are a number of different dimensions to competitiveness in transportation. First, there is competition within and between modes of transportation for freight or passengers. In assessing changes to the transportation system, it is important to consider impacts on the competitiveness of different modes.

Second, there is the role transportation plays in the overall economy. Some industries have developed on the basis of access to local transportation networks. Others, such as the natural resource sectors, rely heavily on transportation to ship products considerable distances. As price-takers in global markets, they may have limited ability to pass on transportation cost increases. In other sectors, speed and service have become key ways of achieving competitive advantage. Many manufacturers have reduced their raw material inventories, relying on “just-in-time” delivery and making speed and service critical.

Third, Canada’s economy, and the transportation sector in particular, has become more integrated with that of the U.S. For example, the automobile industry is highly integrated, producing parts and vehicles for a single North American market. Under new “open-skies” policies, Canadian and American airlines compete more and more on the same routes. Under NAFTA, and as a result of deregulation, truckers and railways compete with U.S. companies in both countries. As a result, the U.S. response to climate change will be an important consideration in determining Canada’s transportation options.

The economic opportunities offered by addressing climate change issues add another dimension. Greater energy efficiency reduces operating costs for carriers and transportation costs for shippers. Further, growth and employment opportunities may emerge in new industries such as the production of alternative fuels, the development of fuel cells, or the manufacture of public transportation vehicles such as buses and subways. Further, cities with efficient transportation systems have a competitive advantage in terms of attracting businesses.

New Technologies Take Time

New technologies will play an important role in Canada’s response to climate change. Canada is playing a leadership role in many emerging transportation technologies, such as the deployment of intelligent transportation systems (ITS), the development of fuel cells and ethanol from biomass, and the production of vehicles using natural gas. However, commercializing and deploying new technologies takes time.

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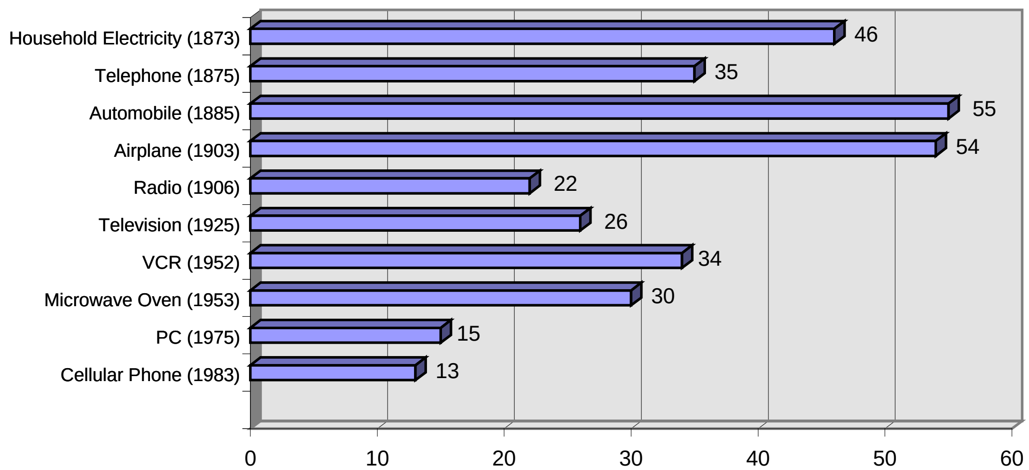
[32] Statistics Canada. *Labour Force 15 Years and Over by Detailed Industry*. Catalogue 93F0027XDB96009. Accessed via the Internet.

Some equipment, such as airplanes, ships, or rail cars stay in service for many years, making rapid changes in the capital stock difficult without policy or market changes. In other cases, such as with automobiles, while the life cycle of the vehicle may be less, the challenge of putting new vehicle technologies on the road is still significant. The time required to commercialize new technology, retool manufacturing plants, provide support for parts and service, and generate consumer acceptance in order to turn over a fleet of millions of vehicles, may take 20-30 years under current conditions and markets.

Further, the transportation infrastructure has evolved over the last hundred years and will also take time to change. Changing the design of cities to favour less energy-intensive transportation requires long-term change. While technology holds great potential for the future, technology alone will not meet the time frames of the Kyoto commitment.

Chart 3.2
Time Taken to Introduce New technologies [33]
(# of years to spread to 25% of the U.S. population)



Safety Concerns
In assessing options to reduce GHG emissions, the overall safety of the transportation system must remain paramount. Often, there are trade-offs between safety and environmental performance. For example, new safety features can add weight to an automobile, reducing its fuel efficiency and increasing GHG emissions. It is important to assess the safety implications of various transportation options and ensure they meet safety standards that continue to evolve.

Other Environmental Benefits
Transportation causes a number of environmental problems beyond GHGs, including water, noise, and air pollution. Transportation is closely linked with urban sprawl, and pollution from the burning of fossil fuels is particularly concentrated in urban centres.

[33] *Wall Street Journal*, June 16, 1997

The major air pollutants from transportation are, most notably, carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOCs) and particulate matter (PM). In 1995, transportation accounted for 52 per cent of all NOx emissions, 40 per cent of CO, 20 per cent of VOCs, and 5 per cent of particulate matter.[34]

In many cases, efforts to reduce GHG emissions will also reduce smog and other air pollutants, particularly in urban centres. For example, reducing distances driven or shifting people to public transit, will reduce both air pollution and GHG emissions. Some transportation options that show a cost if assessed only on their GHG impact, would generate an overall net economic benefit when other air pollutants are taken into account.

It must also be stressed that this “win-win” scenario is not always the case. Efforts to reduce other pollutants may also result in higher GHG emissions. For example, lower standards for NOx emissions from aircraft engines may actually reduce their overall energy efficiency, thereby increasing GHG emissions. Similarly, switching to diesel engines may offer some benefits in VOCs and GHG emissions, but could increase particulate matter. It is extremely important in the transportation sector to assess options for impacts on both GHG and air quality.

Many Diverse Players

Decisions about transportation are made millions of times each day—by carriers, drivers, shippers, consumers and the public. In addition, all four levels of government, federal, provincial/territorial, regional and municipal, have jurisdiction and regulatory authority over different aspects of the transportation system. Thus, gathering data on millions of transportation users and making coordinating changes in the transportation system is complex.

At one level, making changes to reduce emissions from transportation will require co-operation and agreement among various governments. But further, it will require a new climate of policies, market signals or prices that will encourage millions of decision makers to consider the GHG implications of their decisions.

Regional Differences

The importance of transportation to the economy and to local communities varies considerably across the country. The transportation system across Canada reflects the large area and relatively dispersed population of the country, but regional transportation systems have developed differently, depending on a region’s geography and climate, the nature of its economy, the importance of trade, and the location of its population. The role transportation plays in communities also varies, and the transportation options in rural areas will differ from those of urban centres in the same way that solutions which work in one part of the country may not work in others. Therefore, any strategy to reduce GHG emissions will need to be flexible and reflect regional differences and local circumstances.

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[34] Environment Canada, Pollution Data Branch. Criteria Air Contaminants Inventory, 1995.

IV. TRANSPORTATION MEASURES

4.1 INTRODUCTION TO THE MEASURES

4.1.1 Approach to Analysis

The Table commissioned several studies to identify GHG-reduction measures (Appendix 2). The Table developed an analytical framework to provide as much consistency as possible across the different studies (Appendix 3), following the guidelines for the national climate change process. Some key points to be aware of in reviewing the analysis of measures are as follows.

- The Table used the baseline forecast from Canada's Energy Outlook 2020 (produced by Natural Resources Canada [NRCan]) as its reference case. This baseline was updated as a result of analyses carried out by the Table and NRCan (See Section 4.2).

- Costs have been estimated in 1999 dollars, discounted at 10 per cent to equivalent present value, and include the direct and incremental cost of the measure.

- Non-monetary costs and benefits, such as reductions in travel activity, changes in travel time, or changes in consumer surplus or choice, have been estimated, where possible, valued (using Transport Canada guidelines), and included in the measure's **cost per tonne** of GHG reductions. Instances where it was not possible to estimate non-monetary benefits have been noted in the paper. The **financial cost** of the measure, which includes only its monetary cost, has also been identified where it is different from the total cost.

- Other environmental benefits of the measures (such as reductions in smog) have been estimated and quantified, where possible, but were not valued or included in the cost per tonne of the measure. This will be done during the roll-up of all 15 tables' work.

- Certain taxes, tolls and charges, have not been included as costs where they would not represent payments for goods or services, but would be introduced as policy measures to influence users' choices. They remain important for policy decisions nevertheless, and are identified as **resource transfers** in the analysis presented in this report.

4.1.2 Data Constraints

The issues of data availability and quality are important for all of the issue tables, and transportation is no exception. Data on transportation is particularly problematic in that it involves millions of users. In reviewing the analysis, it is important to understand the limitations of the data used.

In some areas, data may not have been available. In other cases, it was necessary to make assumptions based on limited data. And, in some cases, there has been no actual experience with specific measures (for example large-scale increases in fuel prices or feebates for automobiles), so it has been necessary to estimate effects. Details on the data limitations and assumptions are contained in the each of the studies. Some of the key data gaps include:

- accurate descriptions of the road vehicle fleet and its use, distinguishing cars from trucks and buses, urban use from intercity or rural use, commuter trips originating from outside urban areas, the number of occupants or the weight of the load, and the actual fuel consumption;

- the amount of traffic and freight carried by private, not-for-hire truck carriers (i.e. where firms own their own fleet);

- the value of freight carried by different modes and carriers;

- user response to some measures aimed at reducing transportation activities, shifting travel between modes, changing travel behaviour or shifting to different fuels; and,

- the average power, hours of use, load factor, number and age of off-road vehicles and equipment used in Canada.

In conducting its analysis, the Table has used the best data obtainable given the time and resources available. To fill gaps in the data, the Table relied on various sources, including gathering new data from industry or government, empirical studies, expert opinion from workshops and interviews, as well as assumptions and estimates based on the expertise of subgroup members and consultants. These assumptions are identified in each of the studies. The basis for these assumptions and the limitations of the data used are important considerations when assessing the estimated effectiveness of different measures. The Table believes improvements in transportation data are essential for the continued analysis and development of actions to reduce GHG emissions.

4.1.3 Gaps in Analysis

The Table endeavoured to study as much of the emissions attributable to the transportation sector as possible. However, there are some areas that are included in the sector's emissions that were not analyzed due to time or budget constraints, including:

- measures to increase the operating efficiencies of buses, passenger rail and ferries;

- emissions from commercial fishing boats, which are included in the off-road emissions allocated to transportation;

- specific measures aimed at urban commuters travelling greater than 80 kilometres and local travel in rural areas (addressed by the general measures related to fuel taxes, vehicle technology and fuels);

- specific measures aimed at mid-size trucks between 4500 and 8500 kg (i.e. between light-duty and medium/heavy-duty trucks). Trucking awareness and outreach measures apply to all trucks; and,

- shifting freight between modes in locations outside the five specific corridors studied by the Table.

4.2 REVISED BASELINE FORECAST

The initial forecast of GHG emissions under conditions of "business as usual" was taken from NRCan's report *Canada's Energy Outlook: 1996-2020*, published in 1997. During the course of the Table's work, NRCan updated its forecast which, at the time of writing, has not yet been published (detailed revisions are outlined in Table 4.1). Changes to the original baseline forecast of transportation emissions will be made based on:

- more recent records of fuel sales (to 1997) showing 7 per cent greater energy use for the sector in that year than was predicted in the previous *Outlook*, with the largest increases in gasoline and diesel (particularly for off-road use), and aviation turbo fuel;

- increases (to 1997) in road diesel use reported by refineries as sales to industry rather than to transport fuel suppliers. This includes private trucking, but also off-road use (e.g. mining, petroleum, forestry), which is allocated to the transport sector by the international reporting guidelines, but may be used by stationary equipment and not transport vehicles;

- reductions in emission rates of N_2O per unit of fuel from cars and light trucks, demonstrated by improved research evidence;

- revised forecasts of the use of alternate fuels in road vehicles, particularly lower penetration of propane and CNG-fuelled vehicles, off-set to a minor extent by greater use of ethanol; and,

- revisions to assumptions of future changes in activity and fuel use resulting from the Table's analysis. The Table proposed the following adjustments that were accepted by NRCan for the forecasts from 1997 to 2020, in terms of changes in fuel intensity per unit of activity (often referred to as "fuel efficiency"):

  - freight rail: change from 0.5 per cent annual reduction to 1.2 per cent;
  - marine transport: change from fixed intensity to 0.3 per cent annual reduction; and,
  - air transport: change from 2 per cent annual reduction to 1 per cent.

Table 4.1
Changes to Transportation GHG-Emissions Baseline Forecast to 2010
GHG Emissions (million tonnes CO2 equivalent)

Fuel type/source of change	’96 Outlook	’99 Update	Change
Road gasoline			
- increases due to greater economic activity			+ 8.3
- reductions due to revised N_2O emissions			- 9.6
- net total	106.6	105.3	- 1.3
Road diesel total (including off-road)	51.1	55.4	+ 4.3
Alternate fuels	3.0	0.9	- 2.1
Aviation fuels	13.4	17.6	+ 4.2
Rail fuels	7.4	7.1	- 0.3
Marine fuels	6.6	7.0	+ 0.4
Total Transport Sector	**188.1**	**193.3**	**+ 5.2**

4.3 Transportation Measures

This section describes the different measures studied, their costs and benefits, GHG potential, environmental benefits, and any competitiveness issues. Each subgroup began with easier options, progressing through to more difficult and expensive measures. This section describes the measures. The financial cost of the measure, excluding all non-monetary costs and benefits, is noted separately if different from the total cost. Key data issues and assumptions are also presented. The studies (Appendix 2) provide more detail on each of the measures studied. This analysis provides the basis for the Table’s packages of options in Section 5.

4.3.1 Freight

4.3.1.1 Aviation

The aviation industry has made progress in improving its fuel efficiency. For example, aviation fuel consumption per available tonne-kilometre has been reduced by 51 per cent from 1970 to 1995, an average rate of 2.8 per cent per year (it should be noted that it is difficult to allocate GHG emissions to freight or passenger, as in most cases they occupy the same plane).[34] With improvements in fuel efficiency, the amount of fuel used by the industry has grown more slowly than the increase in air activity over the last 15 years. These improvements reflect the significance of fuel costs to airlines and are the result of

[34] Although the fleet of aircraft dedicated only to freight is growing, most air freight continues to move on passenger aircraft, making the allocation of emissions between freight and passenger very difficult. The measures studied by the Table apply to both passenger and freight aviation. The study was managed under the Freight Sub-group as a matter of administrative convenience.

better engine and aircraft design, as well as improved flight planning and flight and ground operations. However, even with these gains in fuel efficiency, the significant growth anticipated in air transportation is expected to result in an increase in greenhouse gas emissions of 43 percent above 1990 levels by 2020 under a "business-as-usual" scenario.

Chart 4.1
Growth of the Aviation Industry Between 1980 and 1997

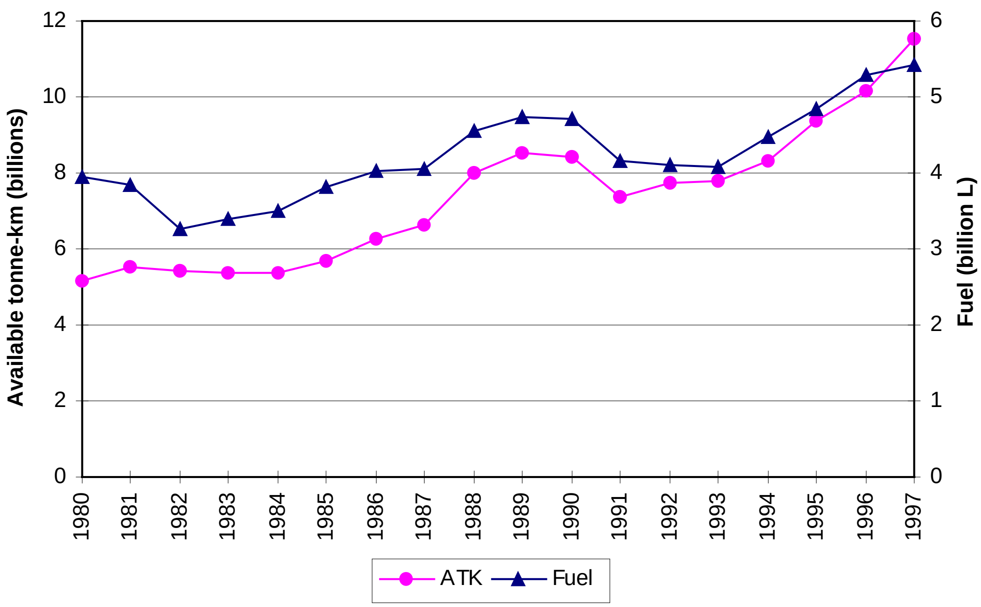


Table 4.2
"Business as Usual" Aviation Forecasts
Based on Statistics Canada Civil Aviation Data

	1990	2010	2020
Fuel (ML)	5907	7205	7936
GHGs (Mt)	15.5	19.0	21.3
Increase over Kyoto target	-	28%	43%
Cumulative GHG reduction (Mt) due to efficiency improvements	-	2.7	4.1

Summary of Aviation Measures Evaluated

Operational and Technological Improvements (D1): There are a number of operational and technological improvements that the Canadian aviation industry could implement between 2000 and 2010 that are not sufficiently advanced to be considered in the "business-as-usual" baseline. These measures include:

- enhancements to air traffic management and navigation systems that provide safer and

more fuel-efficient approaches to airports, and more efficient routing for aircraft;
- replacement of older aircraft;
- the use of preferred trajectories and polar routes; and
- continued improvements in operations.

Because the majority of capital costs for the air navigation system have already been spent, there is a net benefit per tonne for this package of actions.

Accelerated Fleet Replacement (D2): This measure would accelerate the replacement of older, less fuel-efficient aircraft before their normal retirement from Canadian operations. For example, this would entail:

- replacing B737s in 2001 instead of 2005-2010; and,
- replacing B727s, DC9s, F28s in 2002, eight years ahead of normal replacement.

With the above upgrading, the remaining life of the fleet would be 20 to 30 years. There is little realistic scope for additional reductions in greenhouse gases through more aggressive early fleet retirements.

This measure assumes that fuel-efficiency standards would be put in place to induce the accelerated replacement of aircraft. Government incentives would offer an alternative implementation mechanism. The operational and technological measures described above would be included as part of this fleet-replacement measure.

Limit Aviation Activity (D3): The aforementioned measures would not be sufficient to reduce aviation-related GHG emissions to 6 per cent below 1990 levels. Therefore, a third measure was examined whereby, starting in 2001, regulation of all aircraft activity (e.g. entry into the market, routes, frequency of service, load factors, type of aircraft) would be required. Part of the regulatory regime would require a cap on all general aviation and non-airline commercial activity. This measure would reduce aviation fuel consumption to 5552 million litres (i.e. 6 per cent less than in 1990) and effectively reduce the domestic airline fleet by about 30 per cent, or70 aircraft.

Data Issues And Key Assumptions

The allocation of GHG emissions between cargo and passenger air transportation was estimated from information provided by carriers, as there was little actual data and documentation available on air cargo operations and activities. Given the integrated nature of passenger and cargo operations, and the relatively small proportion of fuel that might be allocated to cargo, this study does not make further estimates of GHG emissions specifically related to cargo.

Table 4.3
Summary of Aviation Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)
Operational and technology improvements (D1)	1.6	1.9	-$1350	-$44
Early aircraft replacement (D2)	1.0	0	$2200 to $2900	$311
Limitation of aviation activity (D3)	4.3	6.7	$51 200	$557

Estimating the fuel consumption and GHG emissions for domestic air transportation presented some difficulties. Two sources of information were available: Statistics Canada's *Quarterly Report on Energy Supply*, which represents total fuel sales in Canada, including sales to Canadian carriers for international activities; and Statistics Canada's Canadian Civil Aviation report, which represents total fuel purchased by Canadian airlines, regardless of the country where it was bought. In both sources, no distinction is made for domestic versus international use of the fuel. The latter was used to establish the baseline of fuel use and total GHG emissions, resulting in fuel consumption figures about 12 per cent higher than those in the 1997 Energy Outlook report.

Ancillary Effects Of Measures
The operational and technological improvements of the first measure would reduce other air pollutants such as hydrocarbons, carbon monoxide and nitrogen oxides by about 12 per cent in 2010 and 9 per cent in 2020. The fleet replacement measure would reduce these other air pollutants by 13 per cent in 2010 and 2020. Regulating aviation activity would reduce all air pollutants to about 6 per cent below 1990 levels. However, these emission reductions would be offset to some degree by increases in other modes to accommodate demand.

Regional/Competitiveness Impacts Of Measures
Emissions from international aviation activity do not fall within Canada's target under the Kyoto Protocol. Domestic measures to reduce aviation emissions have to be assessed in the context of the ongoing work of the International Civil Aviation Organisation (ICAO), which is responsible for working with its member countries to reduce these emissions. Future activities of the U.S. on this matter must also be taken into consideration.

The impacts of the accelerated fleet replacement measure would depend on the mechanism for implementation. If fuel-efficiency standards were put in place, air carriers that depend on the low costs of older technology aircraft would face large cost increases. The impact on the competitive and financial position of dedicated courier cargo carriers relative to the surface modes could be substantial. Furthermore, the early retirement of

B737s and F28s would increase financial pressures on passenger airlines with these aircraft in their fleet mix. The impacts of limiting aviation activity could include :

- job losses due to the closure of many air courier cargo firms, charter services, and possibly one major airline;
- likely financial insolvency of many Canadian airports, which are currently investing large amounts of money in airport infrastructure to meet the growing demand for services and to relieve existing congestion;
- impacts on related industries that rely on air transport (e.g. tourism);
- increased costs for air travel as supply is constrained; and
- reduced service to smaller and remote communities, as airlines might focus on routes in more densely populated areas of the country by using larger and more fuel-efficient aircraft. For many remote communities, air is currently the only means of travel.

4.3.1.2 Rail

A number of improvements in the rail sector are expected to continue or accelerate under a program to reduce GHG emissions. Older 3000-horsepower locomotives are being replaced with new 4000-horsepower units (typically, three units can replace five) for a fleet fuel saving of 17-20 per cent. The two major railways have adopted, or are adopting, automatic idle shutdown and/or slower idle speeds that reduce fuel consumption by 1 per cent compared to 1995 levels. Both major railways are making use of lighter rail cars, where feasible, and cars with heavier allowable axle-weights to improve load factors. Lubrication to reduce friction between the wheel flange and the rail, and “meet-pass planners” to allow trains to pace themselves and reduce the time spent idling in sidings are in use. In heavy traffic areas, optimization algorithms are used to gain the maximum system benefits.

The rail industry in Canada, under a memorandum of understanding with Environment Canada, has agreed to cap its nitrogen oxide (NOx) emissions at 115 kilotonnes per year, effective 1992, until at least 2005. To allow the Canadian Council of Ministers of the Environment to monitor compliance, the railway companies in Canada also agreed to report annually on their emissions, including their carbon dioxide emissions, to ensure that they do not exceed the NOx cap. The reduction of nitrous oxide (N_2O) due to NOx regulations needs further study to determine if a reduction in GHG emissions will result.

Summary of Rail Measures Evaluated

Extensions of Technology Upgrades: The capital cost allowance (CCA) could be used to accelerate the introduction of more fuel-efficient equipment (measures E6 and E7). It is estimated that changing the railway CCA from 10 to 25 per cent would encourage the acquisition of an additional 300 locomotives and 3600 rail cars.

Radical technology innovations are unlikely in Canada, especially in the absence of a domestic locomotive manufacturer. The most promising change to diesel locomotive technology would therefore involve adopting the U.S. NOx regulations (E5), which would require each railway to achieve a 60 per cent reduction in NOx from their locomotives built after 2004, and a 30 per cent reduction in rebuilt engines that were originally built between 1973 and 2001. This would degrade fuel efficiency, but result in a net reduction in GHG emissions due to the reduction of N_2O (assuming that the N_2O will be reduced in proportion to NOx).

Operational and Infrastructure Changes: Canada's rail system is predominantly single track. Measures that would help reduce congestion in the system include: geometry changes such as double tracking in heavy traffic areas, use of longer sidings (E9), and reduced curves and grades (particularly in western Canada) (E11); and the use of concrete ties and heavier rails to increase track stiffness (E8).

About 35 per cent of rail traffic is in small shipments of one or several cars. If shippers accept less frequency (E10), the railways could make more efficient use of their locomotives. Reduced average speed (E12) was evaluated as another operational measure to reduce GHG emissions.

Alternatives Involving a New Energy Infrastructure: A number of energy alternatives could be introduced over the next 10 to 15 years. Such changes are mutually exclusive, and their attractiveness is reduced by the introduction of new diesel locomotives, which are now at the beginning of their life cycle.

One alternative is liquefied natural gas (LNG) with diesel pilot injection for ignition (E3). It is estimated that this technology could be introduced in the 2000-2005 time frame, possibly displacing up to 88 per cent of the diesel fuel consumed. The favourable CO_2 emission profile of LNG versus diesel is partially offset by the energy required in the liquefaction process.

Another fuel measure is cellulosic ethanol (E2A and E2B). The estimated time frame for introduction is 2010 to 2015. Cellulosic ethanol has lower life-cycle GHG emissions than corn and grain feedstocks (See Section 4.3.2). Fuel cell implementation was considered using either electrolysis (E1A) or synthesis of methane (E1B) to generate the hydrogen needed for the process. The expected time frame is 2005 to 2010 to begin a five-year installation process.

Three areas were considered for electrification: western Canada (where the bulk of the freight is carried) (E4A), the iron ore railways in Quebec and Labrador (E4C), and an eastern mainline network (E4B). While the technology is available to begin electrification now, the window of opportunity is closing rapidly because the railways are purchasing large numbers of new diesel locomotives. Implicit in a change to electric power is the consideration of the GHG impact of the incremental electricity generation. After 2013, this incremental capacity will be from natural gas in western Canada.

Table 4.4
Summary of Rail Freight Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)
Adopt U.S. NOx regulations (E5)	0.07 to 0.15	0.07 to 0.15	$305 to $391	$127 to $355
CCA incentive to acquire additional fuel-efficient locomotives (E6)	0.22	0.22	$82	$19
CCA incentive to acquire additional fuel-efficient freight cars (E7)	0.08	0.08	$29	$13
Increase the stiffness of track (E8)	0.05	0.05	$122 to $310	$134
Change track configuration (E9)	0.1	0.1	$1553	$223
Restrict service frequency (E10)	0.009	0.010	$129	$725
Eliminate circuitous routings (E11)	0.09	0.09	$91	$30
Reduce train speeds (E12)	0.21	0.21	$79	$20
Fuel cell locomotive (electrolysis-based) (E1A)*	0	2.9	$16 400	$253
Fuel cell locomotive (methane-based) (E1B)*	0	1.2	$11 000	$403
Cellulosic ethanol (dual-fuel configuration) (E2A)*	0	3.0	$3800	$52
Cellulosic ethanol (15% emulsion configuration) (E2B)*	0	0.72	$1640	$94
Liquefied natural gas (E3)	0.34	0.34	$1400	$171
Electrify western mainlines (E4A)	1.98	1.56	$1830	$21
Electrify eastern mainlines (E4B)	0.66	0.83	$1710	$38
Electrify iron ore railways (E4C)	0.22	0.22	$190	$16

* not anticipated to be available in 2010

Data Issues and Key Assumptions

The capital investment required for the various measures is notional in many cases, and needs further analysis. There is a substantial variation in the expected lifetime of the measures, ranging from 15 to 50 years.

Data for CN and CP were assumed to be representative of the rail freight sector as a whole. There are difficulties in identifying cross-border rail traffic, and it was assumed that the amount of Canadian rail traffic in the U.S. was equal to the amount of U.S. traffic in Canada. It was assumed that N_2O emissions would be reduced in proportion to NOx as a whole. If this proves not to be the case, the actual GHG impact of adopting the U.S. NOx regulations will be negative, due to increased locomotive fuel-consumption. A similar concern pertains to conversion to natural gas engines, as manufacturers indicate that NOx emissions would be similar to those from diesel engines.

A number of assumptions were used in the alternative fuel measures. For electrification, it was assumed that the iron ore railways would replace their locomotives in the next few years, and that the mines (and the railway) would then operate over a 50-year period. In the case of fuel cell technology, achieving an acceptable level of efficiency and cost was assumed. It is assumed that cellulosic ethanol production will be driven by light-duty vehicle demand, however, the sustainability of ethanol supply and its economics in the face of such demand is uncertain. Liquefied natural gas technology depends on lower N_2O emissions to deliver GHG savings, which are anticipated but not known. All costs for these measures were estimated from previous studies (some up to 15 years old) and interviews. A more current cost analysis is needed before making the investments implied in these measures. The cost to shippers of longer trip times in the case of slower travel speeds and the cost of reduced frequency were not assessed.

Ancillary Effects of Measures
The reduction of smog-forming pollutants is integral to the U.S. NOx regulations, which would result in health benefits in areas with heavy train travel. Locomotives using alternative energy sources could shift these emissions away from populated areas towards the location of the energy production, depending on the upstream emissions of the alternative fuel used (e.g. electricity-generating plants). There might be incremental safety concerns associated with liquefied hydrogen and natural gas fuel tender.

Regional/Competitiveness Impacts of Measures
Benefits from alternative energy sources would vary across regions. Cellulosic ethanol production would benefit an Ontario-based company. The use of fuel cells would benefit a British Columbia-based company. LNG production would likely take place in the west, particularly in Alberta and Saskatchewan. Electrification programs could stimulate the construction industry locally (Quebec, Atlantic and Western Canada), as well as the electrical equipment manufacturing sector, which is based largely in Ontario and Quebec.

Increasing track stiffness and geometric change could increase employment in the construction industry. The options could also improve reliability and safety. Restrictions on railway operations imply a return to railway regulation. Competitiveness would be profoundly affected by any reduction in speed or service. Reduced rail service could raise costs and encourage shippers to switch to trucks or route freight through the U.S.

4.3.1.3 Marine and Ferries

The domestic marine industry has a number of measures underway that will reduce GHG emissions. These initiatives are included in the baseline forecast and include improved voyage scheduling and cargo planning, navigation and route planning, engine maintenance and tuning, and hull cleaning and treatment. In addition, there are a number of “port measures” which are also factored into the baseline scenario, such as improved berth assignment and scheduling, and the use of shore power, where economically viable.

Measures focus on domestic shipping, specifically freight and ferry activities. The Kyoto Protocol assigns the International Maritime Organisation (IMO) with the responsibility of working with member countries to address emissions from international shipping.

Summary of Marine Measures Evaluated

Accelerated Fleet Renewal for Freight and Ferry Transport (G1 and G2): Starting in 2000, 17 pre-1985 freight vessels and 30 ferries would be replaced. Accelerating fleet renewal would require an external financial stimulus such as the relaxation or elimination of the 25 per cent import duty on new vessels. A variant of this measure was evaluated by assuming full relief from the import duty. Removal of the import duty would, however, hurt what remains of Canada's domestic shipbuilding industry.

Reduced Vessel Speed for Ferries (G3): The average running speed for the national ferry fleet would be reduced over a 20 year period. This could be implemented through regulations or a voluntary speed limit. The main barrier to implementation is that decision making concerning vessel running-speeds is decentralized (although less so for the ferry sector than the freight sector). The establishment or enforcement of mandatory speed limits is therefore not considered. Strong corporate or government leadership would be required to ensure the success of this measure, and fuel conservation in general in the marine sector.

National Shore Power Program for Freight and Ferries (G5 and G6): Shore power would be provided for ships at berth where it is not sufficiently financially attractive for this to occur under the business-as-usual case. The analysis assumes the implementation of a prototype national program to promote shore power, which would also generate the information needed for site-specific business cases for tailored shore-power incentives.

Implementation would likely require government support and entail a number of challenges. Individual berths may require more than a single shore power system in order to service varying requirements from domestic and foreign vessels without restricting berth assignment in the port. Such systems can require extensive shipboard modifications as well as significant infrastructure on the shore side, including dedicated transformers. Safety is paramount in the design and operation of such systems, which are currently in use at some Canadian ports.

Industry Code of Practice for Freight and Ferries (G7 and G8): A national program would be implemented, potentially by the federal government in co-operation with industry associations, to promote environmental best practices in marine transportation. The program would provide information on practices to minimize fuel consumption, training and possibly a carrier recognition program analogous to the safety recognition programs in the trucking industry. The effectiveness of such a program is difficult to predict. A meaningful target would be 0.5 per cent per annum cumulative reduction in GHG emissions over five years from the baseline forecast. This would move the domestic marine sector’s rate of energy efficiency improvement closer to international rates.

Use of Compressed Natural Gas (CNG) Propulsion for Short-Haul Ferries (G4): Up to 10 diesel-powered ferries would be replaced with compressed natural gas-powered ferries, starting in 2000, with implementation limited to a number of short-haul routes. One such CNG ferry is currently in operation in Canada. Safety problems with the engine emission characteristics of the natural gas/diesel bi-fuel engine conversion continue to be a concern, as with new technologies with a short track record.

Table 4.5
Summary of Marine Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)
Accelerated fleet renewal (tankers)[1] (G1)	0.003	0.003	$828.8	$11 151
Accelerated fleet renewal (ferries)[1] (G2)	0.014	0.014	$2980.3	$8654
Reduced vessel speed (ferries) (G3)	0.08	0.09	$419.0	$255
National shore power program (freight) (G5)	0.03	0.03	$108.0	$185
National shore power program (ferry) (G6)	0.04	0.04	$19.0	$25
Code of practice (freight) (G7)	0.02	0.02	$3.4	$9
Code of practice (ferry) (G8)	0.02	0.02	$3.4	$9
Replace diesel-propulsion ferries with bi-fuel diesel CNG engines (G4)	0.002	0.002	$4.0	$97

1 This variant assumes the complete elimination of the existing 25 per cent import duty on new vessels. The cost per tonne information for G1 and G2 numbers are those from the study without the 25 per cent import duty.

Data Issues And Key Assumptions

There is no data source for domestic marine fuel consumption, nor is there comprehensive data on the use of diesel and fuel oil. Domestic marine energy consumption is therefore estimated. A number of assumptions regarding the average energy efficiency of different regional operations (Ontario/Quebec, Atlantic, Pacific and Arctic) were applied in order to arrive at the 1995 estimates for domestic marine energy consumption. The allocation of fuel between marine diesel and heavy fuel oil was assumed to be a 40/60 split, based on industry surveys. No attempt was made to compensate for the under-reporting of fuel consumption noted by Statistics Canada; consequently, the national fuel consumption estimate may be conservative. It was assumed that virtually all the fuel consumed by ferries was marine diesel. Consultants developed the ferry traffic forecasts.

Ancillary Effects Of Measures

The ancillary effects of the measures are not significant in most cases. The accelerated replacement of freight vessels and ferries would contribute to reductions in the emissions inventory of NOx, CO and SOx. Assuming a 40 per cent reduction in NOx emissions from the replacement vessel, the annual savings in NOx emissions per vessel would amount to 0.8 tonnes for tankers and 0.9 tonnes for ferries. The replacement of diesel-powered ferries with CNG-powered ferries would reduce SO_2 and particulate matter emissions. Engine repair costs would decrease, while preventative maintenance cycles would increase.

Regional/Competitiveness Impacts Of Measures
Initiatives to address climate change in the domestic marine sector should take into consideration the international context and future activities by the IMO and the U.S.

It is assumed that each measure would be implemented at the national level, and that the effects of each measure would be distributed in proportion to the ferry and/or freight activity. The measures proposed would have little effect on competitiveness. However, for the freight shore power measure, Canada's competitiveness might be enhanced if domestic ports had more cost-effective terminals than ports in the U.S.

4.3.1.4 Trucking

The trucking sector and truck manufacturers have made efforts to increase the fuel efficiency of the commercial fleet, largely in order to reduce fuel costs and enhance competitiveness. Electronic engines allow carriers to closely monitor vehicle and driver performance and fuel efficiency. Improved aerodynamics, lighter trucks and trailers and engine and driveline improvements have also helped to increase fuel efficiency by approximately 25 per cent since 1990.

Medium- and heavy-duty commercial trucks (over 4500 kg) contribute roughly 27 per cent of Canada’s transportation GHG emissions. All of the technologies and operational practices studied currently exist in some form, with the exception of truck scrappage and engine retrofit programs, and are experiencing varying degrees of success,. The studies evaluated the cost-effectiveness of inducing a more widespread use of these technologies and practices as a means to reduce GHG emissions.

Summary Of Trucking Measures Evaluated

Long Combination Vehicles (F1L and F1H): This measure would allow long combination vehicles (LCVs) to operate under controlled permits on four-lane (or more) divided highways in all provinces. At present, Nova Scotia, Ontario and British Columbia do not permit LCVs. LCVs are tractor-trailer combinations that exceed 25 metres or that have a box length (distance from the front of the first trailer to the back of the last trailer) longer than 20 metres. Permits control the operations of long trucks, including the qualifications of the driver hours of operation, and routes, and these are regulated independently by each jurisdiction allowing long trucks. The analysis conducted did not assume any weight advantages or increases for LCVs as compared to existing configurations. The major implementation issue associated with this measure is the public perception of safety issues associated with larger trucks on the roads.

Fuel Speed Monitoring (F2A and F2B): This measure investigates the cost-effectiveness of the wider use of vehicle monitoring and control systems on modern engines (i.e. road speed and idling limiters) to achieve more fuel-efficient driving. Maximum speeds would be reduced to either 105 km/hr or 90 km/hr for all trucks. The measure would be accompanied by regulation at either the federal or provincial level, mandating speed limiters on truck engines or the enforcement of speed limits. Voluntary speed reductions would be difficult to achieve, as carriers now face pressure from drivers to increase company speed limits. Driver retention could be a significant issue for carriers, as many drivers and owner-operators are paid based on the distance driven ($/km).

Load Matching (F3): This measure assesses the potential of replacing current load-matching practices (e.g. telephone, card index files, salespeople) with Internet-based information services that allow trucking companies, brokers or forwarders to match loads and available equipment. It is assumed that all van and flatbed trailers operating in Canada on trips over 300 kilometres would reduce their empty travel by 1 per cent as a result of the greater efficiencies afforded by this technology. A barrier to the use of this technology is that these operations typically already have their “empty distances” down to 9 per cent.

Tracking (F4): Satellite-tracking allows motor carriers to more efficiently dispatch vehicles and plan their routes. The largest provider of satellite-tracking services in Canada estimates that 40 per cent of the potential market is now using this technology. A scenario was assessed under which the remaining 60 per cent of the potential is equipped with this technology by 2000.

Tires: By 2000, all heavy diesel trucks would be retrofitted with central tire inflation monitoring (CTI) and all new equipment would subsequently contain this equipment (F5B). Lower rolling resistance (LRR) tires are another technology that could improve fuel efficiency. In this case, it was assumed that all trucks with a registered weight of over 4500 kg would be equipped with LRR tires as of 2000 (F5A). Both tire technologies could be introduced through performance standards under the Motor Vehicle Safety Act, or required as retrofits under provincial statutes. Alternatively, incentives could be provided through tax measures or product subsidies. Although operating savings would partially offset the costs of LRR tires and fully offset CTI costs, these savings might not be sufficient incentive for carriers to invest in this technology.

Lubricants (F6): This measure proposes a shift to synthetic or partially-synthetic lubricants in diesel engines. These lubricants reduce internal friction and pumping losses, thereby improving fuel efficiency by 2.5 per cent. However, the pricing and penetration of synthetic oils cannot be predicted with certainty. There is some debate about the effectiveness of synthetic lubricants in preventing engine wear as well as conventional oils do.

Tare weight (F7): It was assumed that all heavy diesel tractor-trailers would reduce their tare, or empty, weight by 1000 kilograms starting in the year 2000. Some reductions in weight (such as through engine specifications or the elimination of optional add-on features such as in the cab) can result in lower equipment costs. Other technologies, such as the use of more aluminum components in trailers, can increase equipment costs. Convincing industry to minimize tare weight in order to reduce GHG emissions may be difficult, particularly as the weight of sub-contracted or owner-operator tractors is not always under the truck company's control.

Scrappage/Engine Retrofit: This measure assesses the effectiveness of decreasing the average age of trucks in the commercial fleet and retrofitting older trucks with new engines. Three variations were analyzed: i) prohibiting the registration of any vehicle older than 20 years (F8A); ii) prohibiting the registration of any vehicle older than 15 years (F8B); and, iii) a five-year shift in the average age of the fleet (i.e. all vehicles would be shifted one five-year age range younger) (F8C). The program could be implemented through a buy-back scheme (such as BC's Scrap-It program), or through the use of tax measures and incentives. Mandatory limits on vehicle age could also be imposed through the motor vehicle registration system.

Under an alternative scenario, it was assumed that vehicles more than 15 years old would be retrofitted, resulting in a 5-10 per cent improvement in fuel consumption (F9). Barriers to the retrofit program include certification of retrofit kits, participation criteria, and short life-span of the expected benefits.

Outreach/Awareness Measures: Driver training, reduced idling and vehicle maintenance programs were identified as having the best potential for changing operating practices and improving fleet fuel economy based on industry surveys and case studies (F10, F11, and F12). When targeted at the heavy-diesel-truck component of the industry, representing about 30 per cent of the total fleet but 80 per cent of the industry's GHG emissions, these measures demonstrated a net benefit per tonne of GHG reductions. Voluntary programs could be delivered through the federal government's FleetSmart program. Programs could also be implemented through mandatory driver training and certification, possibly through the Motor Vehicle Transport Act with complementary provincial regulations.

Table 4.6
Summary of Trucking Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)
Long trucks, Rocky Mtn. Double (F1L)	0.01	0.02	-$400	-$1278
Long trucks, Turnpike Double (F1H)	0.04	0.05	-$870	-$1110
Vehicle speed control (105 km/h) (F2A)	1.2	1.4	$880	$33
Vehicle speed control (90 km/h) (F2B)	3.2	3.8	$6000	$90
Load matching (F3)	0.1	0.1	$313	$156
Tracking (F4)	0.04	0.04	$117	$162
Tires (low rolling resistance) (F5A)	.16	0.2	$380	$114
Tires (central inflation) (F5B)	1.09	1.3	$1800	$78
Lubricants (F6)	1.0	1.2	$430	-$9 to $48
Tare weight (F7)	0.23 to 0.68	0.7	$980	$57 to $223
Scrappage, 20-year threshold (F8A)	1.4	1.6	$8900	$337
Scrappage, 15-year threshold (F8B)	2.3	2.6	$4000	$90
Scrappage, 5-year shift (F8C)	2.3	2.7	-$6000	-$135
Engine retrofit (F9)	2.2 to 3.0	2.6	$1800	$550 to $780
Driver training, general (F10)	2.0	2.3	$215	$5
Driver training, idling (F11)	1.2	1.4	$29	$1
Preventative maintenance (F12)	0.8	0.9	-$8	-$1

Data Limitations and Key Assumptions

A lack of good quality data on truck population and use underlies all of the trucking studies. Some results are based on best estimates. For example, while research data shows that fuel use decreases with properly inflated tires, there is limited data on actual inflation pressures. The data is better for larger carriers with revenues over $1 million. Assumptions were made in defining the current and potential markets of the technologies evaluated.

There is a greater degree of certainty in the results for the technology and scrappage/ retrofit measures, than for the outreach/awareness measures. This is due to data limitations and the analytical approach and methodology used in each study. The effectiveness of outreach measures is not well established from research, and was assumed by the contractor.

Ancillary Effects of Measures

Safety: Assuming a total accident rate of 1.41 per million truck-kilometres, the study estimated that long trucks would reduce total truck travel and hence the number of accidents involving trucks (assuming the accident rate for long trucks is the same as for all trucks). Notwithstanding, there is a public perception regarding safety issues related to long trucks that needs to be addressed. Reducing the speed of trucks has the potential to increase the accident rate, if there is a high speed differential between trucks and cars. Load matching would reduce kilometres travelled and thus reduce accidents. With the scrappage and engine retrofit measures, there may be some positive impact on safety as more modern vehicle performance standards would apply. Reduced accidents and lower maintenance costs are two of the benefits of training in fuel-efficient driving techniques.

Other Emission Reductions: There would be minor reductions in emissions of smog-forming pollutants (i.e. NOx, CO, hydrocarbons and PM) due to decreased fuel use and kilometres travelled. The CTI devices could provide other benefits, including extended tire life, higher equipment reliability, fewer tire failures, and improved vehicle steering and stability. The scrappage and engine retrofit measures would increase the use of new trucks with tighter emission standards, thus reducing air pollutants.

Regional/Competitiveness Impacts of the Measures

The main impact of allowing long trucks would be felt in Ontario, along the Montréal-Toronto-Windsor corridor. This is due to the large size of the Ontario market and the linkages that would be created between regions by opening up the Ontario network to long trucks. Some freight markets (low density, warehouse-to-retail) in the three provinces and between Québec and Ontario could benefit from lower freight rates. The industries using these markets (e.g. the retail sector) would improve their competitiveness slightly, although transportation costs are not a large component of their overall costs.

There might be some negative competitiveness impacts if speed limiters were mandated on Canadian trucks travelling into the U.S. without a similar requirement in the U.S. Drivers and owner-operators would strongly object to reduced speeds, as it could decrease their income. Fleet operators might support the initiative if it was applied equally and consistently to all trucks.

Load matching and reduced tare-weight could increase the competitiveness of the trucking industry, primarily in the long-haul market, potentially by diverting traffic from rail. There would be some impact on employment stimulated by the scrappage and engine retrofits that would benefit truck manufacturers and parts suppliers in Ontario and B.C. Reducing the average age of trucks might have a marginal effect on carrier output, as a result of increased vehicle reliability and lower operating costs. The forced retirement of vehicles would be opposed, particularly by small businesses and farmers. However, there are mechanisms for targeting the program to specific sectors (as in the case of heavy freight vehicles now) which could maximize the effectiveness and minimize the impacts on marginal vehicle users.

The outreach/awareness measures could reduce costs through improved fuel efficiency and place the industry in a slightly more competitive position. These measures would not result in a significant regional impact, as they would apply evenly across Canada.

4.3.1.5 Modal Integration and Modal Shift in Freight

This study examined modal integration and modal shift opportunities across different freight modes in five selected corridors:

- Toronto-Montréal
- Toronto-Halifax
- Toronto-Chicago
- Thunder Bay-Quebec City
- Calgary-Vancouver

The types of commodities and the use of different modes in these corridors varies considerably. Given that air freight is estimated to be less than 1 per cent of the tonne-kms in each of the five corridors, it was not analyzed in the study.

A survey of 31 shippers was conducted to identify factors of importance in modal selection. Shippers were asked to rate from zero (not important) to five (very important) 10 factors in selecting a mode of transport. The results are presented in Table 4.7.

Table 4.7
Factors of Importance in Modal Selection

Factors	Average (5 being the max. score)
1. Cost of freight	4.6
2. Transit time	4.6
3. On-time delivery	4.5
4. Reliability	4.5
5. Damage to goods	4.3
6. Type of goods shipped	3.9
7. Shipment size	3.7
8. Value of commodity	3.6
9. Packaging requirements	3.0
10. Environment/GHG	2.4

The primary factors in selecting a mode of transport are cost and time –in transit. On-time delivery and overall reliability of the transport mode were almost equally important. The shift to just-in-time delivery is a primary driver for faster transit times. GHG concerns are not a factor in modal choice.

The emissions in these corridors are forecast to rise at varying rates based on the relative GHG intensity of the modes and their increase in traffic. Trucking is the fastest growing mode except in the Thunder Bay–Quebec City corridor, where rail is growing fastest.

Intermodal travel is already taking place between truck and rail modes, using CP's Iron Highway and CN's RoadRailer, although there is considerable variability among the five corridors. The proportion of intermodal traffic is in decline in all but the Halifax-Toronto corridor. Generally, trucking is exhibiting the highest growth in these corridors.

Summary of Modal Shift Measures Evaluated

Increases in the capacity of CP's Iron Highway and CN's RoadRailer truck/rail intermodal services, and/or an increase in marine capacity were evaluated in this study. In some cases, a high-intensity scenario was added to the initial measure that essentially doubled the rate of expansion. Measures under the high-intensity scenario were deemed to be aggressive under present economic and policy conditions.

Levels of service and the potential for weather-related service disruptions work against switching to marine. An anticipated need for new vessels and potentially declining rail freight rates could also make the marine mode less attractive.

A major issue with respect to increasing rail intermodal service is improving truck access and reducing delays at intermodal terminals. Train frequency and the reliability of delivery times could also be improved. Shipper awareness of environmental issues is low. A green procurement model is proposed to raise awareness among shippers and carriers. Canada-U.S. collaboration would be required in the Toronto-Chicago corridor.

i) Toronto-Montréal

Shift Road Traffic to Rail Intermodal by Expanding Existing CN/CP Intermodal Services and Express Freight on VIA Passenger Trains (C1A and C1B): The first scenario expands CP's Iron Highway by four trains per day each way and CN's RoadRailer to five cars per day in VIA trains by 2005. By 2015, a further four trains per day would be added to the CP's Iron Highway, four new trains per day introduced by CN's RoadRailer services, and ten CN RoadRailer cars added to VIA trains. In the high-intensity scenario, by 2005 there would be four trains per day on CN's RoadRailer service in addition to the initial expansion by CP and VIA as described above. By 2015, CN's RoadRailer trains would increase to eight trains per day, while CP's Iron Highway and VIA would continue to grow at the rate of the initial expansion.

Shift Rail to Marine Services (C2): A single vessel would operate between the two ports for nine months of the year (the St. Lawrence Seaway is closed in the winter). The vessel would be capable of carrying containers both on deck and in the holds, as well as dry bulk cargoes. A substantial government subsidy would be required to encourage this service.

ii) Toronto-Chicago

Shift Road Traffic to Rail Intermodal by Introducing CN/CP Intermodal Services and Expanding Express Freight on VIA Passenger Trains (C3A and C3B): In a first scenario, CP's Iron Highway would begin operating two trains per day each way, and VIA trains would haul one CN RoadRailer trailer per day each way. By 2015, VIA trains would expand to two CN RoadRailer trailers per day each way, and two CN RoadRailer trains per day would be added. In the high-intensity scenario, CP's Iron Highway and VIA would expand as described above, and two CN RoadRailer trains per day would be introduced each way in 2005. By 2015, CN's RoadRailer would increase to four trains per day each way.

iii) Toronto-Halifax

Shift Road Traffic to Rail Intermodal by Introducing CN Intermodal Services and Expanding Express Freight on VIA Passenger Trains (C4): By 2005, two CN RoadRailer trains/day each way would be introduced, and VIA trains would haul one CN RoadRailer trailer per day each way. By 2015, CN's RoadRailer trains would expand to 60 trailers per train, and VIA would haul two trailers per day each way. Under this measure, truck traffic would be unbalanced, with 87 per cent moving eastward. (Note that CP's Iron Highway would not be considered in a CN corridor).

Shift Rail Traffic to Marine (C5): Under this measure, containers and bulk commodities would move on a lake vessel or a "roll on/roll off" vessel in this corridor for nine months of the year on the St. Lawrence Seaway. No government subsidy would be anticipated.

iv) Thunder Bay-Quebec City

Shift Rail Traffic to Marine (C6): A portion of existing commodities (currently about 92 per cent grain) would be carried using Great Lakes vessels currently laid up or underutilized. No new vessels would be anticipated, nor any government subsidy.

v) Vancouver-Calgary

Shift Road Traffic to Rail Intermodal by Introducing a Double-Stack Container Service (C7A and C7B): In a first instance, the domestic market and some marine containers would shift to rail. By 2005, one train per day each way with double-stack container service would be introduced. By 2015, this service would increase to two trains per day. Under a higher-intensity scenario, there would be two trains per day with double-stack container service each way; this would increase to four trains per day by 2015.

Table 4.8
Summary of Freight Modal Shift Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)
TORONTO-MONTRÉAL CORRIDOR				
Shift road traffic to rail intermodal by expanding existing CN/CP intermodal services and express freight on VIA passenger trains, base case (C1A)	0.01	0.03	$87	$263
As above, higher-intensity scenario (C1B)	0.019	0.038	$140	$283
Shift road traffic to marine services (C2)	0.002	0.002	$58	$2079
TORONTO-CHICAGO CORRIDOR				
Shift road traffic to rail intermodal by introducing CN/CP intermodal services and expanding express freight on VIA passenger trains, base case (C3A)	0.004	0.008	$66	$635
As above, higher-intensity scenario (C3B)	0.008	0.016	$132	$635
HALIFAX-TORONTO CORRIDOR				
Shift road traffic to rail intermodal by introducing CN intermodal services and expanding express freight on VIA passenger trains (C4)	0.011	0.016	$55	$231
Shift rail traffic to marine (C5)	0.006	0.006	$92	$989
THUNDER BAY-QUEBEC CITY CORRIDOR				
Shift rail traffic to marine (C6)	0.010	0.010	$124	$584
VANCOUVER-CALGARY CORRIDOR				
Shift road traffic to rail intermodal by introducing a double-stack container service, base case (C7A)	0.009	0.0180	$45	$192
As above, higher-intensity scenario (C7B)	0.018	0.0360	$89	$190

Data Issues and Key Assumptions

The data for this study included an assessment of existing surveys and data, and a survey of shippers and carriers. Private carriers appear to be under-represented in the survey. The prediction of modal shift is based on judgement, rather than on any empirical data on the relationship between modal choice and price, service, and commodity value.

In the truck mode, a large amount of freight is general or unclassified freight for which the suitability of modal transfer is unknown. Truck data rely on Statistics Canada surveys that are dependent on very small samples per commodity at the community level. There are no credible data on commodity values. No financial data were provided for the rail mode. The consultant allocated costs on the assumption that a relatively small proportion of freight (5–25 per cent) terminated at the corridor end points. There appears to be no empirical basis for this assumption.

Public sector investments, whether through spending programs or tax incentives, are either very roughly estimated or left for future research. Subsidies would likely be required, particularly in the case of switching rail to marine (for port facilities and additional vessels).

Ancillary Effects of Measures

Switching from truck to rail could reduce highway congestion in some corridors, although it would not reduce urban congestion, as truck pick-up and delivery would still be required at trip ends. Switching from rail to marine would reduce rail congestion in Quebec and Ontario and potentially reduce the risk of rail accidents. The effect of an increase in marine traffic on water pollution and shoreline erosion, as well as any negative impacts on fishing and wildlife, would have to be assessed.

Increased use of shipping could prolong the life of the Great Lakes and coastal fleets. Increased tolls on the St. Lawrence Seaway could enable government to prolong the life of the Seaway. Increased marine traffic at Thunder Bay could prolong the life of bulk-grain terminals, potentially allowing increased grain exports via the East Coast.

Regional/Competitiveness Impacts of Measures

Regional effects of these measures would be minimal. An emphasis on marine transport could enhance the role of the major ports involved (Toronto, Halifax, Montréal, Thunder Bay), while switching to rail intermodal could stimulate investment in new terminal facilities in Atlantic Canada. Trading between Canada and the U.S. may create increased import/export opportunities in southwestern Ontario and result in higher demand for transportation services in the Toronto-Chicago corridor.

Enhancing marine transport would make Canadian ports more competitive, although Halifax might make gains at the expense of Montréal. Enhancing the Thunder Bay-Quebec City corridor would enhance the Seaway's ability to compete with the Mississippi River system for grain, coal and iron ore transport. Depending on the degree of the switch from truck to rail, there could be some job losses and consolidation in the trucking industry.

4.3.2 Road Vehicles and Fuels

Two technical studies were commissioned to investigate the role road vehicle technology and fuel changes could play in reducing emissions. The results of these studies were then used as input for two subsequent studies that analyzed specific measures that could potentially be used to bring about such changes in the marketplace.

4.3.2.1 Greenhouse Gas and Fuels

Future transportation fuels may be derived from a number of different sources. In comparing different fuels, it is critical to consider their full life-cycle emissions, including both production and use. This study reviewed future fuel technology and costs from production to end use, calculated life-cycle GHG and other emissions, and estimated the cost-effectiveness of the potential GHG-emission reductions.

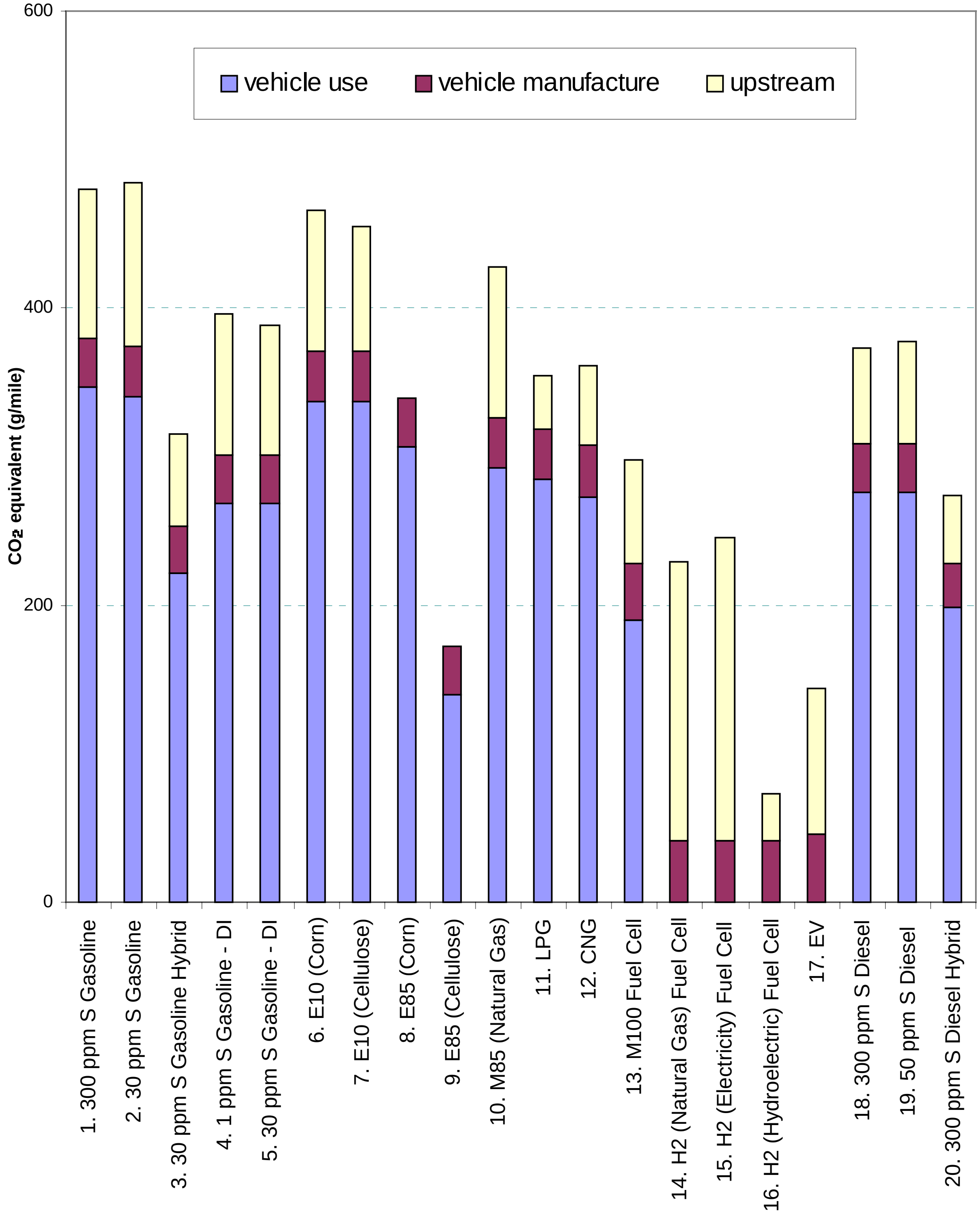
Summary of Fuel Technologies Evaluated

Chart 4.2 summarizes the life-cycle GHG emissions for several transportation fuel options. The graph includes conventional gasoline (Bar #1) and diesel fuel (Bar #18) for comparison, as well as the proposed low-sulphur (30 parts per million) gasoline (Bar #2) that will be required under proposed Canadian regulations and U.S. Tier-2 emission standards beginning in 2004. A low-sulphur diesel that would be needed to enable new light-duty vehicles to meet these emission standards is also shown (Bar #19).

Hybrid –electric-drive vehicles are shown (Bars #3 and 20) for both gasoline- and diesel-powered versions, and the lower portion of the bars for these two technologies clearly shows the significant GHG reduction expected in vehicle operation compared to conventional vehicles. Direct-injection gasoline engines (Bars #4 and 5) and direct-injection diesel engines (Bars #18 and 19) show significant potential reductions in vehicle operation on the low-sulphur fuels, even accounting for the higher GHG emissions from the increased energy used to reduce sulphur levels during the refining process.

The ethanol options (Bars #6 to 9) include a GHG credit from the sequestration of CO_2 from growing corn as the feedstock for the ethanol. While the overall impact on vehicle emissions is small for each litre of ethanol when blended in gasoline at 10 per cent, the fact that this use of ethanol does not require changes to the refuelling system or vehicles makes this option easier to implement (Bars #6 and 7). When ethanol is blended at up to 85 per cent with gasoline (known as E85), the GHG reduction per vehicle is significant, especially for ethanol from a large, modern plant. E85 life-cycle emissions for ethanol from corn could be about 40 per cent lower than those of conventional fuels in 2010(Bar #8). Ethanol manufactured from cellulosic feedstocks, such as grasses and waste agricultural products, are projected to reduce life-cycle emissions by 65 per cent compared to conventional fuels in 2010 (Bar #9). At this time there is a growing number of flexible fuel ethanol vehicles entering the market. These vehicles are designed to operate on gasoline containing ethanol concentrations ranging from 0 to 85 per cent.

Chart 4.2
Passenger Cars - CO_2 Equivalent Emissions, Year 2010



* For E85 from cellulose, upstream CO2 = 157 t, vehicle use CO2 = 325 t. The upstream value has been added to the vehicle use to show the overall total correctly.

Methanol manufactured from natural gas and blended into gasoline at up to 85 per cent, known as M85, and used in a flexible fuel vehicle shows a more modest GHG reduction because of the energy losses in the processing of methanol from natural gas (Bar #10). The gaseous fuels, compressed natural gas and propane, show reductions of about 25 per cent compared to conventional fuels, as they contain less carbon, and their recovery and processing is less carbon-intensive.

Three hydrogen fuel cell technologies are shown, with GHG reductions dependant on the method used to produce the hydrogen for the fuel cell. Bar #13 illustrates fuel cells where the hydrogen is obtained from methanol (derived from natural gas) and reformed on-board the vehicle. Bar #14 shows the case for hydrogen derived from natural gas and carried in high-pressure storage tanks in the vehicle. Bar #15 shows fuel cell vehicles using hydrogen produced by electrolysis, assuming the average electricity generation mix in Canada; if the electricity source is hydro or nuclear, almost all of the GHG emissions are eliminated except for those from the manufacture of the vehicle itself. This is true also for battery-operated electric vehicles (Bar #17). The bar indicates emissions from the average electricity generation mix, and the low level of total emissions reflects the high energy efficiency of electric drive systems in vehicles.

Barriers to Alternative Fuels

A market research study was conducted to assess the barriers to greater use of conventional alternative fuel (ATF) vehicles, such as natural gas or propane, in fleets in urban centres across Canada. The study was expanded to provide a qualitative review of existing programs in North America and their effectiveness in encouraging the uptake of these vehicles.

Focus group sessions were held with urban fleet managers from government, utilities, small business, transit authorities, school boards, delivery companies and truckers. The following top five barriers were identified:

i) higher vehicle purchase price (the majority of participants saw $2000 as the maximum acceptable premium, with a 12-18-month payback based on lower fuel costs);
ii) lack of public refuelling infrastructure (participants were reluctant to install expensive private fuelling stations);
iii) the range of the vehicle between refuelling for vehicles running on a single fuel is currently too short for some applications (bi-fuel vehicles can also run on gasoline);
iv) the reliability of vehicles (primarily the performance of older vehicles that were converted after manufacture to an alternative fuel) and concerns about utility (loss of space due to the tank); and,
v) difficulty in finding ATF equipment that is readily available, and a lack of maintenance and service locations.

The majority of participants selected emissions reductions, cost savings and positive public appearance as the biggest advantage of having ATF vehicles in their fleets. Two key messages may be taken from the market research study results: fleet operators are still willing to use ATF vehicles if the above barriers are remedied; and, there is a need for clear regional strategies and coordinated efforts to support the penetration of ATF vehicles in urban passenger fleets.

Data Issues and Key Assumptions

The general level of information on fuels technology is good. The fuels technology analysis was based on a Canadian adaptation of a full fuel-cycle GHG model originally built by Mark Delucchi at the University of California at Davis. The Canadian adaptation was developed under a joint NRCan-U.S. Department of Energy project. The consultant added data for some specific fuel production issues, drawing from information supplied to the Industry Table for upstream heavy and synthetic oil and gas, and additional information from energy companies.

Previous estimates conducted for Argonne National Laboratory show that the model results can be expected to be reliable to within plus or minus 5 per cent. Changes to the U.S. model to adapt it to Canadian conditions may not have the same degree of confidence. There are uncertainties about the future degree of improvements in vehicle efficiency for alternative fuel vehicles relative to gasoline vehicles, based on fuel attributes such as octane level. While improvements are likely to occur where large numbers of vehicles are produced, they are less likely to be realized for low-volume runs. Efficiency improvements over gasoline vehicles may also be limited under new U.S. emission standards proposed for 2004. There are also uncertainties about the use of some future gasoline direct-injection technologies with gaseous alternative fuels.

There are uncertainties about estimating the size and location of feedstock and fuel production plants, transporting feedstocks and fuels, and whether production of advanced fuels, such as hydrogen, would be at large centralized plants or at smaller distributed locations. The variety of possible configurations gives rise to uncertainty about their average GHG emissions.

4.3.2.2 New Vehicle Technologies

This study reviewed vehicle technologies (passenger cars, light- and heavy-duty trucks and city transit buses) available for the fuels analyzed above. A series of technology cost-curves were derived to estimate the cost of new technologies that improve fuel economy and reduce GHG emissions. The analysis included scenarios with high-volume production (harmonized market introductions in both Canada and the U.S) as well as scenarios where the technologies are introduced only in the Canadian market (low volume). The time frame for introducing new technology is important, as short introduction times increase costs due to the early retirement of existing manufacturing equipment.

Summary of New Vehicle Technologies Evaluated

Cost curves were estimated for four vehicle classes: passenger cars; light pick-up trucks; sport-utility vehicles and large vans; and minivans. Chart 4.3 shows the curve that was developed for passenger cars as an example. The initial point on the cost curve (at the bottom left) represents the 1998 average vehicle efficiency adjusted for a projected 70 kg weight increase to meet future safety and emission control requirements and a projected performance improvement to reduce acceleration time by several percent. Different points on the curve represent combinations of vehicle design changes to improve fuel economy.

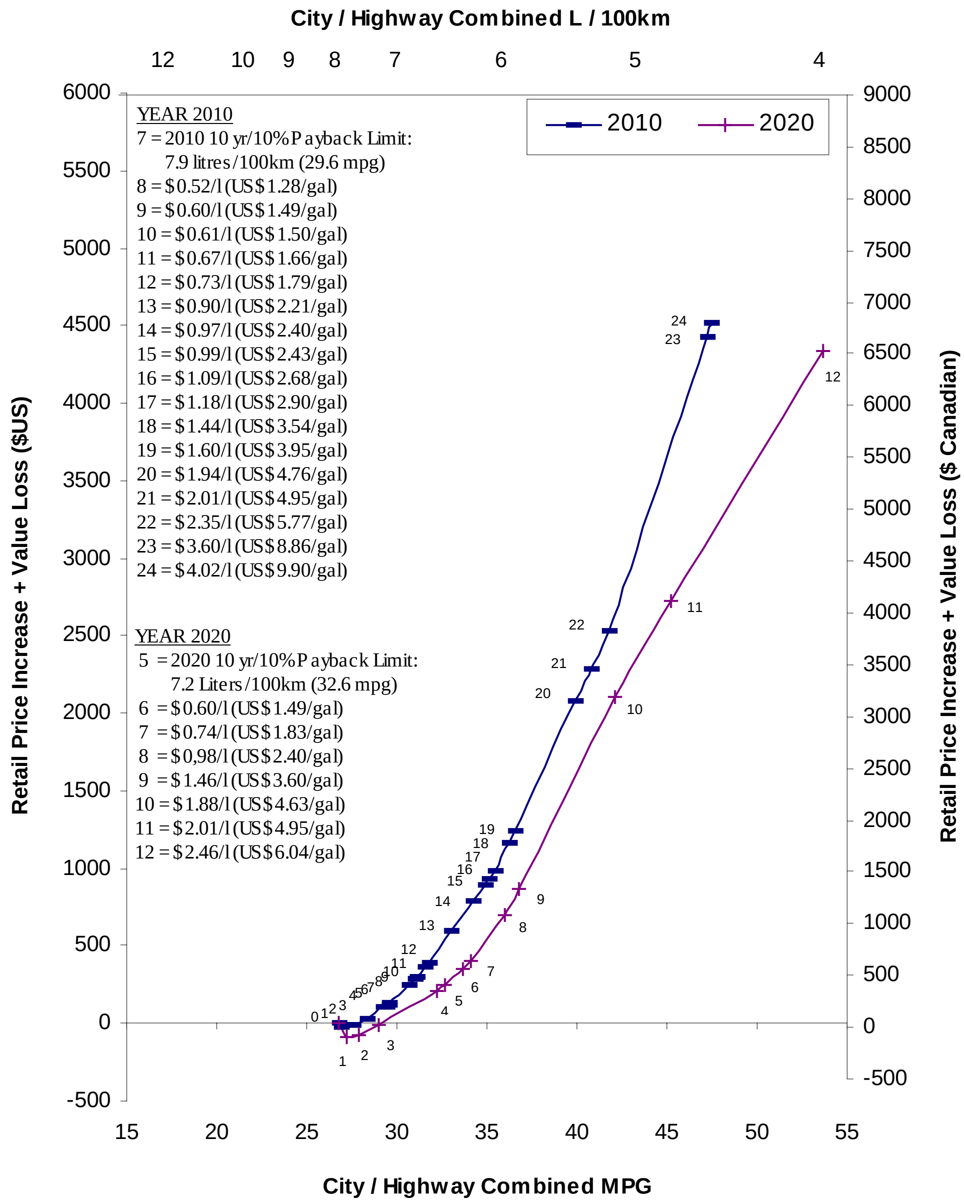
Examples of technologies that are included in the curve, in ascending order of cost, are:

- packaging improvements (same interior space with less weight and/or exterior size);
- reduced engine friction;
- lower aerodynamic drag;
- continuously variable transmissions (CVTs);
- lightweight interiors;
- high-strength steel bodies;
- higher engine compression ratio;
- lower rolling resistance tires;
- aggressive transmission shift logic;
- four-valve engines with variable valve timing, and lift with cylinder deactivation;
- zero-drag brakes;
- aluminum chassis; and
- hybrid drivetrains.

As additional technologies are added, the average cost of the new vehicle rises. Points on the curve are identified with the estimated fuel price needed to pay back the incremental cost of the vehicle through the lifetime fuel savings alone.

Chart 4.3

Fuel Economy Supply Curves for Passenger Car Consistent U.S. / Canadian Policies



In addition to the technologies above, future gasoline (GDI) and diesel (DDI) direct-injection engines for light-duty vehicles could offer significant fuel-efficiency improvements. There is debate on whether a much lower level than the 30 ppm proposed for gasoline would be needed for direct-injection engines; the issue relates to the adverse effect that sulphur has on the efficiency of NOx-reduction emission control systems that are being developed, and whether these systems will be adequate for these engines to meet the low U.S. Tier-2 NOx emission standards proposed for 2004.

Medium- and Heavy-Duty Vehicles

Heavy-duty truck and bus fuel economy has received little attention historically for two reasons. First, most heavy-duty vehicles over ten tons (gross vehicle weight) are diesel powered and, hence, quite efficient. Second, since buyers use these vehicles for commercial proposes, they pay close attention to fuel economy to lower costs and remain competitive. The following efficiency technologies were assessed for these vehicles:

- engine improvements;
- aerodynamic improvements;
- reduced tire rolling resistance; and,
- weight reduction.

The first three technologies are cost effective and could yield a 10 per cent reduction in fuel consumption and GHG emissions by 2010 on a per vehicle basis. Weight reduction is a relatively expensive means of reducing fuel consumption in heavy vehicles. It was estimated that the impact of introducing these technologies could reduce average new truck fuel consumption 3 per cent by 2010, and 11 per cent by 2020.

Several alternative fuels were also considered for trucks and buses, as well as hybrid electric drivetrains for heavy urban vehicles, such as transit buses and garbage trucks. The fuels included biodiesel, propane, ethanol, compressed (CNG) and liquefied natural gas (LNG), and dimethyl ether (DME). For heavy trucks, the fuel option with lowest GHG reduction cost was LNG at $89 per tonne, followed by biodiesel at $228, propane at $371 and DME at $410 (all values are for vehicles manufactured in 2010).

For transit buses, the range of cost effectiveness was $16 per tonne for hybrid electric drivetrains, $104 for compressed natural gas, $227 for biodiesel, and $285 for fuel cells fuelled by methanol or compressed hydrogen (both derived from natural gas). Given the relatively high costs for some of the new fuel options in 2010, it is likely that these fuels would be confined to specialized or niche markets. Costs are expected to be significantly lower by 2020 for some options (e.g. fuel cells), so that their introduction would be more likely after 2010.

Data Issues and Key Assumptions

The general level of information on vehicle technology is good. Sales and stock information are available, as well as a long and robust series of fuel consumption test data for light-duty vehicles from manufacturers. Information on the stock and fuel consumption of medium and heavy trucks is adequate, and has been supplemented by a number of new data sources for vehicles in operation, plus comparative data on fuel consumption and use of various truck categories from U.S. surveys.

Information on available near-term technology for improving fuel consumption is good based on extensive technical literature. Simulation models are available to investigate the effects of integrating new technology in motor vehicles. For advanced technologies, such as hybrids and electric vehicles (fuel cell or battery powered), technical information is available. However, the exact configuration of these technologies in future vehicles by manufacturers has yet to be decided, so the fuel consumption estimates are less certain. Information on alternative fuel vehicles (gaseous and alcohol fuelled) is based on products already in the market.

The incremental vehicle technology prices (estimated as a retail price equivalent) were developed by a consultant who had recently completed a similar analysis for the American Automobile Manufacturers' Association. This work was extended to include advanced-technology vehicles and heavy-duty vehicles.

4.3.2.3 Summary of Vehicle and Fuel Measures Evaluated

Targets for New Light-Duty Vehicle GHG Emissions or Fuel Consumption Per Year: Targets would be set for the average fuel consumption of manufacturers' fleets. The targets could be through either a voluntary or mandatory measure. This does not affect the quantitative analysis, which assumes the success of either method. Canada has relied on voluntary targets that are harmonized with the U.S. (See Chart 4.4 for Canadian fuel-economy levels). It was assumed that an accompanying consumer education and awareness component would be included in the policy. Three levels of targets were considered, and each option assessed both a target harmonized with the U.S. and a Canada-only approach:

a) a 1 per cent per year reduction in fuel consumption per km, beginning in 2004 and lasting 10 years, starting from the Company Average Fuel Consumption (CAFC)[35] Program's 1998 target (11.4 litres per 100 kms for trucks, and 8.6 litres/100 km for cars). Note that this scenario was dropped from further analysis because it did not show any improvement from the baseline;

b) a 2 per cent per year reduction (otherwise the same as "a") (H1A and H1C); and,

c) a 25 per cent reduction for cars and light trucks (combined) by 2010. This would be similar to the voluntary agreement reached between the European Commission and European manufacturers, although the structure of a North American program could be significantly different (H1B and H1D).

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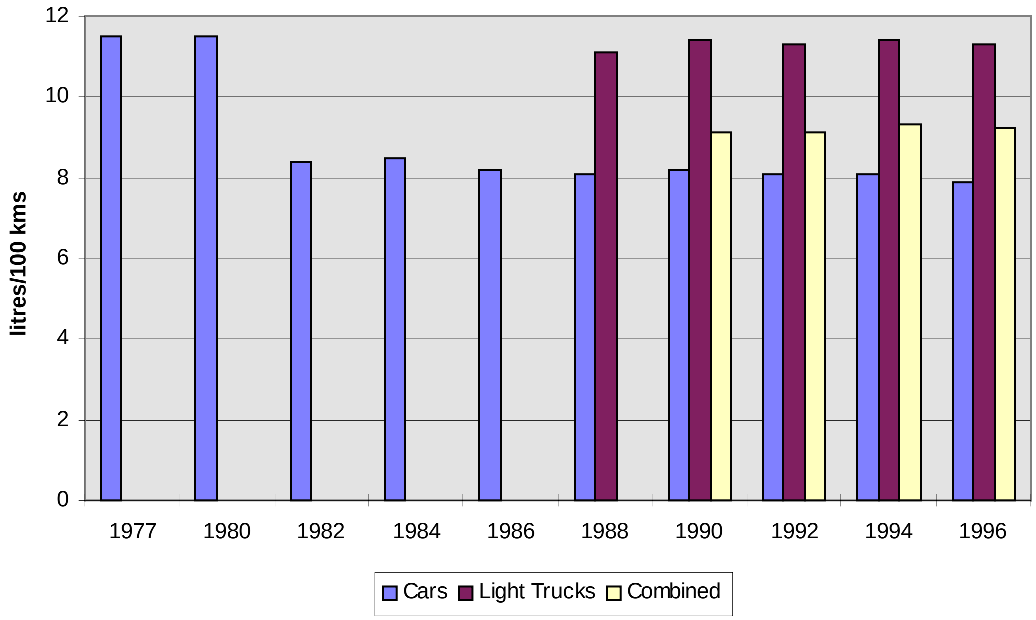
[35] For an explanation of vehicle fuel economy standards and the CAFC program, see the Table's *Foundation paper on Climate Change - Transportation Sector*. December 1998.

Chart 4.4
Canadian Motor Vehicle Fuel Efficiency, 1978-1996



High Efficiency/AFV Purchase Initiative by Government and Private Fleets: This program would include requirements for governments and either requirements or voluntary commitments from other fleet owners to purchase a specified number of alternative fuel vehicles (AFVs) and “best in class” efficiency models of conventional gasoline/diesel vehicles (H2A and H2B).

Vehicles would be chosen based on their availability and GHG emission reductions. This could also include heavy-duty vehicle fleets. Beginning with model year 2001, purchases were assumed of 5000 AFV and 10 000 “best in class” conventional vehicles per year, increasing to 20 000 and 50 000 in 2010 (including next-generation technologies, as available). Purchases would be spread evenly across electric, CNG, and corn ethanol in the near term, with fuel cells and cellulosic ethanol added as they became available. Incremental costs were assumed to be representative of production runs for the North American market rather than just Canada alone.

The analysis did not assess how to ensure voluntary commitments were met, nor how to ensure that manufacturers provide vehicles to meet the mandated requirements for government fleets. This needs to be addressed ,as similar U.S. programs have not always produced expected results.

Vehicle Purchase Incentive Program: Beginning with model year 2001, rebates would be provided for all vehicles with at least 30 per cent lower GHG emissions than their class average (H3A and H3B). This rebate would increase linearly with each percentage of reduction greater than 30 per cent up to a maximum level set to ensure equal valuation of CO_2 reductions. The 30 per cent hurdle could be increased each year to avoid exceeding a pre-determined budget of $40 million per year. This level of funding could provide, for example, an average incentive of $1000 for each of 40 000 vehicles per year, or about 5 per cent of light-duty vehicle sales in Canada.

Research and Development: Research funding or tax credits for "next generation" type technologies would be assumed to augment the U.S. Partnership for a New Generation of Vehicles (PNGV) (See Appendix 6) (H4). This could include fuel infrastructure. Research is important for the ongoing improvement of vehicle and fuel technologies; cases can be cited where support has resulted in technology changes that lower GHG emissions. This measure was not analyzed due to the difficulty of tracing a direct link between research and development and GHG reductions.

Ethanol-Blending Incentives: Incentives would be provided for refiners to blend low-GHG alternative or "replacement" fuels into gasoline (H5A and H5B). This would apply to low-GHG ethanol blends. The current fuel subsidy for grain-derived ethanol (e.g. $0.247 based on the total exemption of federal and provincial fuel taxes for fuel ethanol in Ontario) was assumed to be maintained. As cellulosic ethanol becomes available a GHG-based adjustment could be used in the incentive to reflect the lower emissions of cellulosic versus corn-based ethanol.

Fuel Quality Requirements: Refiners would meet new specifications for gasoline fuel with respect to sulphur content and other relevant characteristics. Newer technology low emission vehicles (LEVs) are designed to run on low-sulphur fuel for optimum performance. Further, new regulations in both Canada and the U.S. will require sulphur levels to be reduced to 30 parts per million. Effects of lower-sulphur fuel were assessed based on changes in refinery process energy, and older and new vehicle catalyst efficiency (including N_2O emissions). Improvements in vehicle fuel economy and emission system degradation may also lead to benefits. The Table assumed certain improvements in fuel quality would be obtained in Canada, based on current market conditions and regulatory developments. No new measure was analyzed as these changes have been included in the business-as-usual forecast.

Regional/Local Alternative Fuel Market Development: This measure would provide incentives for provinces and metropolitan areas to develop alternative fuel infrastructures within the three largest cities, comprising 25 per cent of Canada's population (H7A, H7B and H7C). It assumes that current fuel tax subsidies and incentives would remain in place. It also assumes that adequate refuelling infrastructure would be in place by 2005, and that sales of AFVs would reach 5000 per year in each area by 2005 (alternately assumed to be CNG, LPG, electric, and ethanol vehicles). Where a fuel option was not economically competitive with the base fuel (gasoline or diesel), it was assumed that government would provide a subsidy to make the fuel competitive with gasoline or diesel, and that other incentives could be employed to help market penetration (e.g. priority parking, dedicated lane use).

Table 4.9
Summary of Vehicle and Fuel Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct costs (NPV lifetime) $M	Cost/ Tonne ($)	Financial Cost/ Tonne ($) (if different)
Light-duty vehicle targets, harmonized with U.S., improved 2% per year from current fleet average (H1AH)	1.90	10.1	$3700	$60	$51
Light-duty vehicle targets, harmonized with U.S., improved 2% per year from current targets (H1AL)	1.10	7.9	$2300	$54	$45
Light-duty vehicle targets, harmonized with U.S., improved 25% by 2010 from current fleet average (H1BH)	6.50	16.5	$15 200	$105	$92
Light-duty vehicle targets, harmonized with U.S., improved 25% by 2010 from current target (H1BL)	5.20	14.1	$8900	$74	$56
Light-duty vehicle targets, not harmonized, improved 2% per year from current fleet average (H1C)	1.10	7.9	$4900	$114	$101
Light-duty vehicle targets, not harmonized, improved 25% by 2010 from current fleet average (H1D)	5.20	14.1	$18 900	$157	$139
AFV fleet purchase initiative (H2A)	0.3	0.7	$450	$69	
High-efficiency fleet purchase initiative (H2B)	0.20	0.3	$500	$220	
Vehicle purchase incentive, 30% lower CO2 emissions than class average (H3A)	2.1	6.4	$2000	$41	
Vehicle purchase incentive, 40% lower CO2 emissions than class average (H3B)	0.5	2.0	$510	$35	
Ethanol-blending incentives, low-capacity increase (H5A)	0.50	0.5	$270	$36	
Ethanol-blending incentives, maximum-capacity increase (H5B)	0.80	2.2	$540	$29	
Regional/local ATF market development alternate fuel infrastructure incentive, ethanol high (H7AH)	2.3	8.3	$750	$46	
Regional/local ATF market development alternate fuel infrastructure incentive, ethanol low (H7AL)	2.0	4.9	$600	$54	
Regional/local ATF market development alternate fuel infrastructure incentive, propane (H7B)	0.7-0.9	1.9-3.3	$460	$46-109	
Regional/local ATF market development alternate fuel infrastructure incentive, natural gas (H7C)	0.7-0.8	1.6-3.0	$710	$120-208	
Heavy-duty truck efficiency improvements (H8A)	0.4	2.0	$75	$6	
Heavy-duty truck AFV purchases (H8B)	0.4	1.8	$850	$69	
Transit bus, advanced design/alternate fuels (H9)*	0.217	0.6	$110	$11	
Feebate, Canada –only (H10A)	2.34	5.06	$10 500	$309	
Feebate, Canada only with phase-in (H10B)	2.34	5.06	$9500	$279	
Feebate, North America harmonized (H10C)	2.09	13.13	$9000	$116	
Feebate, North America harmonized with phase-in (H10D)	2.09	13.13	$7800	$100	

* Four potential transit bus technologies were combined in these GHG reduction and cost estimates.

Heavy-Duty Truck Initiatives: These measures combine two separate initiatives that are similar to the above measures for light-duty vehicle targets. In the first scenario, (measure H8A) heavy-duty vehicle manufacturers were assumed to enter into a voluntary commitment to achieve efficiency improvements. In the second scenario (H8B), manufacturers would sell a certain number of alternative fuel vehicles (2500 vehicles in 2010 and 5000 by 2020).

Transit Bus Technologies: Four transit bus technologies were examined:

- compressed natural gas (CNG) (H9B);
- hydrostatic hybrid drive (H9A);
- diesel electric hybrid drive (H9C); and
- hydrogen fuel cell (H9D).

Government was assumed to help defray the initial incremental cost of the bus technology. Costs were assessed over the 18-20-year lifetime typical for buses. Hydrogen fuel cell buses were assumed to be available in commercial quantities beginning in 2010, while the other technologies were assumed to be available immediately or within three years. Sales were assumed to reach 200 buses per year by 2010 (one third of transit bus sales in Canada) for the CNG and hybrid technologies.

Feebates for Cars and Light Trucks: A feebate policy levies surtaxes on higher fuel consuming vehicles and provides a rebate for lower fuel-consuming vehicles (H10). The feebate policy studied assumed that the scheme was revenue neutral, whereby the total fees equalled the total rebates plus administrative costs. Feebates are sometimes considered as an alternative to fuel consumption targets(H1).

Of the 10 measures studied, the measures with the highest GHG impact are the options for a 2 per cent annual improvement in fuel efficiency of cars and light trucks through to 2020, and a 25 per cent improvement by 2010. This is because this measure affects all new light-duty vehicles, whereas most other measures affect only a portion of the fleet or fuel mix. The impact in 2010 is modest or low for most measures because of the very limited time available for retiring the existing stock of vehicles or for building new fuel infrastructure. Results for 2020 are much more promising.

Incentives for ethanol E85 fuel infrastructure generated relatively high GHG-reductions. This measure assumes successful development of ethanol from cellulosic feedstocks and the significant purchase of E85 vehicles by private motorists as well as fleet users. Even though their total contribution is small, the transit bus measures have a low cost for the hybrid technologies and a modest cost for the hydrogen fuel cell.

Data Issues And Key Assumptions

The light-duty vehicle targets, high-efficiency/AFV fleet purchase initiatives, vehicle purchase incentives, ethanol-blending incentives and the regional/local alternative fuel market development incentives were analyzed using three models:

- a transportation energy use and GHG spreadsheet model, known as Champagne;

- the Alternative Fuel Module of the U.S. National Energy Modelling System (NEMS), which is useful for testing policies that change one or more vehicle attributes, such as vehicle price or fuel availability; and
- a fuel efficiency model (FEM) that was developed for the U.S. and subsequently adapted for Canada. The FEM can analyze 14 vehicle size-classes that are each characterized by price, fuel efficiency, weight and horsepower. It has the ability to include up to 100 separate discrete technologies.

A separate analysis that used data from operating history and transit bus technology demonstrations was used for the transit bus technologies evaluated. The technologies assessed included two hybrid drive options, as well as hydrogen fuel cell and compressed natural gas (CNG) buses.

The study on feebate options developed a completely new model for its assessments, with inputs from an expert group drawn mainly from the economic analysis departments of Ford, General Motors and Daimler-Chrysler.

The results of the analysis of measures have a relatively high degree of confidence. However, there is always some degree of uncertainty in predicting market and consumer behaviour. For example, consumer and manufacturer responses to vehicle purchase targets and incentives, including feebates, are difficult to predict.

Ancillary Effects Of Measures

Ancillary effects of the measures are important in some cases. There are significant potential reductions in smog-forming emissions for most of the alternative fuels market development measures.

The transit bus technologies (assuming uptake of factory-built AFVs) have very low emissions (tailpipe and evaporative) and low ozone reactivity, based on recent experience. The transit bus technologies would also have potential for low emissions, as the hybrid engine-duty cycle lends itself to easier emission control, while the hydrogen fuel cell option completely eliminates tailpipe emissions. The CNG bus option results in very low particulate emissions compared to diesel. The level of emissions control for new vehicles, and much of the fleet in 2010, is expected to be very high, so that differences between mass emissions for various types of vehicle will become difficult to measure. Even so, ozone reactivity differences between vehicle/fuel technologies may continue to be an important factor.

Tailpipe emissions that are of most concern in urban areas are totally, or almost totally, eliminated from electric and fuel cell vehicles. Emissions from these vehicles occur where the electricity or fuel is produced. The emissions depend on the location and type of facility, and can vary from zero for hydro-electric plants to significant SOx, NOx and particulate emissions from a coal generating station. Factory-built gaseous-fuel vehicles can achieve very low levels of emissions of air pollutants, and the ozone reactivity of these emissions is low compared to conventionally fuelled vehicles. Hybrid vehicles also have the potential to reduce air pollution.

Regional/Competitiveness Impacts of Measures

The measures affecting fuel efficiency and alternative fuel vehicle production affect Ontario with its major industry concentration, although under the harmonized cases, impacts would be distributed across North America, and to some extent other motor-producing countries in Asia and Europe. Major alternative fuel uptake would continue current patterns around refuelling infrastructure already developed in provinces with the highest vehicle populations: Ontario, British Columbia and Quebec.

Alternative alcohol-based fuel production options would increase economic activity in agricultural and forest-resource industry provinces, while the effect of displacement of future growth of hydrocarbon fuels would impact Alberta and Saskatchewan principally. Transit bus manufacturing in Canada is distributed in Quebec, Ontario, and Manitoba, and the three companies operating in those provinces each have alternative fuel manufacturing capabilities that would benefit from the transit bus measures.

4.3.3 Urban Passenger

Many municipalities are already taking action on measures to combat the congestion costs and health effects of continued urban traffic growth that have the potential to also reduce urban GHG emissions. Most municipal master plans, particularly for larger urban centres, address traffic demand management in some form, including pedestrian/ bicycle infrastructure enhancements, transit improvement, and other measures to influence driving behaviour. There are also private sector and ENGO initiatives, such as commute trip-reduction programs, active transportation promotion campaigns, and car-sharing programs, that have the potential to reduce urban GHG emissions. While these first steps are important, their scope is not broad enough to counter the trend of increasing travel or vehicle kilometres travelled (VKT) in urban areas.

Three analytical studies were undertaken to evaluate GHG reduction measures in urban passenger transportation: i) a broad-brush study that assessed a wide range of strategies and measures across the 25 largest urban centres in Canada (covering 95 per cent of the urban population); ii) case studies that examined strategies and measures in the context of Toronto, Montreal and Vancouver; and, iii) a study that evaluated the cost-effectiveness of establishing tax-exempt status for employer-provided transit passes.

Summary of Urban Passenger Measures Evaluated

The basic urban study assessed the potential emission reductions and costs of applying individual strategies to three classes of urban centres: the three largest centres (Toronto, Montreal, Vancouver), six large centres, and 16 small centres. Where practical, each strategy was also assessed according to a low-intensity scenario (involving moderate changes to the current social, economic, political and technical environment), and a high-intensity scenario (involving significant changes to the current environment), so as to illustrate the potential range of impacts for each strategy.

Enhancing Alternatives to Single-Occupant Vehicle Travel: Increases in current municipal budgets for pedestrian and cycling infrastructure (A1) were assumed (+10 per cent and +20 per cent respectively for the low-intensity scenario, and +20 per cent and +40 per cent for the high-intensity scenario). It was further assumed that such enhancements could achieve a 5-10 per cent reduction in vehicle trips. There is little empirical evidence on which to base effectiveness assumptions.

Three transit enhancement strategies were assessed: infrastructure investments, service improvements, and pricing strategies. Many strategies to reduce auto use depend critically on the availability of fast, convenient, safe and reliable transit service. The effectiveness of transit as a stand-alone reduction measure does not fully reflect the important role transit plays in the success of other measures (see Section 5.4.3 on synergies). Of the three, transit pricing (A4), modelled as a $1 per trip subsidy provided by employers to employees in the low-intensity scenario and coupled with a $1.50 charge per day on vehicles driven to work in the high-intensity scenario, demonstrated the most effectiveness in increasing transit ridership.

Under the transit infrastructure strategy (A2), it was assumed that incremental infrastructure projects would be initiated in addition to investments already planned in the provincial and municipal baseline forecasts. These incremental investments targeted commuter rail, light rail (except for small urban centres), heavy-rail additions (only for Toronto, Montreal and Vancouver) and grade-separated bus lanes. Project planning was assumed to begin in 2000, to be on-line by 2010, and to be operating through 2020.

The transit service enhancements (A3) included more frequency and new routes as well as improvements in safety and convenience. The results of the enhancements were modelled as reductions in average passenger travel and waiting time on the transit system. The results from transit service and infrastructure improvements should be viewed with caution, as they result from fairly generic analysis. Each strategy encompasses a wide range of specific actions that would, ultimately, need to be tailored to each urban centre. The effectiveness of the transit strategies was not found to vary significantly across different-sized cities.

Reductions from the transit service and infrastructure strategies would be enhanced if implemented along with providing tax-exempt status for employer-provided transit passes (A20). A stand-alone measure was evaluated whereby employers were able to offer employees the choice of receiving tax-exempt transit benefits from the employer, or purchasing monthly transit passes through the employer using pre-tax income. The measure was assessed assuming that the overall costs would be shared equally between employers and employees.

The key benefit from such a measure is that it equalizes the tax treatment of employer-provided transit benefits and employer-provided parking benefits (which, due to enforcement difficulties, remain largely untaxed in Canada), and opens up new avenues for marketing public transit to commuters via partnerships between transit authorities and employers. A key uncertainty in the cost-effectiveness estimates is the rate of use expected in Canada, both by employers and employees. In the absence of empirical evidence, estimates were made.

Funding is a major barrier for all of the strategies to enhance travel alternatives. Existing funding mechanisms, which rely on municipal property taxes, are not expected to be sufficient to support these strategies. Several other strategies studied (e.g. parking and road pricing) would generate revenue, while strategic pairings of strategies could generate funds or facilitate other urban measures.

Telecommuting (A5) provides an alternative to work trips and, thus, a direct reduction in GHG. Some of this effectiveness might be reduced through a take-back effect by encouraging workers to live further from their employment. The low-intensity scenario models a national outreach campaign aimed at instilling a voluntary telecommuting strategy in half of existing workplaces with more than 50 employees. Under the high-intensity scenario, telecommuting programs would be mandatory for offices with more than 50 employees.

Discouraging Single-Occupant Vehicle Travel: This group of strategies works largely by increasing the cost of vehicle travel, thereby encouraging shifts to alternatives, trip-pooling, ride sharing, and/or trip reduction. This can be done by imposing new travel costs, such as those delivered through congestion road pricing (A8). Under the low-intensity scenario, this strategy would impose a $0.05/km charge in the off-peak and $.10/km charge during peak travel periods on all urban highways except in small urban centres. The high-intensity scenario would increase this charge to $0.10/km in off-peak and $.20/km in peak travel periods.

Increasing the cost of travel could also be done by converting existing fixed costs of driving into variable costs that reflect the amount of travel. There are different ways to achieve this conversion, however, low- and high-intensity scenarios were assessed in the basic urban study for distance-based insurance premiums (A9) of $0.05/km and $0.10/km respectively. There would be significant actuarial, financial, regulatory, political and technical issues that would need to be resolved prior to implementation. The cost per tonne of this measure is high.

Car sharing (A7) is another way in which costs could be converted to vary with the amount of travel. Participants in such programs share joint access to a fleet of vehicles located in the neighbourhood. Typically, members pay a one-time registration fee, and then user fees based on kilometres driven and time used. Insurance costs, maintenance and fuel are often included in these rates. One of the primary barriers to car-sharing programs is the need for start-up financing and marketing. A strategy was modelled under which the private sector would implement car-sharing programs with “seed capital” of $0.1 per capita per year to assist with marketing and initial vehicle purchases.

Three broad-based parking strategies were assessed, all of which were targeted at increasing the user costs of driving. Parking pricing (A10) increases of $2 for all commuter parking by 2010 were assessed as the low-intensity scenario, increasing to $4 by 2010 in the high-intensity scenario. While this strategy showed the highest effectiveness in terms of reducing vehicle kilometres travelled, it should be cautioned that there are very significant implementation barriers associated with this strategy. Most important is the lack of a regulatory or taxation mechanism to achieve the kind of coverage modelled, and to ensure that the parking charge increase was actually passed on to commuters.

An alternative parking strategy is the parking cash-out (A12), which involves requiring companies that offer free parking to employees to pay interested employees an amount equivalent to the value of the parking privilege. Employees could use this payment for transit passes, van-pooling, etc. A significant barrier to this strategy is the uncertainty of establishing the “real” value of the parking. A low-intensity scenario was considered that required all companies with more than 100 employees to participate in the cash-out program (the high intensity scenarios required participation by all companies with more than 50 employees).

Parking supply management (A11) could also serve to increase the price of parking, and hence the user costs of driving, either alone or as support for other parking strategies. Reductions of 20 per cent and 40 per cent in the supply of parking at new employment sites were modelled.

Ride-sharing programs and incentives (A6) seek to increase the number of passengers per vehicle. This may be done through carpooling (informal sharing of commute trips in a private vehicle) and van-pooling (a group of employees who commute together in a van on a regular basis). A strategy was assessed whereby all employers were required to participate in a ride-sharing program that included carpool matching, preferential parking, and a guaranteed ride home. The strategy included a marketing campaign of $1.0 per capita to accelerate the uptake by employees. This strategy yielded net emission reductions, but could encourage urban sprawl by facilitating commute trips.

Table 4.10
Summary of Urban Passenger Measures

Measure		2010 GHG (Mt)	2020 GHG (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)	Financial Cost/ Tonne ($)
Pedestrian and cycling enhancements (A1)	L	0.3	0.4	$750	$147	$147
	H	0.6	0.7	$1500		
Transit, infrastructure (A2)	L	1.3	1.4	$2120	$102	$102
	H	1.7	1.9	$3180	$115	$115
Transit, service improvements (A3)	L	1.4	1.6	$980	$42	$42
	H	1.9	2.1	$1430	$46	$46
Transit, pricing (A4)	L	1.7	1.9	$980	$27	$12 to
	H	5.7	6.4	$1930	$16	$19
Tax-exempt transit pass (A20)		0.2	0.2	-$3398	-$941	-$941
Telecommuting (A5)	L	0.4	0.4	-$730	-$99	-$99
	H	1.0	1.1	$4690	$223	$223
Road pricing (A8)	L	0.9	1.0	$1070	$72	$72
	H	1.8	2.0	$4290	$120	$120
Distance-based vehicle charges (A9)	L	0.2	0.3	$570	$146	$146
	H	0.4	0.5	$2010	$190	$291
Car-sharing programs (A7)		0.3	0.4	$20	$3	$3
Parking pricing (A10) -	L	7.7	8.6	$11 300	$89	$0**
	H	3.7	15.4	$40 000	$179	$0**
	H*	0.52	0.58	$2140	$202	$202
Parking, employer cash-out (A12)	L	0.2	0.2	$630	$178	$178
	H	0.4	0.5	$1260		
Parking, supply (A11)	L	0.2	0.2	not	not	not
	H	0.4	0.4	estimated	estimated	estimated
Ride sharing (voluntary)(A6L) to be studied						
Ride sharing (mandatory) (A6H)		2.4	2.7	$7300	$144	$144
Vehicle inspection and maintenance (A13)		0.4	0	$810	$1350	$1350
Accelerated vehicle retirement (A14)	L	0.1	0	$100	$77	$77
	H	0.2	0	$230	$62	$62
Traffic signalization improvements (A15)	L	0.4	0.4	$90	$14	$14
	H	0.8	1.1	$940	$70	$70
Driver education/awareness (A16)	L	0.4	0.4	-$500 to	-$76 to	-$76 to
	H	1.2	1.3	-$1530	-$78	-$78
3 CITY PACKAGES						
Vancouver, primary measures (A19)		0.8	1.0	$1810	$99	$99
Toronto (no ITS) (A18a)		1.9	2.7	$4705	$105	$105
Toronto (with ITS) (A18b)		2.0	2.9	$5139	$106	$106
Montréal (no road pricing) (A17a)		0.9	1.2	$1418	$68	$68
Montréal (with road pricing) (A17b)		1.1	1.4	$2467	$98	$98

* Uses blended estimate reflecting GHG estimates from Three Cities Study, with cost estimates derived by Table.
** Costs estimated by consultant were imputed value of foregone trips, with no allowance for administrative costs.

Improving the Fuel Economy of the On-Road Urban Passenger Fleet: A group of strategies was studied that seek to improve the fuel economy of in-use passenger vehicles (excluding new vehicles). They include vehicle inspection and maintenance programs (A13), accelerated vehicle retirement (scrappage) (A14), driver education and awareness (A16), traffic signalization improvements (A15), and lower highway speed limits. These strategies have limited potential, and most are not expected to have a significant influence on GHG emission increases. Only traffic signalization holds potential for significant GHG-emission reductions. This strategy was modelled as a wide range of programs to reduce traffic delays and manage incidents. Driver education may hold some potential for effectiveness, but empirical evidence is difficult to provide. This strategy was modelled as a national drivers' fuel-efficiency awareness program, with fuel-efficiency knowledge required for licensing and renewals.

Integrated Strategies: Analysis of the individual measures led to the conclusion that no single approach will effect substantial changes to the emissions status quo in urban centres. Seven packages were assessed, which integrated the individual strategies outlined above into different combinations for illustrative purposes. These packages explored various themes, including incentives only, levels of intensity, lowest cost, and public acceptability. The results from the packages ranged from a 4 per cent to a 17 per cent reduction from the 2010 baseline forecast (with the exception of one aggressive high-intensity package, which achieved a 40 per cent reduction). These results should be treated with caution, as we have little to no experience in implementing such packages of measures, nor in achieving large reductions in urban passenger emissions.

The need to combine strategies in order to achieve significant GHG reductions was a strong element in the results of the case studies conducted in Vancouver, Toronto and Montreal. A package of measures was developed in workshops held in each city, consisting of primary and complementary measures. Primary measures were those with the greatest potential for achieving significant GHG emission reductions, subject to achieving local public and political support. Complementary measures were those that were important for supporting the primary measures or achieving attitudinal change. Participants stressed the importance of focusing efforts on the primary measures in order to avoid having efforts dispersed on too many fronts at the expense of meaningful results.

The primary measures identified were remarkably consistent across cities, including investment in public transport (rapid transit and service delivery), land-use planning and control, region-wide parking pricing, parking supply management (Vancouver only), road pricing mechanisms (except for Montreal), ITS (except for Toronto), public education and awareness.

Similar barriers to implementation of these primary packages were identified in each city. They included the existing institutional framework, fiscal inequities, lack of funding, lack of political and public awareness or 'buy-in', economic impacts of the packages on or within a region, lack of co-operation between levels of government, lack of participation by senior levels of government in funding and implementation, current trends in land development and market forces, resistance to pricing mechanisms, and a lack of a stable source of funding for transit. Workshops in all three cities identified similar actions to overcome these barriers: i) strong federal, provincial and regional partnerships; ii) centralized responsibility for funding and planning/decision-making with respect to both land use and transportation planning; and, iii) a stable, dedicated funding source for transportation measures.

Data Issues and Key Assumptions

Uncertainties arise in the studies' quantitative results for several reasons. Although Canadian jurisdictions have some experience with many of the strategies considered, their experience has not generally been subject to quantitative analysis of their cost-effectiveness. Evidence from the U.S. and Europe is more prevalent, but does not always apply in the Canadian context. In the absence of empirical evidence, assumptions have been made as to the effectiveness of a given level of intervention. Further uncertainty is introduced by the fact that current effectiveness-estimates may not hold for the years 2010 and 2020, when public awareness, urban densities, congestion levels, fuel prices and other factors may have changed.

As a result, there is relatively low certainty associated with measures such as pedestrian/bicycle infrastructure enhancements, car-sharing programs, telecommuting, distance-based vehicle charges, parking-supply management, traffic signalization improvements and driver-education programs. Packages that combine measures also have low certainty, because they have no empirical track record. Measures such as transit infrastructure improvements, road and parking pricing, parking cash-out schemes and ride sharing have a broader empirical base to draw from and thus have a moderate degree of certainty in their quantitative analysis.

Due to time and data constraints, the studies do not attempt to estimate the impact of the measures on congestion or the associated costs/benefits from congestion reduction. Depending on the nature of the measure, and whether there is significant congestion in a given urban area, these benefits are potentially quite large. Measures that deter passenger-vehicle use (e.g. road charges) should bring reductions in congestion and generate cost reductions for the remaining traffic that outweigh the costs incurred by those deterred from driving. Measures that use incentives (e.g. transit improvements) to achieve modal shift from passenger cars might initially achieve these benefits, but they might also permit offsetting traffic to fill the void.

The cost estimates should be viewed as order of magnitude only, as the strategies are defined in fairly general terms and the costs are based on estimates of per capita or per unit costs applied to an assumed level of intervention. Costs may be expected to vary across individual urban centres. Moreover, the effectiveness and cost estimates for individual measures are not always compatible across the three studies. For example, the private costs of travel time changes, losses of convenience, and loss of comfort resulting from measures to induce reductions in automobile use (i.e. transit pricing subsidies, road and parking charges, distance-based vehicle charges, vehicle scrappage) were quantified in the basic urban study, but not in the other two studies. There is debate as to the most appropriate way in which to treat these non-monetary costs when evaluating the cost-effectiveness of deterrents to automobile use. Differences between the studies reflect the different approaches of the contractors, the views of the steering committees, and the level of detailed information available for the analysis. The size of these cost estimates can be significant, depending on how they are treated.

The combined baseline emissions projections for Toronto, Montreal and Vancouver are roughly 15 per cent higher in the case studies than in the basic urban study, due to differences in methodology. The growth rates projected in the two studies for 2010 and 2020 are consistent, however. The studies have highlighted the need to reconcile the national and local emissions forecasts, and to develop improved local analytical tools with which to assess the cost-effectiveness of the urban passenger transportation measures.

Ancillary Effects of Measures

Most of the strategies evaluated for urban passenger transportation derive their GHG reduction benefits by reducing vehicle kilometres travelled (VKT). Significant benefits from the reduction of congestion and other air contaminants are expected to accompany these VKT reductions. Although difficult to estimate with any level of precision to 2010/2020, savings would also result to municipalities in reduced road infrastructure costs. Where active transportation forms part of the strategies, additional health benefits would accrue. Strategies that expand non-auto travel alternatives serve to increase mobility in urban areas, particularly for individuals without access to a personal vehicle. Pricing strategies that discourage VKT (particularly for commuting) and transit enhancement strategies support more compact urban form which, in turn, is expected to generate savings for municipalities in providing infrastructure for residential areas.

Some negative impacts might be expected from these strategies. They include negative safety impacts from increased pedestrian/cycling activity, safety and noise impacts from increased traffic on residential streets, and increased noise from more compact urban use and transit expansion. Opportunities have been identified, through planning and other means, to mitigate these potential impacts.

Regional/Competitiveness Impacts of Measures

A number of competing influences—some negative, some positive, and some distributional—have been identified. In large part, they reflect both the benefits that would stem from access to a more efficient, less congested transportation system, and the increased costs to businesses and individuals from funding the infrastructure and transit strategies and the higher costs of vehicle use. The strategies identified may be expected to influence business and residential location decisions, the freight sector, vehicle manufacturers (although the effect of the strategies on vehicle ownership compared to use is unclear), urban fuel retailers, general retail and tourism.

4.3.4 Intercity Passenger Transportation

Current trends in intercity transportation, defined as trips with a one-way distance exceeding 80 kilometres, are away from the more fuel-efficient modes of transportation. This reflects growth in personal vehicle use and the number of vehicles owned, low prices for transportation fuels, a long-term decline in ridership on bus and rail services, and societal values that reinforce all of the above. At present, travel by private automobile and light trucks accounts for roughly 84 per cent of all intercity passenger activity (as measured by passenger kilometres). Air travel accounts for 10 per cent, bus 5 per cent and rail and ferries less than 1 per cent each.

Some limited initiatives have been undertaken in the intercity and urban road transportation network with the objective of improving road vehicle fuel-efficiency. These include high-occupancy vehicle (HOV) lanes, the use of rigid pavement materials, and a range of intelligent transportation system (ITS) technologies. Some ITS technologies that have been adopted in municipalities across Canada as a means to combat growing urban congestion also have potential to reduce GHG emissions. In addition, a number of commercial vehicle electronic clearance systems have been implemented in order to reduce idling times at border crossings and inspection stations.

Summary of Intercity Passenger Measures Evaluated

The three studies considered shifting travel to more emission-efficient means of transportation, improvements to road infrastructure, and the effectiveness of ITS in reducing GHG emissions. Many of the measures have applications for both intercity and urban transportation.

Measures to Favour Passenger Modal Shift for GHG Reduction: The challenge of shifting people out of their personal vehicles to a degree that could result in significant GHG reductions is formidable. For example, to reduce GHG emissions to 6 per cent below 1990 levels in 2010 outside of the Quebec City-Windsor corridor would require approximately 39 per cent of air and 44 per cent of automobile travel to be diverted to buses.

Within the Quebec City-Windsor corridor, large proportional increases in rail traffic would be required to generate even small percentage reductions in car and air traffic. Measures that make rail more attractive would also tend to attract new passengers and divert passengers from competing bus routes.

A number of factors were identified that determine modal choice for intercity travel, including price, service (frequency and trip time), comfort, amenities, security, connections and information. A number of approaches through which to influence these factors was considered, including: i) increasing the price of car and air modes; ii) subsidizing the price of bus and rail modes; iii) improving the speed, comfort and convenience of bus and rail; iv) terminal investments to promote seamless surface intermodal transportation; v) coordinating carrier resources; and, vi) traveller information.

While all of these approaches were felt to be worthy of consideration, many were excluded either because their GHG emission effects would be predominantly within each mode (rather than causing a shift across modes) or because no data were available for their quantitative evaluation. Ultimately, only two measures were selected for in-depth analysis:

i) an intercity bus subsidy (B1), which would reduce bus fares to below the variable cost of single-occupant vehicle travel (i.e. a $0.05/passenger kilometre subsidy subject to a fare maximum of $0.07/passenger-kilometre); and,

ii) investment in electrified high-speed rail between Quebec City and Toronto (B2). Funded by government, construction would occur over six years, and operation would continue for the life of the infrastructure (estimated at 60 years).

Both measures would require substantial government support in terms of funding and program administration. As well, significant competitiveness issues would be raised with the introduction of high-speed rail, particularly for the bus, air and existing rail passenger services in this corridor. The degree to which air carriers operating in this corridor would respond competitively is unknown, and was not estimated in the analysis.

The impact that an intercity bus subsidy might have on modes other than single-passenger vehicles could not be predicted because of the lack of actual data. In the longer-distance markets, there was felt to be almost no potential for modal shift from air to bus, with discount air fares already close to standard bus fares, and substantial trip-time differentials.

Table 4.11
Summary of Intercity Modal Shift Passenger Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)
Intercity bus subsidy (B1)	0.3-1.4	0.4-1.8	$1095 to $3285	$120
High-speed rail (B2)	0.281	0.423	$1800 to $7000	$60 to $240

Highway Infrastructure and Opportunities for Reduction of GHG Emissions: This study assessed how changes in the maintenance and use of roads and highways could reduce GHG emissions. The study looked at construction and design technologies available for highways, management and use of the highway and road infrastructure, and measures for reducing congestion. Six measures were selected for in-depth analysis.

A road pricing scenario (B3) was evaluated whereby the road user on urban and intercity networks would pay the full cost of this use, including the external environmental costs. It was estimated that this measure would increase costs for intercity travel by approximately 10 per cent, and costs for urban travel by as much as 100 per cent.

Enforcement of existing national highway system speed limits (B4) would reduce auto and truck speeds, as these posted limits are frequently exceeded (many posted limits are currently set at 100 km/hour and 110 km/hour). A second measure would reduce speed limits on the national highway system to 90 km/hour with strict enforcement (B5).

More frequent re-surfacing of urban and intercity roads (B6) was modelled to reduce roughness and improve vehicle fuel-efficiency, as well as the use of rigid pavements (concrete cement) (B7) on 6500 km of the estimated 25 000 km of the national highway system as sections come due for reconstruction. Rigid pavements would be limited to routes with high truck traffic, where they would be more economical on a life-cycle basis. Previous studies showed fuel savings ranging from 1.5-20 per cent, with more recent estimates at 15 per cent. For the purpose of the study, the calculations were done using 10 per cent.

The effectiveness of high-occupancy vehicle (HOV) lanes (B8) was evaluated, in which 225 km of urban general-purpose road lanes were dedicated to the use of high- occupancy vehicles (vehicles with at least two occupants, including transit buses) and 450 km of freeway HOV lanes were constructed. The analysis was based on only two reports conducted with limited case studies. The results of the two reports differ. The study estimates a positive impact on GHG emissions, and the results were extrapolated to a national level. Most of the cost savings are from time savings for HOV users.

The major barriers to full road-cost pricing and reduced speed limits are public and political resistance. There would be concerns regarding the social and economic impacts in rural areas, where alternative travel is not available. Rigid pavements have raised some concerns with respect to maintenance costs. The long-term time frame for implementing some of the infrastructure measures, which in the case of rigid pavements is over a 40-year cycle, contributes to their uncertainty, even though the emission reductions and ancillary benefits to air quality could be considerable. HOV lanes are usually quite expensive and most effective on highways at least 16 km long with high congestion, where there are appreciable time savings to the high-occupancy vehicles.

Most of the cost and saving of the infrastructure measures are from time savings, operational savings and costs, and activity-reduction value estimates.

Table 4.12
Summary of Road Infrastructure Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)	Financial Cost/ Tonne ($)
Road pricing (B3)	2.8	3.2	$3900	$68	$0
Enforcement of existing speed limit (B4)	4.2	4.7	$850	$10	-$59
Reduction of highway speed limit to 90 km/h (B5)	8.3	9.2	$5000	$31	-$63
More frequent resurfacing (B6)	0.4	0.5	$1200	$133	$133
Use of rigid pavement (B7)	0.3	0.5	-$300	-$15	-$15
High-occupancy vehicle (HOV) lanes (B8)	0.9	1.1	-$20 000	-$1000	-$187

Deployment of Intelligent Transportation Systems on Canada's Road Network: Intelligent transportation systems (ITS) are in use in some areas of Canada. This study looked at the ITS technology currently being researched either in Canada or elsewhere, and assessed eight measures for reducing GHG emissions. The proposed measures included: the use of incident management systems (B9) to provide early detection and response to incidents; adaptive signal control systems (B10), which respond to real-time traffic conditions; advanced traveller information systems (B11), which facilitate pre-trip and en-route travel decisions; transit automated vehicle location systems (B12), which track the location of vehicles and permit real-time adjustments to the transit schedule; electronic toll collection (B13), which allows for non-stop tolling in the use of road pricing; the Transit Smartcard (B14), which improves transit user and operator convenience; commercial vehicle electronic clearance (B15), which reduces idling and waiting times at borders and weigh stations; and advanced vehicle control systems (B16), which use on-board sensing technologies to avoid collisions.

Most ITS technology, such as traffic control, transit automated vehicle location systems and the Smartcard, is more applicable to urban centres than to intercity travel.. Their deployment often requires substantial architecture and capital investment, and coordination across several regions. The measures generally reduce emissions by improving traffic flow and reducing congestion. While many of the proposed measures would result in a financial benefit, the primary barriers are initial funding and inter-agency coordination. Software licensing and legal liability, the need for a national architecture, high operational and maintenance costs, and public reluctance are other barriers to this otherwise beneficial technology. Most of the benefits of the ITS measures are from time savings for road users.

Table 4.13
Summary of ITS Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)	Financial Cost/ Tonne ($)
Incident management (B9)	0.108	0.215	-$170	-$39	$162
Traffic control (B10)	0.100	0.141	-$880	-$278	$16
En-route and pre-trip traveller information (B11)	0.154	0.300	$33	$6	$302
Transit automated vehicle-location systems (B12)	0.004	0.008	$11	$65	$65
Electronic toll collection (ETC) (B13)	0.253	0.549	-$1500	-$137	$117
Transit Smartcard (B14)	0.025	0.051	-$27	-$28	$167
Commercial vehicle electronic clearance (B15)	0.016	0.032	-$150	-$254	-$254
Advanced vehicle control systems (B16)	0.047	0.206	-$13	-$4	$218

Data Issues And Key Assumptions
Data on passenger vehicle travel is not widely available. There are public statistics available for air and rail, and some for bus. In some cases, due to a lack of public data, the consultants had access to confidential data from the industry. In particular, there was no opportunity to review the data used for the high-speed rail measure. Separation of intercity travel from urban and commuter travel is most difficult for the automobile mode. The Canadian Travel Survey, which is designed to serve the needs of the hospitality industry, provides a broad overview of the travel preferences and trends of Canadians. The National Highway System was another source of data, used by the study on infrastructure, and data on vehicle purchases were also available. For some measures (i.e. high-speed rail or a large financial bus subsidy) there was no practical experience, and assumptions were made on effects. For measures aimed at reducing congestion, such as ITS, it was difficult to assess the additional traffic that would be generated from less congestion, which would reduce some of the GHG benefits of these measures.

There was limited data on consumers' willingness to change modes of travel in response to price changes, subsidies or other factors. The marketing and operational options to improve intercity passenger rail and bus were not analyzed and need further work.

In proposing any major new mega-project, such as high-speed rail or a transit automated vehicle location network, the customary uncertainties of market conditions and demand predictions, technological change, cost overruns, and environmental approval, would apply. Generally, the measures with a longer forecast period would have a lower level of certainty. This is generally the case for major capital projects such as high-speed rail, which has a 60 year forecast period.

For the study on infrastructure, the estimates were extrapolated to a national level from limited case studies using the National Highway System data. The key assumption for the ITS measures was the penetration rate of the new technology in large and medium cities in Canada. These penetration rates were based on the consultant's best knowledge, not on any study.

Ancillary Effects of Measures
Measures that reduce GHG emissions from intercity travel are often geared at reducing congestion or improving driving efficiency, and are associated with a number of ancillary benefits, such as reductions in fuel consumption, air pollution, travel time, and collisions.

Regional/Competitiveness Impacts
The reduction of the highway speed limit to 90 km/h would have a greater impact on the provinces of Alberta, New Brunswick and Nova Scotia, which have an existing posted speed limit of 110 km/h.

A subsidy on existing public transportation would provide less benefit to the rural regions, where individuals have limited bus service options and rely more on their cars than their urban counterparts. Many of the ITS options would provide benefits only to congested urban centres, and would not apply to rural areas.

Introduction of commercial vehicle electronic clearance at land border crossings would expedite freight entry into Canada. The U.S. is introducing intelligent transportation systems into its cities, and Canada is a leader in the research and development of ITS technology. Expansion of this technology in the Canadian urban and inter-urban transportation network would keep Canadian cities in line with global development and foster growth in this progressive sector. Other measures, such as road pricing/electronic toll collection, or reduced speed limits, could have a negative impact on the trucking industry and/or tourism sector.

4.3.5 Fuel Pricing and Taxes

A study examined the potential for using fuel taxes to reduce GHG emissions in the transportation sector, including a comprehensive literature review and a workshop of international and Canadian experts on fuel price elasticities and fuel tax design. Elasticities estimate the level of consumer response to changes in price. These were estimated for each fuel, in both the short-term and long-term. In the long-term, it is estimated that one third of the response is due to reduced activity or use, and two thirds to changes in technology and efficiency. The results of this workshop were used as input to the detailed analysis in the study.

Both levels of government impose taxes on transportation fuels. Excise taxes are levied as a fixed tax per unit volume. In addition, the federal Goods and Services Tax (GST) and some provincial taxes are levied as a fraction of the price of the fuel. The federal excise tax rates differ between gasoline and diesel fuel, but do not vary with the end use (except for fuel to be used in vessels or aircraft in international trade). Most provinces have similar structures, while exempting a few end uses such as agriculture, fishing , mining and forestry. Some alternative fuels, such as ethanol, are exempt from excise taxes.

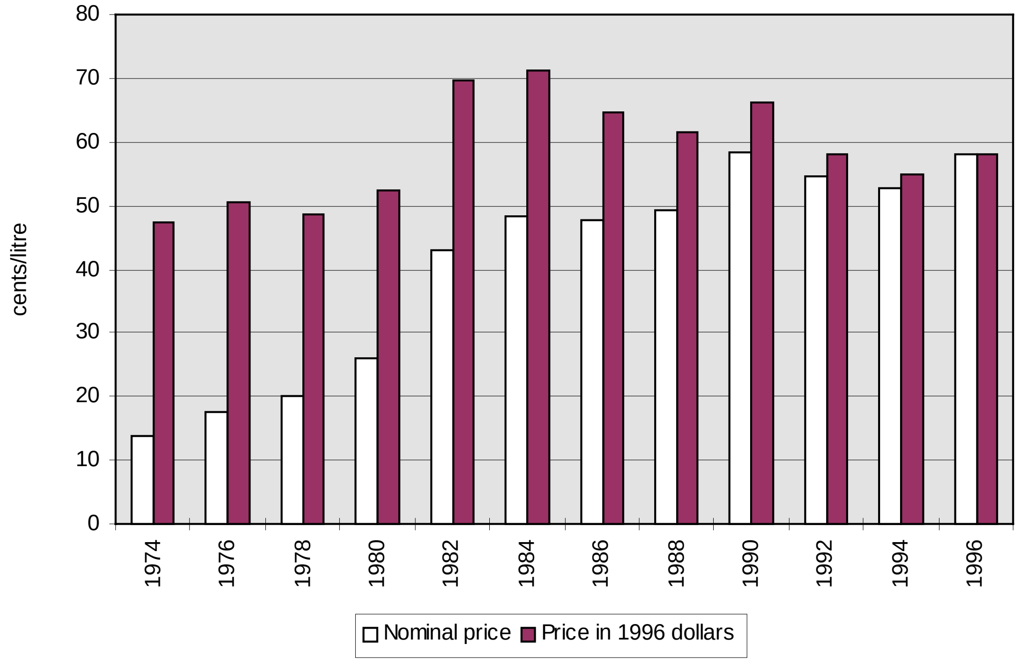
The average rate of taxation at the provincial level is higher than at the federal level. Most provinces levy excise taxes, but not sales taxes, on fuels. In Harmonized Sales Tax (HST) provinces, the combined tax is applied to fuels. Some provinces have levied additional taxes or dedicated a portion of provincial taxes in urban areas to allow municipal or regional governments to use fuel taxes explicitly for urban transportation. This is the case in B.C. for the Greater Vancouver Regional District and Victoria, and for Quebec in the Montréal region.

Table 4.14
Federal and Provincial Excise Taxes on Road Gasoline and Diesel
(cents per litre, as of January 1, 1999, excluding sales taxes)

	Gasoline	Diesel
Federal excise tax	10.0	4.0
Provincial taxes		
Newfoundland	16.5	16.5
Prince Edward Island	13.0	13.5
Nova Scotia	13.5	15.4
New Brunswick	10.7	13.7
Quebec(2) (3)	15.2	16.2
Ontario	14.7	14.3
Manitoba	11.5	10.9
Saskatchewan	15.0	15.0
Alberta	9.0	9.0
British Columbia(4)	11.0	11.5
Yukon	6.2	7.2
Northwest Territories(5)	10.7	9.1

(1) In Newfoundland, New Brunswick and Nova Scotia, the GST and the retail sales taxes are replaced by a single, harmonized value-added tax, applicable on all petroleum products.
(2) A transit tax of 1.5 cents/litre is applicable to gasoline in Montréal and surrounding municipalities.
(3) The clear gasoline tax is 12.2 cents/litre in the region between the Quebec border and Red Bay in Labrador.
(4) In the Greater Vancouver Regional District and Victoria there is a transit tax of 4 cents/litre and 2.5 cents/litre.
(5) The gasoline tax is based on a 17 per cent valorem rate, and the diesel tax is 85 per cent of the gasoline tax.

Chart 4.5
Gasoline Retail Prices 1974-1996



Summary Of Fuel Tax Measures Evaluated

Fuel Tax (National): The objective was to determine how much of a fuel price increase would be required to reduce transportation fuel use by enough to achieve the Kyoto target for the entire transportation sector. Meeting this target would require an increase in all existing fuel excise taxes phased in over four years in equal nominal amounts (I1). Tax revenues could be returned through reductions in other taxes, such as income tax or sales taxes.

The tax increases required to achieve the Kyoto target would more than double gasoline prices—from about \$0.54 per litre to about \$1.40 per litre by the year 2010. Other fuels would also have large price increases. This price increase would lead to the desired 28 per cent reduction in transportation fuel use, owing to lower activity (distances travelled, seat miles in passenger modes, freight tonne-miles) and efficiency improvements.

The study did not estimate direct costs, as taxes represent transfers of income, not costs to the economy. The only direct costs would be administrative costs of imposing higher taxes. Such costs are likely to be minimal since they are simply increases in existing taxes. Using base-case elasticities, the tax would collect \$670 billion over the 20 year period from 2000 to 2020. It is estimated that, in most years, the tax would produce increased revenues to the federal and provincial governments of over \$33 billion per year.

Embedded GHG Tax (National): This scenario (I2) is the same as the one above, with the exception that all existing fuel excise taxes would be increased in proportion to their GHG efficiency (emissions per activity unit). The new taxes would also more than double gasoline prices to about $1.40 per litre, and would substantially increase the price of other transportation fuels. The tax would generate something in the order of $700 billion over the period 2000-2020.

Urban Gas Tax: Almost two thirds of GHG transport emissions originate in urban areas. Three levels of urban gasoline tax increases were examined: one, two and four cents a litre (I3A, I3B and I3C). The taxes would be increased one cent per year until the full tax was reached, and kept at that level until 2020. For example, in the four-cent-a-litre case, gasoline prices would rise to $0.58 per litre by 2004. The analysis suggests that even relatively modest tax increases, if applied early and allowed to remain in place, could produce a reduction in GHG emissions. Such GHG reductions would be reinforced if the revenues generated were used to support other measures, such as improved public transportation and related measures.

Road Gasoline and Diesel Tax: Two price scenarios were examined. One would involve a 10-cent tax starting in 2000 at a level of one cent per litre and increased by one cent each year until 2010 (I4A). The tax would then be maintained at that level until 2020. The other would involve a 20-cent tax rise over the same period (I4B). As the chart below shows, the analysis done for the Table estimates that the two tax measures would have a significant impact on GHG emissions.

Table 4.15
Summary of Fuel Tax Measures[36]

Measure	2010 GHG Savings (Mt)			2020 GHG Savings (Mt)			2010 Tax Revenues ($B)			2020 Tax Revenues ($B)		
	L	M	H	L	M	H	L	M	H	L	M	H
Fuel tax (national) (I1)		54			89		92.9	36.6	21.2	86.5	32.1	17.3
Embedded GHG tax (I2)		54			89		92.9	36.6	21.2	86.5	32.1	17.3
Urban tax (1 cent) (I3A)	0.3	0.4	0.5	0.4	0.7	0.9	0.2	0.2	0.1	0.2	0.2	0.1
Urban tax (2 cents) (I3B)	0.5	0.8	1.0	0.9	1.3	1.8	0.3	0.3	0.3	0.3	0.3	0.3
Urban tax (4 cents) (I3C)	1.0	1.4	1.9	1.7	2.6	3.5	0.7	0.6	0.6	0.6	0.6	0.6
Road gas and diesel tax (10 cents) (I4A)	4.7	7.5	10.3	10.3	16	22.1	5.8	5.4	5.1	4.6	5.3	6.0
Road gas and diesel tax (20 cents) (I4B)	8.6	14	18.6	18.6	29	38.8	11.3	10.5	9.7	8.3	9.9	11.6

Data And Key Assumptions

A major objective of the study was to reach consensus on transportation fuel price

[36] GHG and revenue estimates are provided as ranges to reflect high, medium and low elasticities

elasticities. The effectiveness of any fuel tax in reducing GHG emissions depends on how responsive, or elastic, fuel use is to the tax. The study focused on own-price elasticity; defined as the percentage change in demand for the fuel divided by the percentage change in the fuel price. It used three elasticity cases: a base elasticity case, with an upper and lower range of values for the analysis.

There was considerable information on gasoline price elasticities for cars and light trucks. This was not the case for air, bus, and freight transport. Elasticities for gasoline use in cars and light trucks were estimated to range from -0.1 to -0.2 for the short run, with a base estimate of -0.15. For the long-run elasticity, the range is -0.4 to -0.8, with a base estimate of -0.6. The study concluded that short- and long-term elasticities were generally higher for road gasoline than for the other modes.

It should be noted that in the Table's analytical framework, tax increases did not represent resource costs unless used to purchase goods or services. Taxes to influence behaviour were treated as resource transfers (see Section 5.3 for the amount of the resources transfers). However, this is not to suggest that tax increases are costless to consumers who pay the higher taxes. Further, the actions taken in response to higher fuel prices produce various costs and benefits to consumers that have not been estimated in this analysis.

Ancillary Effects Of Measures

The reduction in fuel use resulting from the imposition of fuel taxes would result in a significant reduction in other environmental impacts, including emissions of sulphur oxides, nitrogen oxides, and particulates. Further, the reduction in activity levels (especially VKT) could produce some reduction in congestion.

Regional/Competitiveness Impacts Of Measures

The regional and competitiveness impacts would differ according to the nature and magnitude of fuel tax increases. For example, with the large price increases, it might be expected that domestic oil producers and refiners and oil service providers, distributors and retailers and the major oil-producing provinces of Alberta and Saskatchewan would be affected adversely by reduced fuel use. Transportation equipment manufacturers, importers and parts suppliers, primarily located in Ontario and Quebec, would also be affected. Although the change in vehicle fleet size is not expected to be large, individual manufacturers and importers would be impacted disproportionately based on their model mix and model range.

If revenues were not used to offset other taxes, Canadian industries would experience an increase in costs relative to other jurisdictions if the other countries (notably the U.S.) did not adopt similar policies. That could reduce Canadian ability to compete with goods and services from those markets.

At the same time, there would be business and economic opportunities resulting from the adjustment to higher fuel prices. Examples might include companies that develop and market alternative energy and efficiency-related technologies, products and services.

4.3.6 Emissions Trading

A study was undertaken to evaluate the potential of applying emissions trading schemes to the transportation sector. Such schemes allow the trading of emission permits between firms. Firms with high costs of reducing emissions may purchase credits from firms with lower costs. This reduces the overall cost of meeting a target to the economy as a whole.

Cost savings attributable to an emissions trading program depend on the range of abatement costs across participants (i.e. cost savings tend to be larger where the range in marginal costs across program participants is greater), and the costs incurred in creating the system and carrying out transactions.

There has been some but limited experience with emissions trading involving mobile sources, such as those from transportation. However, much of the experience with trading systems involves large stationary sources, such as power plants in the U.S. The Table's analysis assumed that transportation fuels were not captured as part of a broader, national trading system. A wide array of possible trading programs was identified, and four options were analyzed in more detail, but largely qualitatively.

Summary Of Emissions Trading Measures Evaluated

Nationwide Transportation Carbon Cap (J1): This trading program would cover all consumers of transportation fuel. Households, firms, and governmental and non-governmental organizations would receive carbon permits that would have to be surrendered in proportion to fuel purchases.

Given the enormous number of participants, a key issue is whether the transaction and administrative costs could be reduced to a level that would make the program cost-effective. Total annualized administrative and transactions costs were estimated to be approximately $219 million. Fuel suppliers and the administering agency would incur most of these costs in setting up and maintaining the permit tracking system, and in overseeing the transfer of permits.

This program offers the highest relative potential for abatement cost-savings when compared to other emissions trading measures that provide only partial coverage of the transportation sector, because nationwide participation would maximize differences in marginal costs. However, the potential cost-savings associated with this program could not be estimated, because information on the differences in marginal cost of abatement throughout the transportation sector were not available.

Mobile Source Emission Reduction Credit Measures (J2): Mobile source emission reduction credit (MERC) measures could be added to a basic trading system that includes only stationary sources of GHG emissions (utilities, factories, etc.), thereby increasing their flexibility in meeting their emission reduction goals and providing partial coverage of the transportation sector. A number of MERC measures are possible. Firms could earn tradable credits for GHG emissions reduced as a result of vehicle scrappage programs, a vehicle repair, replacement, and retrofit program, clean-fuel fleet measure, or urban transportation measures. The analysis of these measures is preliminary, and further study would be needed prior to implementation.

A more detailed analysis of the transactions and administrative costs of a scrappage program are presented. For this program, stationary sources would earn emission-reduction credits by permanently removing high-emission vehicles from use. The major implementation cost would be the cost of purchasing vehicles. As compared with other CO_2 reduction opportunities in the transportation sector, a vehicle scrappage program is likely to result in much higher costs per tonne of emission reductions. Based on a number of assumptions, the total administrative costs estimated for the program would be approximately $14.9 million per year or about $2252 per tonne.

Manufacturer- and Importer-Based Fuel Consumption Standard (J3): This measure assumes that all manufacturers and importers of light-duty vehicles sold in Canada would be required to satisfy fuel consumption limits averaged across all new vehicles sold with the standard weighted by vehicle class. Participants in the trading program would be able to earn fuel consumption credits (FCC) by surpassing their fuel-efficiency standard. Banking of excess FCCs for future sale or use would be allowed.

Transactions and administrative costs would be incurred by two groups: the manufacturers and importers covered by the program, and the administering agency. The costs of repaying borrowed FCCs would be the major outlay for manufacturers and importers, while the cost of developing and maintaining the tracking system would be the most significant portion of the costs borne by the administering agency.

An assumption-driven model was used to provide order-of-magnitude estimates of the cost savings of this trading program. For fuel consumption reductions of 15 per cent, 20 per cent and 30 per cent resulting from scenarios of low, moderate and high fuel-economy standards, the trading program would result in cost savings of 24 per cent, 15 per cent and 8 per cent respectively over the costs associated with the standards alone. Improved estimates of cost savings could be obtained by incorporating manufacturer-specific costs of reductions curves in the model.

Clean-Fuel Fleet Consumption Credits Program (J4): Under this program, owners and operators of fleets above a given size would have the opportunity to participate in FCC trading by introducing clean-fuel vehicles into their existing fleets. Program participants would earn FCCs in proportion to their actual use of clean fuel; that is, the FCCs generated by program participants would be based on actual use of alternative fuels and the carbon content of the alternative fuel relative to that of gasoline or diesel.

The most significant trading costs for the clean-fuel fleet companies would be related to tracking the number of kilometres driven, preparing annual reports, and installing odometers in dual-fuel vehicles. For the administering agency, the largest outlays would be incurred as a result of creating and operating the tracking and reporting system.

Based on a comparison of the value of existing fuel subsidies and a value of FCCs, an evaluation of the scale of the effects of offering FCCs to alternative fuel vehicles suggests that a clean-fleet fuel consumption program would offer an inducement approximately one fifth as large as current fuel subsidies.

4.3.7 Off-Road Emissions

The off-road sector covers a wide variety of vehicles and equipment, spanning several different sectors of the economy. The off-road engines consume both gasoline and diesel, and vary considerably in both size and function. For example, the off-road sector comprises such items as lawnmowers, leaf blowers, snow blowers, all-terrain vehicles, golf carts, watercraft, tractors, forklifts, welders, combines, chainsaws, skidders, asphalt pavers and excavators, to name a few. As Chart 4.6 illustrates, the off-road sector was estimated to account for about 11.6 per cent of total transportation GHG emissions in 1995 (this increased to 13 per cent by 1997).

About three quarters of Canada's off-road GHG emissions come from the consumption of diesel fuel, primarily in the agricultural, mining and construction sectors. It is particularly noteworthy that almost one third of the diesel used in Canada is consumed for off-road purposes. At 5 per cent, off-road sources account for a much lower, but still significant, percentage of domestic gasoline consumption.

Due to data limitations, it is difficult to predict with any precision future off-road GHG emissions. However, it is estimated that such emissions will likely be in the vicinity of 26 MT in 2010 (Table 4.16), almost 80 per cent of which will come from the consumption of diesel fuel. This represents more than a 50 per cent rise in off-road emissions from the 1990 level of approximately 16 Mt. The agricultural sector is currently expected to account for the highest contribution to total emissions, followed by the construction and mining sector, recreational marine vessels and recreational vehicles, and lawn-and-garden equipment. The remaining sectors are expected to account for less than 3 per cent of total off-road emissions.

Currently, there are no measures underway or planned in Canada to reduce emissions from the off-road sector. This is mainly due to the lack of information on this sector that would support the development and implementation of off-road mitigation measures. In this regard, the off-road study commissioned by the Transportation Table is important, as it supports the development of an inventory of off-road emissions based on existing information.

Chart 4.6
Off-Road Sector GHG Emissions, 1995

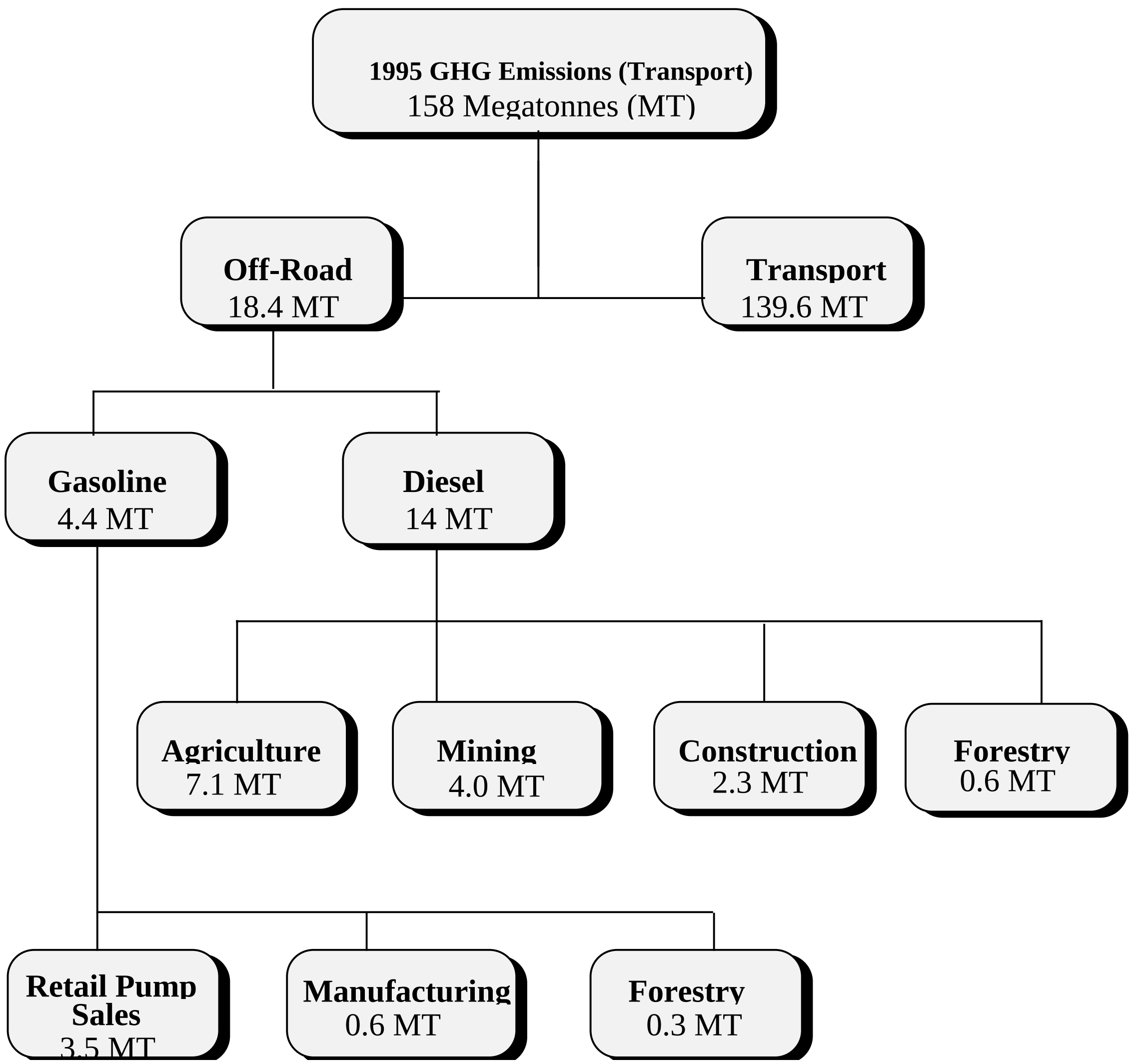


Table 4.16
Off- Road GHG Emissions, 1990 & 2010

	Megatonnes	
	1990	**2010**
Agriculture	6.8	11.1
Construction and mining	3.0	4.7
Recreational marine and recreational	3.0	4.6
Lawn and garden	1.8	3.0
Light commercial	0.5	0.8
Industrial	0.5	0.7
Logging	0.4	0.4
Airport service	0.1	0.2
Total	**16.0**	**25.6**

The figures were generated by the Transportation Table's off-road study and normalized to the CO_2-equivalent emissions estimates, based on *Canada's Energy Outlook* fuel consumption totals.

Summary Of Off-Road Measures Evaluated

Measures were targeted at three specific engine types:
i) recreational engines (55-60 hp snowmobile and personal water craft);
ii) construction and mining equipment (255-400 hp); and,
iii) agricultural equipment (150-200 hp).

Fuel Efficiency Regulations (K1): Performance standards for the fuel economy of new engines in the three selected engine-classes would be regulated under the Energy Efficiency Act. The new standards would be phased in over a five-year period beginning in January 2000, and would be in full effect by December 2005. Costs and emissions reductions were estimated over a 10-year period starting January 2000 and achieving full projected benefits by 2010.

Performance standards would not have a major impact on the use of the three equipment types evaluated in the study. In the case of recreational equipment, more efficient four-stroke engines are available, and prices for the two engine technologies are similar. However, the regulations would improve fuel efficiency by an estimated 15 per cent for the two recreational vehicles analyzed. Smaller impacts (5 per cent) are expected for the construction, mining and agricultural engines. Transferring the technology for more efficient diesel engines from on-road use to the much larger construction and agricultural engines should reduce fuel consumption at a relatively modest cost.

There are a number of implementation issues that would need to be addressed with respect to fuel efficiency regulations. Low turnover rates for most off-road equipment will increase the time required to achieve changes to the full fleet. Performance standards must be based on accurate test results and undergo appropriate verification processes before implementation. This would require better information on off-road equipment and its use.

Public Awareness Campaign (K2): The objective of the measure would be to educate consumers about the benefits of purchasing energy-efficient vehicles and equipment. The campaign would run during the first five years (2000-2005) in order to influence public purchasing behaviour at an early stage and, where applicable, assist in creating market demand so that prices can begin to fall during the final five years of the program. Through more informed choices, consumers would voluntarily select cost-effective and energy-efficient technologies over traditional technologies due to the expected fuel savings and additional benefits. Studies show that engines and equipment used for business can anticipate full payback of any additional costs within five years, based on technology improvements.

Public awareness campaigns could be effective in changing consumer opinions (e.g. for or against specific products) and in launching "eco-logos" (e.g. energy-efficiency labels for fuel-efficient vehicles and equipment), as well as in raising awareness of the fuel consumption/emission rates of various equipment.

Voluntary Memorandum of Understanding (MOU) With Manufacturers (K3): This measure would include signing a voluntary MOU with manufacturers or distributors in order to up-grade the stock of vehicles and equipment models to be more energy efficient (using similar standards to those proposed in the fuel-efficiency regulations).

Table 4.17
Summary of Off-Road Measures

Measure	2010 GHG Savings (Mt)	2020 GHG Savings (Mt)	Direct Costs (NPV lifetime) ($M)	Cost/ Tonne ($)
Regulation (K1)	2.0 to 2.5	n/a	$20 to $36	n/a
Public awareness (K2)	0.2 to 0.3	n/a	$9 to $13	n/a
Voluntary MOU with manufacturers (K3)	1.76	n/a	$25 to $42	n/a

Data And Key Assumptions

The study broke new ground in terms of developing a more sophisticated inventory of off-road emissions, using a "bottom-up" approach. However, because of the lack of readily available Canadian data, it was necessary to utilise off-road data from the U.S.. All of the average power, hours of use, load factor, and raw data were taken from U.S. averages.

The effectiveness of the measures was estimated using U.S. data on the use of off-road equipment and applying it to the estimated number of each type of equipment in Canada. It is believed that U.S. use of some of its most important types of equipment is significantly greater, due notably to climatic differences. This means that the projected GHG emissions and potential for reductions may be overestimated.

Ancillary Effects Of Measures

The strongest ancillary environmental and health-benefits effects are those that arise from the introduction of fuel-efficiency regulations. Many technology improvements, such as four-stroke overhead-valve (OHV) engines, can both reduce emissions and improve fuel efficiency. The health impact of reducing exposure to CO, benzene and VOCs and other pollutants has been well documented. In addition, non-road contributions to ozone formation by small off-road gasoline engines (less than 25 hp) alone produce 10 per cent of U.S. mobile source hydrocarbon emissions. In addition, regulations that would phase out older equipment types over the 10-year period would improve safety and health, and reduce fuel costs.

Regional/Competitiveness Impacts Of Measures

Manufacturers that currently produce engine types that meet the new efficiency specifications would have a competitive advantage over others. However, this could be minimized if tighter standards were phased in over a five-year period.

V. THE OPTIONS FOR TRANSPORTATION

This section outlines the Table's assessment of the various measures studied. It outlines how these measures should be packaged or grouped together, and describes the key factors in assessing the options for reducing GHGs from transportation.

5.1 THE TABLE'S APPROACH TO ASSESSING THE MEASURES

The Table analyzed more than 100 measures to reduce GHG emissions from transportation. A ranking of measures according to their cost per tonne of GHG reduced would not necessarily provide the best strategy for addressing transportation and climate change issues. Cost-effectiveness is very important, but there are other key social and economic factors that must also be considered in determining the best measures for reducing emissions.

A number of criteria were developed to assess the measures and determine which have the best potential for implementation or further active investigation (Table 5.1).

Table 5.1
Criteria for Assessing Transportation Climate Change Measures

Cost	Total economic cost per tonne of GHG reduction.
GHG Impact	Total GHG reduced in 2010 and 2020.
Ancillary impacts	Impacts on other aspects of quality of life (e.g. safety, health, air quality).
Economic impacts	Enhances Canadian business and generates jobs and new technologies. Measure can function autonomously or international support can be developed. Measure is affordable over the long term.
Complementarity	Measure reinforces or enhances the effectiveness of other measures or is required for other measures to work.
Implementation/ Administration	Ease of implementation, degree to which administration is burdensome, costly or complex.
Certainty or absence of risk	Reliability of data and confidence that measure will work over the short and long terms.
Equity effects	Measure disproportionately affects a sector or region, mobility across the country, or requires significant transfers (e.g. taxes, fees, charges).
Public support	Public adequately informed to accept measures, or potential for public support if educated.
Other cost information	"Hard" or financial cost of reductions, private or government investment.

It was not possible, given the Table's budget and schedule, to complete a detailed assessment of all of these factors, or to examine in sufficient detail the range of issues related to implementation. For example, while the Table adopted a criteria that no measure should diminish existing safety standards, a more detailed examination of safety issues may be needed in some instances. As such, it was not possible to identify a single package of measures to reach the Kyoto target. However, the Table has identified sufficient options to reach and go beyond the Kyoto target in transportation.

Table members discussed the measures in the context of these criteria and identified the measures as falling into one of the following four categories:

1. ***Most Promising Measures***: measures that are cost effective (generally have positive benefits or cost less than $10/tonne), are easier to implement, or do not involve significant resource transfers. They may require some additional analysis and design. These are close to but go beyond "no regrets" measures, as conventionally defined.

2. ***Promising Measures:*** measures that have potential for various levels of GHG reductions at low to modest cost, or which are included to complement other measures in the package. They may need some additional development for a variety of reasons, such as they depend on significant government or private investment, require international harmonization, or would benefit from greater public debate and acceptance.

3. ***Less Promising Measures:*** measures that would result in GHG reductions, but likely at significantly higher costs. These measures may have GHG reduction potential in the medium to longer term, or may be implemented for reasons in addition to GHG reductions, but they require significant additional analysis, much greater public acceptance, or considerable technological development.

4. ***Unlikely Measures:*** measures that Table members believe do not warrant active consideration at this time due to high cost (over $200 per tonne), limited potential to reduce emissions, or extreme difficulty in implementation. Measures were also categorized as ***unlikely*** if they were made redundant by ***most promising*** or ***promising*** measures.

The Table assembled the measures into five themes or packages. These packages provide a useful framework for grouping measures that work well together, are aimed at a particular end use, or provide a focus for action in the transportation sector, including:[37]

1. ***Passenger Transportation*** measures, which affect the movement of people both in urban areas and between cities (inter-city);

2. ***Road Infrastructure*** measures, which affect the development, maintenance and use of the country's road transportation network;

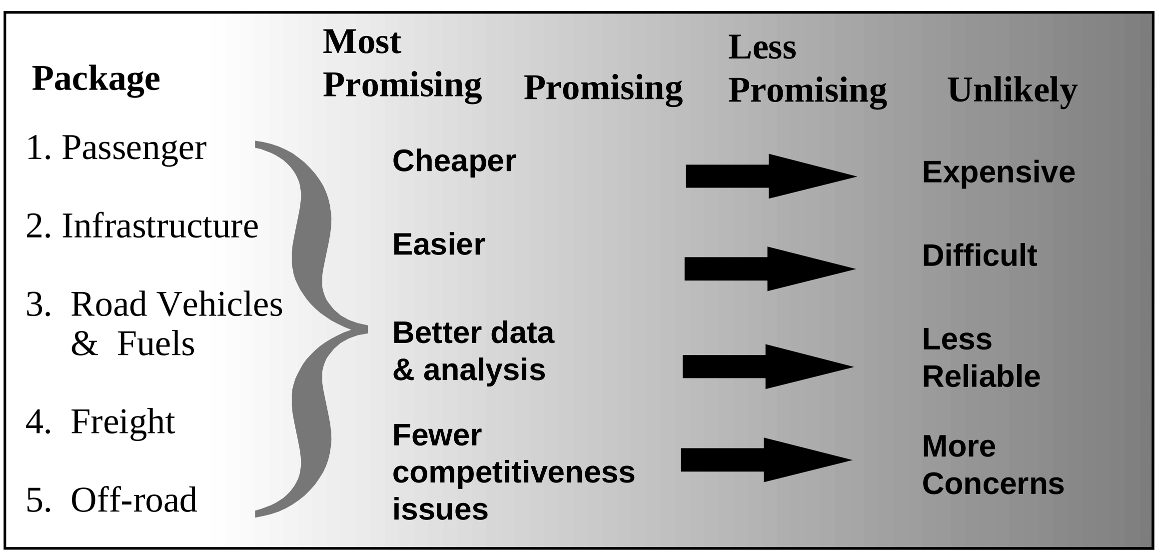
3. ***Road Vehicle and Fuel*** measures, which affect the design and purchase of light and heavy duty cars, trucks, and buses and their various fuels*;*

4. ***Freight Transportation*** measures, which affect the movement of goods by different modes, including rail, truck, air and ships; and,

5. ***Off-road*** measures, which affect the design and use of off-road equipment, including, forestry, agricultural, mining, construction, consumer and recreational equipment.

The framework for the Table's packages is outlined in Chart 5.1. Not every measure assigned to a category, such as *most promising*, necessarily meets all of the criteria (for example, a higher-cost measure may have been included that reinforces or complements another *most promising* measure). The criteria were used as general guidelines in assessing the measures.

Chart 5.1
Packaging Transportation Measures



[37] The reader should note that the Table's option packages combine measures differently than the way in which they are presented in Chapter 4.

5.2 OPTIONS FOR REDUCING TRANSPORTATION EMISSIONS

5.2.1 Passenger Package

Passenger travel represents an important area in which to reduce emissions from transportation, particularly in urban areas. It accounts for the bulk of transportation GHG emissions, but involves changing the travel, commuting and living habits of millions of Canadians who make billions of trips to work, shopping, school and recreational activities.

The Passenger Package is summarized in Table 5.2. Most of the measures are aimed at urban travel, which accounts for 60 per cent of passenger transportation emissions. A clear conclusion of the Table's work is that there is no single measure that can bring about significant reductions in urban emissions. The Table's analysis, which was reinforced by the three case studies in Montreal, Toronto and Vancouver, emphasized the importance of integrated strategies that combine reinforcing actions addressing public behaviour, demand, technology, infrastructure and land use across urban regions.

The ***most promising*** measures include early actions that would increase public awareness and send signals to change travel behaviour, primarily in urban areas. Combined, these measures could reduce emissions by 3.7 Mt, or about 7 per cent of Canada's Kyoto target in transportation, and generate a net benefit of $100/tonne. The measures are generally voluntary and are expected to meet with general public acceptance. Telecommuting and car-sharing programs would reduce the number of automobile trips, whereas enhanced driver education would increase the energy efficiency of driving practices.

The package would level the playing field on the tax treatment of employer-provided transit and parking benefits by removing an unintended bias that favours parking over transit. Given the difficulty of collecting taxes on all parking benefits, this measure would exempt employer-provided transit benefits from income tax, similar to the practice that is currently in place in the U.S.. The measure could reinforce voluntary efforts by employers to develop workplace trip-reduction programs, including transit, ride sharing, carpooling and telecommuting. This measure is cost effective, generating a net benefit of $941 per tonne, but is based on assumptions concerning the rate of take-up by employers and savings from reduced parking space. The amount claimed, and therefore the tax reduction for governments, depends directly on the take-up of the measure. The study estimated the maximum revenue reduction for government at $1.1 billion over 20 years; however, the actual amount would likely be less. Although there is uncertainty with respect to both the benefits and costs if this measure were implemented, it is likely that the actual benefits would significantly outweigh the costs.

Two intercity measures are included in the *most promising* package: a code of practice for ferry operators to improve operating efficiencies; and a range of actions to improve energy efficiency in the aviation sector, such as improving flight routes and ground operations.

The ***promising*** measures are a more aggressive effort to promote cost-effective, quality alternatives to automobile use. The package combines strong incentives for alternatives such as transit and biking, while discouraging car use through charges on parking. Taken together, the *promising* measures would achieve an estimated GHG reduction of 10.1 Mt, or 19 per cent of the transportation target, at a cost of $49 per tonne.

Transit ridership in Canada has levelled out since 1994, after declining from the early 1990s. The four transit measures are aimed at increasing transit use in urban centres through subsidies to reduce the price of transit, improving transit services and expanding infrastructure. These would generate reductions of 9.3 Mt or 17 per cent of the Kyoto target in transportation, with significant benefits in urban air-quality and congestion. The biking/pedestrian measures would make urban centres more pedestrian-friendly by expanding biking and walking lanes, installing bike racks, and improving security. While the reductions are modest (0.3 Mt) and more expensive than the transit measures, such improvements are underway in many cities and these visible alternatives provide important signals to reinforce changing public behaviour.

In addition to these incentives, this package also encourages a shift by increasing parking charges in the three major cities of Toronto, Montreal and Vancouver (the measure assumes a $3 to $5 charge on 20 per cent of all commuting trips, primarily in the city

The Importance of Urban Transit

Providing fast, convenient, safe and reliable transit service is fundamental to any meaningful strategy to reduce GHG emissions from urban passenger transportation. Transit serves only 5 per cent of the overall urban passenger market, but typically carries 50-70 per cent of commuters during peak hours to the downtown areas.

Transit's success will depend on having a mix of strategies that influence both demand for transit (through pricing and marketing strategies) and supply (through infrastructure and service delivery). All of the Table's transit measures are seen as *most promising* and *promising*, and provide potential for effective GHG reductions. In most cases, new investment will be needed, particularly for infrastructure and service improvements. However, this should reduce investments in roads, parking and related facilities for car use.

There are at least three key challenges facing transit if it is to play a substantial role in reducing transportation GHG emissions. They are:

- ***funding:*** municipalities currently fund transit through a combination of fares and subsidies. Some of the transit measures identified by the Table would involve large expenditures, which may call for innovative funding mechanisms. One option would be to combine transit improvements with initiatives that generate revenue and encourage a shift to transit, such as parking and road pricing or dedicated municipal fuel taxes;

- ***land-use policies****:* transit costs have escalated as services have moved into low-density suburban areas, due to longer distances and lower ridership. Land-use and transportation planning must be better integrated to reverse this trend and to encourage urban development that is conducive to the provision of efficient public transit service; and,

- ***public awareness of transit opportunities****:* there is a need for better public awareness to promote the benefits of transit and to address misconceptions (e.g. in one survey, transit travel times were overestimated by 45 per cent, while car travel times were underestimated by 20 per cent).

centre). Existing research, confirmed by the Table's analysis, indicates that parking charges would be a highly effective instrument. This measure would reduce emissions by 0.5 Mt in 2010. Although the cost per tonne is high, this is offset by the revenues generated from the charges.

Less promising measures may have some potential, but require additional work. For example, intercity bus service is important, as it represents the only public transportation service available in many rural areas. However, support for bus services in these areas is an option that the Table was not able to assess in adequate detail. Urban road-pricing faces a number of design and analytical issues, including the problem of diverting traffic onto streets not priced, the administrative challenges of collecting tolls on urban streets, and the likelihood of considerable public resistance. Applying parking charges to all of Canada's major urban areas, while generating significant GHG reductions, requires additional analysis and design. A mandatory ride-sharing program, which would require the participation of major employers, was seen as difficult to administer and imposing a financial burden, particularly on smaller employers. Although not specifically analyzed, a voluntary ride-sharing program should be considered as part of the *most promising* or *promising* package. Inspection and maintenance programs do not appear to be a cost-effective means of reducing GHG, although they are important for air-quality reasons.

Applying parking pricing to all major urban centres would generate much larger reductions of up to 8 Mt, if a charge of $2 per trip were applied to all commuting trips in all major urban centres. However, this measure requires additional work. The ability to levy parking charges in some private areas, such as outside a factory or mall, needs further investigation. Additional work is needed to be able to target the measure more precisely to daily commuters and to avoid promoting a shift of business away from downtown centres. Consultation is also needed with municipal governments, who would have responsibility to implement such a charge. Finally, this measure would require targeted awareness measures to build public support. However, parking charges represent an area of considerable potential, particularly when combined with measures to promote alternatives such as transit.

The remaining measures are not seen as likely candidates for GHG mitigation. The Table saw little potential for high-speed rail in the Quebec-Windsor corridor as a GHG reduction measure. However, it concluded that additional analysis is needed in the area of conventional passenger rail. In this category are a number of measures aimed at ferries, such as shore power and fleet replacement, that achieve very small reductions at high cost. Converting ferries to natural gas has potential in some areas, if combined with a broader thrust to expand the use of alternative fuels. Measures to accelerate the replacement of older ships and airplanes are expensive, and restricting airplane travel was also seen as an *unlikely* measure.

Table 5.2 PASSENGER PACKAGE

PASSENGER PACKAGE ~ MOST PROMISING MEASURES

Measure		GHG (Megatonnes) 2010	GHG (Megatonnes) 2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
A 20	Tax-exempt transit benefits[38]	0.2	0.2	-$941		$0	-$1138
A 5 L	Telecommuting	0.4	0.4	-$99		$90	
A 16H	Driver education	1.2	1.3	-$78		$90	
B 14	Transit fare smart-card	0.03	0.05	-$28	$167	$0	
A 7	Car sharing	0.3	0.4	$3		$20	
D 1	Short-term aviation measures	1.6	1.9	-$44		$0	
G 8	Code of practice, ferries	0.02	0.02	$9		$3	
TOTAL		***3.7***	***4.3***	***-$100***	***-$97***	***$203***	***-$1138***

PASSENGER PACKAGE ~ PROMISING MEASURES

Measure		GHG (Megatonnes) 2010	GHG (Megatonnes) 2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
A 4H	Transit pricing	5.7	6.4	$16	$12-19	$850	
A 3H	Transit service improvements	1.9	2.1	$46		$1430	
B 12	Transit automatic vehicle location	0.004	0.008	$65		$0	
A 2H	Transit infrastructure	1.7	1.9	$115		$3180	
A 1 L	Pedestrian and bicycle	0.3	0.4	$147		$750	
A 10L	Parking pricing (Tor-Mtl-Van)	0.52	0.58	$202		$1713	$34 255
A 6L	Voluntary ride sharing (to be studied)						
G 4	Natural gas ferry propulsion	0.002	0.002	$97		$0	
TOTAL		***10.1***	***11.4***	***$49***	***$46***	***$7923***	***$34 255***

[38] The transit pass measure generates a large net benefit of $941 per tonne. Excluding this from the totals, the remaining measures produce reductions of 3.5 Mt, with a net benefit of $54 per tonne and a financial benefit of $51 per tonne.

PASSENGER ~ LESS PROMISING MEASURES							
Measure		GHG (Megatonnes)		Total Cost	Financial Cost	Government Cost	
		2010	2020	$/tonne	$/tonne (if different)	Direct Cost ($M to 2020)	Transfers ($M to 2020)
A 14	Accelerated vehicle retirement	0.2	0	$62		$40	
A 10H	Parking pricing	7.7	8.6	$89	$36-72	$0	$60 654
A 8	Urban road pricing	1.4	1.5	$120		$0	$12 696
A 6H	Mandatory ride-sharing	2.4	2.7	$144		$180	
B 1	Intercity bus subsidy	0.3-1.4	0.4-1.8	$110-$160		$1,095-$3,285	$1168
A 13	Vehicle inspection and maintenance	0.4	0	$1350		$0	

PASSENGER ~ UNLIKELY MEASURES							
Measure		GHG (Megatonnes)		Total Cost	Financial Cost	Government Cost	
		2010	2020	$/tonne	$/tonne (if different)	Direct Cost ($M to 2020)	Transfers ($M to 2020)
G 6	Shore power for ferries	0.04	0.04	$25		$18	
B 2	High-speed rail (Quebec-Windsor)	0.3	0.4	$60-$240		$4400	
A 12	Parking cash-out	0.2-0.4	0.4	$178		$0	
A 9	Distance-based vehicle charges	0.2-0.4	0.4	$146-$190		$135	$60 $725
G 3	Reduced ferry speeds	0.08	0.09	$255		$0	
D 2	Early aircraft replacement	1.0	0	$311		$0	
D 3	Limitation of air travel activity	4.3	6.7	$557		$0	
G 2	Accelerated fleet renewal of ferries	0.01	0.01	$8625		$0	
A 11	Parking supply restrictions	0.2-0.4	0.3	not estimated		not estimated	

5.2.2 Road Infrastructure Package

Changes in the way we build, maintain and use our roads and highways can also play a role in reducing GHG emissions. The Road Infrastructure Package is summarized in Table 5.3.

The ***most promising*** measures focus on two areas. Three measures involve the broader use of intelligent transportation systems (ITS) aimed at reducing congestion and improving traffic flow. There is a growing interest in ITS in both Canada and the U.S. as a means of improving traffic flow, border crossings and freight movement. Although these measures would not generate significant reductions (the combined total is only about 0.22 Mt), they would all produce net benefits ranging from $39 to $278 per tonne (most of this benefit is a result of operational and time savings). An additional measure improves energy efficiency through greater coordination of traffic signals in urban areas. Combined, these four measures would require government investments in the order of $2.4 billion over 20 years.

The other *most promising* measure is the enforcement of speed limits. Generally, fuel efficiency declines significantly above 70-80 km per hour, depending on the age of the vehicle. The Table's analysis indicates that slowing all traffic—including cars, trucks and buses—to the existing posted speed-limits would generate significant GHG reductions of 4.2 Mt ,at a net cost of about $10 per tonne. This estimate includes additional costs to government of about $800 million over 20 years for better enforcement. Simply obeying the law would generate significant reductions at a reasonable cost and improve public safety.

The ***promising*** group of measures includes two additional ITS measures as well as changes to the construction and maintenance of roads. The ITS measures include improved traveller information and advanced in-vehicle control systems that would allow travellers to avoid congested areas. They offer modest reductions, but at almost no net cost. However, like the other ITS measures they would have a much higher financial cost of $200-300 per tonne. There is some concern that ITS, by improving traffic congestion, could actually induce more traffic onto the roads, thereby increasing GHG emissions.

More frequent resurfacing of the national highway system (moving to a 15-year cycle from a 20year one) would generate some energy-efficiency improvements, saving 0.4 Mt, but at $133 per tonne and a government cost of $1.8 billion over 20 years. High-occupancy vehicle (HOV) lanes would result in reductions of close to 1 Mt and generate a net benefit of $1,000 per tonne. Most of the benefit comes from time savings for users of the lanes. This measure has potential, particularly when combined with some of the Passenger Package measures aimed at promoting more ride sharing and transit, which would also benefit from dedicated lanes. However, additional work is needed to examine the feasibility of additional lanes in congested urban areas, and to assess some concerns about enforcement and whether they induce additional traffic. Further, the costs to government of over $1.5 billion over 20 years would be significant, and warrant additional analysis. These *promising* measures require additional work, but would generate a reduction of 1.5 Mt at a net benefit of close to $500 per tonne.

The ***less promising*** measures also have the potential for significant reductions of GHG, but pose a number of difficult challenges. Electronic toll collection, combined with road pricing in both urban and intercity areas, would reduce emissions by over 3 Mt (this measure includes the reductions in the urban-only road-pricing measure in the Passenger Package). Road tolls are in use throughout the U.S., but are not common in Canada. It could be an effective instrument, but represents a difficult public-policy issue. It requires a greater understanding of the full costs of various modes of transportation that the data do not presently support. Further, this measure would require significant efforts to build public acceptance and understanding.

The use of rigid (concrete) pavement on the national highway system as roads are replaced would improve fuel efficiency by about 10 per cent, primarily for heavy trucks. Although the production of concrete has higher GHG emissions than asphalt production, this measure would result in GHG reductions on a life-cycle basis compared to asphalt roads. However, there is some uncertainty in the estimates of fuel efficiency improvements, ranging from 1-20 per cent, with the most recent work by the National Research Council estimating 15 per cent (the Table's analysis used 10 per cent). Provincial governments have concerns about the costs of concrete versus asphalt (concrete has higher up-front costs, resulting in fewer kilometres of road maintenance from fixed capital budgets). There also remain uncertainties regarding the performance of concrete roads in the Canadian climate.

Reducing speed limits to a maximum of 90 km per hour would generate significant reductions in GHG emissions of 8.3 Mt in 2010, at a reasonable cost of $31 per tonne. This measure was seen as having limited potential, as it would not be well supported by the public and would require intrusive and significant levels of enforcement.

The Importance of Technology

Technology will play a key role in Canada's ability to reduce GHG emissions from transportation. To date, new technologies have been instrumental in improving energy efficiencies in several key areas. For example, fuel economies in light-duty vehicles, aviation and trucking have improved considerably as a result of more efficient engines, improved design and new, lighter-weight materials. While technology is critical, technology alone would not be sufficient to reach the Kyoto target in transportation by 2010.

Canada has been playing a leadership role in many new transportation technologies. Ongoing research and development will be crucial to achieving GHG reductions. Some of the key areas identified in the Table's studies for continued research and development include:

- improvements in car and truck designs, engines and materials;
- fuel cells for road, rail and marine use;
- production, distribution and use of alternative fuels, such as cellulosic ethanol;
- intelligent transportation systems (ITS);
- urban transit systems and vehicles (buses, commuter rail, subways);
- ensuring that new designs, technologies and fuels meet safety standards; and,
- transportation systems and links to urban design and land use.

Table 5.3 **ROAD INFRASTRUCTURE PACKAGE**

ROAD INFRASTRUCTURE ~ MOST PROMISING MEASURES								
Measure		**GHG (Megatonnes)**		**Total Cost**	**Financial Cost**	**Government Cost**	
		2010	**2020**	**$/tonne**	**$/tonne (if different)**	**Direct Cost ($M to 2020)**	**Transfers ($M to 2020)**
B 10	Adaptive traffic signals	0.1	0.1	-$278	$16	$135	
B 15	Commercial vehicle electronic clearance	0.02	0.03	-$254		$180	
B 9	Incident management	0.1	0.2	-$39	$162	$803	
B 4	Enforcement of current speed limits	4.2	4.7	$10	-$59	$850	
A 15	Synchronization of traffic signals	0.6	0.8	$14-$70		$1315	
TOTAL		***5.0***	***5.8***	***$2***	***-$38***	***$3283***	

ROAD INFRASTRUCTURE ~ PROMISING MEASURES							
Measure		**GHG (Megatonnes)**		**Total Cost**	**Financial Cost**	**Government Cost**	
		2010	**2020**	**$/tonne**	**$/tonne (if different)**	**Direct Cost ($M to 2020)**	**Transfers ($M to 2020)**
B 8	High-occupancy vehicle (HOV) lanes[39]	0.9	1.1	-$1000	-$187	$1500	
B 16	Advanced vehicle control systems	0.05	0.2	-$4	$218	$0	
B 11	Traveller information	0.2	0.3	$6	$302	$0	
B 6	More frequent resurfacing	0.4	0.5	$133		$1800	
TOTAL		***1.5***	***2.1***	***-$496***	***-$4***	***$3300***	

[39] HOV lanes generate a large net benefit of $1,000 per tonne as a result of time and fuel savings for the users of the lanes. Excluding this measure from the totals, the remaining measures generate 0.06 Mt at a total cost of $68 per tonne and a financial cost of $200 per tonne.

ROAD INFRASTRUCTURE ~ LESS PROMISING MEASURES							
Measure		**GHG (Megatonnes)**		**Total Cost**	**Financial Cost**	**Government Cost**	
		2010	**2020**	**$/tonne**	**$/tonne (if different)**	**Direct Cost ($M to 2020)**	**Transfers ($M to 2020)**
B 13	Electronic toll-collection	0.3	0.5	-$137	$117	$0	
B 7	Rigid pavements (cement)	0.3	0.5	-$15		$0	
B 5	Reduce speed limits to 90 km/hour	8.3	9.2	$31	-$63	$1700	
B 3	Road pricing	2.8	3.2	$68	$0	$0	$355 $194

ROAD INFRASTRUCTURE ~ UNLIKELY MEASURES							
Measure		**GHG (Megatonnes)**		**Total Cost**	**Financial Cost**	**Government Cost**	
		2010	**2020**	**$/tonne**	**$/tonne (if different)**	**Direct Cost ($M to 2020)**	**Transfers ($M to 2020)**
	No measures assigned						

5.2.3 Road Vehicles and Fuels Package

Road vehicle technology and changes to transportation fuels are critical elements to consider in assessing options to reduce GHG emissions from transportation. However, measures to improve vehicle technologies and increase the use of alternative fuels are complex, and can raise important economic and competitiveness issues. For example, many of the new vehicle technologies will depend on providing cleaner, lower-sulphur fuels. As a result, the Table is not proposing a group of ***most promising*** measures - several measures in this area have potential but will require additional development and/or harmonization with the U.S.

The ***promising*** measures combined would generate reductions of 8.9 Mt of GHG, at an average cost of about $64 per tonne. The largest reduction would come from setting a target, harmonized with the U.S., of a 25 per cent reduction in GHG emissions by 2010 from new cars and light trucks over existing targets (actual levels are lower than the current standard for cars). The measure proposes a 25 per cent reduction for cars, and a similar reduction for light-duty trucks. Automakers in Europe and Japan have agreed to a voluntary target of an approximately 25 per cent improvement in fuel efficiency by 2010. This would reduce GHG emissions by an estimated 5.2 Mt by2010, at a cost of $74 per tonne. The financial cost is $56 per tonne, with the difference being the lost value to the consumer of certain vehicle choices and attributes.

It is important to note that this measure proposes a harmonized target with the U.S. A Canada-only target was also analyzed, however, while the emission reduction estimates were similar, the cost almost doubled to $157 per tonne. This reflects the additional cost of modifying vehicles solely for the Canadian market and a further loss of consumer choice, as some models would have limited availability in Canada. Due to the integrated nature of automobile manufacturing, where cars and trucks are made for a single market, the current practice is to harmonize standards for fuel efficiency, environment and safety as much as possible between Canada and the U.S. Maintaining harmonized standards leads to much greater manufacturing efficiencies and lower vehicle costs. This measure would require agreement with the U.S. on such a target.

The measure also assumes that the improvements would be made to fuel quality that many new technologies require, such as reducing sulphur levels in gasoline. The analysis of the measures also assumes fuel prices would be kept at a level that made newer technologies attractive to the consumer. The analysis also assumes that manufacturers would select the best mix from more than 100 incremental and advanced fuel-economy technologies to reach the goal. Manufacturers would likely start with the lower-cost incremental technologies, which include reductions in weight, engine friction and aerodynamic drag, improved tires, and cylinder deactivation. More costly technologies, such as hybrid drives and fuel cells, would likely be introduced in smaller quantities, and some manufacturers might choose to expand their alternative-fuel vehicle production for natural gas, propane and ethanol.

Other measures have been assessed that would be aimed at overcoming barriers to the use of alternative fuels, particularly in niche markets. Several measures provide support for the production and distribution of alternative fuels. The most cost-effective is aimed at expanding the production of ethanol for blending with gasoline, focusing initially on grain ethanol and adding plants using cellulosic feedstocks (based on its potential for greater GHG reductions and improved economics) as the technology becomes commercialized. This would reduce emissions by 0.8 Mt in 2010, at a cost of $29 per tonne.

Support could also be provided to expand the fuel infrastructure for propane and natural gas in the three largest urban centres, and to increase its use in larger government and industrial fleets. Additional measures are proposed to increase the use of alternative fuels in niche markets, such as mandating targets for all government fleets and voluntary targets for industry, and for use in transit buses and heavy-duty trucks. The bus technologies are cost effective at $11 per tonne, although they would require government subsidies and would generate savings of only 0.2 Mt in 2010 because the size of the bus fleet is not large. Expanding the use of alternative fuels in heavy-duty vehicles would reduce emissions by an estimated 0.4 Mt in 2010, at $69 per tonne. Between now and 2010, the dominance of diesel engines in this market will likely limit new fuels to niche markets, where their advantages are particularly strong. This measure assumes that sales of alternative fuel vehicles would represent 2500 vehicles in 2010 compared to total sales of 35 000. Combined, the *promising* alternative fuel measures would reduce emissions by

Alternative and Future Fuels

Canada has been a pioneer in the use of alternative transportation fuels (ATF) since 1980. The fuels of commercial interest today are those derived from natural gas (compressed natural gas for vehicles [NGV] and propane), as well as ethyl alcohol (ethanol) from grains such as corn. Emerging fuels, such as ethanol from cellulosic materials including grasses and wood, also show excellent potential. Battery-operated electric vehicles are being tested in field trials and there is much interest in vehicles powered by hydrogen fuel cells developed in Canada.

Several of these fuels offer potential for reducing pollution from vehicles, lowering GHG emissions and ultimately providing zero-emission vehicles. However, in considering different fuels it is important to also consider emissions over their full life cycle, including the production of the fuel itself.

Canada has significant expertise in developing ATFs. Fuel cells, such as the one being developed by Ballard in British Columbia, can run on a range of ATFs, such as hydrogen or methanol. They are currently being tested in transit buses in Vancouver. Governments have promoted new fuel development through tax incentives, research, trials, and financial incentives. However, to date these fuels have not been able to capture a significant share of the market due to cost, lack of infrastructure and technical challenges.

The Table studied several measures to help foster markets for low-carbon alternative and future fuels, including:

- alternative-fuel vehicle purchase incentives;
- incentives for ethanol from grain and cellulose;
- promoting infrastructure in urban areas;
- natural-gas, hybrid, and hydrogen transit buses;
- alternative fuels for heavy trucks; and,
- natural gas and fuel cells for marine and rail.

up to 3.2 Mt at an average cost of $77 per tonne and at a total cost of $3 billion over 20 years, including a government cost of $392 million.

The ***less promising*** category includes two measures aimed at encouraging consumers to buy more fuel-efficient cars. The feebate studied is a revenue-neutral program offering rebates for more fuel-efficient vehicles, and fees or taxes on less fuel-efficient models. The feebate studied would generate 2.1 Mt in 2010, rising to 13 Mt in 2020 at a cost of $100 per tonne. If the feebate were not harmonized with the U.S., the cost would increase to $279 per tonne. The measure is considered *less promising*, as we know very little about feebates. There is no actual experience with feebates at the proposed level and scale by which to judge their effectiveness. The analysis done by the consultant was the first of its kind, and considerably more work would be required.

The other measure aimed at consumers would provide incentives to encourage people to purchase vehicles that are in the top 30 per cent of their class in terms of GHG emissions. This measure would not encourage people to shift from a less fuel-efficient class of vehicle to another. Rather, it is aimed at encouraging people to buy those models within the class of vehicle they wish to buy that are in the top 30 per cent of their class. This measure would achieve a reduction of 2.1 Mt, but would be complex to administer and track.

Two measures to expand fuelling infrastructure for ethanol in dedicated E85 vehicles are seen as *less promising*, even though costs are moderate at $46 to $54 per tonne. This reflects the challenges related to the high fuel subsidy that would be needed for the fuelling infrastructure to be developed. ***Unlikely*** measures are less promising variations of those found in the above categories.

Table 5.4 ROAD VEHICLES & FUELS PACKAGE

ROAD VEHICLES & FUELS ~ MOST PROMISING MEASURES

Measure		GHG (Megatonnes) 2010	GHG (Megatonnes) 2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
	No measures assigned						
TOTAL							

ROAD VEHICLES & FUELS ~ PROMISING MEASURES

Measure		GHG (Megatonnes) 2010	GHG (Megatonnes) 2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
H 8A	Heavy-duty truck efficiency improvements	0.4	2.0	$6		$3	
H 9	Transit bus design and alternate fuels	0.2	0.6	$11		$329	
H 5B	Ethanol capacity incentives, high	0.8	2.2	$29		$2	
H 2A	AFV fleet purchase	0.3	0.7	$69		$7	
H 8B	Heavy-duty Truck AFV purchases	0.4	1.8	$69		$3	
H 1BL	Target harmonized: 25 per cent by 2010 over current target	5.2	14.1	$74	$56	$3	
H 7B	Alternate fuel infrastructure, propane	0.7-0.9	2.6	$46-$109		$26	
H 7C	Alternate fuel infrastructure, natural gas	0.7-0.8	2.3	$120-$208		$26	
TOTAL		***8.9***	***26.3***	***$64***	***$52***	***$398***	

ROAD VEHICLES & FUELS ~ LESS PROMISING MEASURES							
Measure		**GHG (Megatonnes)**		**Total Cost**	**Financial Cost**	**Government Cost**	
		2010	**2020**	**$/tonne**	**$/tonne (if different)**	**Direct Cost ($M to 2020)**	**Transfers ($M to 2020)**
H 10D	Feebate, harmonized with phase-in	2.1	13.1	$100		$0	
H 7AH	Alternate fuel infrastructure, ethanol high	2.3	8.3	$46		$26	
H 7AL	Alternate fuel infrastructure, ethanol low	2.0	4.9	$54		$26	
H 3A	Vehicle purchase incentive, 30 per cent best of class	2.1	6.4	$41		$7	

ROAD VEHICLES & FUELS ~ UNLIKELY MEASURES							
Measure		**GHG (Megatonnes)**		**Total Cost**	**Financial Cost**	**Government Cost**	
		2010	**2020**	**$/tonne**	**$/tonne (if different)**	**Direct Cost ($M to 2020)**	**Transfers ($M to 2020)**
H 10C	Feebate, harmonized	2.1	13.1	$116		$0	
H 5A	Ethanol capacity incentives, low	0.5	0.5	$36		$2	
H 1AL	Target harmonized: 2 per cent per year over current target	1.1	7.9	$54	$45	$3	
H 1AH	Target harmonized: 2 per cent per year over actual fleet average	1.9	10.1	$60	$51	$3	
H 10A	Feebate, Canada only	2.3	5.1	$309		$0	
H 10B	Feebate, Canada only, phased-in	2.3	5.1	$279		$0	
H 1BH	Target harmonized: 25 per cent by 2010 over actual fleet average	6.5	16.5	$105	$92	$3	
H 1C	Target, Canada only: 2 per cent per year	1.1	7.9	$114	$101	$3	
H 1D	Target, Canada only: 25 per cent by 2010	5.2	14.1	$157	$139	$3	
H 2B	High-efficiency fleet purchase incentives	0.2	0.3	$220		$7	
H 3B	Vehicle purchase incentive, 40 per cent best class	0.5	2.0	$35		$7	

5.2.4 Freight Package

The ***most promising*** set of measures in freight represent cost effective, voluntary efforts. Combined, they would reduce emissions by 2.0 Mt in 2010, at a cost of $6 per tonne. Training for truck drivers in energy efficiency, improved operating practices and truck idling would provide cost-effective reductions. A code of practice in the marine sector would also be cost-effective, although the reductions are small as the mode is not a large contributor of GHG emissions. It should be also noted that it is difficult to estimate the effectiveness of education and awareness measures.

The Table has identified a range of ***promising*** measures that would generate reductions of 7.0 Mt at a small net benefit of $3 per tonne of GHG. In trucking, this includes adopting longer trucks in three provinces where they are not currently permitted. Although this is a highly cost-effective measure that would generate a net benefit of up to $1300 per tonne, the GHG reductions would be modest (0.05 Mt). Actual reductions could be less, depending on which provinces allow their use and the conditions they attach under permit. The study assumes that no changes to infrastructure are required. Further, while some experts believe these trucks improve road safety, it is recognized that there are public perceptions about safety issues related to longer trucks. Three other trucking measures seem more effective, and would reduce emissions by up to 3 Mt, all at a net benefit. However, they have not been included as *most promising* measures because they require additional analysis.

Load-matching services are emerging, and expanding these would reduce empty or partial trips. However, the measure requires careful design to work effectively.

Reducing Emissions Through Voluntary Action

Voluntary actions play an important role in encouraging businesses and consumers to reduce GHG emissions. Some large companies, such as equipment manufacturers, airlines and larger trucking companies, have joined the Voluntary Challenge and Registry (VCR) and prepared plans covering their GHG emissions. Other voluntary programs provide information for drivers and fleet managers on how to reduce energy consumption.

Product labelling can help consumers understand the impacts of their actions on energy use. F or example, the auto industry and Natural Resources Canada affix fuel-consumption labels to new vehicles. The Canadian Trucking Alliance has developed an environmental code of practice and the rail industry has a voluntary Memorandum of Understanding with Environment Canada covering air emissions from its operations.

The Table identified a number of voluntary measures to reduce GHG emissions, including:

- energy-efficiency improvements in aviation;
- car sharing, ride sharing and telecommuting for individuals or employers to implement trip-reduction programs for their employees;
- enhanced driver-education and training programs for consumers and truck drivers;
- codes of practice in the marine sector; and,
- projects that could generate credits to companies inside and outside the sector.

Potential voluntary actions include increasing the participation of transportation companies in the VCR, expanding product labelling, developing agreements or covenants, and implementing a system to provide credits for projects that reduce GHG reductions in transportation.

New lubricants would also provide significant reductions, however, the estimates may be optimistic. Finally, a truck scrappage program that shifts the average age of the fleet by five years would provide significant reductions at a net benefit. However, the design of a specific measure to achieve this shift needs to be assessed.

Reducing speeds for trucks would generate significant reductions at low cost. Enforcement could be achieved through on-board electronic monitors, which prevent speeds from exceeding the limit. Reductions from limiting trucks to 105 km per hour are not included here, as they are part of the *most promising* Passenger measures to enforce existing speed limits. However, reducing truck speeds to 90 km per hour would generate an additional 3.2 Mt of GHG at a cost of $90 per tonne (fuel and operational savings are outweighed by the costs of additional driving time). The measure would be welcomed by some in the industry, provided that it applies across all carriers, so that those driving slower are not put at a competitive disadvantage compared to those driving faster. Some jurisdictions do not support trucks and cars travelling at different speeds, although this is the practice in some parts of the U.S. Further, some regions with very long hauling distances might be disadvantaged by this measure.

Two measures to encourage a more rapid turnover of the capital stock in rail would also provide cost-effective reductions of about 0.3 Mt at a cost of between $13-19 per tonne. To achieve this, the capital cost allowance on rail would need to be increased to a level similar to that on trucking in order to encourage the purchase of more fuel-efficient engines and cars.

A number of ***less promising*** measures show some potential to reduce GHG emissions from freight. These include alternative fuels and fuel cells for railways. However, the time frames involved in commercializing and introducing the new technology generate little reduction within the Kyoto time period. The measures prove more effective over the longer term to 2020. Additional trucking improvements, such as improved tires, tare weight reductions and tracking systems would generate reductions, but at higher costs ranging from $70-300 per tonne.

A wide array of measures studied are considered ***unlikely***. Opportunities to shift freight from truck to rail or marine in the five corridors studied generated small GHG reductions at considerable cost. However, data in this area is weak, and the Table’s analysis, viewed by some as optimistic, was preliminary and looked at opportunities under existing economic conditions. Electrification of railways and accelerated replacements of ships to encourage the use of more efficient technologies also appear to be expensive options.

Table 5.5 FREIGHT PACKAGE

FREIGHT ~ MOST PROMISING MEASURES

Measure		GHG (Megatonnes) 2010	GHG (Megatonnes) 2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
F 10	Truck-driver training, energy efficiency	2.0	2.3	$6		$2	
G 7	Code of practice, marine freight	0.02	0.02	$9		$3	
TOTAL		***2.0***	***2.3***	***$6***	***$6***	***$5***	

FREIGHT ~ PROMISING MEASURES

Measure		GHG (Megatonnes) 2010	GHG (Megatonnes) 2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
F 1L	Long trucks, Rocky Mountain Double	0.01	0.02	-$1278		$0	
F 1H	Long trucks, Turnpike Double[40]	0.04	0.05	-$1110		$0	
F 8C	Accelerated truck scrappage (5 years)	2.3	2.7	-$135		$0	
E 7	Rail freight car capital cost allowance	0.08	0.08	$13		$29	
E 6	Rail locomotive capital cost allowance	0.2	0.2	$19		$82	
F 6	Truck lubricants	1.0	1.2	-$9-$48		$0	
F 2B	Truck speed control to 90 km/hr	3.2	3.8	$90		$0	
F 3	Trucking load-matching	0.1	0.1	$156		$0	
TOTAL		***7.0***	***8.1***	***-$3***	***-$3***	***$111***	

[40] The two long truck measures generate a large net benefit of $1,110 and $1,278 per tonne. Excluding these from the totals, the remaining measures produce reductions of 6.9 Mt, at a cost of $6 per tonne.

FREIGHT ~ LESS PROMISING MEASURES							
Measure		**GHG (Megatonnes)**		**Total Cost**	**Financial Cost**	**Government Cost**	
		2010	**2020**	**$/tonne**	**$/tonne (if different)**	**Direct Cost ($M to 2020)**	**Transfers ($M to 2020)**
E 2A	Rail, cellulosic-ethanol fuel	0	3.0	$52		$3800	
E 2B	Rail, cellulosic-ethanol fuel, 15 per cent	0	0.7	$94		$1640	
F 5A	Truck tires, low rolling-resistance	1.1	1.3	$78		$0	
F 5B	Truck tires, central inflation	0.2	0.2	$114		$0	
F 7	Truck, tare weight reduction	0.3-1.0	0.4-1.1	$57-$223		$0	
F 4	Truck tracking	0.04	0.04	$162		$0	
E 3	Rail, LNG fuel, duel-fuel configuration	0.3	0.3	$171		$1400	
E 5	Rail, U.S. NOx regulations	0.07-0.15	0.1	$127-$355		$348	
E 1A	Rail locomotive fuel cell, electrolysis	0	2.9	$253		$16 400	

FREIGHT ~ UNLIKELY MEASURES

Measure		GHG (Megatonnes) 2010	2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost Direct Cost ($M to 2020)	Transfers ($M to 2020)
F 12	Trucking, preventative maintenance	0.8	0.9	-$1		$2	
F 11	Trucking, driver training in idling	1.2	1.4	$6		$0	
E 4C	Electrification, iron-ore railways	0.2	0.2	$16		$190	
E 12	Reduce train speeds	0.2	0.2	$20		$0	
E 4A	Electrification, western region	2.0	1.6	$21		$1830	
E 11	Rail, eliminate circuitous routings	0.1	0.1	$30		$0	
E 4B	Electrification, eastern region	0.7	0.8	$38		$1710	
F 8B	Truck, accelerated scrappage (15 yrs)	2.3	2.6	$90		$0	
E 8	Increased rail track stiffness	0.05	0.05	$134		$282	
G 5	Shore power, marine freight	0.03	0.03	$185		$100	
C 7B	Shift: Van-Cal, road to rail (high)	0.02	0.04	$190		$8	
C 7A	Shift: Van-Cal, road to rail (low)	0.009	0.02	$192		$4	
E 9	Rail, track-configuration improvements	0.1	0.1	$223		$1815	
C4	Shift: Hal-Tor, road to rail	0.01	0.02	$231		$2	
C 1A	Shift: Mtl-Tor, road to rail (low)	0.01	0.03	$263		$4	
C 1B	Shift: Mtl-Tor, road to rail (high)	0.02	0.04	$283		$11	
F 8A	Truck, accelerated scrappage (20 yrs)	1.4	1.6	$337		$0	
E 1B	Rail locomotive fuel cell, methane	0	1.2	$403		$11 000	
C 6	Shift: Thunder Bay-Que, rail to marine	0.01	0.01	$584		$18	
C 3A	Shift: Tor-Chi, road to rail (low)	0.004	0.008	$635		$1	
C 3B	Shift: Tor-Chi, road to rail (high)	0.008	0.016	$635		$8	
F 9	Truck, engine retrofit	2.2-3.0	2.6	$550-$780		$0	
E 10	Rail, restrict local service frequency	0.009	0.01	$725		$129	
C 5	Shift: Hal-Tor, rail to marine	0.006	0.006	$989		$46	
C 2	Shift: Mtl-Tor, rail to marine	0.002	0.002	$2079		$29	
G 1	Accelerated renewal, marine tankers	0.003	0.003	$11 151		$0	

5.2.5 Off-Road Package

Approximately 13 per cent of transportation GHG emissions are from off-road sources. This exceeds the emissions from ships and railways combined, and is greater than the emissions from aviation. However, very little is known about this extremely diverse mix of equipment, which includes forestry, mining, agricultural, construction, recreational and lawn-and-garden equipment, as well as recreational vehicles such as all-terrain vehicles, snowmobiles and pleasure craft.

The Table was not able to identify any ***most promising*** measures due to the lack of data available on the wide variety of engines and equipment in this category, although its work has improved our understanding of these emissions. Within the time and resources available, the Table identified three possible measures as ***promising*** that would achieve reductions of up to 4 Mt (Table 5.6). However, these estimates are based on very preliminary analysis, and it was not possible to reasonably estimate the cost-effectiveness of such measures. Considerably more work is required in this area.

Table 5.6 OFF-ROAD PACKAGE

OFF-ROAD ~ MOST PROMISING MEASURES

Measure		GHG (Megatonnes) 2010	2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
	No measures assigned						
TOTAL							

OFF-ROAD ~ PROMISING MEASURES

Measure		GHG (Megatonnes) 2010	2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
K 1	Fuel efficiency standards	2.0-2.5	-	not estimated		$3	
K 2	Public-awareness campaign	0.2-0.3	-	not estimated		$13	
K 3	Voluntary measure	1.76	-	not estimated		$4	
TOTAL		***4.3***	***-***	***not estimated***		***$19***	

OFF-ROAD ~ LESS PROMISING/UNLIKELY MEASURES

Measure		GHG (Megatonnes) 2010	2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost: Direct Cost ($M to 2020)	Government Cost: Transfers ($M to 2020)
	No measures assigned						
TOTAL							

5.2.6 Summary of Packages

The Table's ***most promising*** and ***promising*** measures are summarized in Tables 5.7 and 5.8. The *most promising* set of measures would generate 10.8 Mt of GHG reductions in 2010, at a net benefit of $32 per tonne and a financial benefit of -$51 per tonne. This represents about 20 per cent of the Kyoto target in transportation. The cost to governments would be $3.5 billion over 20 years.

The *promising* package would generate 31.8 Mt of GHG reductions in 2010 (almost 60 per cent of the Kyoto target in transportation), at a cost of $ 5 per tonne and a financial cost of $34 per tonne. The costs to governments would be $11.7 billion over 20 years (current combined government expenditures on transportation are approximately $17 billion annually), although the measures would generate $34 billion in revenues.

Assuming that all of the *most promising* or *promising* measures were implemented and achieved the reductions estimated, there would still be a gap of 10-14 Mt **if** Canada wished to reach the Kyoto target in transportation (which requires a reduction of approximately 54 Mt by 2010). The balance would have to be achieved either through fuel taxes or the use of some of the measures in the *less promising* package. Both of these approaches generally rely on pricing mechanisms to reduce emissions.

Table 5.7 SUMMARY OF MOST PROMISING MEASURES

Measure		GHG (Megatonnes)		Total Cost	Financial Cost	Government Cost	
		2010	2020	$/tonne	$/tonne (if different)	Direct Cost ($M to 2020)	Transfers ($M to 2020)
A 20	Tax-exempt transit benefits[41]	0.2	0.2	-$941		$0	-$1138
B 10	Adaptive traffic signals	0.1	0.1	-$278	$16	$135	
B 15	Commercial vehicle electronic clearance	0.02	0.03	-$254		$180	
A 5 L	Telecommuting	0.4	0.4	-$99		$90	
A 16H	Driver education	1.2	1.3	-$78		$90	
D 1	Short-term aviation measures	1.6	1.9	-$44		$0	
B 9	Incident management	0.1	0.2	-$39	$162	$803	
B 14	Transit fare smart-card	0.03	0.05	-$28	$167	$0	
A 7	Car sharing	0.3	0.4	$3		$20	
F 10	Truck-driver training, energy efficiency	2.0	2.3	$6		$2	
G 7	Code of practice , marine freight	0.02	0	$9		$3	
G 8	Code of practice, ferries	0.02	0.02	$9		$3	
B 4	Enforcement of current speed limits	4.2	4.7	$10	-$59	$850	
A 15L	Synchronize traffic signals	0.6	0.8	$14-$70		$1315	
TOTAL		***10.8***	***12.4***	***-$32***	***-$51***	***$3492***	***-$1138***

[41] The transit pass measure generates a large net benefit of $941 per tonne. Excluding this from the totals, the remaining measures produce reductions of 10.6 Mt with a net benefit of $16 per tonne and a financial benefit of $35 per tonne.

Table 5.8 SUMMARY OF PROMISING MEASURES

Measure		GHG (Megatonnes)		Total Cost	Financial Cost	Government Cost	
		2010	2020	$/tonne	$/tonne (if different)	Direct Cost ($M to 2020)	Transfers ($M to 2020)
F 1L	Long trucks, Rocky Mountain Double	0.01	0.02	-$1278		$0	
F 1H	Long trucks, Turnpike Double	0.04	0.05	-$1110		$0	
B 8	High-occupancy vehicle lanes[42]	0.9	1.1	-$1000	-$187	$1500	
F 8C	Accelerated truck scrappage (5 yrs)	2.3	2.7	-$135		$0	
B 16	Advanced vehicle control systems	0.05	0.2	-$4	$218	$0	
H 8A	Heavy-duty truck efficiency improv.	0.4	2.0	$6		$3	
B 11	Traveller information	0.2	0.3	$6	$302	$0	
H 9	Transit bus design and alternate fuels	0.2	0.6	$11		$329	
E 7	Rail freight-car capital cost allowance	0.08	0.08	$13		$29	
A 4H	Transit pricing	5.7	6.4	$16	$12-19	$850	
E 6	Rail locomotive capital cost allowance	0.2	0.2	$19		$82	
F6	Truck lubricants	1.0	1.2	-$9-$48		$0	
H 5B	Ethanol capacity incentive (high)	0.8	2.2	$29		$2	
A 3H	Transit service improvements	1.9	2.1	$46		$1430	
B12	Transit automatic vehicle location	0.004	0.01	$65		$0	
H 2A	AFV fleet purchase incentive	0.3	0.7	$69		$7	
H 8B	Heavy-duty truck AFV purchase	0.4	1.8	$69			
H 1BL	Targets harmonized: 25 per cent by 2010 over current target	5.2	14.1	$74	$56	$3	
H 7B	Alternate fuel infrastructure, propane	0.7-0.9	2.6	$46-$109		$26	
F 2B	Truck speed control 90 km/hr	3.2	3.8	$90		$0	
G 4	Natural gas ferries	0.002	0.002	$97		$0	
A 2H	Transit infrastructure	1.7	1.9	$115		$3180	

[42] The two long truck measures and the HOV measure generate large net benefits. Excluding all three from the totals, the remaining Promising measures generate 30.8 Mt at a total and financial cost of $44 per tonne.

SUMMARY OF PROMISING MEASURES (cont'd)

Measure		GHG (Megatonnes) 2010	GHG (Megatonnes) 2020	Total Cost $/tonne	Financial Cost $/tonne (if different)	Government Cost Direct Cost ($M to 2020)	Government Cost Transfers ($M to 2020)
B 6	More frequent resurfacing	0.4	0.5	$133		$1800	
A 1L	Pedestrian and bicycle enhancements	0.3	0.4	$147		$750	
H 7C	Natural gas infrastructure incentive	0.7-0.8	2.3	$120-$208		$26	
F 3	Trucking load matching	0.1	0.11	$156		$0	
A 10L	Parking pricing (Tor-Mtl-Van)	0.5	0.6	$202		$1713	$34 255
K 3	Off-road, voluntary	1.76	-	n/a		$4	
K 2	Off-road, public awareness	0.2-0.3	-	n/a		$13	
K 1	Off-road, fuel-efficiency standards	2.0-2.5	-	n/a		$3	
TOTAL		***31.8***	***47.9***	***$5***	***$34***	***$13 398***	***$33 597***

5.3 TAXES, PRICING AND REVENUES

The role of taxation, pricing and revenues is a particularly important policy issue in assessing transportation options. A number of the measures studied by the Table include the use of market mechanisms such as prices and fees. Prices play an important role in determining the overall demand for transportation, the development and take-up of new, more efficient technologies, and the choice of transportation services. Charges and fees can be used to better reflect the full cost of different transportation services, ensuring their most efficient use.

5.3.1 Full-Cost Pricing

Transportation analysts in many countries, including Canada, the U.S. and Europe, have been assessing full-cost pricing of transportation as a means of reducing pollution and GHG emissions. Transportation costs generally include:

- costs covered by existing charges to the user (such as capital and operating costs, insurance, etc.);
- costs met by direct subsidies from government from either general or transportation-related taxes (such as highway construction, transit subsidies, etc.); and,
- external costs that are imposed by transportation, such as congestion, pollution, accident, policing and health costs, but are not captured by the market or reflected in the prices borne by users of transportation services.

The rationale for moving to full-cost pricing of transportation is one of economic efficiency and equity. As long as different transportation options do not reflect their full cost, including their impact on the environment, transportation will be overused, resulting in higher economic costs and more pollution. Another rationale for full-cost pricing is the argument that transportation need not be treated solely as a "public good" to be borne by society as a whole, but instead as a "private good" to be paid for by the user (the user-pay principle). Transportation policy in Canada tends to recognize that there are both public and private dimensions to transportation; governments subsidize some costs, while users pay the rest. Recently, Canadian policy is moving towards reducing transportation subsidies and shifting more of the cost to the user.

However, policy in Canada has not yet attempted to systematically capture the external environmental costs of transportation. For markets to be guided towards the most energy-efficient and least-polluting options, it is necessary that the costs of environmental impacts be reflected in the prices paid by the user. Further, these costs should be as closely tied to the source of the impact itself as possible, in this case reflecting the level of GHG emissions from various transportation services.

While the principle of full-cost pricing may be agreed to by many, it remains an extremely complex issue. For example, while some would argue that governments are subsidizing automobile travel by paying for the costs of roads, others would argue that these costs are effectively being borne by the users through taxes on gasoline and diesel fuels, although these taxes are paid to general revenues and not tied directly to transportation expenditures. Some would argue further that, if followed, the concept should apply to some modes that are presently subsidized, such as passenger rail and transit.

The Table analyzed several economic instruments, such as fuel taxes, road pricing and parking charges, as a means of reflecting more of the full cost of transportation. However, the Table did not have the time or resources to do the significant research and obtain the necessary data to analyze the appropriate level or means of implementing full-cost pricing, or to determine which services are subsidized and to what degree. Full-cost pricing remains a potential approach to better reflect the environmental costs of transportation, but requires a significant and longer-term analytical effort.

5.3.2 Fuel Taxes

The Table studied various fuel tax/pricing options as part of its analysis (Table 5.9) but did not reach a consensus on the use of fuel taxes as a measure to reduce GHG emissions.

It should be noted that in the Table's analytical framework, taxes and charges do not represent resource costs unless they are used to purchase goods or services. They are treated as resource transfers, but have been identified and are significant. This is not to suggest that tax increases are costless to consumers who pay higher taxes or to governments that offer tax incentives. Further, the actions taken in response to higher fuel prices produce various costs and benefits to consumers that have not been estimated in this analysis.

A national tax on all fuels was assessed to understand what level of price signal would be required if a fuel tax was the only option used to reach the Kyoto target in transportation. The analysis indicated that fuel taxes could be used as a single, stand-alone measure to achieve the Kyoto target, if the tax level were set high enough. Higher fuel prices create an incentive for producers and consumers to take many of the actions stimulated by the other measures described in this report. However, the tax levels required would be very high - unacceptably high, in the Table's view - and were not supported as a sound approach to reducing emissions. The magnitude of the fuel tax required, if it was the only measure used to reach the Kyoto target in transportation, illustrates the value Canadians place on the convenience, necessity and pleasure of transportation, and indicates that the incentives required to induce them to reduce transportation activity could be complex and costly. This finding may be at odds with some of the lower costs estimated for specific measures.

Some Table members believe that fuel taxes, at substantially lower levels, are a necessary complement to other measures aimed at reducing distances travelled or introducing more efficient vehicle technologies or alternative fuels. The use of moderate fuel taxes as a means of funding improvements in transportation, particularly in urban areas as a source of funding for transit, generated the most, but not unanimous, support. The Table's discussion of a fuel tax focused primarily on two of the options studied:

- an additional 1 cent per litre per year for 10 years (total of 10 cents per litre by 2010), which could generate GHG reductions of between 4.7 and 10.3 Mt; and,
- an urban gas tax of 4 cents per litre (1 cent per litre per year for 4 years), which could generate GHG reductions of between 1 and 1.9 Mt.

Much of the Table's discussion concerned the possible use of these two options as a source of funding to improve transportation services and efficiency, and to support other GHG measures such as for transit (the transit measures combined would require a government investment of $5.5 billion over 20 years; the urban gas tax at 4 cents per litre would generate between $4.4 - $5 billion).

However, there are mixed views on using fuel taxes as a measure to reduce GHG emissions. Those who support the concept make the following arguments:

- In real terms, the price of gasoline is similar to levels in the late 1970s, prior to the "oil shocks" (see Chart 4.5). This provides little economic incentive to encourage more energy-efficient technologies or to expand the use of alternative fuels.
- With no price signal, drivers do not value the energy efficiency of cars highly. Surveys by auto manufacturers indicate that fuel economy ranks extremely low on consumer lists of factors influencing their choice of vehicle. With no market demand, new energy-efficient technologies being developed by auto manufacturers will not find significant take-up in the market. Fuel prices are an important complement to the take-up of new car technologies.
- Fuel prices are a factor in changing behaviour to reduce trips and distances travelled, and encourage commuters to move to ride sharing or alternatives such as transit.
- GHG emissions increase in direct proportion to increases in fuel consumed. Thus, taxes on fuels provide a good proxy for GHGs and are consistent with a move to pricing the external environmental costs of transportation.
- Public support for fuel taxes could be improved if the funds were dedicated to improving transportation, such as in the U.S.

Those who oppose fuel taxes as a measure make the following arguments:

- The estimates of GHG reductions are based on assumptions of consumer and driver response. Some believe these estimates are overly optimistic, particularly at lower levels of tax increases.

- Fuel tax increases, which include road diesel, would put trucking at a competitive disadvantage and shift trucking to the U.S. They would increase the costs of transportation, which would impact those sectors where truck transport is a large proportion of total costs and where there is limited opportunity to pass on increases to the consumer, such as resource industries like agriculture or forestry. It would also make Canadian exports less competitive in U.S. markets if not harmonized.
- There are a number of equity issues related to fuel taxes. A tax on gasoline is regressive, and hits lower-income earners harder than higher-income earners. A national tax could be seen as unfair to rural areas, where there are no alternatives to the automobile.
- Consumers could be induced to undertake more cross-border shopping if the spread between fuel prices in Canada and the U.S. becomes too large. Similar concerns relate to the urban gas tax which, if too large, could encourage people to drive outside the city to purchase gas.
- Increasing road fuel taxes could discourage tourism, particularly from the U.S.
- At present, there is a lack of political and public support for fuel tax increases.

Some of these issues could be dealt with in the design of the tax. For example, offsetting the gas tax hike with cuts in income or sales taxes could mitigate impacts on the economy and be used to address equity issues for low-income earners. Preliminary analysis showed that offsetting the fuel tax with cuts to the Goods and Services Tax (GST) would be more beneficial than cuts to income taxes. For example, an increase of 1 cent per litre per year for 10 years was estimated to reduce GDP by 0.6 per cent in 2010, after which time the impacts would begin to disappear. However, if the tax is offset by a reduction in the GST, the reduction in the GDP would fall to 0.2 per cent in 2010, with no effects on overall government revenues. Alternative arguments favour cutting “direct” taxes—that is, personal or corporate income taxes—on the grounds that such taxes provide a disincentive to effort and innovation, and that reducing these taxes can provide a net stimulus to national output. It must also be noted that a reduction in other taxes could create some “take-back effect,” whereby the higher disposable income would increase the demand for transportation and therefore negate some of the GHG reductions of the tax.

The urban tax option could address rural equity issues. Those living in areas with few alternatives to the private automobile would not be subject to the fuel tax. The urban gas tax could also be designed to allow the municipalities to keep some or all of the revenue, thereby providing funding for investments in transportation measures to further reduce GHG emissions and other pollutants, particularly transit. Local or provincial fuel tax revenues are being used to fund transportation projects in Montreal, Vancouver and Victoria, and such an approach has already been proposed by other cities such as Ottawa, Toronto and Calgary.

Table 5.9 **FUEL TAXES**

FUEL TAXES [43]							
Measure		**GHG (Megatonnes)**		**Total Cost**	**Financial Cost**	**Government Cost**	
		2010	**2020**	**$/tonne**	**$/tonne (if different)**	**Direct Cost ($M to 2020)**	**Transfers ($M to 2020)**
I 1 & 2	National fuel tax to achieve Kyoto target	54.0	89.0	not applicable[44]			$278 000 *($160 000-700 000)*
I 3A	Urban gas tax, 1 cent/litre	0.4 *(0.3-0.5)*	0.7 *(0.4-0.9)*	not applicable			$1400 *($1300-1500)*
I 3B	Urban gas tax, 2 cents/litre	0.8 *(0.5-1.0)*	1.3 *(0.9-1.8)*	not applicable			$2600 *($2400-2800)*
I 3C	Urban gas tax, 4 cents/litre	1.4 *(1.0-1.9)*	2.6 *(1.7-3.5)*	not applicable			$4700 *($4400-5000)*
I 4A	Road gasoline and diesel, 10 cents	7.5 *(4.7-10.3)*	16.3 *(10.3-22.1)*	not applicable			$28 000 *($26 000-30 000)*
I 4B	Road gasoline and diesel, 20 cents	13.7 *(8.6-18.6)*	29 *(18.6-38.8)*	not applicable			$55 000 *($50 000-60 000)*

[43] The first figure is based on the Table's estimate of the fuel tax elasticity for different fuels. Where a range is shown in brackets, it indicates the high and low end of the elasticity estimate.
[44] In the Table's analytical framework, taxes and charges do not represent resources costs unless used to purchase goods or services. They are treated as resource transfers. This is not to suggest that tax changes are costless to consumers or to governments.

5.3.3 Other Economic Instruments

A number of other measures involve the setting of fees or charges as a means of reflecting more of the full cost of transportation activities, as well as reducing demand. These include such measures as parking charges, road pricing, and distance-based vehicle charges. The transfers associated with these different measures are summarized in Table 5.10.

Table 5.10
Transportation Pricing Measures Analyzed

Measure		Revenues from charge, toll, fee to 2020 (NPV - $ billions)
A 8	Urban road pricing	$12
A 9	Distance-based vehicle charges	$60
A 10H	Parking pricing	$60
B 3	Road pricing, urban and intercity	$350

5.3.4 Other Impacts on Revenues

Another important dimension of the taxes and pricing issue is the impact of the transportation measures on tax revenues to government. Transportation fuels are one of the few forms of energy taxed directly by governments in Canada, primarily through federal and provincial fuel taxes, but also in some areas through gas taxes at the municipal level. Thus any measures to reduce GHG emissions from transportation that result in less fuel consumption will also reduce tax revenues to government.

The impacts on government tax revenue through reductions in fuel consumption are illustrated in Table 5.11. This is not all lost revenues from today's gas tax base (federal and provincial governments collected $12.9 billion in 1997-98)[45]. It represents fuel tax revenue lost from the higher expected levels of fuel use in the "business as usual" forecast for 2010. The *most promising* and *promising* measures taken together would result in foregone tax revenue growth of $23.8 billion over 20 years. By comparison, this is equivalent to the amount of additional revenue that would be generated by the 10-cents-per-litre (1 cent per year for 10 years) tax on road gasoline and diesel fuel (Table 5.9; measure I4A).

Alternatively, some of the measures, such as fuel taxes, parking charges or road pricing, would generate significant revenues for federal, provincial and municipal governments that could be used to fund transportation programs or finance tax cuts in other areas. For

[45] Transportation in Canada 1998. Transport Canada.

example, each 1-cent-per-litre increase in gasoline taxes would generate $350 million in annual revenue. Each $1 per day increase in parking charges on 20 per cent of all trips in the three largest cities would generate $900 million annually in revenues. Although these measures do not have a financial cost per tonne, these types of measures result in significant resource transfers in the economy that must be considered.

Table 5.11
Impacts of Transportation Measures on Fuel Tax Revenues

Measures Package	Reductions in Fuel Tax Revenue to 2020 ($ millions)		
	Most Promising	Promising	TOTAL
1. Passenger package	-$1500	-$6917	-$8417
2. Road infrastructure	-$4096	-$1229	-$5325
3. Road vehicles and fuels	$0	-$5106	-$5106
4. Freight	-$977	-$3934	-$4911
5. Off-road	$0	n/a	$0
TOTAL	**$6573**	**$17 186**	**-$23 759**

5.4 CONSIDERATIONS

5.4.1 Competitiveness Issues

The issue of competitiveness is of particular importance in transportation. The Table's studies identified competitiveness issues, where possible, and these are noted in Chapter 4. In addition, the Table commissioned a separate study to explore competitiveness issues, relying on interviews with senior executives representing the transportation sector, shippers, equipment manufacturers and traditional and alternative fuel producers.

There are a number of dimensions to competitiveness issues in transportation. First, there is the impact transportation has on the competitiveness of other industries and the Canadian economy. Given the long distances in Canada and the economy's heavy reliance on trade, transportation costs play an important role in determining the competitiveness of Canadian goods. However, transportation costs are only one way in which transportation affects Canada's competitiveness. Transportation also affects Canada's ability to compete for international investment capital, with surveys of the factors affecting business investment decisions consistently ranking transportation services as one of the most important considerations.

Other transportation issues affecting the economy's competitiveness include the following:

- faster and more reliable transportation supports the use of just-in-time delivery in manufacturing, thereby reducing inventory overhead and costs;
- efficient transportation allows for greater labour mobility and access to more skilled workers as well as access to a broader range of suppliers;
- better transportation networks allow easier specialization of corporate functions in different locations to increase efficiency; and
- better access to larger markets can allow companies to concentrate their operations and achieve greater economies of scale.

The second competitiveness issue is the ability of Canada's transportation sector to compete internationally. Most carriers believe that harmonization, particularly with the U.S., is essential to limit impacts on their competitiveness. For example, under new "open-skies" policies, Canadian and U.S. airlines compete more and more on the same routes. Under NAFTA, and as a result of deregulation, truckers and railways compete with U.S. companies to move goods in both countries. In addition, both the air and marine modes have requirements to harmonize action internationally through the International Civil Aviation Organization and the International Maritime Organization. Raising costs in Canada may divert activity to the U.S. and not generate real GHG reductions. In particular, fuel taxes, if not harmonized with the U.S., were often cited as a major competitiveness concern.

Vehicle manufacturers also stressed the importance of a harmonized approach with the U.S. As already discussed, the Table's analysis has shown that there are significant benefits to maintaining a harmonized approach to vehicle standards for energy efficiency. But Canadian transportation equipment manufacturers also compete directly with Mexican locations for investment capital, and transportation costs are an important factor in investment decisions. Under the Kyoto Protocol, Mexico faces no emission reduction targets. In addition, reducing demand for vehicles would directly affect Canada's economy and exports.

Petroleum refiners are highly integrated on a North American basis, while upstream oil and gas producers must compete internationally with other commodity producers. Given the mobility of capital, the industry feels that measures affecting refiners need to be harmonized on a North American basis, while measures at the production end need to be harmonized internationally.

A third dimension of the issue relates to competition within modes. Different modes compete for different segments of the market for both passengers and freight. It is important to understand the implications of different measures on the competitiveness between different modes. For example between trucking and rail for freight traffic, or between rail, bus and airlines for intercity passenger traffic.

A final dimension of competitiveness that should not be overlooked is the opportunities climate change can create for Canadian companies. Canadian competitiveness could be improved by reducing energy use and costs, stimulating the innovation and adoption of new technologies, expanding markets for alternative fuels, improving the efficiency of Canada's transportation system by reducing congestion, and expanding the demand for Canadian vehicles for public transportation, such as buses and subways.

The competitiveness study identified a number of sectors that see economic opportunities that could be created by the proposed measures. These include intercity buses benefiting from a passenger-mode shift; tourism, which envisions benefits from enhancing and better managing urban passenger transportation, a better range of options for intercity transportation, and more tourist-friendly urban areas; and alternative fuel suppliers, including some companies that are also active in petroleum fuels.

The study also identified that the cumulative effects of different GHG measures are complex and may be significant. For example, transportation is a significant portion of the cost of coal, so measures that increase the cost of rail could affect the competitiveness of coal exports. This, combined with possible GHG measures in other sectors such as electricity, could reduce the demand for coal. Reduced exports of coal could, in turn, have an impact on the competitiveness of Canada's western ports, with possible consequences for other sectors that rely on these ports, such as grain or wood products.

Coming to grips with the competitiveness impacts of GHG reduction measures will require a more quantitative analysis than was possible for the Transportation Table. Moreover, such an analysis should take into account possible measures in other sectors. This will be an important consideration in integrating the work of the different issue tables. As a first step, the Table's work suggests that there are important competitiveness implications, both negative and positive, that require close consideration when looking at the various GHG reduction measures analyzed by the Table.

5.4.2 Air Quality

Transportation is a significant contributor to air pollution, particularly in urban centres. In 1995, transportation accounted for 52 per cent of all NOx, 40 per cent of CO, 20 per cent of VOCs and 5 per cent of particulate matter emissions in Canada.[46] In many cases, measures to reduce GHG emissions will also reduce emissions of air contaminants that contribute to smog in urban centres. As indicated earlier, the financial value of this benefit has not been included in the cost-and-benefit calculations of the different measures, however, this will be done at a later stage of the national process. Tables 5.12 and 5.13 summarize the changes in air pollution for each package of the *most promising* and *promising measures*. The impacts of each measure on air pollution, including fuel tax options, are presented in Appendix 4.

Table 5.12

[46] Environment Canada, Pollution Data Branch. Criteria Air Contaminants Inventory, 1995.

Impacts of Most Promising Measures on Air Pollutants

MOST PROMISING MEASURES	Changes in Criteria Air Contaminants (tonnes in 2010)				
	Sulphur Oxides SOx	Nitrogen Oxides NOx	Volatile Organics VOC	Particulate Matter PM	Carbon Monoxide CO
Passenger	-570	-4780	-2780	-350	-17 630
Road infrastructure	+10	+140	+130	+10	+1,160
Road vehicles and fuels	No measures				
Freight	-230	-470	-150	-30	-400
Off-road	No measures				
TOTAL Most Promising	**-790**	**-5110**	**-2800**	**-370**	**-16 870**

Table 5.13
Impacts of Promising Measures on Air Pollutants

PROMISING MEASURES	Changes in Criteria Air Contaminants (tonnes in 2010)				
	Sulphur Oxides SOx	Nitrogen Oxides NOx	Volatile Organics VOC	Particulate Matter PM	Carbon Monoxide CO
Passenger	-810	-21 190	-14 200	-1300	-130 430
Road infrastructure	-20	-390	-410	-30	-3790
Road vehicles and fuels	-1620	-40 240	-4660	-2850	-42 240
Freight	-470	-11 790	-710	-360	-5910
Off-road	Not estimated				
TOTAL Promising	**-2920**	**-73 610**	**-19 980**	**-4540**	**-182 370**

5.4.3 The Importance of Synergies Among Measures

There are important synergies or relationships among measures and packages. Transportation is a complex system of infrastructure, vehicles, fuels, service providers and consumers (drivers and shippers). Thus, a successful GHG strategy in transportation will require actions on the various components of the system. The interaction of the different elements of the transportation system and the interaction among measures are important. Following is a summary of the three types of synergies to be accounted for.

1) Overlap Among Transportation Measures

The effects of some measures will be reduced due to overlap among measures. For example, reducing trucking speed limits would reduce fuel consumption. As a result, other trucking measures, such as improved tires, lubricants or driving practices, would generate fewer GHG reductions, as the fuel consumption in trucking would have already been reduced. These overlap effects have not been calculated by the Table, but need to be accounted for during the roll-up and modelling of all of the issues tables' work. It should also be noted that some measures that improve traffic flow or reduce congestion may induce additional traffic onto roads, thereby partially reducing their effectiveness.

2) Synergies Among Transportation Measures

Measures, when combined, can reinforce and enhance their effectiveness. The Table did not undertake to quantify such synergistic effects. However, the five packages provide a framework that combines measures that complement each other. There are also important synergies across the packages. For example, a stand-alone effort to encourage urban commuters to reduce driving requires high-quality and convenient alternatives, such as better transit services. These efforts can be enhanced by changes to the road infrastructure to create designated lanes for high-occupancy vehicles, bicycles or buses. Measures to encourage new automobile technologies or the increased use of alternative fuels would be more effective when combined with a signal to consumers through higher fuel prices.

3) Synergies With Other Tables' Measures

The effectiveness of transportation measures would also be enhanced if combined with the actions of other issue tables. For example, the effectiveness of many transportation measures requires an effective public awareness campaign to build public support for some of the changes. Transportation measures also need to be linked to urban land-use and design actions being studied by the Municipalities Table. These synergy effects between transportation and other Tables have not been studied.

VI. Conclusions And Recommendations

Given its vast size and small population, an efficient transportation system is critical to Canada's competitiveness, trade and tourism. Transportation also plays a key role in Canadians' quality of life, as people make billions of trips each year travelling for work, recreation, medical care, and personal and family reasons.

However, transportation is the single largest source of GHG in Canada, accounting for 25 per cent of the total in 1997. GHG emissions from transportation are expected to exceed 1990 levels by 32 per cent by 2010 and 53 per cent by 2020, if current growth patterns continue.

For almost all industrialized nations that signed the Kyoto Protocol, transportation is a large and growing source of GHG emissions. It is also one of the most complex and challenging sectors to address. However, given the size and growth of emissions, it will be hard to ignore transportation if Canada is to meet its Kyoto commitments.

Although targets have not been allocated for each sector, meeting the Kyoto target in transportation would require a 28 per cent reduction by 2010 (about 54 Mt) from "business as usual". There is no single technology or solution that will meet this goal. A balanced GHG strategy for transportation must address the various parts of a complex system that includes vehicles, infrastructure, fuels, service providers, shippers and, most importantly, the public.

In reviewing the analysis of the different measures, it is important to understand the limitations of the data used in the analysis. Assumptions were made where data was limited or not available. In some cases, there is no actual experience with specific measures (for example large-scale increases in fuel prices or feebates for automobiles), so it was necessary to estimate effects. The basis for these assumptions and the limitations of the data used are important considerations when assessing the estimated effectiveness of different measures.

The Table grouped its measures into five packages: Passenger; Road Infrastructure; Road Vehicles and Fuels; Freight; and Off-Road. These packages provide a useful framework for grouping measures that work well together, are aimed at a particular end use, or provide a focus for action in the transportation sector.

The Table also used a range of criteria as general guidelines to assess the measures as falling into one of the four following categories:

1. ***Most Promising Measures***: Measures that are cost-effective (generally have positive benefits or cost less than $10/tonne), are easier to implement, or do not involve significant resource transfers. They may require some additional analysis and design.

2. ***Promising Measures:*** Measures that have potential for various levels of GHG reductions at low to modest cost, or which are included to complement other measures in the package. They may need some additional analysis or development.

3. ***Less Promising Measures:*** Generally, higher-cost measures that may have GHG reduction potential in the medium to longer term and/or require significant additional analysis, much greater public acceptance, or considerable technological development.

4. ***Unlikely Measures:*** Measures that Table members believe do not warrant active consideration at this time due to high cost (over $200 per tonne of GHG), limited potential to reduce emissions, or extreme difficulty in implementation. Also included are measures made redundant by those in the first three categories.

The Table did not propose a single set of measures to achieve a 6 per cent reduction over 1990 levels. However, the various measures analyzed could generate sufficient reductions to reach or go beyond the Kyoto target in transportation, as required by the Table's mandate. The final strategy needs to be flexible to determine which measures work best to meet regional and local needs.

The ***most promising*** measures could reduce GHG emissions by up to 10.8 Mt by 2010 (20 per cent of the Kyoto target), at a net economic benefit of $32 per tonne. That is not to say that these reductions are costless; they could include non-monetary benefits such as time savings or require government or private sector investment, but generate an overall net benefit for the country. The cost of the individual measures in this category ranges from a benefit of over $900 per tonne to a cost of $14 per tonne.

The ***promising*** measures could reduce emissions by a further 31.8 Mt by 2010 (almost 60 per cent of the Kyoto target) at a net economic cost of $5 per tonne, with individual measures ranging from a benefit of over $1,200 per tonne to a cost of $200 per tonne. These measures move beyond voluntary measures, relying on financial incentives, infrastructure improvements and targets to encourage new technologies, improve energy and transportation efficiency, and change practices and behaviour. However, these measures may require significant government or private-sector investment, additional analysis, or international discussions before implementation.

To further reduce emissions in transportation beyond the *most promising* (11 Mt) and *promising* (32 Mt) measures, more aggressive versions of some of these measures were assessed. A number of ***less promising*** measures were also identified that are more difficult and expensive, or require significantly more analysis. Some of these measures restrict activity or introduce pricing mechanisms, such as road and parking pricing.

Fuel taxes were also assessed. However, the Table did not reach agreement on the use of fuel taxes as a possible measure to reduce GHG emissions. The analysis indicated that fuel taxes could be used as a single stand-alone measure to achieve the Kyoto target, if the level were set high enough. Higher fuel prices create an incentive for producers and consumers to take many of the actions stimulated by the other measures described in this report. However, the tax levels that would be required turned out to be unacceptably high in the Table's view. The magnitude of the fuel tax required, if it were the only measure used to reach the Kyoto target in transportation, illustrates the value that Canadians place on the convenience, necessity and pleasure of transportation and indicates that the incentive required to induce them to reduce transportation activity can be complex and costly. This finding may be at odds with some of the lower costs estimated for specific measures.

Some Table members believe that fuel taxes, at substantially lower levels, are a necessary complement to other measures aimed at reducing distances travelled or introducing more efficient vehicle technologies or alternative fuels. Pricing can play an important role in shifting behaviour and encouraging more efficient use of transportation. For others, the measure raises concerns about the economic and social impacts of higher fuel taxes. The use of moderate fuel taxes as a means of funding improvements in transportation, particularly in urban areas as a source of funding for transit, generated the most, but not unanimous, support.

Although the Table involved a significant number of stakeholders through its sub-groups, the measures have not had the benefit of a peer review or broader input from the transportation community. The Table will be consulting further and preparing a companion document identifying stakeholder and regional views on the measures.

Recommendations for Further Work

This report identifies options to reduce GHG emissions from the transportation sector. Whereas previous climate change analyses have focused on different elements of transportation, this is the first time that a holistic analysis has been undertaken to analyze the costs and benefits of options across the entire transportation system. However, the Table's analysis covered a large and complex area of study in a relatively short period of time. Thus, this report is not intended to provide a prescription for implementing different measures. This may require more detailed analysis, design and consultation.

Rather, the report is intended to identify the costs and benefits of different options to reduce GHG emissions, highlight areas of potential, and identify issues and concerns to be addressed. It represents an important but initial step. Further work will be needed in the following areas.

1. **Improving Transportation Data**
   The Table identified a number of areas where the data on transportation is limited. Given that climate change is a long-term issue, it is expected that there will be a need for ongoing analysis of transportation and climate change issues. It is recommended that the federal, provincial and territorial ministers of transportation develop a strategy to improve the quality of transportation data in Canada.

2. **Additional Analysis**
   The Table identified a number of areas where additional analysis is needed as a result of its work, including the following two examples.

   i) **Gaps in the Table's studies**: Due to budget and time constraints, a number of areas were not adequately reviewed by the Table and require additional analysis, including:
      - regional impacts of the proposed transportation measures to understand their impacts on provinces and territories, transport costs, rural communities, etc.;
      - options to reduce emissions through improvements and greater efficiencies in intercity rail and bus operations;
      - emissions from commuter travel less than 80 kilometres, if outside the municipal area, or greater than 80 kilometres one way, if not intercity travel;
      - technologies for medium-duty trucks (between 4500 kg and 8500 kg);
      - cross-price elasticities of the potential for shifts between modes and fuels;
      - additional voluntary actions in the areas of parking policies and ride sharing; and,
      - synergy effects between transportation measures and public outreach and urban-design actions.

      Further, the Table recognizes that a solid understanding of the competitiveness implications of GHG reduction measures is critical. The Table's work provides an initial but only qualitative assessment of some of the key competitiveness concerns. Competitiveness issues will require additional and more quantitative analysis.

   ii) **GHG reduction measures**: The Table highlighted a number of measures, particularly in the *most promising* and *promising* categories, that have potential for cost-effective GHG reductions, but require additional analysis, design and consultations. A strategy for active follow-up work on these measures is needed.

3. **Mechanisms for Taking Action**
   Climate change is a relatively new issue for many in the Canadian transportation sector. GHG impacts are not generally considered in the development of new transportation policies and plans or in assessing infrastructure investments. Governments at all levels should develop new practices and analytical tools to incorporate GHG considerations into transportation policies, programs, plans and infrastructure investments.

   Some members believe Canada would benefit from a national mechanism similar to the U.S. Transportation Equity Act for the 21st Century that would enable it to move forward on transportation issues, such as climate change (TEA-21-See Appendix 6). Although not explicitly designed to meet climate change objectives, TEA-21 has a number of elements that will help reduce both pollution and GHG emissions from transportation.

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Appendix 2

Transportation Climate Change Table - Analytical Studies

The Transportation Climate Change Table completed 24 analytical studies that contain additional detail on the sector, emissions and the measures analyzed and the assumptions made. Copies of the studies are available on the Table's web site at **www.tc.gc.ca**.

1. **The Potential for Emissions Trading to Reduce the Costs of GHG Abatement in the Canadian Transportation Sector. ICF Kaiser Ltd.**
   Provides an overview of four options to apply emissions trading in the transportation sector. The study looked at options within transportation only, assuming that transportation fuels were not part of a broader, national emissions trading system.

2. **Off-Road Vehicles and Engines: GHG Emissions and Mitigation Measures. ICF Kaiser Ltd.**
   Approximately 12 per cent of the emissions attributed to the transportation sector come from "off-road" sources. This study provides improved estimates on the sources of these off-road emissions, and the potential to reduce emissions from sources such as recreational vehicles, gardening equipment, construction equipment, and equipment used in agriculture, forestry and mining.

3. **The Potential of Fuel Taxes to Reduce Greenhouse Gas Emissions in Transportation. Hagler Bailly Ltd.**
   The study summarizes a detailed literature review and experts workshop on responses in the demand for fuel in response to price increases (demand elasticities). It summarizes the impact on emissions of raising fuel taxes and the policy, social and economic issues related to different models of fuel taxes.

4. **Competitiveness Issues and Opportunities in Reducing Greenhouse Gas Emissions in Transportation. Hagler Bailly Ltd.**
   The study summarizes key competitiveness issues in transportation based on a survey of the sector and interviews with different transportation companies. It assesses some of the key competitiveness issues resulting from some of the measures to reduce emissions studied by the Table.

5. **Assessment of Freight Forecasts and GHG Emissions. Delcan.**
   The study provides a revised baseline forecast of GHG emissions for the freight sector and estimates emissions for each mode (air, marine, rail and trucking).

6. **Assessment of Modal Integration and Shift Opportunities. Delcan and KPMG.**
   Presents the results of a survey designed to identify and improve understanding of the key factors for shippers in selecting different modes for shipping their freight. It analyzes the potential and the costs and benefits of measures to shift freight to more efficient modes in five corridors.

7. **Potential to Reduce Greenhouse Gas Emissions From Air Freight. Sypher: Mueller International Inc.**
   Estimates options to reduce GHG emissions from air freight. The study addresses various aspects of Canada's air-freight transportation system, including: aircraft technologies, airport efficiencies, navigation and routing systems, and aircraft operating procedures.

8. **Survey of Rail Industry Technological Improvements and Socio-Economic Factors. Research and Traffic (RTS) Group.**
Identifies opportunities for GHG reductions through technological improvements, including estimated reductions, costs and barriers in adopting new technologies. The study assesses options related to tax regulations, public infrastructure and pricing that affect the ability of railways to reduce GHG emissions.

9. **Opportunities to Reduce GHG Emissions in the Marine Transportation Industry. Bronson Consulting Inc.**
Reviews emissions from the marine sector and assesses the potential of technological, operational and infrastructure opportunities to reduce GHG emissions from the marine sector**.**

10. **Awareness and Outreach Measures to Reduce GHG Emissions from the Trucking Sector. Ray Barton and L-P Tardif et associés**.
Analyzes the costs and benefits of initiatives to change operating and driving practices in the trucking sector to improve fuel efficiency.

11. **The Potential for GHG Reductions from Improved Use of Existing and New Technologies in the Trucking Industry. Instrumental Solutions (Gordon Taylor, Fred Nix and Michel Delaquis).**
Assesses the potential for GHG emission reductions from new and existing technologies in the trucking sector in seven specific areas, including the extended use of long combination vehicles (LCVs), fuel-speed monitoring systems, and load matching and tracking services.

12. **Potential for GHG Reductions from Scrappage Programs for Older Trucks and Engines. Instrumental Solutions (Gordon Taylor, Fred Nix and Michel Delaquis).**
Assesses the potential costs and benefits of a scrappage program to replace older trucks and engines with more efficient technologies.

13. **Alternative and Future Fuels and Energy Sources for Road Vehicles. Levelton.**
Analyzes options for future fuels and their vehicles and infrastructures. The study quantifies the GHG-reduction potential of each fuel/vehicle option based on their full-fuel cycle and the cost of reduction. It identifies barriers to introducing and increasing the long-term use of these fuels in Canada.

14. **Alternative and Future Technologies for Road Vehicles. Senes and Sierra Research.**
Assesses the technical and economic potential of changes in vehicle technology and fuels and quantifies their GHG-reduction potential. The study provides cost estimates for various new vehicle technologies.

15. **Road Vehicle and Fuels Technology Measures and Analysis. Energy and Environmental and Analysis Inc.**
The study analyzes specific policy measures, including regulatory, voluntary and incentive programs, to increase the supply and use of alternative fuels and new technologies for light- and heavy-duty vehicles. The study draws on the data and analysis from the previous two studies.

16. **Vehicle Technologies for Heavy-Duty Trucks and Buses. Sypher: Mueller International.**
A special analysis of potential measures for heavy-duty trucks and transit buses.

17. **Potential of Feebates to Reduce GHG Emissions. HLB Decision Economics Inc.**

The study analyzes the GHG-reduction potential of providing a system of incentives and penalties to increase the use of more fuel-efficient vehicles in Canada. The costs, benefits and reduction potential of feebates are analyzed.

18. **Strategies to Reduce GHG Emissions from Passenger Transportation in Urban Canada. Hagler-Bailly.**
    Estimates the GHG reductions possible from measures and combinations of measures to decrease the use of single-occupant passenger vehicles in urban areas and improve the fuel economy of the urban "in-use" fleet. Measures examined include active transportation, public transit, ride sharing and high-occupancy vehicle facilities, car sharing, telecommuting, inspection and maintenance programs for urban vehicles, vehicle-scrappage programs and pricing mechanisms such as parking charges and road pricing.

19. **Strategies to Reduce GHG Emissions from Passenger Transportation in Three Large Urban Areas. Delcan with KPMG and A.K. Socio-Technical Consultants.**
    The study identifies the most practical package of measures to reduce GHG and other emissions from urban passenger transportation in the Greater Toronto Area, the Montreal Region and the Greater Vancouver Regional District. The study includes the results of workshops in each city and presents the views of key transportation stakeholders on which measures have the best potential to succeed.

20. **Alternative Fuels Market Research Study. Bronson Consulting Inc.**
    Identifies the key barriers to expanding the use of alternative fuels and vehicles in urban centres across Canada. The study summarizes the results of interviews, focus groups and other market-research tools with fleet managers and owners of light-, medium- and heavy-duty vehicles.

21. **Tax-Exempt Status for Employer-Provided Transit Benefits. IBI Group.** Examines the potential of changes in the tax treatment of employer-provided parking and transit benefits as a means of encouraging greater use of public transit.

22. **Measures to Favour Modal Shift for Greenhouse-Gas Reduction. Research and Traffic (RTS) Group.**
    The study analyzes the emissions from different modes of intercity passenger travel. It identifies the potential for modal shift and analyzes measures to encourage a shift to more fuel-efficient modes of intercity passenger travel.

23. **Highway Infrastructure and Opportunities for a Reduction of Greenhouse Gases. Consultant: Louis Tardif et associés.**
    Identifies potential measures and options for GHG reductions that would result from changes to the design and construction of road infrastructure and different methods for the maintenance and use of existing infrastructure.

24. **GHG-Reduction Benefits of Intelligent Transportation. IBI Group.**
    Identifies the potential of intelligent transportation systems (ITS) to reduce GHG emissions on Canada's road/highway transportation network. ITS includes technologies on the roadway and in cars to improve traffic flow, enable road pricing schemes, monitor traffic speeds and reduce congestion.

Appendix 3

Analytical Approach and Methodology

Analytical Process

The Transportation Table is one of 15 issue tables established to examine and report on potential means of reducing emissions. Coordination of the analytical processes was necessary to ensure coverage of options in all sectors, consistency in data, measurement and analytical methods, and then to combine measures appropriately where they were envisaged to be implemented jointly. An Analysis and Modelling Group (AMG) was established with broad responsibility for methodological guidance and, ultimately, for the joint comparisons of options and combinations of measures in what is referred to as the “roll-up” stage of strategy development.

The AMG provided guidance on estimating and forecasting greenhouse-gas (GHG) emissions, and on the economic analysis to be employed, comparing emissions-mitigation options primarily on the simple basis of economic cost per tonne. They required also that ancillary effects be identified, primarily the effects on criteria air contaminants (CACs); that the distributions of costs and other impacts between the public and private sectors and among levels of government be revealed; and that the distributions of all impacts be estimated by province/territory. Subsequently the AMG organized a series of workshop discussions on certain issues of methodology and issued further advice and clarification to the tables. The most pertinent for the Transportation Table were the guidelines on cost-effectiveness estimation, modelling of the effects of CACs on health and their valuation, and the treatment of the effects of measures on sectoral and national competitiveness. In addition, the AMG arranged for Environment Canada to provide to the Table the relevant CAC-emission factors by fuel and type of transport activity.

The Table was responsible for the identification and analysis of sectoral options, which it undertook through contracted projects. The results were combined and summarized by the Secretariat through an Analytical Support Group (ASG) of Natural Resources Canada and Transport Canada staff. Early in the Table’s work, the ASG prepared an analytical framework for the contractors, expanding on the initial guidance from the AMG—including advice on certain specific methodological issues affecting the sector (the framework follows below). Subsequently, discussions between the AMG and ASG provided confirmation of the advice on two more obscure aspects of the framework—namely the treatment of taxes and the valuation of activity changes—and a clarification of the advice on the latter was produced by the ASG (also attached).

The ASG prepared spreadsheets for the combination and summarization of the impacts of options and measures assessed in the contracted projects. These duplicated the baseline aggregate emissions forecast in the *Outlook* and its recent amendments, and added details of transport activities necessary to simulate the effects of measures. These included all passenger and freight activities in aviation, marine, and rail transport and, more particularly in the case of road transport, extended GHG- and CAC-emissions forecasting capabilities through the use of a vehicle fleet model that included more details on vehicle types, ages and models. This allowed the effects of all measures to be re-estimated using the most recent evidence on emission rates, with greater sensitivity to the changing mix of vehicles over time than was feasible by the contractors who assessed each measure.

The ASG's spreadsheets also provide the capability to estimate the effects of measures in any proposed combinations, allowing for recognizable overlaps and synergies.

Transportation Table's Analytical Framework

1. INTRODUCTION

The purpose of this document is to provide a framework for the analytical work that the Transportation Table will be conducting. It reflects and expands upon the direction provided to all tables by the Analysis and Modeling Group (AMG), addressing the special needs and characteristics of the Transportation Table. This document highlights a number of issues the Transportation Table needs to address in carrying out its mandate.

2. TRANSPORTATION TABLE MANDATE

The mandate of the Table is to identify specific measures to mitigate greenhouse-gas emissions from Canada's transportation sector. The Table will identify and analyze a range of potential measures to reduce greenhouse-gas emissions. The analysis of these measures should include their greenhouse-gas impacts during the budget period 2008-2012, and their costs and benefits.

The Table is responsible for examining all aspects of Canada's transportation system, including: all modes (rail, road, marine, air); transportation fuels; passenger transport (intercity passenger; urban passenger); transportation equipment (excluding emissions from manufacturing); transportation infrastructure; freight transport; urban transit; vehicle technology and standards; inter-modal transportation; and transportation-demand management.

3. ROLE OF ANALYSIS AND MODELING GROUP

This framework reflects guidance received from the Analysis and Modeling Group (AMG). The AMG is to address issues surrounding the data, analytical and modeling needs of developing a coherent national climate-change implementation strategy. Operating as a task group of NAICC-CC, the AMG will work closely with the Transportation Table to support its work to ensure that the Table has the necessary analytical and modeling support; and uses coherent baseline data and a common analytical template to ensure consistency and comparability of the analysis of various measures/options. In addition, the AMG will identify emerging analytical issues and propose methods/approaches to resolve these issues.

The AMG has provided guidelines for developing and analyzing measures to reduce GHG emissions. These guidelines are very succinct in their description of the methods for evaluating options, explaining the output the Group expects tables to provide for each option, but not suggesting the appropriate methods of analysis. Essentially, the requirements are to:

- estimate the costs and CO_2-equivalent emission-reduction benefits of each option, such that comparable cost-effectiveness ratios can be produced in $/tonne of emissions reduced;
- estimate associated indirect benefits or costs, including notable reductions in air-pollutant emissions; and,
- combine options for the sector into an incremental-abatement cost function.

Such consultation will be valuable and essential, as there are aspects of the options for transportation that pose analytical questions that are unique or at least unlikely to be important for other tables, and that must be resolved if the analysis is to be consistent across tables. Some of the considerations that are initially apparent to the Secretariat are mentioned below, with some suggestions for the Table's approach that arise from them. The advice of Table members on these issues will be welcomed, and the advice of the AMG is also being sought.

AMG Guidelines

The AMG guidelines are summarized below and detailed in Appendix 1 to this document.

- ***Measures*** – Tables are to consider a wide range of measures, including both broad market-based instruments and more focused regulatory measures. It will be important to define any proposed measure with sufficient precision to enable assessment of its costs, benefits and impacts. Each measure should identify the objective, the instrument to be employed (nature, degree of application, timing) and the organization responsible for implementation (level of government, stakeholders). The measures should be developed considering initiatives already included in NRCan's *Canada's Energy Outlook: 1996-2020*.

- ***Assumptions*** – The NRCan Reference Case in *Outlook*, including its underlying assumptions about energy prices and economic growth, should be used as the basis for the analysis of all measures. *Outlook* is the official projection used as the basis for negotiations in Kyoto and for Canada's submissions to the Conference of Parties. The assumptions and forecasts are discussed in more detail in Section 4 below.

- ***Cost curves*** – The National Air Issues Coordinating Committee has expressed a desire to see cost curves developed for each sector. However, there are a number of different assumptions that could be made in estimating the costs per tonne of measures (e.g. social versus private discount-rate) and in aggregating individual costs to obtain a cost curve (e.g. how to treat overlaps). It is important that these cost curves be developed using an analytical framework that is common to all tables.

- ***Assessment of costs, benefits, energy and emission impacts of measures*** – The output of the analysis of each measure should include: the market segment to be affected by the proposed measures or set of measures, the rate of expected change, and the associated required investment and net costs, with the share to be borne by the private sector, federal government and municipalities. This information should be provided for Canada by province, sector and year. Tables are to estimate the overall social, economic, health and environmental costs and benefits, including ancillary environmental benefits, and to detail competitiveness implications. It is suggested that the analysis of indirect costs and benefits and impacts only be done when the impacts are expected to be significant. The roll-up will estimate the combined economic and environmental impacts of all measures.

4. BASELINE FORECAST

As noted above, the Transportation Table will use the official NRCan Reference Case as the baseline emissions forecast from which the effects of options will be measured in 2010 and 2020. The assumptions and forecasts made about transportation are described briefly in *Outlook* (pp. 30-36 and A4, and Annex C-20). They arise from:

- NRCan's overall forecasts of national economic activity and energy prices (see Annex C-1 to

3), which determine the forecasts of sales of new road vehicles;

- NRCan's modeling of road-vehicle fleets and their usage and fuel consumption, based on annual new vehicle sales, combined with scrappage rates by vehicle age and average annual kilometres per vehicle by age;
- Transport Canada's forecasts of activity for modes other than road vehicles (i.e. air, rail and marine), which are based on forecasts of economic activity by sector and region; and
- NRCan's forecasts of the effects of energy efficiency programs already in place or expected under the National Action Program on Climate Change. It is important that there be no double-counting of these effects when the Table estimates the effects of new options, so the assumptions in that document should be examined carefully. The initiatives considered address road vehicles and include some significant improvements to fleet fuel-efficiency expected to arise as a consequence of the NAPCC rather than any actions that might be taken in the Climate Change Strategy. They include voluntary shifts of new vehicle purchases to more fuel-efficient models, increased purchases of alternative-fueled vehicles, and operational efficiencies in trucking undertaken voluntarily by the carriers.

5. TRANSPORTATION TABLE APPROACH

The Table will build an incremental package of measures to reach the Kyoto target of six percent below 1990 levels within transportation (averaged over the period 2008-2012.) This package would begin with easier and cheaper options, building through to more difficult and expensive measures. Thus, the report of the Table would identify incremental measures and their associated costs and benefits that would achieve progressively greater reductions within transportation until reaching or, if possible, exceeding a six-per-cent reduction from 1990 levels. However, it is recognized that the final national climate change strategy may, or may not, require Canada to reach the Kyoto target in the transportation sector.

The Transportation Table will be establishing a number of subgroups to carry out its analytical work and to consult with stakeholders. More specifically, the subgroups are to:

- provide technical expertise to the Table and oversee technical work needed;
- review emissions forecasts and assumptions/estimates for transportation in *Outlook*; and
- develop options and measures to reduce GHG emissions, and manage specific studies/analytical work.

The major policy instruments and regulatory issues will be dealt with by the main Table. This, however, does not preclude subgroups from discussing and presenting options on relevant issues (e.g. inter-modal shifts).

6. PROPOSED METHODOLOGY AND KEY ISSUES

There are a number of ways to estimate the costs and benefits of potential GHG emission reduction measures. The purpose of this section is to propose how the Transportation Table might best proceed in view of the guidance provided by the AMG and taking into account the particular characteristics of the transportation sector. There are many issues that need to be addressed, including the choice, availability and reliability of data, and items to be included or excluded. These issues and others are discussed below, and suggestions have been made, for the consideration of the Table, as to how to deal with them.

A. ESTIMATING BENEFITS

GHG Emissions Reductions

The forecasts presented in *Outlook* are, first of all, the trends in consumption of each transportation fuel (road gasoline, diesel, propane, CNG, electricity and others; rail diesel; aviation turbo and gasoline; and marine heavy fuel-oil, diesel and gasoline). These are then converted, using constant emissions factors for each type of fuel, into trends in emissions of CO_2, methane and nitrous oxide. These are finally combined, using constant radiation-forcing equivalency factors for each gas, into emissions of greenhouse gases expressed as a CO_2 equivalent.

In order to assess the effectiveness of potential options, the forecasts for road-fuel emissions will probably need to be broken down further by type of vehicle (particularly private car, privately-used light trucks, commercially-used light truck, heavy truck, intercity bus, urban bus, other transit vehicles) and type of operation (rural vs. urban, peak vs. off-peak). The lack of data on road-vehicle use make even this kind of baseline analysis very uncertain. A start has been made by Transport Canada to produce Table 2.1 in the draft foundation paper and, subsequently, the emissions per passenger-km and tonne-km in Tables 4.4 and 4.5. But the estimates are judgmental, and an early task of the Table should be to produce consensual estimates and forecasts of traffic, fuel use and emissions.

Reductions in emissions must then be estimated and projected for each option for 2010 and 2020. This will normally require an estimate of the change in traffic, which must be converted to a reduction in the use of each type of fuel and, subsequently, to a reduction in GHG emissions. The conversion will be simple for an option that reduces fuel use in the same proportion as traffic (e.g. a general fuel price increase), but more complex for an option that addresses traffic with fuel use that is different from the average (e.g. congested urban traffic).

When analyzing options, it will be important to take into account second-round or buy-back effects of increases in emissions after initial reductions, when users adapt to the options over the longer term (e.g. when improvements in vehicle fuel-efficiency encourage increased vehicle-kms). A key issue is how best to do this.

Other Benefits

Other benefits will be relevant to the decision processes on options. The Transportation Table should identify and quantify other benefits as precisely as possible. Particular attention should be paid to coincident reductions in smog-contributing emissions (NO_x and VOCs) and particulate emissions at relevant locations and times. The Analysis & Modeling Group intends to advise on appropriate factors for converting fuel savings to other pollution reductions that will be provided by Environment Canada. Other quantifiable benefits might include reductions in transport accidents and noise.

The AMG advises Tables to quantify all such benefits, but not to attempt to estimate the effects they would have on health, as the Group will assess the combined effects of all measures (notably the effects of smog reductions) at the roll-up stage for all measures.

The AMG is considering whether and how tables should attempt to estimate monetary values for such benefits. It will also continue to consider whether equivalent monetary values can be confidently assigned to the target GHG emissions reductions. Monetary values of environmental emissions reductions continue to be sufficiently uncertain that—unlike values of travel time or transport-accident risk reductions—they have not been adopted in standard cost-benefit models for public investments in most jurisdictions of the world. Because of this, the primary analysis of options will be a comparison of their simple cost-effectiveness ratios in $ per tonne of GHG emissions reduced.

B. ESTIMATING COSTS

In order to compare estimates of cost-effectiveness among options, the costs must be estimated on a consistent basis. This requires that concepts and measurements be the same across all tables, notably:

- *Cost estimation must follow some common arithmetical processes*, including:
  - common currency units–we should use constant dollars at prices in 1999, the year the analysis will be presented; and
  - representation of future amounts by their equivalent "present" values (which we can take to mean values in 1999) using a discount rate that is uniform among tables. It is recommended that the Table adopt a rate of 10 per cent (real), which is the rate the federal Treasury Board Secretariat requires for federal investments.

- *Costs must be incremental* (i.e. imposed as a consequence of the option). In particular this might conflict with some accounting conventions that spread costs among existing operations. For example, if a new route or more frequent service was added to some public transport operation, the local accounting rules might assign it some of the company's administrative overhead, but that only represents true cost if some additional administration is imposed, in which case we should try to estimate the cost for the incremental activities. As another example, the cost to a vehicle manufacturer of an equipment modification should identify all the costs specifically imposed by the modification in capital equipment, processes and materials. It should ignore the overhead costs of the plants and of such activities as administration and marketing that might be assigned to it by accounting conventions, unless those overhead items can be expected to increase as a consequence of the modification.

- *Costs must be comprehensive.* While only incremental costs are relevant, any cost logically imposed by the option should be included. This means that all costs imposed on the private sector operations and transport users by government actions are relevant. Thus, for example, the costs of new vehicle/craft construction regulations imposed by government would include primarily the cost to vehicle/craft manufacturers of making the necessary equipment modifications. The costs of a government-required vehicle inspection program would include not only the costs of the testing facilities and their operations, but also the costs of additional repairs or maintenance undertaken by vehicle owners in order to pass the tests. It also means that all the life-cycle costs of new equipment are relevant, including extra operating and maintenance costs over their anticipated lifetime, as well as the costs of their production. The same goes for the costs of public infrastructure, where any increase in maintenance costs is also relevant.

- *Costs should include government subsidies and tax expenditures* .Where an option involves amounts of new, direct government subsidies, such as for public transport facilities or operations, the costs should be identified either as the financial costs of the new facilities or services themselves, or as the subsidy that pays for them. Similarly, tax reductions allowed by government to support any option will be counted as costs of the program. The tax reductions are relevant when comparing the cost-effectiveness of options, as the government tax reductions could be used for alternative options. It will also be important for the Table to clarify who bears the costs—government (by level), industry, users, or others (e.g. society-at-large for air emissions).

Treatment of New Taxes/Fees/Tolls

A number of the options to be considered by the Table intend to induce emissions reductions through some form of price increase to users that is imposed by government, for example via fuel taxes, vehicle purchase taxes (or feebates generating net revenues), vehicle license fees, road tolls, parking surcharges, airport landing fees, and port fees. Should such price increases be included as costs for the purposes of estimating cost-effectiveness ratios? The answer (subject to Table discussion and ratification by the AMG) is that these payments are not real costs, comparable to those costs of transport investments and operations of the kinds of options considered above. The tax/fee/toll payments are transfers to governments that constitute windfall gains to those authorities, available to produce benefits elsewhere or to reduce other taxes by an equivalent amount. They might, conceivably, even produce more-than-equivalent gains if used to reduce distorting taxes elsewhere, and stimulate new activity. It is not, therefore, appropriate to use these payments as costs in cost-effectiveness ratios for comparison with options that impose real costs of additional resource use.

Consequently it is proposed that the Table should not produce cost-effectiveness estimates for options for which the prime instrument is a taxfee/toll increase. Their effects should be forecast, as for other options, but will be presented by the Table in a separate list.

Treatment of Transport Activity Restrictions.

A number of other options will achieve their effects not by imposing price increases, but by some sort of activity restriction through government regulation, for example, road speed limits, load limits, vehicle weight and dimension limits, restrictions of hours of operations in cities, minimum occupancy rules, or restrictions on entry to certain areas. For these options, the immediate monetary costs attributable to the regulations might be quite small; perhaps just the costs to the authorities of enforcement. But the Table must also attempt to identify the costs involved in the changes in activities induced by the regulation. Some of these will be additional financial costs to commercial users of adapting their operations to the regulations. For example, truck carriers might have to pay additional driver costs, costs of modifying vehicles, or of purchasing replacement vehicles. And if the regulation could be expected to reduce commercial vehicle activity, the losses in carrier net revenues should also be counted as costs.

However, the effects on private (non-commercial) users, which might be much more extensive than those on commercial users, are not likely to be identifiable as financial costs. Instead they will arise as increases in travel times reductions in trips, or replacement by pooled trips or shorter trips. These might not have any obvious monetary value, but are certainly felt by users to be unwelcome effects of the measures. It might be possible to assign equivalent money values for them, for example on average values for user time losses. The Table could adopt the standard values used by Transport Canada for cost-benefit assessments of transport investments (referenced in Transport Canada's published *Benefit-Cost Analysis Guide*, Report TP11875, 1994). These value working time losses at average wage-rates among users, with separate estimates for transport modes, and non-working time losses at one-half average wage-rates for all modes.

For trips completely foregone or replaced by others producing fewer emissions, it might also be possible to infer equivalent money values by analogy to the cost-benefit evaluation methods used in transport agencies. Transport Canada will advise on particular cases.

It is recommended that, where possible, the Table should include in the costs of options these equivalent monetary values for losses of time or other aspects of mobility that normally have no financial value. While such costs are clearly not as certain and "hard" as the financial costs of investments in equipment or expenses of operations that comprise the costs of the technology options, these costs will be important to the transport sector. For the Transportation Table, they could prove to be the major components of costs for a number of prominent measures, notably traffic demand management measures. The Table might wish to list separately the social costs with appropriate qualifications, and the cost-effectiveness ratios of options calculated using them.

A related topic for some potential emission-reduction measures is the appropriate treatment of taxes and fees: it is suggested that deterrent fees (road tolls, parking surcharges, etc. that are not fees for infrastructure or services) should be treated as costless transfers.

1. *Congestion charges* (e.g. the road pricing case):
   The normal case to be considered is of a fee charged to deter road use; in the classic case, a congestion fee charged as some form of toll, equal to the difference between the average cost perceived by users and the marginal costs they impose, including the increased time costs of congestion faced by all users (and possibly other disamenities). The fee causes some users not to make their trips, others to possibly shift to other modes, while the remainder pay the fee and make their trips. The fee itself is a transfer, in that it involves no resource use (assuming, as noted, that it is indeed a deterrent fee and not a fee to cover infrastructure costs), and becomes available to the tolling agency for use elsewhere. But the transfer is by no means the end of the story of the costs of the measure, as:

   - those who still use the facility will gain from the reduced congestion an increase in speed and possibly a reduction in vehicle operating costs (maybe even including fuel costs). All those costs need to be estimated, from an examination of the relationship between traffic volume and generalized user costs (i.e. incremental costs including the value of time). Unfortunately, the change in generalized cost does not necessarily bear any relationship to the fee, so it cannot be estimated simply from the fee itself;

   - those who switch modes will lose the difference between the value to them of using the road and the value of using the alternative mode. On the simple assumption that an increasing number would have diverted at each level of fee up to that selected, the average loss can be approximated as half the fee; and,

   - for those deterred from travelling by the fee, we can infer that they lose the consumers' surplus they otherwise enjoyed. As with (b), the cost can be approximated as averaging half the fee.

   In this road pricing case, the conventional analysis shows that the gains to the remaining traffic (i.e. those that still use the facility) outweigh the losses to those "tolled off" the facility; so that there is a net social benefit over costs. This net benefit is expected to be substantial, so should not be ignored in the Table's analysis.

2. *Parking surcharge case*:
The amounts of surcharges would again be transfers, reflecting no additional infrastructure or service costs, and being available for the charging agency to recycle to other uses. But the changes in user costs could again be significant. The parking surcharges might simply be a form of congestion charging if applied in the same congested conditions, in which case the analysis should be the same as in case 1. If not applied in congested conditions, there will not be gains to remaining users to offset the losses to those deterred. And those losses will again be easy to approximate: for those deterred from travelling at all, as well as those diverting to other modes, the loss in consumers' surplus can be approximated by the "rule of half" (i.e. half the value of the surcharge multiplied by the change in traffic volume).

The intermediate case might be that parking surcharges are imposed partly in congested and partly in uncongested conditions; or alternatively the charge might exceed the "efficient" congestion charge (i.e. be greater than the amount of travel time externality; a case that might also occur with direct road pricing if the price exceeded the congestion externality in order to deter more traffic than would remain with "optimal" congestion). Then it need not be the case that the gains to remaining users outweighed losses to those tolled-off.

3. *General deterrent taxes or other deterrent fees* (without congestion, in all modes):
These cases should be similar to a parking surcharge, without the complications of congestion. The fees themselves are transfers, consisting of losses to remaining users that pay them and gains to the charging agency, with no resource usage. The losses to those diverting to other modes or deterred from travelling should be estimated as in the uncongested parking surcharge case.

4. *Regulated travel restrictions:*
Examples might include area restrictions, time restrictions, and regulated caps on modal activity (e.g. the "Park Planes" option in aviation). Such travel restrictions would have similar features to the uncongested fees, however, without the complication of determining whether the fees are a transfer. If the regulations are in congested conditions, reducing activity in order to allow remaining users to travel faster, then the analysis in Case 1 applies, as it is necessary to estimate the relationship between traffic volume and travel time in order to determine the changes in generalized costs in the mode concerned.

If congestion is not an issue, or entire types of activity are eliminated, the losses to users diverting to other modes can be estimated as half the difference in generalized costs of the two modes; while the loss to those ceasing to travel cannot strictly be determined without estimating the relationship between generalized cost and demand. An imprecise alternative would be to assume that no user was entirely deterred, but that all chose some alternative mode.

Finally, if the restriction applied to a commercial public mode, the loss of carriers' profit would also be a legitimate cost.

C. ASSESSING COMBINATIONS OF MEASURES

It will be important in estimating the combined effects of measures to avoid double counting their effects. Where the effects of different options are on the same traffic, their combined effects will often be less than the sum of their effects taken alone. Analysis of the combined effects will probably be a simple extension to the analysis of their individual effects, based on the logic of the particular cases . The decision will probably be simply whether measures address different traffic, in which case their effects will be additive, or whether they address the same traffic, in which case their combined effect can probably be approximated by multiplication of their proportional effects.

The combinations and their sequencing can also technically affect the cost-effectiveness ratios of the options, as for those competing for the same traffic, options undertaken earlier will have larger absolute effects than those undertaken later, when emissions have already been reduced by other options. The logic of the particular combinations should again suggest the solutions: if options could be introduced simultaneously the combined emissions reduction should be deemed to be shared among them, while if the nature of the options determined their sequencing, their effects should be assigned sequentially.

D. ESTIMATION OF INCREMENTAL ABATEMENT FUNCTIONS

The AMG suggests that tables attempt to estimate incremental-abatement functions for the combinations of measures considered in their sector. A proposal made by the Electricity Table includes the identification for each option in electricity generation of an optimum level for its introduction (optimum being the most efficient scale for production by that technology, based on cost characteristics and demand). Once the optimum level is specified for each option, a unique level of GHG emissions reduction and cost-effectiveness ratio would be defined for it, and all options could then be ranked by cost-effectiveness and plotted sequentially as a curve, showing successive emissions reductions possible as the cost-effectiveness ratio increases.

It appears unlikely that the Transportation Table can produce such a function, partly because we do not expect to produce estimates of cost-effectiveness for all of the tax/fee/toll proposals, but even among all remaining options it is unlikely that we will be able to identify the optimum scale of each option. All of the regulatory proposals could be introduced at any of several scales (e.g. different speed limits, vehicle weight limits, time or area access restrictions), and the decision on scale must be essentially a political one.

Instead, given that scale is likely to be variable for our options and that cost-effectiveness is likely to vary with scale (particularly that incremental emissions reductions are likely to become more expensive, e.g. through technological solutions), it would be desirable for the variability to be revealed. This means that, if possible, the Transportation Table should estimate a function for each option showing how the cost-effectiveness ratio varies with scale.

E. ESTIMATING EMPLOYMENT/ OUTPUT/COMPETITIVENESS EFFECTS

The AMG also suggests that tables leave the assessment of the potential effects of options on output or employment to the AMG to undertake at the roll-up stage. At that point, the combined effects to be expected for each sector of the economy and region will be assessed, combining the effects of all options. As options from other tables are likely to have effects on the transportation sector, it is recommended that we leave this task to the AMG. It will be necessary, however, for the Transportation Table to examine the regional effects of its options and combinations of these options to reveal for the roll-up any differential effects expected by region.

Appendix 4

Air Quality Impacts: Estimates of the Effects of Measures on Criteria Air Contaminants (CACs)

PASSENGER PACKAGE

PASSENGER - MOST PROMISING MEASURES

MEASURE		Reductions in Criteria Air Contaminants in 2010 (tonnes)					
		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
A 20	Tax-exempt transit benefits	0.2	-4	-1,029	305	-21	2,648
A 5 L	Telecommuting	0.4	22	438	466	34	4,256
A 16H	Driver education	1.2	-19	-370	-394	-29	-3,597
B 14	Transit fare smartcard	0.03	-2	-265	66	-6	565
A 7	Car sharing	0.3	21	414	441	32	4,023
D 1	Short-term aviation measures	1.6	343	5,155	1,763	306	9,357
G 8	Code of practice - ferries	0.02	212	437	137	31	380
Total		***3.7***	***573***	***4,780***	***2,784***	***347***	***17,632***

PASSENGER - PROMISING MEASURES

MEASURE		Reductions in Criteria Air Contaminants in 2010 (tonnes)					
		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
A 4H	Transit pricing	5.7	353	6,514	7,561	536	68,947
A 3H	Transit service improvements	1.9	114	1,960	2,492	171	22,706
B 12	Transit Automatic Vehicle Location	0.0	(no veh-km change)				
A 2H	Transit infrastructure	1.7	102	1,762	2,233	152	20,352
A 1L	Pedestrian and bicycle	0.3	20	382	412	30	3,757
A 10L	Parking pricing (Tor-Mtl-Van)	0.5	203	10,528	1,492	406	14,633
A 6L	Voluntary ridesharing (to be studied)		(GHG mpact not identified)				
G 4	Natural gas ferry propulsion	0.002	22	44	14	3	39
Total		***10.1***	***813***	***21,191***	***14,203***	***1,298***	***130,434***

PASSENGER - LESS PROMISING MEAURES

MEASURE		Reductions in Criteria Air Contaminants in 2010 (tonnes)					
		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
A 14	Accelerated vehicle retirement	0.1-0.2	(no veh-km change)				
A 10H	Parking pricing	7.7	477	8,842	10,208	726	93,094
A 8	Urban road pricing	0.9-1.8	87	1,706	1,815	133	16,563
A 6H	Mandatory ridesharing	2.4	156	3,271	3,187	243	29,121
B 1	Intercity bus subsidy	0.3-1.4	5	-3,128	1,484	-42	13,081
A 13	Vehicle Inspection & Maintenance	0.4	(no veh-km change)				

PASSENGER - UNLIKELY MEASURES								
MEASURE		Reductions in Criteria Air Contaminants in 2010 (tonnes)						
		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
G 6	Shore power for ferries	0.04	395	815	255	58	709
B 2	High-speed rail (Que-Windsor)	0.3	(not modelled)				
A 12	Parking cash out	0.2-0.4	20	402	428	31	3,904
A 9	Distance-based veh charges	0.2-0.4	20	386	428	31	3,909
G 3	Reduced ferry speeds	0.081	844	1,741	546	123	1,515
D 2	Early aircraft replacement	1.0	523	7,871	2,692	467	14,285
D 3	Limitation of air travel activity	4.3	911	13,700	4,685	813	24,866
G 2	Accelerated fleet renewal of ferries	0.014	142	293	92	21	255
A 11	Parking supply restrictions	0.2-0.4	19	366	389	29	3,549

INFRASTRUCTURE PACKAGE

INFRASTRUCTURE - MOST PROMISING MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
B 10	Adaptive traffic signals	0.1	(no veh-km change)				
B 15	Commercial vehicle electronic clearance	0.02	(no veh-km change)				
B 9	Incident management	0.1	(no veh-km change)				
B 4	Enforcement of current speed limits	4.2	(no veh-km change)				
A 15	Synchronized traffic signals	0.6	-6	-140	-126	-10	-1,155
Total		***5.0***	***-6***	***-140***	***-126***	***-10***	***-1,155***

INFRASTRUCTURE - PROMISING MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
B 8	High-occupancy vehicle lanes	0.9	20	385	414	30	3,790
B 16	Advanced vehicle control systems	0.05	(no veh-km change)				
B 11	Traveller information	0.2	(no veh-km change)				
B 6	More frequent resurfacing	0.4	(no veh-km change)				
Total		***1.5***	***20***	***385***	***414***	***30***	***3,790***

INFRASTRUCTURE - LESS PROMISING MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
B 13	Electronic toll collection	0.3	(no veh-km change)				
B 7	Rigid pavements (cement)	0.3	(no veh-km change)				
B 5	Reduced speed limits to 90 k/h	8.3	(no veh-km change)				
B 3	Road pricing	2.8	178	3,466	3,733	267	34,131

INFRASTRUCTURE - UNLIKELY MEASURES

[No measures assigned]

FREIGHT PACKAGE

FREIGHT - MOST PROMISING MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
F 10	Truck driver training - energy efficiency	2.0	(no veh-km change)				
G 7	Code of practice - marine freight	0.02	227	469	147	33	408
Total		***2.0***	***227***	***469***	***147***	***33***	***408***

FREIGHT - PROMISING MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
F 1L	Long trucks - Rocky Mountain Double	0.01	32	1,895	135	68	1,428
F 1H	Long trucks - Turnpike Double	0.04	53	3,137	224	112	2,364
F 8C	Accelerated truck scrappage (5-yr shift)	2.3					
E 7	Rail freight car capital cost allowance	0.08	264	3,927	184	95	755
E 6	Rail locomotive capital cost allowance	0.22	92	1,374	65	33	264
F 6	Truck lubricants	1.0	(no veh-km change)				
F 2B	Truck speed control to 90 k/h	3.2	(no veh-km change)				
F 3	Trucking load matching	0.1	25	1,452	104	52	1,095
Total		***7.0***	***466***	***11,785***	***712***	***360***	***5,906***

FREIGHT - LESS PROMISING MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
E 2A	Rail cellulosic ethanol fuel	0	no effect in 2010				
E 2B	Rail cellulosic ethanol fuel 15%	0	(no veh-km change)				
F 5A	Truck tires - low rolling resistance	1.1	no effect in 2010				
F 7	Truck weight reduction	0.3-1.0	(no veh-km change)				
F 5B	Truck tires-central inflation	0.2	8	498	36	18	375
F 4	Truck tracking	0.04	408	6,069	285	147	1,167
E 3	Rail LNG fuel - dual fuel configuration	0.3	no effect in 2010				
E 5	Rail US NOx regulations	0.07-0.15	no effect in 2010				
E 1A	Rail locomotive fuel cell - electrolysis	0	181	2,691	126	65	517

FREIGHT - UNLIKELY MEASURES								
			Reductions in Criteria Air Contaminants in 2010 (tonnes)					
MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
F 12	Trucking - preventative maintenance	0.8	(no veh-km change)				
F 11	Trucking - driver idling training	1.2	(no veh-km change)				
E 4C	Electrification - iron ore railways	0.22	258	3,836	180	93	737
E 12	Reduce train speeds	0.21	254	3,784	178	92	727
E 4A	Electrification - western region rail	1.98	2,376	35,371	1,661	858	6,799
E 11	Rail - eliminate circuitous routings	0.09	112	1,663	78	40	320
E 4B	Electrification - eastern region rail	0.66	796	11,847	556	287	2,277
F 8B	Truck accelerated scrappage - 15 years	2.3					
E 8	Increased rail track stiffness	0.05	63	937	44	23	180
G 5	Shore power - marine freight	0.03	301	622	195	44	541
C 7B	Shift: Van-Cal, road to rail (high)	0.018	6	334	24	12	252
C 7A	Shift: Van-Cal, road to rail (low)	0.009	3	167	12	6	126
E 9	Rail track configuration improvements	0.1	147	2,195	103	53	422
C 4	Shift: Hal-Tor, road to rail	0.011	3	204	15	7	154
C 1A	Shift: Mtl-Tor, road to rail (low)	0.010	3	184	13	7	139
C 1B	Shift: Mtl-Tor, road to rail (high)	0.019	6	353	25	13	266
F 8A	Truck accelerated scrappage - 20 years	1.4					
E1B	Rail locomotive fuel cell - methane	0	(no veh-km change)				
C 3A	Shift: Tor-Chi, road to rail (low)	0.004	1	74	5	3	56
C 3B	Shift: Tor-Chi, road to rail (high)	0.008	3	149	11	5	112
F 9	Truck engine retrofit	2.2-3.0					
E 10	Rail - restrict local service frequency	0.009	11	169	8	4	33
C 6	Shift: Thund Bay-Que, rail to marine	0.010	12	178	8	4	34
C 5	Shift: Hal-Tor, rail to marine	0.006	7	107	5	3	21
C 2	Shift: Mtl-Tor, rail to marine	0.002	2	32	2	1	6
G 1	Accelerated marine tanker fleet renewal	0.003	29	60	19	4	52

ROAD VEHICLES & FUELS PACKAGE

ROAD VEHICLES & FUELS - MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES & FUELS - PROMISING MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
H 8A	Heavy duty truck efficiency improvements	0.4	(no veh-km change)				
H 9	Transit Bus design and alt fuels	0.2					
H 5B	Ethanol capacity incentives - high	0.8	210	-524	446	183	1,861
H 2A	AFV fleet purchase	0.3	189	406	805	274	4,073
H 8B	Heavy duty truck AFV purchases	0.4	779	39,862	1,285	1,702	31,352
H 1BL	Target harmonized: 25% by 2010 from present target	5.2	(no veh-km change)				
H 7B	Alt fuel infrastructure - propane	0.7-0.9	225	292	967	337	2,496
H 7C	Alt fuel infrastructure - nat gas	0.7-0.8	221	199	1,152	354	2,459
Total		***8.9***	***1,624***	***40,235***	***4,655***	***2,850***	***42,240***

ROAD VEHICLES & FUELS - LESS PROMISING MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
H 10D	Feebate - NA harmonized, with phase-in	2.1	(no veh-km change)				
H 7AH	Alt fuel infrastructure - ethanol high	2.3	236	-59	780	348	2,546
H 7AL	Alt fuel infrastructure - ethanol low	2.0	210	-41	714	308	2,263
H 3A	Vehicle purchase incentive - 30% best of class	2.1	409	-1,413	818	362	3,458

ROAD VEHICLES & FUELS - UNLIKELY MEASURES

MEASURE		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
			Reductions in Criteria Air Contaminants in 2010 (tonnes)				
H 10C	Feebate harmonized	2.1	(no veh-km change)				
H 5A	Ethanol capacity incentives - low	0.5	23	-335	284	117	1,188
H 1AL	Target harmonized: 2% per year from present target	1.1	(no veh-km change)				
H 1AH	Target harmonized: 2% per year from actual fleet average	1.9	(no veh-km change)				
H 10A	Feebate Canada only	2.3	(no veh-km change)				
H 10B	Feebate Canada only, phased-in	2.3	(no veh-km change)				
H 1BH	Target harmonized: 25% by 2010 from actual fleet average	6.5	(no veh-km change)				
H 1C	Target Canada only: 2% per year	1.1	(no veh-km change)				
H 1D	Target Canada only: 25% by 2010	5.2	(no veh-km change)				
H 2B	High efficiency fleet purchase incentive	0.2	0	0	0	0	0
H 3B	Vehicle purchase incentive - 40% best of class	0.5	407	-1,017	2,874	356	2,610

OFF-ROAD PACKAGE

OFF-ROAD - MOST PROMISING MEASURES

MEASURE		Reductions in Criteria Air Contaminants in 2010 (tonnes)					
		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO

[No measures assigned]

OFF-ROAD - PROMISING MEASURES

MEASURE		Reductions in Criteria Air Contaminants in 2010 (tonnes)					
		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
K 1	Fuel efficiency standards	2.0-2.5	(not modelled)				
K 2	Public awarness campaign	0.2-0.3	(not modelled)				
K 3	Voluntary measure	1.76	(not modelled)				
Total		***4.3***					

OFF-ROAD - LESS PROMISING / UNLIKELY MEASURES

[No measures assigned]

FUEL TAXES

MEASURE		Reductions in Criteria Air Contaminants in 2010 (tonnes)					
		GHG 2010 MT	Sulfur Oxides SOx	Nitrogen oxides NOx	Volatile Organics VOC	Particulates PM	Carbon monoxide CO
I 1/2	National Fuel Tax to achieve Kyoto target	54.0	629,000	345,000	969,000	1,690,000	551,000
I 3A	Urban gas tax - 1 cent/litre	0.3-0.5	31	606	47	896	5,971
I 3B	Urban gas tax - 2 cents/litre	0.5-1.0	60	1,162	89	1,718	11,444
I 3C	Urban gas tax - 4 cents/litre	1.0-1.9	109	2,128	164	3,145	20,953
I 4A	Road gasoline and diesel - 10 cents/litre	4.7-10.3	974	41,081	14,327	1,800	82,136
I 4B	Road gasoline and diesel - 20 cents/litre	8.6-18.6	1,782	75,251	26,199	3,296	150,139

Notes on estimation of Criteria Air Contaminants

1. CACs from road vehicles were estimated from a model relating CACs to vehicle-kilometres; where the measure's effect on GHGs derives from operating efficiencies, rather than vehicle-kilometre changes, CAC changes are more complex and no model was available.
2. Blank cells have not yet been estimated.

Appendix 5

Regional Distribution of Transportation Measures

The following tables present estimates of the distributions by region of the following main impacts of the measures:

- GHG emission reductions in 2010 and 2020;
- private, government and total costs to 2020; and,
- reductions of four Criteria Air Contaminants in 2010: sulphur oxides, nitrogen oxides, volatile organic compounds and particulates.

The distributions are based on the forecasts in the Natural Resources Canada *Outlook* and its July 1999 update, which combine the Territories with British Columbia, and all four eastern provinces into the Atlantic Region. (Estimates for each of the latter provinces will be available to the Transportation Table Secretariat in the near future.)

The distributions in the tables are necessarily approximate. The estimates of the effects of the measures at the national level are subject to uncertainty, as noted repeatedly in the studies, and in this Paper. In most cases, no separate investigation has been made of their applicability and impacts by jurisdiction. In order to provide some indication of the effects by jurisdiction, simple approximations of regional distributions have been made for most of the measures by allocating the effects, both emission reductions and costs, according to the current and forecast distributions of the most relevant fuel use and GHG emissions. In a number of cases, the measures are directed at only a subset of provinces or regions, in which case the allocation is by the relevant GHG emissions in those locations. In some other cases, namely the truck scrappage and engine refit options, it was judged more appropriate to allocate the effects of the measures according to the numbers of vehicles affected.

PASSENGER PACKAGE

PASSENGER PACKAGE ~ MOST PROMISING MEASURES		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	0.027	0.024	0.004	0.006	0.079	0.041	0.006	0.188
A 5 L	Telecommuting	0.043	0.052	0.011	0.013	0.155	0.065	0.011	0.350
A 16H	Driver education	0.147	0.176	0.037	0.045	0.528	0.220	0.037	1.191
B 14	Transit fare smartcard	0.004	0.003	0.001	0.001	0.011	0.005	0.001	0.025
A 7	Car sharing	0.040	0.048	0.010	0.012	0.145	0.060	0.010	0.327
D 1	Short-term aviation measures	0.378	0.247	0.033	0.070	0.535	0.208	0.130	1.600
G 8	Code of practice - ferries	0.007	-	-	-	0.003	0.005	0.006	0.021
TOTAL		0.645	0.556	0.095	0.147	1.455	0.604	0.198	3.70

PASSENGER PACKAGE ~ PROMISING MEASURES		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	0.834	0.734	0.127	0.188	2.402	1.241	0.175	5.700
A 3H	Transit service improvements	0.278	0.245	0.042	0.063	0.801	0.414	0.058	1.900
B 12	Transit Automatic Vehicle Location	0.001	0.000	0.000	0.000	0.002	0.001	0.000	0.004
A 2H	Transit infrastructure	0.244	0.214	0.037	0.055	0.702	0.363	0.051	1.666
A 1L	Pedestrian and bicycle	0.038	0.045	0.010	0.012	0.136	0.057	0.009	0.307
A 10L	Parking pricing (Tor-Mtl-Van)	0.078	-	-	-	0.277	0.167	-	0.523
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	0.001	-	-	-	0.000	0.000	0.001	0.002
TOTAL		1.472	1.239	0.216	0.317	4.319	2.242	0.295	10.10

PASSENGER PACKAGE ~ LESS PROMISING MEASURES		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement	0.021	0.025	0.008	0.007	0.062	0.030	0.013	0.165
A 10H	Parking pricing	0.954	1.141	0.240	0.290	3.416	1.422	0.237	7.700
A 8	Urban road pricing	0.167	0.200	0.042	0.051	0.599	0.249	0.042	1.350
A 6H	Mandatory ridesharing	0.297	0.356	0.075	0.090	1.065	0.443	0.074	2.400
B 1	Intercity bus subsidy	0.112	0.129	0.043	0.034	0.323	0.155	0.067	0.863
A 13	Vehicle Inspection & Maintenance	0.052	0.060	0.020	0.016	0.150	0.072	0.031	0.400

PASSENGER PACKAGE ~ UNLIKELY MEASURES		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	0.013	-	-	-	0.006	0.008	0.011	0.038
B 2	High-speed rail (Que-Windsor)	-	-	-	-	0.211	0.070	-	0.281
A 12	Parking cash out	0.037	0.044	0.009	0.011	0.133	0.055	0.009	0.300
A 9	Distance-based veh charges	0.037	0.044	0.009	0.011	0.133	0.055	0.009	0.300
G 3	Reduced ferry speeds	0.027	-	-	-	0.012	0.018	0.024	0.081
D 2	Early aircraft replacement	0.235	0.158	0.020	0.044	0.334	0.130	0.080	1.000
D 3	Limitation of air travel activity	1.010	0.677	0.085	0.188	1.434	0.560	0.344	4.300
G 2	Accelerated fleet renewal of ferries	0.005	-	-	-	0.002	0.003	0.004	0.014
A 11	Parking supply restrictions	0.037	0.044	0.009	0.011	0.133	0.055	0.009	0.300

PASSENGER PACKAGE ~ MOST PROMISING MEASURES									
		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	0.028	0.025	0.004	0.006	0.081	0.042	0.006	0.192
A 5 L	Telecommuting	0.047	0.057	0.012	0.014	0.179	0.072	0.012	0.394
A 16H	Driver education	0.161	0.195	0.041	0.049	0.610	0.244	0.040	1.340
B 14	Transit fare smartcard	0.007	0.007	0.001	0.002	0.021	0.011	0.002	0.051
A 7	Car sharing	0.044	0.053	0.011	0.013	0.167	0.067	0.011	0.367
D 1	Short-term aviation measures	0.449	0.293	0.040	0.083	0.635	0.247	0.154	1.900
G 8	Code of practice - ferries	0.007	-	-	-	0.003	0.005	0.006	0.022
TOTAL		0.744	0.630	0.110	0.167	1.697	0.687	0.230	4.27

PASSENGER PACKAGE ~ PROMISING MEASURES									
		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	0.936	0.824	0.143	0.211	2.697	1.393	0.197	6.400
A 3H	Transit service improvements	0.307	0.270	0.047	0.069	0.885	0.457	0.065	2.100
B 12	Transit Automatic Vehicle Location	0.001	0.001	0.000	0.000	0.003	0.002	0.000	0.008
A 2H	Transit infrastructure	0.294	0.264	0.042	0.062	0.776	0.381	0.056	1.876
A 1L	Pedestrian and bicycle	0.041	0.050	0.011	0.013	0.157	0.063	0.010	0.345
A 10L	Parking pricing (Tor-Mtl-Van)	0.087	-	-	-	0.308	0.186	-	0.582
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	0.001	-	-	-	0.000	0.000	0.001	0.002
TOTAL		1.667	1.410	0.242	0.354	4.826	2.482	0.328	11.31

PASSENGER PACKAGE ~ LESS PROMISING MEASURES									
		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement	-	-	-	-	-	-	-	-
A 10H	Parking pricing	1.065	1.274	0.268	0.324	3.816	1.588	0.265	8.600
A 8	Urban road pricing	0.186	0.222	0.047	0.057	0.666	0.277	0.046	1.500
A 6H	Mandatory ridesharing	0.334	0.400	0.084	0.102	1.198	0.499	0.083	2.700
B 1	Intercity bus subsidy	0.124	0.142	0.048	0.038	0.357	0.171	0.074	0.953
A 13	Vehicle Inspection & Maintenance	-	-	-	-	-	-	-	-

PASSENGER PACKAGE ~ UNLIKELY MEASURES									
		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	0.014	-	-	-	0.006	0.009	0.012	0.041
B 2	High-speed rail (Que-Windsor)					0.317	0.106		0.423
A 12	Parking cash out	0.043	0.052	0.011	0.013	0.155	0.065	0.011	0.350
A 9	Distance-based veh charges	0.050	0.059	0.012	0.015	0.177	0.074	0.012	0.400
G 3	Reduced ferry speeds	0.029	-	-	-	0.013	0.019	0.025	0.087
D 2	Early aircraft replacement	-	-	-	-	-	-	-	-
D 3	Limitation of air travel activity	1.574	1.056	0.133	0.293	2.235	0.872	0.536	6.700
G 2	Accelerated fleet renewal of ferries	0.005	-	-	-	0.002	0.003	0.004	0.014
A 11	Parking supply restrictions	0.037	0.044	0.009	0.011	0.133	0.055	0.009	0.300

PASSENGER PACKAGE ~ MOST PROMISING MEASURES		Private Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	-497	-438	-76	-112	-1,432	-740	-105	-3,398
A 5 L	Telecommuting	-101	-118	-25	-31	-362	-152	-25	-815
A 16H	Driver education	-199	-238	-50	-60	-723	-298	-50	-1,619
B 14	Transit fare smartcard	-4	-4	-1	-1	-12	-6	-1	-28
A 7	Car sharing	0	0	0	0	0	0	0	0
D 1	Short-term aviation measures	-319	-208	-28	-59	-451	-175	-109	-1,350
G 8	Code of practice - ferries	0	0	0	0	0	0	0	0
TOTAL		-1,120	-1,006	-180	-262	-2,980	-1,372	-289	-7,209

PASSENGER PACKAGE ~ PROMISING MEASURES		Private Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	158	139	24	36	455	235	33	1,080
A 3H	Transit service improvements	0	0	0	0	0	0	0	0
B 12	Transit Automatic Vehicle Location	2	1	0	0	4	2	0	10
A 2H	Transit infrastructure	0	0	0	0	0	0	0	0
A 1L	Pedestrian and bicycle	0	0	0	0	0	0	0	0
A 10L	Parking pricing (Tor-Mtl-Van)	64	0	0	0	227	137	0	428
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	1	0	0	0	1	1	1	4
TOTAL		224	140	24	36	686	374	34	1,519

PASSENGER PACKAGE ~ LESS PROMISING MEASURES		Private Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement	16	18	6	5	46	23	10	124
A 10H	Parking pricing	1,401	1,675	352	426	5,018	2,089	348	11,310
A 8	Urban road pricing	332	397	83	101	1,189	495	83	2,680
A 6H	Mandatory ridesharing	882	1,055	222	268	3,159	1,315	219	7,120
B 1	Intercity bus subsidy	0	0	0	0	0	0	0	0
A 13	Vehicle Inspection & Maintenance	106	121	40	32	303	145	63	810

PASSENGER PACKAGE ~ UNLIKELY MEASURES		Private Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	1	0	0	0	0	0	0	2
B 2	High-speed rail (Que-Windsor)					0	0		0
A 12	Parking cash out	117	140	29	36	419	175	29	945
A 9	Distance-based veh charges	97	116	24	30	348	145	24	785
G 3	Reduced ferry speeds	140	0	0	0	63	93	123	419
D 2	Early aircraft replacement	599	402	51	112	851	332	204	2,550
D 3	Limitation of air travel activity	12,032	8,067	1,017	2,242	17,080	6,665	4,097	51,200
G 2	Accelerated fleet renewal of ferries	994	0	0	0	451	664	871	2,980
A 11	Parking supply restrictions	0	0	0	0	0	0	0	0

PASSENGER PACKAGE ~ MOST PROMISING MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	0	0	0	0	0	0	0	0
A 5 L	Telecommuting	11	13	3	3	40	17	3	89
A 16H	Driver education	11	13	3	3	40	17	3	89
B 14	Transit fare smartcard	0	0	0	0	0	0	0	0
A 7	Car sharing	2	3	1	1	8	3	1	18
D 1	Short-term aviation measures	0	0	0	0	0	0	0	0
G 8	Code of practice - ferries	1	0	0	0	1	1	1	3
TOTAL		25	28	6	7	88	37	7	199

PASSENGER PACKAGE ~ PROMISING MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	124	109	19	28	358	185	26	850
A 3H	Transit service improvements	209	184	32	47	603	311	44	1,430
B 12	Transit Automatic Vehicle Location	0	0	0	0	0	0	0	0
A 2H	Transit infrastructure	399	339	62	95	1,194	632	87	2,808
A 1L	Pedestrian and bicycle	93	109	23	28	333	140	23	748
A 10L	Parking pricing (Tor-Mtl-Van)	257	0	0	0	908	548	0	1,713
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	0	0	0	0	0	0	0	0
TOTAL		1,082	741	135	198	3,396	1,817	180	7,549

PASSENGER PACKAGE ~ LESS PROMISING MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement	5	6	2	2	15	7	3	39
A 10H	Parking pricing	0	0	0	0	0	0	0	0
A 8	Urban road pricing	0	0	0	0	0	0	0	0
A 6H	Mandatory ridesharing	22	27	6	7	80	33	6	180
B 1	Intercity bus subsidy	285	327	109	87	819	393	169	2,190
A 13	Vehicle Inspection & Maintenance	0	0	0	0	0	0	0	0

PASSENGER PACKAGE ~ UNLIKELY MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	6	0	0	0	3	4	5	18
B 2	High-speed rail (Que-Windsor)					3,300	1,100		4,400
A 12	Parking cash out	0	0	0	0	0	0	0	0
A 9	Distance-based veh charges	17	20	4	5	60	25	4	135
G 3	Reduced ferry speeds	0	0	0	0	0	0	0	0
D 2	Early aircraft replacement	0	0	0	0	0	0	0	0
D 3	Limitation of air travel activity	0	0	0	0	0	0	0	0
G 2	Accelerated fleet renewal of ferries	0	0	0	0	0	0	0	0
A 11	Parking supply restrictions	0	0	0	0	0	0	0	0

PASSENGER PACKAGE ~ MOST PROMISING MEASURES									
		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	-497	-438	-76	-112	-1,432	-740	-105	-3,398
A 5 L	Telecommuting	-90	-105	-22	-27	-323	-136	-22	-726
A 16H	Driver education	-188	-225	-47	-57	-683	-282	-47	-1,530
B 14	Transit fare smartcard	-4	-4	-1	-1	-12	-6	-1	-28
A 7	Car sharing	2	3	1	1	8	3	1	18
D 1	Short-term aviation measures	-319	-208	-28	-59	-451	-175	-109	-1,350
G 8	Code of practice - ferries	1	0	0	0	1	1	1	3
TOTAL		-1,095	-977	-174	-255	-2,893	-1,335	-282	-7,010

PASSENGER PACKAGE ~ PROMISING MEASURES									
		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	282	249	43	64	813	420	59	1,930
A 3H	Transit service improvements	209	184	32	47	603	311	44	1,430
B 12	Transit Automatic Vehicle Location	2	1	0	0	4	2	0	10
A 2H	Transit infrastructure	399	339	62	95	1,194	632	87	2,808
A 1L	Pedestrian and bicycle	93	109	23	28	333	140	23	748
A 10L	Parking pricing (Tor-Mtl-Van)	321	0	0	0	1,135	685	0	2,141
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	1	0	0	0	1	1	1	4
TOTAL		1,305	881	160	234	4,082	2,191	214	9,067

PASSENGER PACKAGE ~ LESS PROMISING MEASURES									
		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement	21	24	8	6	61	30	13	163
A 10H	Parking pricing	1,401	1,675	352	426	5,018	2,089	348	11,310
A 8	Urban road pricing	332	397	83	101	1,189	495	83	2,680
A 6H	Mandatory ridesharing	904	1,081	227	275	3,239	1,348	225	7,300
B 1	Intercity bus subsidy	285	327	109	87	819	393	169	2,190
A 13	Vehicle Inspection & Maintenance	106	121	40	32	303	145	63	810

PASSENGER PACKAGE ~ UNLIKELY MEASURES									
		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	6	0	0	0	3	4	6	19
B 2	High-speed rail (Que-Windsor)					3,300	1,100		4,400
A 12	Parking cash out	117	140	29	36	419	175	29	945
A 9	Distance-based veh charges	114	136	29	35	408	170	28	920
G 3	Reduced ferry speeds	140	0	0	0	63	93	123	419
D 2	Early aircraft replacement	599	402	51	112	851	332	204	2,550
D 3	Limitation of air travel activity	12,032	8,067	1,017	2,242	17,080	6,665	4,097	51,200
G 2	Accelerated fleet renewal of ferries	994	0	0	0	451	664	871	2,980
A 11	Parking supply restrictions	0	0	0	0	0	0	0	0

PASSENGER PACKAGE ~ MOST PROMISING MEASURES		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	-1	-1	0	0	-2	-1	0	-4
A 5 L	Telecommuting	3	3	1	1	10	4	1	22
A 16H	Driver education	-2	-3	-1	-1	-8	-3	-1	-19
B 14	Transit fare smartcard	0	0	0	0	-1	0	0	-2
A 7	Car sharing	3	3	1	1	9	4	1	21
D 1	Short-term aviation measures	81	54	7	15	114	45	27	343
G 8	Code of practice - ferries	71	0	0	0	32	47	62	212
TOTAL		153	57	7	16	155	95	90	573

PASSENGER PACKAGE ~ PROMISING MEASURES		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	52	45	8	12	149	77	11	353
A 3H	Transit service improvements	17	15	3	4	48	25	3	114
B 12	Transit Automatic Vehicle Location	0	0	0	0	0	0	0	0
A 2H	Transit infrastructure	15	13	2	3	43	22	3	102
A 1L	Pedestrian and bicycle	2	3	1	1	9	4	1	20
A 10L	Parking pricing (Tor-Mtl-Van)	31	0	0	0	108	65	0	203
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	7	0	0	0	3	5	6	22
TOTAL		116	76	13	19	356	193	18	792

PASSENGER PACKAGE ~ LESS PROMISING MEASURES		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement	0	0	0	0	0	0	0	0
A 10H	Parking pricing	59	71	15	18	212	88	15	477
A 8	Urban road pricing	11	13	3	3	39	16	3	87
A 6H	Mandatory ridesharing	19	23	5	6	69	29	5	156
B 1	Intercity bus subsidy	1	1	0	0	2	1	0	5
A 13	Vehicle Inspection & Maintenance								

PASSENGER PACKAGE ~ UNLIKELY MEASURES		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	132	0	0	0	60	88	115	395
B 2	High-speed rail (Que-Windsor)								
A 12	Parking cash out	3	3	1	1	9	4	1	20
A 9	Distance-based veh charges	3	3	1	1	9	4	1	20
G 3	Reduced ferry speeds	281	0	0	0	128	188	247	844
D 2	Early aircraft replacement	123	82	10	23	175	68	42	523
D 3	Limitation of air travel activity	214	144	18	40	304	119	73	911
G 2	Accelerated fleet renewal of ferries	47	0	0	0	21	32	42	142
A 11	Parking supply restrictions	2	3	1	1	8	3	1	19

PASSENGER PACKAGE ~ MOST PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	-151	-133	-23	-34	-434	-224	-32	-1,029
A 5 L	Telecommuting	54	65	14	17	194	81	13	438
A 16H	Driver education	-46	-55	-12	-14	-164	-68	-11	-370
B 14	Transit fare smartcard	-39	-34	-6	-9	-112	-58	-8	-265
A 7	Car sharing	51	61	13	16	184	76	13	414
D 1	Short-term aviation measures	1,211	812	102	226	1,720	671	413	5,155
G 8	Code of practice - ferries	146	0	0	0	66	97	128	437
TOTAL		1,228	717	89	201	1,454	576	515	4,780

PASSENGER PACKAGE ~ PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	953	839	145	214	2,745	1,418	200	6,514
A 3H	Transit service improvements	287	252	44	65	826	427	60	1,960
B 12	Transit Automatic Vehicle Location								
A 2H	Transit infrastructure	258	227	39	58	743	384	54	1,762
A 1L	Pedestrian and bicycle	47	57	12	14	170	71	12	382
A 10L	Parking pricing (Tor-Mtl-Van)	1,579	0	0	0	5,580	3,369	0	10,528
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	15	0	0	0	7	10	13	44
TOTAL		3,124	1,375	240	351	10,063	5,668	327	21,147

PASSENGER PACKAGE ~ LESS PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement								
A 10H	Parking pricing	1,095	1,310	275	333	3,923	1,633	272	8,842
A 8	Urban road pricing	211	253	53	64	757	315	53	1,706
A 6H	Mandatory ridesharing	405	485	102	123	1,451	604	101	3,271
B 1	Intercity bus subsidy	-408	-467	-156	-124	-1,170	-562	-242	-3,128
A 13	Vehicle Inspection & Maintenance								

PASSENGER PACKAGE ~ UNLIKELY MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	272	0	0	0	123	181	238	815
B 2	High-speed rail (Que-Windsor)								
A 12	Parking cash out	50	60	13	15	178	74	12	402
A 9	Distance-based veh charges	48	57	12	15	171	71	12	386
G 3	Reduced ferry speeds	581	0	0	0	263	388	509	1,741
D 2	Early aircraft replacement	1,850	1,240	156	345	2,626	1,025	630	7,871
D 3	Limitation of air travel activity	3,219	2,159	272	600	4,570	1,784	1,096	13,700
G 2	Accelerated fleet renewal of ferries	98	0	0	0	44	65	86	293
A 11	Parking supply restrictions	45	54	11	14	162	68	11	366

PASSENGER PACKAGE ~ MOST PROMISING MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	45	39	7	10	129	66	9	305
A 5 L	Telecommuting	58	69	15	18	207	86	14	466
A 16H	Driver education	-49	-58	-12	-15	-175	-73	-12	-394
B 14	Transit fare smartcard	10	8	1	2	28	14	2	66
A 7	Car sharing	55	65	14	17	196	81	14	441
D 1	Short-term aviation measures	414	278	35	77	588	230	141	1,763
G 8	Code of practice - ferries	46	0	0	0	21	30	40	137
TOTAL		578	402	59	109	993	435	208	2,784

PASSENGER PACKAGE ~ PROMISING MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	1,106	973	168	249	3,186	1,646	233	7,561
A 3H	Transit service improvements	364	321	56	82	1,050	542	77	2,492
B 12	Transit Automatic Vehicle Location								
A 2H	Transit infrastructure	327	287	50	73	941	486	69	2,233
A 1L	Pedestrian and bicycle	51	61	13	16	183	76	13	412
A 10L	Parking pricing (Tor-Mtl-Van)	224	0	0	0	791	477	0	1,492
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	5	0	0	0	2	3	4	14
TOTAL		2,071	1,643	287	420	6,150	3,228	391	14,189

PASSENGER PACKAGE ~ LESS PROMISING MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement								
A 10H	Parking pricing	1,330	1,523	510	404	3,819	1,834	789	10,208
A 8	Urban road pricing	237	271	91	72	679	326	140	1,815
A 6H	Mandatory ridesharing	415	475	159	126	1,192	572	246	3,187
B 1	Intercity bus subsidy	193	221	74	59	555	267	115	1,484
A 13	Vehicle Inspection & Maintenance								

PASSENGER PACKAGE ~ UNLIKELY MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	85	0	0	0	39	57	75	255
B 2	High-speed rail (Que-Windsor)								
A 12	Parking cash out	56	64	21	17	160	77	33	428
A 9	Distance-based veh charges	56	64	21	17	160	77	33	428
G 3	Reduced ferry speeds	182	0	0	0	82	122	160	546
D 2	Early aircraft replacement	632	424	53	118	898	350	215	2,692
D 3	Limitation of air travel activity	1,101	738	93	205	1,563	610	375	4,685
G 2	Accelerated fleet renewal of ferries	31	0	0	0	14	20	27	92
A 11	Parking supply restrictions	51	58	19	15	145	70	30	389

PASSENGER PACKAGE ~ MOST PROMISING MEASURES		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 20	Tax-exempt transit benefits	-3	-3	0	-1	-9	-5	-1	-21
A 5 L	Telecommuting	4	5	1	1	15	6	1	34
A 16H	Driver education	-4	-4	-1	-1	-13	-5	-1	-29
B 14	Transit fare smartcard	-1	-1	0	0	-3	-1	0	-6
A 7	Car sharing	4	5	1	1	14	6	1	32
D 1	Short-term aviation measures	72	48	6	13	102	40	24	306
G 8	Code of practice - ferries	10	0	0	0	5	7	9	31
TOTAL		83	50	7	14	112	48	34	347

PASSENGER PACKAGE ~ PROMISING MEASURES		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 4H	Transit pricing	78	69	12	18	226	117	17	536
A 3H	Transit service improvements	25	22	4	6	72	37	5	171
B 12	Transit Automatic Vehicle Location								
A 2H	Transit infrastructure	22	20	3	5	64	33	5	152
A 1L	Pedestrian and bicycle	4	4	1	1	13	6	1	30
A 10L	Parking pricing (Tor-Mtl-Van)	61	0	0	0	215	130	0	406
A 6L	Voluntary ridesharing (to be studied)								
G 4	Natural gas ferry propulsion	1	0	0	0	0	1	1	3
TOTAL		190	115	20	29	591	323	27	1,295

PASSENGER PACKAGE ~ LESS PROMISING MEASURES		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
A 14	Accelerated vehicle retirement								
A 10H	Parking pricing	95	108	36	29	271	130	56	726
A 8	Urban road pricing	17	20	7	5	50	24	10	133
A 6H	Mandatory ridesharing	32	36	12	10	91	44	19	243
B 1	Intercity bus subsidy	-5	-6	-2	-2	-16	-7	-3	-42
A 13	Vehicle Inspection & Maintenance								

PASSENGER PACKAGE ~ UNLIKELY MEASURES		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
G 6	Shore power for ferries	19	0	0	0	9	13	17	58
B 2	High-speed rail (Que-Windsor)								
A 12	Parking cash out	4	5	2	1	12	6	2	31
A 9	Distance-based veh charges	4	5	2	1	12	6	2	31
G 3	Reduced ferry speeds	41	0	0	0	19	27	36	123
D 2	Early aircraft replacement	110	74	9	20	156	61	37	467
D 3	Limitation of air travel activity	191	128	16	36	271	106	65	813
G 2	Accelerated fleet renewal of ferries	7	0	0	0	3	5	6	21
A 11	Parking supply restrictions	4	4	1	1	11	5	2	29

ROAD INFRASTRUCTURE PACKAGE

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 10	Adaptive traffic signals	0.012	0.015	0.003	0.004	0.044	0.018	0.003	0.100
B 15	Commercial vehicle electronic clearance	0.002	0.003	0.001	0.000	0.005	0.004	0.001	0.016
B 9	Incident management	0.013	0.016	0.003	0.004	0.048	0.020	0.003	0.108
B 4	Enforcement of current speed limits	0.552	0.638	0.200	0.156	1.475	0.831	0.347	4.200
A 15	Synchronized traffic signals	0.050	0.059	0.012	0.015	0.177	0.074	0.012	0.400
TOTAL		0.630	0.731	0.220	0.180	1.749	0.948	0.367	4.82

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 8	High-occupancy vehicle lanes	0.118	0.137	0.043	0.034	0.316	0.178	0.074	0.900
B 16	Advanced vehicle control systems	0.006	0.007	0.002	0.002	0.018	0.008	0.004	0.047
B 11	Traveller information	0.020	0.023	0.008	0.006	0.058	0.028	0.012	0.154
B 6	More frequent resurfacing	0.053	0.061	0.019	0.015	0.140	0.079	0.033	0.400
TOTAL		0.197	0.227	0.072	0.056	0.532	0.293	0.123	1.50

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 13	Electronic toll collection	0.033	0.038	0.012	0.009	0.089	0.050	0.021	0.253
B 7	Rigid pavements (cement)	0.039	0.046	0.014	0.011	0.105	0.059	0.025	0.300
B 5	Reduced speed limits to 90 k/h	1.091	1.261	0.396	0.309	2.914	1.643	0.685	8.300
B 3	Road pricing	0.368	0.425	0.134	0.104	0.983	0.554	0.231	2.800

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES									
		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 10	Adaptive traffic signals	0.017	0.021	0.004	0.005	0.063	0.026	0.004	0.141
B 15	Commercial vehicle electronic clearance	0.004	0.005	0.001	0.001	0.009	0.008	0.003	0.032
B 9	Incident management	0.027	0.032	0.007	0.008	0.095	0.040	0.007	0.215
B 4	Enforcement of current speed limits	0.618	0.714	0.224	0.175	1.650	0.930	0.388	4.700
A 15	Synchronized traffic signals	0.050	0.059	0.012	0.015	0.177	0.074	0.012	0.400
TOTAL		0.716	0.832	0.249	0.204	1.995	1.078	0.414	5.49

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES									
		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 8	High-occupancy vehicle lanes	0.145	0.167	0.053	0.041	0.386	0.218	0.091	1.100
B 16	Advanced vehicle control systems	0.027	0.031	0.010	0.008	0.077	0.037	0.016	0.206
B 11	Traveller information	0.039	0.045	0.015	0.012	0.112	0.054	0.023	0.300
B 6	More frequent resurfacing	0.066	0.076	0.024	0.019	0.176	0.099	0.041	0.500
TOTAL		0.276	0.319	0.102	0.080	0.751	0.408	0.171	2.11

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES									
		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 13	Electronic toll collection	0.072	0.083	0.026	0.020	0.193	0.109	0.045	0.549
B 7	Rigid pavements (cement)	0.066	0.076	0.024	0.019	0.176	0.099	0.041	0.500
B 5	Reduced speed limits to 90 k/h	1.210	1.398	0.439	0.343	3.230	1.821	0.759	9.200
B 3	Road pricing	0.421	0.486	0.153	0.119	1.124	0.633	0.264	3.200

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES

Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
		Private Cost $m to 2020							
B 10	Adaptive traffic signals	-126	-150	-32	-38	-450	-187	-31	-1,015
B 15	Commercial vehicle electronic clearance	-42	-57	-14	-9	-96	-82	-29	-330
B 9	Incident management	-120	-144	-30	-37	-431	-180	-30	-972
B 4	Enforcement of current speed limits	0	0	0	0	0	0	0	0
A 15	Synchronized traffic signals	-63	-76	-16	-19	-226	-94	-16	-510
TOTAL		-351	-427	-92	-103	-1,204	-543	-106	-2,827

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES

Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
		Private Cost $m to 2020							
B 8	High-occupancy vehicle lanes	-2,827	-3,266	-1,026	-801	-7,549	-4,256	-1,775	-21,500
B 16	Advanced vehicle control systems	-2	-2	-1	-1	-5	-2	-1	-13
B 11	Traveller information	4	5	2	1	12	6	3	33
B 6	More frequent resurfacing	-79	-91	-29	-22	-211	-119	-50	-600
TOTAL		-2,903	-3,355	-1,054	-822	-7,752	-4,371	-1,823	-22,080

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES

Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
		Private Cost $m to 2020							
B 13	Electronic toll collection	-197	-228	-72	-56	-527	-297	-124	-1,500
B 7	Rigid pavements (cement)	-39	-46	-14	-11	-105	-59	-25	-300
B 5	Reduced speed limits to 90 k/h	434	501	158	123	1,159	653	272	3,300
B 3	Road pricing	513	593	186	145	1,369	772	322	3,900

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 10	Adaptive traffic signals	17	20	4	5	60	25	4	135
B 15	Commercial vehicle electronic clearance	23	31	8	5	53	45	16	180
B 9	Incident management	99	119	25	30	356	148	25	803
B 4	Enforcement of current speed limits	112	129	41	32	298	168	70	850
A 15	Synchronized traffic signals	74	89	19	23	266	111	18	600
TOTAL		325	388	96	95	1,033	497	133	2,568

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 8	High-occupancy vehicle lanes	197	228	72	56	527	297	124	1,500
B 16	Advanced vehicle control systems	0	0	0	0	0	0	0	0
B 11	Traveller information	0	0	0	0	0	0	0	0
B 6	More frequent resurfacing	237	273	86	67	632	356	149	1,800
TOTAL		434	501	158	123	1,159	653	272	3,300

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 13	Electronic toll collection	0	0	0	0	0	0	0	0
B 7	Rigid pavements (cement)	0	0	0	0	0	0	0	0
B 5	Reduced speed limits to 90 k/h	224	258	81	63	597	337	140	1,700
B 3	Road pricing	0	0	0	0	0	0	0	0

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES									
		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 10	Adaptive traffic signals	-109	-130	-27	-33	-390	-163	-27	-880
B 15	Commercial vehicle electronic clearance	-19	-26	-7	-4	-44	-37	-13	-150
B 9	Incident management	-21	-25	-5	-6	-75	-31	-5	-169
B 4	Enforcement of current speed limits	112	129	41	32	298	168	70	850
A 15	Synchronized traffic signals	11	13	3	3	40	17	3	90
TOTAL		-26	-39	4	-9	-171	-46	27	-259

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES									
		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 8	High-occupancy vehicle lanes	-2,629	-3,039	-955	-745	-7,022	-3,959	-1,651	-20,000
B 16	Advanced vehicle control systems	-2	-2	-1	-1	-5	-2	-1	-13
B 11	Traveller information	4	5	2	1	12	6	3	33
B 6	More frequent resurfacing	158	182	57	45	421	238	99	1,200
TOTAL		-2,469	-2,853	-896	-699	-6,594	-3,718	-1,550	-18,780

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES									
		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 13	Electronic toll collection	-197	-228	-72	-56	-527	-297	-124	-1,500
B 7	Rigid pavements (cement)	-39	-46	-14	-11	-105	-59	-25	-300
B 5	Reduced speed limits to 90 k/h	657	760	239	186	1,756	990	413	5,000
B 3	Road pricing	513	593	186	145	1,369	772	322	3,900

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES									
		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 10	Adaptive traffic signals								
B 15	Commercial vehicle electronic clearance								
B 9	Incident management								
B 4	Enforcement of current speed limits								
A 15	Synchronized traffic signals	-1	-1	0	0	-3	-1	0	-6
TOTAL		-1	-1	0	0	-3	-1	0	-6

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES									
		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 8	High-occupancy vehicle lanes	3	3	1	1	7	4	2	20
B 16	Advanced vehicle control systems								
B 11	Traveller information								
B 6	More frequent resurfacing								
TOTAL		3	3	1	1	7	4	2	20

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES									
		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 13	Electronic toll collection								
B 7	Rigid pavements (cement)								
B 5	Reduced speed limits to 90 k/h								
B 3	Road pricing	23	27	8	7	62	35	15	178

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 10	Adaptive traffic signals								
B 15	Commercial vehicle electronic clearance								
B 9	Incident management								
B 4	Enforcement of current speed limits								
A 15	Synchronized traffic signals	-17	-21	-4	-5	-62	-26	-4	-140
TOTAL		-17	-21	-4	-5	-62	-26	-4	-140

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 8	High-occupancy vehicle lanes	51	58	18	14	135	76	32	385
B 16	Advanced vehicle control systems								
B 11	Traveller information								
B 6	More frequent resurfacing								
TOTAL		51	58	18	14	135	76	32	385

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 13	Electronic toll collection								
B 7	Rigid pavements (cement)								
B 5	Reduced speed limits to 90 k/h								
B 3	Road pricing	456	527	165	129	1,217	686	286	3,466

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 10	Adaptive traffic signals								
B 15	Commercial vehicle electronic clearance								
B 9	Incident management								
B 4	Enforcement of current speed limits								
A 15	Synchronized traffic signals	-16	-19	-6	-5	-47	-23	-10	-126
TOTAL		-16	-19	-6	-5	-47	-23	-10	-126

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 8	High-occupancy vehicle lanes	54	63	20	15	146	82	34	414
B 16	Advanced vehicle control systems								
B 11	Traveller information								
B 6	More frequent resurfacing								
TOTAL		54	63	20	15	146	82	34	414

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 13	Electronic toll collection								
B 7	Rigid pavements (cement)								
B 5	Reduced speed limits to 90 k/h								
B 3	Road pricing	491	567	178	139	1,311	739	308	3,733

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

ROAD INFRASTRUCTURE PACKAGE ~ MOST PROMISING MEASURES									
		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 10	Adaptive traffic signals								
B 15	Commercial vehicle electronic clearance								
B 9	Incident management								
B 4	Enforcement of current speed limits								
A 15	Synchronized traffic signals	-1	-1	0	0	-4	-2	-1	-10
TOTAL		0	0	0	0	0	0	0	0

ROAD INFRASTRUCTURE PACKAGE ~ PROMISING MEASURES									
		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 8	High-occupancy vehicle lanes	4	4	1	1	10	6	2	30
B 16	Advanced vehicle control systems								
B 11	Traveller information								
B 6	More frequent resurfacing								
TOTAL		4	4	1	1	10	6	2	30

ROAD INFRASTRUCTURE PACKAGE ~ LESS PROMISING MEASURES									
		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
B 13	Electronic toll collection								
B 7	Rigid pavements (cement)								
B 5	Reduced speed limits to 90 k/h								
B 3	Road pricing	35	41	13	10	94	53	22	267

ROAD INFRASTRUCTURE PACKAGE ~ UNLIKELY MEASURES

[No measures assigned]

FREIGHT PACKAGE ~ MOST PROMISING MEASURES									
		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency	0.257	0.346	0.088	0.057	0.589	0.503	0.177	2.017
G 7	Code of practice - marine freight	0.007	-	-	-	0.003	0.005	0.006	0.022
TOTAL		0.264	0.346	0.088	0.057	0.592	0.508	0.183	2.04

FREIGHT PACKAGE ~ PROMISING MEASURES									
		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	0.004	-	-	-	0.010	-	0.001	0.015
F 1H	Long trucks - Turnpike Double	0.010	-	-	-	0.024	-	0.002	0.037
F 8C	Accelerated truck scrappage (5-yr shift)	0.117	0.942	0.410	0.152	0.326	0.265	0.119	2.330
E 7	Rail freight car capital cost allowance	0.016	0.015	0.007	0.005	0.024	0.007	0.002	0.077
E 6	Rail locomotive capital cost allowance	0.046	0.044	0.019	0.015	0.068	0.020	0.007	0.220
F 6	Truck lubricants	0.132	0.178	0.046	0.029	0.303	0.259	0.091	1.039
F 2B	Truck speed control to 90 k/h	0.405	0.547	0.140	0.090	0.931	0.795	0.280	3.188
F 3	Trucking load matching	0.012	0.016	0.004	0.003	0.027	0.023	0.008	0.094
TOTAL		0.743	1.743	0.625	0.294	1.713	1.370	0.511	7.00

FREIGHT PACKAGE ~ LESS PROMISING MEASURES									
		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel	-	-	-	-	-	-	-	-
E 2B	Rail cellulosic ethanol fuel 15%	-	-	-	-	-	-	-	-
F 5A	Truck tires - low rolling resistance	0.139	0.187	0.048	0.031	0.318	0.272	0.096	1.089
F 7	Truck weight reduction	0.085	0.114	0.029	0.019	0.195	0.166	0.058	0.666
F 5B	Truck tires - central inflation	0.020	0.027	0.007	0.004	0.046	0.039	0.014	0.157
F 4	Truck tracking	0.005	0.006	0.002	0.001	0.011	0.009	0.003	0.036
E 3	Rail LNG fuel - dual fuel configuration	0.072	0.068	0.029	0.023	0.106	0.031	0.011	0.340
E 5	Rail US NOx regulations	0.023	0.022	0.009	0.007	0.034	0.010	0.004	0.110
E 1A	Rail locomotive fuel cell - electrolysis	-	-	-	-	-	-	-	-

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		GHG Reduction in 2010 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance	0.103	0.139	0.035	0.023	0.236	0.201	0.071	0.807
F 11	Trucking - driver idling training	0.154	0.208	0.053	0.034	0.353	0.302	0.106	1.210
E 4C	Electrification - iron ore railways	-	-	-	-	-	0.161	0.054	0.215
E 12	Reduce train speeds	0.045	0.042	0.018	0.014	0.066	0.020	0.007	0.212
E 4A	Electrification - western region rail	0.741	0.700	0.302	0.238	-	-	-	1.982
E 11	Rail - eliminate circuitous routings	0.020	0.019	0.008	0.006	0.029	0.009	0.003	0.093
E 4B	Electrification - eastern region rail	-	-	-	-	0.474	0.141	0.049	0.664
F 8B	Truck accelerated scrappage - 15 years	0.134	0.860	0.374	0.145	0.369	0.296	0.131	2.310
E 8	Increased rail track stiffness	0.011	0.010	0.004	0.004	0.016	0.005	0.002	0.052
G 5	Shore power - marine freight	0.010	-	-	-	0.004	0.006	0.008	0.029
C 7B	Shift: Van-Cal, road to rail (high)	0.008	0.010	-	-	-	-	-	0.018
C 7A	Shift: Van-Cal, road to rail (low)	0.004	0.005	-	-	-	-	-	0.009
E 9	Rail track configuration improvements	0.025	0.024	0.010	0.008	0.037	0.011	0.004	0.120
C 4	Shift: Hal-Tor, road to rail	-	-	-	-	0.005	0.004	0.002	0.011
C 1A	Shift: Mtl-Tor, road to rail (low)	-	-	-	-	0.005	0.005	-	0.010
C 1B	Shift: Mtl-Tor, road to rail (high)	-	-	-	-	0.010	0.009	-	0.019
F 8A	Truck accelerated scrappage - 20 years	0.068	0.550	0.240	0.089	0.191	0.155	0.070	1.362
E 1B	Rail locomotive fuel cell - methane	-	-	-	-	-	-	-	-
C 3A	Shift: Tor-Chi, road to rail (low)	-	-	-	-	0.004	-	-	0.004
C 3B	Shift: Tor-Chi, road to rail (high)	-	-	-	-	0.008	-	-	0.008
F 9	Truck engine retrofit	0.149	0.958	0.417	0.162	0.411	0.330	0.145	2.571
E 10	Rail - restrict local service frequency	0.002	0.002	0.001	0.001	0.003	0.001	0.000	0.009
C 6	Shift: Thund Bay-Que, rail to marine	-	-	-	-	0.008	0.002	-	0.010
C 5	Shift: Hal-Tor, rail to marine	-	-	-	-	0.004	0.001	0.000	0.006
C 2	Shift: Mtl-Tor, rail to marine	-	-	-	-	0.001	0.000	-	0.002
G 1	Accelerated marine tanker fleet renewal	0.001	-	-	-	0.000	0.001	0.001	0.003

FREIGHT PACKAGE ~ MOST PROMISING MEASURES		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency	0.296	0.400	0.102	0.066	0.679	0.580	0.204	2.327
G 7	Code of practice - marine freight	0.007	-	-	-	0.003	0.005	0.006	0.021
TOTAL		0.303	0.400	0.102	0.066	0.683	0.585	0.210	2.35

FREIGHT PACKAGE ~ PROMISING MEASURES		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	0.005	-	-	-	0.012	-	0.001	0.018
F 1H	Long trucks - Turnpike Double	0.013	-	-	-	0.030	-	0.003	0.046
F 8C	Accelerated truck scrappage (5-yr shift)	0.134	1.083	0.472	0.175	0.375	0.305	0.137	2.682
E 7	Rail freight car capital cost allowance	0.016	0.015	0.007	0.005	0.024	0.007	0.002	0.077
E 6	Rail locomotive capital cost allowance	0.046	0.044	0.019	0.015	0.068	0.020	0.007	0.220
F 6	Truck lubricants	0.152	0.205	0.052	0.034	0.349	0.298	0.105	1.197
F 2B	Truck speed control to 90 k/h	0.482	0.651	0.166	0.107	1.106	0.945	0.332	3.790
F 3	Trucking load matching	0.014	0.019	0.005	0.003	0.032	0.027	0.010	0.110
TOTAL		0.863	2.018	0.721	0.339	1.997	1.603	0.598	8.14

FREIGHT PACKAGE ~ LESS PROMISING MEASURES		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel	0.633	0.598	0.258	0.203	0.934	0.277	0.097	3.000
E 2B	Rail cellulosic ethanol fuel 15%	0.152	0.143	0.062	0.049	0.224	0.067	0.023	0.720
F 5A	Truck tires - low rolling resistance	0.160	0.215	0.055	0.035	0.366	0.313	0.110	1.255
F 7	Truck weight reduction	0.095	0.128	0.033	0.021	0.218	0.186	0.065	0.746
F 5B	Truck tires - central inflation	0.023	0.031	0.008	0.005	0.053	0.045	0.016	0.181
F 4	Truck tracking	0.005	0.007	0.002	0.001	0.011	0.009	0.003	0.038
E 3	Rail LNG fuel - dual fuel configuration	0.072	0.068	0.029	0.023	0.106	0.031	0.011	0.340
E 5	Rail US NOx regulations	0.023	0.022	0.009	0.007	0.034	0.010	0.004	0.110
E 1A	Rail locomotive fuel cell - electrolysis	0.612	0.578	0.249	0.197	0.903	0.268	0.094	2.900

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		GHG Reduction in 2020 - megatonnes							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance	0.118	0.160	0.041	0.026	0.272	0.232	0.082	0.931
F 11	Trucking - driver idling training	0.178	0.240	0.061	0.039	0.408	0.348	0.122	1.396
E 4C	Electrification - iron ore railways	-	-	-	-	-	0.161	0.054	0.215
E 12	Reduce train speeds	0.045	0.043	0.018	0.015	0.067	0.020	0.007	0.214
E 4A	Electrification - western region rail	0.584	0.552	0.238	0.188	-	-	-	1.561
E 11	Rail - eliminate circuitous routings	0.020	0.019	0.008	0.006	0.029	0.009	0.003	0.094
E 4B	Electrification - eastern region rail	-	-	-	-	0.592	0.176	0.062	0.830
F 8B	Truck accelerated scrappage - 15 years	0.153	0.985	0.429	0.167	0.423	0.339	0.150	2.645
E 8	Increased rail track stiffness	0.011	0.010	0.004	0.004	0.016	0.005	0.002	0.052
G 5	Shore power - marine freight	0.009	-	-	-	0.004	0.006	0.008	0.028
C 7B	Shift: Van-Cal, road to rail (high)	0.015	0.021	-	-	-	-	-	0.036
C 7A	Shift: Van-Cal, road to rail (low)	0.008	0.010	-	-	-	-	-	0.018
E 9	Rail track configuration improvements	0.025	0.024	0.010	0.008	0.037	0.011	0.004	0.120
C 4	Shift: Hal-Tor, road to rail	-	-	-	-	0.007	0.006	0.002	0.016
C 1A	Shift: Mtl-Tor, road to rail (low)	-	-	-	-	0.016	0.013	-	0.029
C 1B	Shift: Mtl-Tor, road to rail (high)	-	-	-	-	0.020	0.018	-	0.038
F 8A	Truck accelerated scrappage - 20 years	0.078	0.630	0.274	0.102	0.218	0.177	0.080	1.559
E 1B	Rail locomotive fuel cell - methane	0.253	0.239	0.103	0.081	0.374	0.111	0.039	1.200
C 3A	Shift: Tor-Chi, road to rail (low)	-	-	-	-	0.008	-	-	0.008
C 3B	Shift: Tor-Chi, road to rail (high)	-	-	-	-	0.016	-	-	0.016
F 9	Truck engine retrofit	0.149	0.958	0.417	0.162	0.411	0.330	0.145	2.571
E 10	Rail - restrict local service frequency	0.002	0.002	0.001	0.001	0.003	0.001	0.000	0.010
C 6	Shift: Thund Bay-Que, rail to marine	-	-	-	-	0.008	0.002	-	0.010
C 5	Shift: Hal-Tor, rail to marine	-	-	-	-	0.004	0.001	0.000	0.006
C 2	Shift: Mtl-Tor, rail to marine	-	-	-	-	0.001	0.000	-	0.002
G 1	Accelerated marine tanker fleet renewal	0.001	-	-	-	0.000	0.001	0.001	0.003

FREIGHT PACKAGE ~ MOST PROMISING MEASURES									
		Private Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency	24	33	8	5	56	48	17	192
G 7	Code of practice - marine freight	0	0	0	0	0	0	0	0
TOTAL		24	33	8	5	56	48	17	192

FREIGHT PACKAGE ~ PROMISING MEASURES									
		Private Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	-112	0	0	0	-258	0	-25	-396
F 1H	Long trucks - Turnpike Double	-246	0	0	0	-565	0	-56	-866
F 8C	Accelerated truck scrappage (5-yr shift)	-304	-2,457	-1,071	-397	-851	-691	-311	-6,082
E 7	Rail freight car capital cost allowance	0	0	0	0	0	0	0	0
E 6	Rail locomotive capital cost allowance	0	0	0	0	0	0	0	0
F 6	Truck lubricants	54	73	19	12	124	106	37	426
F 2B	Truck speed control to 90 k/h	771	1,041	266	171	1,769	1,512	531	6,061
F 3	Trucking load matching	40	54	14	9	91	78	27	313
TOTAL		202	-1,290	-773	-206	312	1,005	204	-545

FREIGHT PACKAGE ~ LESS PROMISING MEASURES									
		Private Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel	0	0	0	0	0	0	0	0
E 2B	Rail cellulosic ethanol fuel 15%	0	0	0	0	0	0	0	0
F 5A	Truck tires - low rolling resistance	229	309	79	51	525	448	158	1,797
F 7	Truck weight reduction	123	165	42	27	281	240	85	964
F 5B	Truck tires - central inflation	48	65	17	11	111	95	33	380
F 4	Truck tracking	15	20	5	3	34	29	10	117
E 3	Rail LNG fuel - dual fuel configuration	0	0	0	0	0	0	0	0
E 5	Rail US NOx regulations	0	0	0	0	0	0	0	0
E 1A	Rail locomotive fuel cell - electrolysis	0	0	0	0	0	0	0	0

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		Private Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance	-2	-2	-1	0	-4	-3	-1	-12
F 11	Trucking - driver idling training	15	21	5	3	35	30	11	121
E 4C	Electrification - iron ore railways	0	0	0	0	0	0	0	0
E 12	Reduce train speeds	17	16	7	5	25	7	3	79
E 4A	Electrification - western region rail	0	0	0	0	0	0	0	0
E 11	Rail - eliminate circuitous routings	19	18	8	6	28	8	3	91
E 4B	Electrification - eastern region rail	0	0	0	0	0	0	0	0
F 8B	Truck accelerated scrappage - 15 years	231	1,490	648	252	639	513	226	4,000
E 8	Increased rail track stiffness	-14	-13	-6	-4	-21	-6	-2	-66
G 5	Shore power - marine freight	3	0	0	0	1	2	2	8
C 7B	Shift: Van-Cal, road to rail (high)	34	47	0	0	0	0	0	81
C 7A	Shift: Van-Cal, road to rail (low)	17	24	0	0	0	0	0	41
E 9	Rail track configuration improvements	-55	-52	-22	-18	-82	-24	-8	-262
C 4	Shift: Hal-Tor, road to rail	0	0	0	0	25	21	7	53
C 1A	Shift: Mtl-Tor, road to rail (low)	0	0	0	0	45	38	0	83
C 1B	Shift: Mtl-Tor, road to rail (high)	0	0	0	0	70	59	0	129
F 8A	Truck accelerated scrappage - 20 years	445	3,590	1,565	581	1,243	1,009	454	8,887
E 1B	Rail locomotive fuel cell - methane	0	0	0	0	0	0	0	0
C 3A	Shift: Tor-Chi, road to rail (low)	0	0	0	0	65	0	0	65
C 3B	Shift: Tor-Chi, road to rail (high)	0	0	0	0	124	0	0	124
F 9	Truck engine retrofit	102	656	286	111	281	226	100	1,762
E 10	Rail - restrict local service frequency	0	0	0	0	0	0	0	0
C 6	Shift: Thund Bay-Que, rail to marine	0	0	0	0	56	17	0	72
C 5	Shift: Hal-Tor, rail to marine	0	0	0	0	33	10	3	46
C 2	Shift: Mtl-Tor, rail to marine	0	0	0	0	22	7	0	29
G 1	Accelerated marine tanker fleet renewal	276	0	0	0	125	185	242	828

FREIGHT PACKAGE ~ MOST PROMISING MEASURES		Government Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency	0	0	0	0	1	0	0	2
G 7	Code of practice - marine freight	1	0	0	0	1	1	1	3
TOTAL		1	0	0	0	1	1	1	5

FREIGHT PACKAGE ~ PROMISING MEASURES		Government Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	0	0	0	0	0	0	0	0
F 1H	Long trucks - Turnpike Double	0	0	0	0	0	0	0	0
F 8C	Accelerated truck scrappage (5-yr shift)	0	0	0	0	0	0	0	0
E 7	Rail freight car capital cost allowance	6	6	2	2	9	3	1	29
E 6	Rail locomotive capital cost allowance	17	16	7	6	26	8	3	82
F 6	Truck lubricants	0	0	0	0	0	0	0	0
F 2B	Truck speed control to 90 k/h	0	0	0	0	0	0	0	0
F 3	Trucking load matching	0	0	0	0	0	0	0	0
TOTAL		23	22	10	8	35	10	4	111

FREIGHT PACKAGE ~ LESS PROMISING MEASURES		Government Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel	801	757	326	258	1,183	351	123	3,800
E 2B	Rail cellulosic ethanol fuel 15%	346	327	141	111	510	152	53	1,640
F 5A	Truck tires - low rolling resistance	0	0	0	0	0	0	0	0
F 7	Truck weight reduction	0	0	0	0	0	0	0	0
F 5B	Truck tires - central inflation	0	0	0	0	0	0	0	0
F 4	Truck tracking	0	0	0	0	0	0	0	0
E 3	Rail LNG fuel - dual fuel configuration	295	279	120	95	436	129	45	1,400
E 5	Rail US NOx regulations	73	69	30	24	108	32	11	348
E 1A	Rail locomotive fuel cell - electrolysis	3,459	3,268	1,408	1,112	5,105	1,516	531	16,400

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		Government Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance	0	0	0	0	0	0	0	2
F 11	Trucking - driver idling training	0	0	0	0	0	0	0	0
E 4C	Electrification - iron ore railways	0	0	0	0	0	143	48	190
E 12	Reduce train speeds	0	0	0	0	0	0	0	0
E 4A	Electrification - western region rail	685	647	279	220	0	0	0	1,830
E 11	Rail - eliminate circuitous routings	0	0	0	0	0	0	0	0
E 4B	Electrification - eastern region rail	0	0	0	0	1,221	362	127	1,710
F 8B	Truck accelerated scrappage - 15 years	0	0	0	0	0	0	0	0
E 8	Increased rail track stiffness	59	56	24	19	88	26	9	282
G 5	Shore power - marine freight	33	0	0	0	15	22	29	100
C 7B	Shift: Van-Cal, road to rail (high)	3	5	0	0	0	0	0	8
C 7A	Shift: Van-Cal, road to rail (low)	2	2	0	0	0	0	0	4
E 9	Rail track configuration improvements	383	362	156	123	565	168	59	1,815
C 4	Shift: Hal-Tor, road to rail	0	0	0	0	1	1	0	2
C 1A	Shift: Mtl-Tor, road to rail (low)	0	0	0	0	2	2	0	4
C 1B	Shift: Mtl-Tor, road to rail (high)	0	0	0	0	6	5	0	11
F 8A	Truck accelerated scrappage - 20 years	0	0	0	0	0	0	0	0
E 1B	Rail locomotive fuel cell - methane	2,320	2,192	945	746	3,424	1,017	356	11,000
C 3A	Shift: Tor-Chi, road to rail (low)	0	0	0	0	1	0	0	1
C 3B	Shift: Tor-Chi, road to rail (high)	0	0	0	0	8	0	0	8
F 9	Truck engine retrofit	0	0	0	0	0	0	0	0
E 10	Rail - restrict local service frequency	27	26	11	9	40	12	4	129
C 6	Shift: Thund Bay-Que, rail to marine	0	0	0	0	14	4	0	18
C 5	Shift: Hal-Tor, rail to marine	0	0	0	0	33	10	3	46
C 2	Shift: Mtl-Tor, rail to marine	0	0	0	0	22	7	0	29
G 1	Accelerated marine tanker fleet renewal	0	0	0	0	0	0	0	0

FREIGHT PACKAGE ~ MOST PROMISING MEASURES		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency	25	33	9	5	57	48	17	194
G 7	Code of practice - marine freight	1	0	0	0	1	1	1	3
TOTAL		26	33	9	5	57	49	18	198

FREIGHT PACKAGE ~ PROMISING MEASURES		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	-112	0	0	0	-258	0	-25	-396
F 1H	Long trucks - Turnpike Double	-246	0	0	0	-565	0	-56	-866
F 8C	Accelerated truck scrappage (5-yr shift)	-304	-2,457	-1,071	-397	-851	-691	-311	-6,082
E 7	Rail freight car capital cost allowance	6	6	2	2	9	3	1	29
E 6	Rail locomotive capital cost allowance	17	16	7	6	26	8	3	82
F 6	Truck lubricants	54	73	19	12	124	106	37	426
F 2B	Truck speed control to 90 k/h	771	1,041	266	171	1,769	1,512	531	6,061
F 3	Trucking load matching	40	54	14	9	91	78	27	313
TOTAL		226	-1,268	-764	-198	346	1,016	208	-434

FREIGHT PACKAGE ~ LESS PROMISING MEASURES		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel	801	757	326	258	1,183	351	123	3,800
E 2B	Rail cellulosic ethanol fuel 15%	346	327	141	111	510	152	53	1,640
F 5A	Truck tires - low rolling resistance	229	309	79	51	525	448	158	1,797
F 7	Truck weight reduction	125	168	43	28	286	244	86	980
F 5B	Truck tires - central inflation	48	65	17	11	111	95	33	380
F 4	Truck tracking	15	20	5	3	34	29	10	117
E 3	Rail LNG fuel - dual fuel configuration	295	279	120	95	436	129	45	1,400
E 5	Rail US NOx regulations	73	69	30	24	108	32	11	348
E 1A	Rail locomotive fuel cell - electrolysis	3,459	3,268	1,408	1,112	5,105	1,516	531	16,400

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		Total Cost $m to 2020							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance	-1	-2	0	0	-3	-3	-1	-11
F 11	Trucking - driver idling training	15	21	5	3	35	30	11	121
E 4C	Electrification - iron ore railways	0	0	0	0	0	143	48	190
E 12	Reduce train speeds	17	16	7	5	25	7	3	79
E 4A	Electrification - western region rail	685	647	279	220	0	0	0	1,830
E 11	Rail - eliminate circuitous routings	19	18	8	6	28	8	3	91
E 4B	Electrification - eastern region rail	0	0	0	0	1,221	362	127	1,710
F 8B	Truck accelerated scrappage - 15 years	231	1,490	648	252	639	513	226	4,000
E 8	Increased rail track stiffness	46	43	19	15	67	20	7	216
G 5	Shore power - marine freight	36	0	0	0	16	24	32	108
C 7B	Shift: Van-Cal, road to rail (high)	38	51	0	0	0	0	0	89
C 7A	Shift: Van-Cal, road to rail (low)	19	26	0	0	0	0	0	45
E 9	Rail track configuration improvements	328	309	133	105	483	144	50	1,553
C 4	Shift: Hal-Tor, road to rail	0	0	0	0	26	22	8	55
C 1A	Shift: Mtl-Tor, road to rail (low)	0	0	0	0	47	40	0	87
C 1B	Shift: Mtl-Tor, road to rail (high)	0	0	0	0	75	65	0	140
F 8A	Truck accelerated scrappage - 20 years	445	3,590	1,565	581	1,243	1,009	454	8,887
E 1B	Rail locomotive fuel cell - methane	2,320	2,192	945	746	3,424	1,017	356	11,000
C 3A	Shift: Tor-Chi, road to rail (low)	0	0	0	0	66	0	0	66
C 3B	Shift: Tor-Chi, road to rail (high)	0	0	0	0	132	0	0	132
F 9	Truck engine retrofit	102	656	286	111	281	226	100	1,762
E 10	Rail - restrict local service frequency	27	26	11	9	40	12	4	129
C 6	Shift: Thund Bay-Que, rail to marine	0	0	0	0	70	21	0	91
C 5	Shift: Hal-Tor, rail to marine	0	0	0	0	66	19	7	92
C 2	Shift: Mtl-Tor, rail to marine	0	0	0	0	45	13	0	58
G 1	Accelerated marine tanker fleet renewal	276	0	0	0	125	185	242	828

FREIGHT PACKAGE ~ MOST PROMISING MEASURES									
		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency								
G 7	Code of practice - marine freight	76	0	0	0	34	51	66	227
TOTAL		76	0	0	0	34	51	66	227

FREIGHT PACKAGE ~ PROMISING MEASURES									
		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	9	0	0	0	21	0	2	32
F 1H	Long trucks - Turnpike Double	15	0	0	0	35	0	3	53
F 8C	Accelerated truck scrappage (5-yr shift)								
E 7	Rail freight car capital cost allowance	56	53	23	18	82	24	9	264
E 6	Rail locomotive capital cost allowance	19	18	8	6	29	9	3	92
F 6	Truck lubricants								
F 2B	Truck speed control to 90 k/h								
F 3	Trucking load matching	3	4	1	1	7	6	2	25
TOTAL		102	75	32	25	174	39	19	466

FREIGHT PACKAGE ~ LESS PROMISING MEASURES									
		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel								
E 2B	Rail cellulosic ethanol fuel 15%								
F 5A	Truck tires - low rolling resistance								
F 7	Truck weight reduction								
F 5B	Truck tires - central inflation								
F 4	Truck tracking	1	1	0	0	2	2	1	8
E 3	Rail LNG fuel - dual fuel configuration	86	81	35	28	127	38	13	408
E 5	Rail US NOx regulations	38	36	16	12	56	17	6	181
E 1A	Rail locomotive fuel cell - electrolysis								

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		SOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance								
F 11	Trucking - driver idling training								
E 4C	Electrification - iron ore railways	0	0	0	0	0	193	64	258
E 12	Reduce train speeds	54	51	22	17	79	23	8	254
E 4A	Electrification - western region rail	889	840	362	286	0	0	0	2,376
E 11	Rail - eliminate circuitous routings	24	22	10	8	35	10	4	112
E 4B	Electrification - eastern region rail	0	0	0	0	568	169	59	796
F 8B	Truck accelerated scrappage - 15 years								
E 8	Increased rail track stiffness	13	13	5	4	20	6	2	63
G 5	Shore power - marine freight	100	0	0	0	46	67	88	301
C 7B	Shift: Van-Cal, road to rail (high)	2	3	0	0	0	0	0	6
C 7A	Shift: Van-Cal, road to rail (low)	1	2	0	0	0	0	0	3
E 9	Rail track configuration improvements	31	29	13	10	46	14	5	147
C 4	Shift: Hal-Tor, road to rail	0	0	0	0	2	1	0	3
C 1A	Shift: Mtl-Tor, road to rail (low)	0	0	0	0	2	1	0	3
C 1B	Shift: Mtl-Tor, road to rail (high)	0	0	0	0	3	3	0	6
F 8A	Truck accelerated scrappage - 20 years	0	0	0	0	0	0	0	0
E 1B	Rail locomotive fuel cell - methane								
C 3A	Shift: Tor-Chi, road to rail (low)	0	0	0	0	1	0	0	1
C 3B	Shift: Tor-Chi, road to rail (high)	0	0	0	0	3	0	0	3
F 9	Truck engine retrofit								
E 10	Rail - restrict local service frequency	2	2	1	1	4	1	0	11
C 6	Shift: Thund Bay-Que, rail to marine	0	0	0	0	9	3	0	12
C 5	Shift: Hal-Tor, rail to marine	0	0	0	0	5	2	1	7
C 2	Shift: Mtl-Tor, rail to marine	0	0	0	0	2	0	0	2
G 1	Accelerated marine tanker fleet renewal	10	0	0	0	4	6	9	29

FREIGHT PACKAGE ~ MOST PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency								
G 7	Code of practice - marine freight	157	0	0	0	71	105	137	469
TOTAL		157	0	0	0	71	105	137	469

FREIGHT PACKAGE ~ PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	538	0	0	0	1,235	0	122	1,895
F 1H	Long trucks - Turnpike Double	891	0	0	0	2,045	0	201	3,137
F 8C	Accelerated truck scrappage (5-yr shift)								
E 7	Rail freight car capital cost allowance	828	783	337	266	1,222	363	127	3,927
E 6	Rail locomotive capital cost allowance	290	274	118	93	428	127	45	1,374
F 6	Truck lubricants								
F 2B	Truck speed control to 90 k/h								
F 3	Trucking load matching	185	249	64	41	424	362	127	1,452
TOTAL		2,732	1,306	519	400	5,354	852	622	11,785

FREIGHT PACKAGE ~ LESS PROMISING MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel								
E 2B	Rail cellulosic ethanol fuel 15%								
F 5A	Truck tires - low rolling resistance								
F 7	Truck weight reduction								
F 5B	Truck tires - central inflation								
F 4	Truck tracking	63	86	22	14	145	124	44	498
E 3	Rail LNG fuel - dual fuel configuration	1,280	1,209	521	412	1,889	561	197	6,069
E 5	Rail US NOx regulations	568	536	231	182	838	249	87	2,691
E 1A	Rail locomotive fuel cell - electrolysis								

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		NOx Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance								
F 11	Trucking - driver idling training								
E 4C	Electrification - iron ore railways	0	0	0	0	0	2,877	959	3,836
E 12	Reduce train speeds	798	754	325	257	1,178	350	123	3,784
E 4A	Electrification - western region rail	13,231	12,501	5,386	4,254	0	0	0	35,371
E 11	Rail - eliminate circuitous routings	351	331	143	113	518	154	54	1,663
E 4B	Electrification - eastern region rail	0	0	0	0	8,456	2,511	880	11,847
F 8B	Truck accelerated scrappage - 15 years								
E 8	Increased rail track stiffness	198	187	80	64	292	87	30	937
G 5	Shore power - marine freight	207	0	0	0	94	138	182	622
C 7B	Shift: Van-Cal, road to rail (high)	142	192	0	0	0	0	0	334
C 7A	Shift: Van-Cal, road to rail (low)	71	96	0	0	0	0	0	167
E 9	Rail track configuration improvements	463	437	188	149	683	203	71	2,195
C 4	Shift: Hal-Tor, road to rail	0	0	0	0	95	81	28	204
C 1A	Shift: Mtl-Tor, road to rail (low)	0	0	0	0	99	85	0	184
C 1B	Shift: Mtl-Tor, road to rail (high)	0	0	0	0	190	163	0	353
F 8A	Truck accelerated scrappage - 20 years	0	0	0	0	0	0	0	0
E 1B	Rail locomotive fuel cell - methane								
C 3A	Shift: Tor-Chi, road to rail (low)	0	0	0	0	74	0	0	74
C 3B	Shift: Tor-Chi, road to rail (high)	0	0	0	0	149	0	0	149
F 9	Truck engine retrofit								
E 10	Rail - restrict local service frequency	36	34	15	11	53	16	5	169
C 6	Shift: Thund Bay-Que, rail to marine	0	0	0	0	138	41	0	178
C 5	Shift: Hal-Tor, rail to marine	0	0	0	0	76	23	8	107
C 2	Shift: Mtl-Tor, rail to marine	0	0	0	0	25	7	0	32
G 1	Accelerated marine tanker fleet renewal	20	0	0	0	9	13	18	60

FREIGHT PACKAGE ~ MOST PROMISING MEASURES										
		VOCs Emissions in 2010								
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency								
G 7	Code of practice - marine freight	49	0	0	0	22	33	43	147
TOTAL		49	0	0	0	22	33	43	147

FREIGHT PACKAGE ~ PROMISING MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	38	0	0	0	88	0	9	135
F 1H	Long trucks - Turnpike Double	64	0	0	0	146	0	14	224
F 8C	Accelerated truck scrappage (5-yr shift)								
E 7	Rail freight car capital cost allowance	39	37	16	13	57	17	6	184
E 6	Rail locomotive capital cost allowance	14	13	6	4	20	6	2	65
F 6	Truck lubricants								
F 2B	Truck speed control to 90 k/h								
F 3	Trucking load matching	13	18	5	3	30	26	9	104
TOTAL		168	67	26	20	342	49	40	712

FREIGHT PACKAGE ~ LESS PROMISING MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel								
E 2B	Rail cellulosic ethanol fuel 15%								
F 5A	Truck tires - low rolling resistance								
F 7	Truck weight reduction								
F 5B	Truck tires - central inflation								
F 4	Truck tracking	5	6	2	1	10	9	3	36
E 3	Rail LNG fuel - dual fuel configuration	60	57	24	19	89	26	9	285
E 5	Rail US NOx regulations	27	25	11	9	39	12	4	126
E 1A	Rail locomotive fuel cell - electrolysis								

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		VOCs Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance								
F 11	Trucking - driver idling training								
E 4C	Electrification - iron ore railways	0	0	0	0	0	135	45	180
E 12	Reduce train speeds	37	35	15	12	55	16	6	178
E 4A	Electrification - western region rail	621	587	253	200	0	0	0	1,661
E 11	Rail - eliminate circuitous routings	16	16	7	5	24	7	3	78
E 4B	Electrification - eastern region rail	0	0	0	0	397	118	41	556
F 8B	Truck accelerated scrappage - 15 years								
E 8	Increased rail track stiffness	9	9	4	3	14	4	1	44
G 5	Shore power - marine freight	65	0	0	0	29	43	57	195
C 7B	Shift: Van-Cal, road to rail (high)	10	14	0	0	0	0	0	24
C 7A	Shift: Van-Cal, road to rail (low)	5	7	0	0	0	0	0	12
E 9	Rail track configuration improvements	22	21	9	7	32	10	3	103
C 4	Shift: Hal-Tor, road to rail	0	0	0	0	7	6	2	15
C 1A	Shift: Mtl-Tor, road to rail (low)	0	0	0	0	7	6	0	13
C 1B	Shift: Mtl-Tor, road to rail (high)	0	0	0	0	14	12	0	25
F 8A	Truck accelerated scrappage - 20 years	0	0	0	0	0	0	0	0
E 1B	Rail locomotive fuel cell - methane								
C 3A	Shift: Tor-Chi, road to rail (low)	0	0	0	0	5	0	0	5
C 3B	Shift: Tor-Chi, road to rail (high)	0	0	0	0	11	0	0	11
F 9	Truck engine retrofit								
E 10	Rail - restrict local service frequency	2	2	1	1	2	1	0	8
C 6	Shift: Thund Bay-Que, rail to marine	0	0	0	0	6	2	0	8
C 5	Shift: Hal-Tor, rail to marine	0	0	0	0	4	1	0	5
C 2	Shift: Mtl-Tor, rail to marine	0	0	0	0	1	0	0	2
G 1	Accelerated marine tanker fleet renewal	6	0	0	0	3	4	6	19

FREIGHT PACKAGE ~ MOST PROMISING MEASURES									
		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 10	Truck driver training - energy efficiency								
G 7	Code of practice - marine freight	11	0	0	0	5	7	10	33
TOTAL		0	0	0	0	0	0	0	0

FREIGHT PACKAGE ~ PROMISING MEASURES									
		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 1L	Long trucks - Rocky Mountain Double	19	0	0	0	44	0	4	68
F 1H	Long trucks - Turnpike Double	32	0	0	0	73	0	7	112
F 8C	Accelerated truck scrappage (5-yr shift)								
E 7	Rail freight car capital cost allowance	20	19	8	6	30	9	3	95
E 6	Rail locomotive capital cost allowance	7	7	3	2	10	3	1	33
F 6	Truck lubricants								
F 2B	Truck speed control to 90 k/h								
F 3	Trucking load matching	7	9	2	1	15	13	5	52
TOTAL		85	35	13	10	172	25	20	360

FREIGHT PACKAGE ~ LESS PROMISING MEASURES									
		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
E 2A	Rail cellulosic ethanol fuel								
E 2B	Rail cellulosic ethanol fuel 15%								
F 5A	Truck tires - low rolling resistance								
F 7	Truck weight reduction								
F 5B	Truck tires - central inflation								
F 4	Truck tracking	2	3	1	1	5	4	2	18
E 3	Rail LNG fuel - dual fuel configuration	31	29	13	10	46	14	5	147
E 5	Rail US NOx regulations	14	13	6	4	20	6	2	65
E 1A	Rail locomotive fuel cell - electrolysis								

FREIGHT PACKAGE ~ UNLIKELY MEASURES									
		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
F 12	Trucking - preventative maintenance								
F 11	Trucking - driver idling training								
E 4C	Electrification - iron ore railways	0	0	0	0	0	70	23	93
E 12	Reduce train speeds	19	18	8	6	29	8	3	92
E 4A	Electrification - western region rail	321	303	131	103	0	0	0	858
E 11	Rail - eliminate circuitous routings	9	8	3	3	13	4	1	40
E 4B	Electrification - eastern region rail	0	0	0	0	205	61	21	287
F 8B	Truck accelerated scrappage - 15 years								
E 8	Increased rail track stiffness	5	5	2	2	7	2	1	23
G 5	Shore power - marine freight	15	0	0	0	7	10	13	44
C 7B	Shift: Van-Cal, road to rail (high)	5	7	0	0	0	0	0	12
C 7A	Shift: Van-Cal, road to rail (low)	3	3	0	0	0	0	0	6
E 9	Rail track configuration improvements	11	11	5	4	17	5	2	53
C 4	Shift: Hal-Tor, road to rail	0	0	0	0	3	3	1	7
C 1A	Shift: Mtl-Tor, road to rail (low)	0	0	0	0	4	3	0	7
C 1B	Shift: Mtl-Tor, road to rail (high)	0	0	0	0	7	6	0	13
F 8A	Truck accelerated scrappage - 20 years	0	0	0	0	0	0	0	0
E 1B	Rail locomotive fuel cell - methane								
C 3A	Shift: Tor-Chi, road to rail (low)	0	0	0	0	3	0	0	3
C 3B	Shift: Tor-Chi, road to rail (high)	0	0	0	0	5	0	0	5
F 9	Truck engine retrofit								
E 10	Rail - restrict local service frequency	1	1	0	0	1	0	0	4
C 6	Shift: Thund Bay-Que, rail to marine	0	0	0	0	3	1	0	4
C 5	Shift: Hal-Tor, rail to marine	0	0	0	0	2	1	0	3
C 2	Shift: Mtl-Tor, rail to marine	0	0	0	0	1	0	0	1
G 1	Accelerated marine tanker fleet renewal	1	0	0	0	1	1	1	4

ROAD VEHICLES AND FUELS PACKAGE

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		GHG Reduction in 2010 - megatonnes							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements	0.051	0.069	0.018	0.011	0.117	0.100	0.035	0.400
H 9	Transit Bus design and alt fuels	0.032	0.028	0.005	0.007	0.091	0.047	0.007	0.217
H 5B	Ethanol capacity incentives - high	0.104	0.119	0.040	0.032	0.299	0.144	0.062	0.800
H 2A	AFV fleet purchase	0.039	0.045	0.015	0.012	0.112	0.054	0.023	0.300
H 8B	Heavy duty truck AFV purchases	0.051	0.069	0.018	0.011	0.117	0.100	0.035	0.400
H 1BL	Target harmonized: 25% by 2010 from present target	0.678	0.776	0.260	0.206	1.945	0.934	0.402	5.200
H 7B	Alt fuel infrastructure - propane	0.105	0.122	0.038	0.030	0.281	0.158	0.066	0.800
H 7C	Alt fuel infrastructure - nat gas	0.099	0.114	0.036	0.028	0.263	0.148	0.062	0.750
TOTAL		1.158	1.340	0.428	0.337	3.226	2.879	0.692	8.87

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		GHG Reduction in 2010 - megatonnes							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in	0.272	0.312	0.104	0.083	0.782	0.375	0.162	2.090
H 7AH	Alt fuel infrastructure - ethanol high	0.300	0.343	0.115	0.091	0.860	0.413	0.178	2.300
H 7AL	Alt fuel infrastructure - ethanol low	0.261	0.298	0.100	0.079	0.748	0.359	0.155	2.000
H 3A	Vehicle purchase incentive - 30% best of class	0.268	0.306	0.102	0.081	0.768	0.369	0.159	2.053

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		GHG Reduction in 2010 - megatonnes							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized	0.272	0.312	0.104	0.083	0.782	0.375	0.162	2.090
H 5A	Ethanol capacity incentives - low	0.065	0.075	0.025	0.020	0.187	0.090	0.039	0.500
H 1AL	Target harmonized: 2% per year from present target	0.143	0.164	0.055	0.044	0.412	0.198	0.085	1.100
H 1AH	Target harmonized: 2% per year from actual fleet avg.	0.248	0.283	0.095	0.075	0.711	0.341	0.147	1.900
H 10A	Feebate Canada only	0.305	0.349	0.117	0.093	0.875	0.420	0.181	2.340
H 10B	Feebate Canada only, phased-in	0.305	0.349	0.117	0.093	0.875	0.420	0.181	2.340
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.	0.847	0.970	0.324	0.257	2.432	1.168	0.502	6.500
H 1C	Target Canada only: 2% per year	0.143	0.164	0.055	0.044	0.412	0.198	0.085	1.100
H 1D	Target Canada only: 25% by 2010	0.674	0.771	0.258	0.205	1.933	0.928	0.399	5.168
H 2B	High efficiency fleet purchase incentive	0.026	0.030	0.010	0.008	0.075	0.036	0.015	0.200
H 3B	Vehicle purchase incentive - 40% best of class	0.064	0.074	0.025	0.020	0.185	0.089	0.038	0.493

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		GHG Reduction in 2020 - megatonnes							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements	0.254	0.343	0.088	0.056	0.584	0.499	0.175	2.000
H 9	Transit Bus design and alt fuels	0.082	0.072	0.012	0.018	0.236	0.122	0.017	0.560
H 5B	Ethanol capacity incentives - high	0.287	0.328	0.110	0.087	0.823	0.395	0.170	2.200
H 2A	AFV fleet purchase	0.091	0.104	0.035	0.028	0.262	0.126	0.054	0.700
H 8B	Heavy duty truck AFV purchases	0.229	0.309	0.079	0.051	0.525	0.449	0.158	1.800
H 1BL	Target harmonized: 25% by 2010 from present target	1.838	2.103	0.704	0.558	5.275	2.533	1.090	14.100
H 7B	Alt fuel infrastructure - propane	0.342	0.395	0.124	0.097	0.913	0.515	0.215	2.600
H 7C	Alt fuel infrastructure - nat gas	0.302	0.349	0.110	0.086	0.808	0.455	0.190	2.300
TOTAL		3.425	4.005	1.261	0.981	9.425	5.093	2.069	26.26

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		GHG Reduction in 2020 - megatonnes							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in	1.711	1.958	0.655	0.520	4.912	2.358	1.015	13.130
H 7AH	Alt fuel infrastructure - ethanol high	1.082	1.238	0.414	0.329	3.105	1.491	0.642	8.300
H 7AL	Alt fuel infrastructure - ethanol low	0.639	0.731	0.245	0.194	1.833	0.880	0.379	4.900
H 3A	Vehicle purchase incentive - 30% best of class	0.839	0.960	0.321	0.255	2.409	1.157	0.498	6.439

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		GHG Reduction in 2020 - megatonnes							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized	1.711	1.958	0.655	0.520	4.912	2.358	1.015	13.130
H 5A	Ethanol capacity incentives - low	0.065	0.075	0.025	0.020	0.187	0.090	0.039	0.500
H 1AL	Target harmonized: 2% per year from present target	1.030	1.178	0.394	0.313	2.955	1.419	0.611	7.900
H 1AH	Target harmonized: 2% per year from actual fleet avg.	1.316	1.507	0.504	0.400	3.778	1.814	0.781	10.100
H 10A	Feebate Canada only	0.660	0.755	0.253	0.200	1.893	0.909	0.391	5.060
H 10B	Feebate Canada only, phased-in	0.660	0.755	0.253	0.200	1.893	0.909	0.391	5.060
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.	2.151	2.461	0.824	0.653	6.173	2.964	1.275	16.500
H 1C	Target Canada only: 2% per year	1.030	1.178	0.394	0.313	2.955	1.419	0.611	7.900
H 1D	Target Canada only: 25% by 2010	1.838	2.103	0.704	0.558	5.275	2.533	1.090	14.100
H 2B	High efficiency fleet purchase incentive	0.039	0.045	0.015	0.012	0.112	0.054	0.023	0.300
H 3B	Vehicle purchase incentive - 40% best of class	0.256	0.293	0.098	0.078	0.736	0.353	0.152	1.966

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		Private Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements	9	12	3	2	21	18	6	72
H 9	Transit Bus design and alt fuels	-33	-29	-5	-7	-94	-49	-7	-223
H 5B	Ethanol capacity incentives - high	70	81	27	21	202	97	42	540
H 2A	AFV fleet purchase	58	67	22	18	168	81	35	448
H 8B	Heavy duty truck AFV purchases	107	145	37	24	246	211	74	844
H 1BL	Target harmonized: 25% by 2010 from present target	1,157	1,324	443	351	3,322	1,595	686	8,879
H 7B	Alt fuel infrastructure - propane	57	66	21	16	152	86	36	433
H 7C	Alt fuel infrastructure - nat gas	90	104	33	26	241	136	57	685
TOTAL		1,517	1,770	581	451	4,257	2,174	928	11,678

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		Private Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in	1,014	1,160	388	308	2,910	1,397	601	7,780
H 7AH	Alt fuel infrastructure - ethanol high	95	108	36	29	272	130	56	726
H 7AL	Alt fuel infrastructure - ethanol low	75	85	29	23	214	103	44	573
H 3A	Vehicle purchase incentive - 30% best of class	258	295	99	78	740	355	153	1,979

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		Private Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized	1,177	1,347	451	357	3,378	1,622	698	9,030
H 5A	Ethanol capacity incentives - low	35	40	14	11	101	49	21	271
H 1AL	Target harmonized: 2% per year from present target	303	347	116	92	869	417	180	2,323
H 1AH	Target harmonized: 2% per year from actual fleet avg.	480	550	184	146	1,378	662	285	3,684
H 10A	Feebate Canada only	1,367	1,565	524	415	3,924	1,884	811	10,490
H 10B	Feebate Canada only, phased-in	1,233	1,411	472	374	3,539	1,699	731	9,460
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.	1,981	2,268	759	602	5,687	2,731	1,175	15,202
H 1C	Target Canada only: 2% per year	645	738	247	196	1,850	888	382	4,945
H 1D	Target Canada only: 25% by 2010	2,462	2,818	943	748	7,067	3,393	1,460	18,891
H 2B	High efficiency fleet purchase incentive	65	74	25	20	186	90	39	498
H 3B	Vehicle purchase incentive - 40% best of class	65	74	25	20	187	90	39	499

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements	0	1	0	0	1	1	0	3
H 9	Transit Bus design and alt fuels	48	42	7	11	139	72	10	329
H 5B	Ethanol capacity incentives - high	0	0	0	0	1	0	0	2
H 2A	AFV fleet purchase	1	1	0	0	2	1	1	7
H 8B	Heavy duty truck AFV purchases	0	1	0	0	1	1	0	3
H 1BL	Target harmonized: 25% by 2010 from present target	0	0	0	0	1	1	0	3
H 7B	Alt fuel infrastructure - propane	4	4	1	1	9	5	2	27
H 7C	Alt fuel infrastructure - nat gas	4	4	1	1	9	5	2	27
TOTAL		57	53	11	13	164	86	16	400

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in	0	0	0	0	0	0	0	0
H 7AH	Alt fuel infrastructure - ethanol high	4	4	1	1	10	5	2	27
H 7AL	Alt fuel infrastructure - ethanol low	4	4	1	1	10	5	2	27
H 3A	Vehicle purchase incentive - 30% best of class	1	1	0	0	2	1	1	7

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized	0	0	0	0	0	0	0	0
H 5A	Ethanol capacity incentives - low	0	0	0	0	1	0	0	2
H 1AL	Target harmonized: 2% per year from present target	0	0	0	0	1	1	0	3
H 1AH	Target harmonized: 2% per year from actual fleet avg.	0	0	0	0	1	1	0	3
H 10A	Feebate Canada only	0	0	0	0	0	0	0	0
H 10B	Feebate Canada only, phased-in	0	0	0	0	0	0	0	0
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.	0	0	0	0	1	1	0	3
H 1C	Target Canada only: 2% per year	0	0	0	0	1	1	0	3
H 1D	Target Canada only: 25% by 2010	0	0	0	0	1	1	0	3
H 2B	High efficiency fleet purchase incentive	1	1	0	0	2	1	1	7
H 3B	Vehicle purchase incentive - 40% best of class	1	1	0	0	2	1	1	7

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		Total Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements	10	13	3	2	22	19	7	75
H 9	Transit Bus design and alt fuels	16	14	2	3	45	23	3	106
H 5B	Ethanol capacity incentives - high	71	81	27	21	203	97	42	542
H 2A	AFV fleet purchase	59	68	23	18	170	82	35	455
H 8B	Heavy duty truck AFV purchases	108	146	37	24	248	212	75	851
H 1BL	Target harmonized: 25% by 2010 from present target	1,158	1,325	443	352	3,323	1,595	687	8,882
H 7B	Alt fuel infrastructure - propane	60	70	22	17	161	91	38	460
H 7C	Alt fuel infrastructure - nat gas	94	108	34	27	250	141	59	712
TOTAL		1,575	1,824	592	464	4,422	2,260	945	12,083

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		Total Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in	1,014	1,160	388	308	2,910	1,397	601	7,780
H 7AH	Alt fuel infrastructure - ethanol high	98	112	38	30	281	135	58	752
H 7AL	Alt fuel infrastructure - ethanol low	78	89	30	24	224	108	46	600
H 3A	Vehicle purchase incentive - 30% best of class	259	296	99	79	743	357	153	1,985

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		Total Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized	1,177	1,347	451	357	3,378	1,622	698	9,030
H 5A	Ethanol capacity incentives - low	36	41	14	11	102	49	21	273
H 1AL	Target harmonized: 2% per year from present target	303	347	116	92	870	418	180	2,326
H 1AH	Target harmonized: 2% per year from actual fleet avg.	481	550	184	146	1,379	662	285	3,687
H 10A	Feebate Canada only	1,367	1,565	524	415	3,924	1,884	811	10,490
H 10B	Feebate Canada only, phased-in	1,233	1,411	472	374	3,539	1,699	731	9,460
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.	1,982	2,268	759	602	5,688	2,731	1,175	15,205
H 1C	Target Canada only: 2% per year	645	738	247	196	1,851	889	383	4,949
H 1D	Target Canada only: 25% by 2010	2,463	2,818	943	748	7,068	3,394	1,460	18,894
H 2B	High efficiency fleet purchase incentive	66	75	25	20	189	91	39	505
H 3B	Vehicle purchase incentive - 40% best of class	66	75	25	20	189	91	39	506

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		SOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements								
H 9	Transit Bus design and alt fuels								
H 5B	Ethanol capacity incentives - high	27	31	10	8	78	38	16	210
H 2A	AFV fleet purchase	25	28	9	7	71	34	15	189
H 8B	Heavy duty truck AFV purchases	99	134	34	22	227	194	68	779
H 1BL	Target harmonized: 25% by 2010 from present target								
H 7B	Alt fuel infrastructure - propane	30	34	11	8	79	45	19	225
H 7C	Alt fuel infrastructure - nat gas	29	34	11	8	78	44	18	221
TOTAL		210	261	75	54	533	354	136	1,624

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		SOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in								
H 7AH	Alt fuel infrastructure - ethanol high	31	35	12	9	88	42	18	236
H 7AL	Alt fuel infrastructure - ethanol low	27	31	10	8	79	38	16	210
H 3A	Vehicle purchase incentive - 30% best of class	53	61	20	16	153	73	32	409

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		SOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized								
H 5A	Ethanol capacity incentives - low	3	3	1	1	9	4	2	23
H 1AL	Target harmonized: 2% per year from present target								
H 1AH	Target harmonized: 2% per year from actual fleet avg.								
H 10A	Feebate Canada only								
H 10B	Feebate Canada only, phased-in								
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.								
H 1C	Target Canada only: 2% per year								
H 1D	Target Canada only: 25% by 2010								
H 2B	High efficiency fleet purchase incentive								
H 3B	Vehicle purchase incentive - 40% best of class	53	61	20	16	152	73	31	407

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		NOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements								
H 9	Transit Bus design and alt fuels								
H 5B	Ethanol capacity incentives - high	-68	-78	-26	-21	-196	-94	-41	-524
H 2A	AFV fleet purchase	53	61	20	16	152	73	31	406
H 8B	Heavy duty truck AFV purchases	5,070	6,844	1,747	1,125	11,637	9,942	3,495	39,862
H 1BL	Target harmonized: 25% by 2010 from present target								
H 7B	Alt fuel infrastructure - propane	38	44	14	11	103	58	24	292
H 7C	Alt fuel infrastructure - nat gas	26	30	10	7	70	39	16	199
TOTAL		5,120	6,901	1,765	1,139	11,766	10,019	3,527	40,235

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		NOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in								
H 7AH	Alt fuel infrastructure - ethanol high	-8	-9	-3	-2	-22	-11	-5	-59
H 7AL	Alt fuel infrastructure - ethanol low	-5	-6	-2	-2	-15	-7	-3	-41
H 3A	Vehicle purchase incentive - 30% best of class	-184	-211	-71	-56	-529	-254	-109	-1,413

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		NOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized								
H 5A	Ethanol capacity incentives - low	-44	-50	-17	-13	-125	-60	-26	-335
H 1AL	Target harmonized: 2% per year from present target								
H 1AH	Target harmonized: 2% per year from actual fleet avg.								
H 10A	Feebate Canada only								
H 10B	Feebate Canada only, phased-in								
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.								
H 1C	Target Canada only: 2% per year								
H 1D	Target Canada only: 25% by 2010								
H 2B	High efficiency fleet purchase incentive								
H 3B	Vehicle purchase incentive - 40% best of class	-133	-152	-51	-40	-380	-183	-79	-1,017

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		VOCs Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements								
H 9	Transit Bus design and alt fuels								
H 5B	Ethanol capacity incentives - high	58	66	22	18	167	80	34	446
H 2A	AFV fleet purchase	105	120	40	32	301	145	62	805
H 8B	Heavy duty truck AFV purchases	164	221	56	36	375	321	113	1,285
H 1BL	Target harmonized: 25% by 2010 from present target								
H 7B	Alt fuel infrastructure - propane	127	147	46	36	339	191	80	967
H 7C	Alt fuel infrastructure - nat gas	151	175	55	43	404	228	95	1,152
TOTAL		605	729	220	165	1,587	965	384	4,655

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		VOCs Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in								
H 7AH	Alt fuel infrastructure - ethanol high	102	116	39	31	292	140	60	780
H 7AL	Alt fuel infrastructure - ethanol low	93	107	36	28	267	128	55	714
H 3A	Vehicle purchase incentive - 30% best of class	107	122	41	32	306	147	63	818

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		VOCs Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized								
H 5A	Ethanol capacity incentives - low	37	42	14	11	106	51	22	284
H 1AL	Target harmonized: 2% per year from present target								
H 1AH	Target harmonized: 2% per year from actual fleet avg.								
H 10A	Feebate Canada only								
H 10B	Feebate Canada only, phased-in								
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.								
H 1C	Target Canada only: 2% per year								
H 1D	Target Canada only: 25% by 2010								
H 2B	High efficiency fleet purchase incentive								
H 3B	Vehicle purchase incentive - 40% best of class	375	429	143	114	1,075	516	222	2,874

ROAD VEHICLES AND FUELS PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

ROAD VEHICLES AND FUELS PACKAGE ~ PROMISING MEASURES

Measure		PM10 Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 8A	Heavy duty truck efficiency improvements								
H 9	Transit Bus design and alt fuels								
H 5B	Ethanol capacity incentives - high	24	27	9	7	69	33	14	183
H 2A	AFV fleet purchase	36	41	14	11	102	49	21	274
H 8B	Heavy duty truck AFV purchases	216	292	75	48	497	424	149	1,702
H 1BL	Target harmonized: 25% by 2010 from present target								
H 7B	Alt fuel infrastructure - propane	44	51	16	13	118	67	28	337
H 7C	Alt fuel infrastructure - nat gas	47	54	17	13	124	70	29	354
TOTAL		0	0	0	0	0	0	0	0

ROAD VEHICLES AND FUELS PACKAGE ~ LESS PROMISING MEASURES

Measure		PM10 Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10D	Feebate - NA harmonized, with phase-in								
H 7AH	Alt fuel infrastructure - ethanol high	45	52	17	14	130	63	27	348
H 7AL	Alt fuel infrastructure - ethanol low	40	46	15	12	115	55	24	308
H 3A	Vehicle purchase incentive - 30% best of class	47	54	18	14	135	65	28	362

ROAD VEHICLES AND FUELS PACKAGE ~ UNLIKELY MEASURES

Measure		PM10 Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
H 10C	Feebate harmonized								
H 5A	Ethanol capacity incentives - low	15	17	6	5	44	21	9	117
H 1AL	Target harmonized: 2% per year from present target								
H 1AH	Target harmonized: 2% per year from actual fleet avg.								
H 10A	Feebate Canada only								
H 10B	Feebate Canada only, phased-in								
H 1BH	Target harmonized: 25% by 2010 from actual fleet avg.								
H 1C	Target Canada only: 2% per year								
H 1D	Target Canada only: 25% by 2010								
H 2B	High efficiency fleet purchase incentive								
H 3B	Vehicle purchase incentive - 40% best of class	46	53	18	14	133	64	28	356

OFF-ROAD PACKAGE

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING		GHG Reduction in 2010 - megatonnes							
Measure		**BC+T**	**AB**	**SK**	**MB**	**ON**	**QC**	**ATL**	**Canada**
K 1	Fuel efficiency standards	0.271	0.787	0.268	0.105	0.440	0.263	0.116	2.250
K 2	Public awareness campaign	0.030	0.087	0.030	0.012	0.049	0.029	0.013	0.250
K 3	Voluntary measure	0.212	0.615	0.210	0.082	0.344	0.206	0.091	1.760
TOTAL		0.513	1.490	0.507	0.199	0.833	0.498	0.221	4.26

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING		GHG Reduction in 2020 - megatonnes							
Measure		**BC+T**	**AB**	**SK**	**MB**	**ON**	**QC**	**ATL**	**Canada**
K 1	Fuel efficiency standards	-	-	-	-	-	-	-	-
K 2	Public awareness campaign	-	-	-	-	-	-	-	-
K 3	Voluntary measure	-	-	-	-	-	-	-	-
TOTAL									

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING

Measure		Private Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
K 1	Fuel efficiency standards	3	9	3	1	5	3	1	26
K 2	Public awareness campaign	0	-1	0	0	0	0	0	-2
K 3	Voluntary measure	4	10	4	1	6	3	2	30
TOTAL		6	19	6	2	10	6	3	54

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
K 1	Fuel efficiency standards	0	1	0	0	0	0	0	3
K 2	Public awareness campaign	2	4	1	1	2	1	1	13
K 3	Voluntary measure	0	1	0	0	1	0	0	4
TOTAL		2	7	2	1	4	2	1	19

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING

Measure		Total Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
K 1	Fuel efficiency standards	3	10	3	1	5	3	1	28
K 2	Public awareness campaign	1	4	1	1	2	1	1	11
K 3	Voluntary measure	4	12	4	2	7	4	2	34
TOTAL		9	25	9	3	14	8	4	73

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING

Measure		SOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
K 1	Fuel efficiency standards	3	10	3	1	5	3	1	28
K 2	Public awareness campaign	1	4	1	1	2	1	1	11
K 3	Voluntary measure	4	12	4	2	7	4	2	34
TOTAL		9	25	9	3	14	8	4	73

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING		NOx Emissions in 2010							
Measure		**BC+T**	**AB**	**SK**	**MB**	**ON**	**QC**	**ATL**	**Canada**
K 1	Fuel efficiency standards	3	10	3	1	5	3	1	28
K 2	Public awareness campaign	1	4	1	1	2	1	1	11
K 3	Voluntary measure	4	12	4	2	7	4	2	34
TOTAL		9	25	9	3	14	8	4	73

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING		VOCs Emissions in 2010							
Measure		**BC+T**	**AB**	**SK**	**MB**	**ON**	**QC**	**ATL**	**Canada**
K 1	Fuel efficiency standards	3	10	3	1	5	3	1	28
K 2	Public awareness campaign	1	4	1	1	2	1	1	11
K 3	Voluntary measure	4	12	4	2	7	4	2	34
TOTAL		9	25	9	3	14	8	4	73

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ MOST PROMISING MEASURES

[No measures assigned]

OFF-ROAD PACKAGE ~ PROMISING

Measure		PM10 Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
K 1	Fuel efficiency standards	3	10	3	1	5	3	1	28
K 2	Public awareness campaign	1	4	1	1	2	1	1	11
K 3	Voluntary measure	4	12	4	2	7	4	2	34
TOTAL		9	25	9	3	14	8	4	73

OFF-ROAD PACKAGE ~ LESS PROMISING/UNLIKELY MEASURES

[No measures assigned]

FUEL TAXES

FUEL TAX VARIANTS

Measure		GHG Reduction in 2010 - megatonnes							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	7.099	8.204	2.577	2.011	18.960	10.690	4.458	54.000
I 3A	Urban gas tax - 1 cent/litre	0.050	0.059	0.012	0.015	0.177	0.074	0.012	0.400
I 3B	Urban gas tax - 2 cents/litre	0.093	0.111	0.023	0.028	0.333	0.139	0.023	0.750
I 3C	Urban gas tax - 4 cents/litre	0.180	0.215	0.045	0.055	0.643	0.268	0.045	1.450
I 4A	Road gasoline and diesel - 10 cents/litre	0.986	1.139	0.358	0.279	2.633	1.485	0.619	7.500
I 4B	Road gasoline and diesel - 20 cents/litre	1.788	2.066	0.649	0.507	4.775	2.692	1.123	13.600

FUEL TAX VARIANTS

Measure		GHG Reduction in 2020 - megatonnes							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	11.701	13.521	4.248	3.315	31.249	17.618	7.347	89.000
I 3A	Urban gas tax - 1 cent/litre	0.081	0.096	0.020	0.025	0.288	0.120	0.020	0.650
I 3B	Urban gas tax - 2 cents/litre	0.167	0.200	0.042	0.051	0.599	0.249	0.042	1.350
I 3C	Urban gas tax - 4 cents/litre	0.322	0.385	0.081	0.098	1.154	0.480	0.080	2.600
I 4A	Road gasoline and diesel - 10 cents/litre	2.130	2.461	0.773	0.603	5.688	3.207	1.337	16.200
I 4B	Road gasoline and diesel - 20 cents/litre	3.773	4.360	1.370	1.069	10.077	5.681	2.369	28.700

FUEL TAX VARIANTS

Measure		Private Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	-	-	-	-	-	-	-	-
I 3A	Urban gas tax - 1 cent/litre	-	-	-	-	-	-	-	-
I 3B	Urban gas tax - 2 cents/litre	-	-	-	-	-	-	-	-
I 3C	Urban gas tax - 4 cents/litre	-	-	-	-	-	-	-	-
I 4A	Road gasoline and diesel - 10 cents/litre	-	-	-	-	-	-	-	-
I 4B	Road gasoline and diesel - 20 cents/litre	-	-	-	-	-	-	-	-

FUEL TAX VARIANTS

Measure		Government Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	-	-	-	-	-	-	-	-
I 3A	Urban gas tax - 1 cent/litre	-	-	-	-	-	-	-	-
I 3B	Urban gas tax - 2 cents/litre	-	-	-	-	-	-	-	-
I 3C	Urban gas tax - 4 cents/litre	-	-	-	-	-	-	-	-
I 4A	Road gasoline and diesel - 10 cents/litre	-	-	-	-	-	-	-	-
I 4B	Road gasoline and diesel - 20 cents/litre	-	-	-	-	-	-	-	-

FUEL TAX VARIANTS

Measure		Total Cost $m to 2020							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	-	-	-	-	-	-	-	-
I 3A	Urban gas tax - 1 cent/litre	-	-	-	-	-	-	-	-
I 3B	Urban gas tax - 2 cents/litre	-	-	-	-	-	-	-	-
I 3C	Urban gas tax - 4 cents/litre	-	-	-	-	-	-	-	-
I 4A	Road gasoline and diesel - 10 cents/litre	-	-	-	-	-	-	-	-
I 4B	Road gasoline and diesel - 20 cents/litre	-	-	-	-	-	-	-	-

FUEL TAX VARIANTS

Measure		SOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	82,695	95,561	30,021	23,430	220,853	124,516	51,924	629,000
I 3A	Urban gas tax - 1 cent/litre	4	5	1	1	11	6	3	31
I 3B	Urban gas tax - 2 cents/litre	8	9	3	2	21	12	5	60
I 3C	Urban gas tax - 4 cents/litre	14	17	5	4	38	22	9	109
I 4A	Road gasoline and diesel - 10 cents/litre	128	148	46	36	342	193	80	974
I 4B	Road gasoline and diesel - 20 cents/litre	234	271	85	66	626	353	147	1,782

FUEL TAX VARIANTS

Measure		NOx Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	45,358	52,414	16,466	12,851	121,136	68,296	28,480	345,000
I 3A	Urban gas tax - 1 cent/litre	80	92	29	23	213	120	50	606
I 3B	Urban gas tax - 2 cents/litre	153	177	55	43	408	230	96	1,162
I 3C	Urban gas tax - 4 cents/litre	280	323	102	79	747	421	176	2,128
I 4A	Road gasoline and diesel - 10 cents/litre	5,401	6,241	1,961	1,530	14,424	8,132	3,391	41,081
I 4B	Road gasoline and diesel - 20 cents/litre	9,893	11,433	3,592	2,803	26,422	14,897	6,212	75,251

FUEL TAX VARIANTS

Measure		VOCs Emissions in 2010							
		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	127,395	147,216	46,249	36,094	340,233	191,822	79,990	969,000
I 3A	Urban gas tax - 1 cent/litre	6	7	2	2	17	9	4	47
I 3B	Urban gas tax - 2 cents/litre	12	14	4	3	31	18	7	89
I 3C	Urban gas tax - 4 cents/litre	22	25	8	6	58	32	14	164
I 4A	Road gasoline and diesel - 10 cents/litre	1,884	2,177	684	534	5,030	2,836	1,183	14,327
I 4B	Road gasoline and diesel - 20 cents/litre	3,444	3,980	1,250	976	9,199	5,186	2,163	26,199

FUEL TAX VARIANTS									
		PM10 Emissions in 2010							
Measure		BC+T	AB	SK	MB	ON	QC	ATL	Canada
I 1/2	National Fuel Tax to achieve Kyoto target	222,186	256,754	80,661	62,951	593,389	334,550	139,509	1,690,000
I 3A	Urban gas tax - 1 cent/litre	118	136	43	33	315	177	74	896
I 3B	Urban gas tax - 2 cents/litre	226	261	82	64	603	340	142	1,718
I 3C	Urban gas tax - 4 cents/litre	413	478	150	117	1,104	623	260	3,145
I 4A	Road gasoline and diesel - 10 cents/litre	237	273	86	67	632	356	149	1,800
I 4B	Road gasoline and diesel - 20 cents/litre	433	501	157	123	1,157	652	272	3,296

Notes on allocation by province/region
(i) Territories are included with British Columbia, as in the Natural Resources Canada *Outlook*
(ii) Atlantic Canada provinces remain combined, as within the Natural Resources Canada detailed *Outlook* by fuel type. Provincial estimates will be produced shortly.
(iii) Emissions and costs have been allocated to provinces/regions based on distributions of GHG emissions and forecast emissions by fuel derived from the Natural Resources Canada Outlook, using the type(s) of fuel derived from the Natural Resources Canada *Outlook,* and using the type of fuel judged to be most appropriate for each.

Appendix 6

Transportation and Climate Change Initiatives in Other Countries

Introduction

This section describes policies and initiatives underway in other countries to address transportation and climate change issues. In particular, the section briefly describes the situation in the United States, the European Union and Japan.

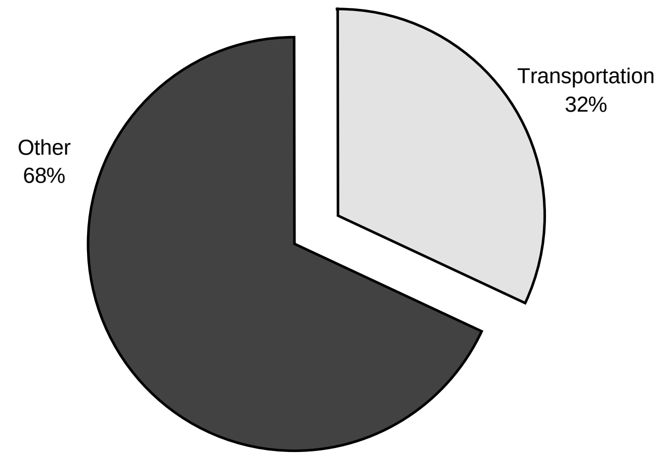
This section does not address issues related to ratifying the Kyoto Protocol in each country. Further, it does not discuss work underway on broader instruments, such as emissions trading, but deals only with transportation initiatives. Many nations are still in the process of analyzing policies or programs in the transportation sector; in other cases, the section describes programs that were put in place to address other objectives but that will have a direct effect on reducing greenhouse-gas emissions from the transportation sector.

United States

Of particular importance to Canada are the actions taken by the United States in the transportation sector. This is because the transportation sectors of the two countries are closely linked. Aircraft now operate under a "open skies" policy, vehicle manufacturers have integrated operations between both countries, environmental regulations of road vehicles have been harmonized, and truck and rail traffic flow freely between the two countries.

Transportation Emissions
Under the Kyoto Protocol, the United States would reduce its GHG emissions by 7 per cent over 1990 levels; a reduction of 26 per cent from its forecasted emissions in 2010. Transportation represents almost one third (32 per cent) of U.S. greenhouse-gas emissions, slightly higher than in Canada (25 per cent). The on-road share is similar, accounting for 80 per cent of transportation sector emissions. Almost all (97 per cent) of transportation depends on fossil fuels, accounting for two thirds of all U.S. demand for oil. GHG emissions from transportation will increase 32 per cent by 2010, the same rate as in Canada (32 per cent).

Chart A6-1
Transportation's Share of GHG Emissions - U.S.



The White House Initiative on Climate Change

The White House Initiative on Global Climate Change was launched in 1993 by President Clinton to focus on new technologies and "win-win" solutions to climate change. Funding for the initiatives is determined during the budget process each year. Funding for the initiatives was increased by 25 per cent in 1999 to close to $1 billion, including:

- $350 million for renewable energy, including providing solar energy for one million homes and expanding the use of ethanol from 80 000 to one million barrels per day by 2010;
- $550 million for energy efficiency initiatives, including the Partnership for A New Generation of Vehicles (see below) and work on fuel cells for heavy-duty vehicles and ships; and,
- $120 million for energy efficiency for buildings, housing and lighting.

An additional $730 million has been proposed by the White House for the 2000 budget.

The Partnership for a New Generation of Vehicles (PNGV)

The PNGV is a joint research project involving the U.S. government, Ford, General Motors and Daimler-Chrysler. The program was launched in 1993 to:

- improve competitiveness in vehicle manufacturing;
- apply commercially viable innovations to conventional vehicles; and,
- develop a vehicle that achieves three times the fuel economy of today's mid-sized sedans, while maintaining consumer preferences for performance, utility, safety and cost of ownership.

The program is designed to produce a commercial prototype mid-sized car that achieves approximately 80 miles per gallon (U.S.) by 2004. In addition to design improvements, the program is also focusing on new, lighter-weight materials, hybrid engines and fuel-cell technology.

Government funding of approximately $300 million is matched by industrial partners. Partners in the program include over 10 U.S. government agencies, the “Big Three” auto companies, academia, auto industry suppliers and others.

The program does not explicitly address the challenge of creating a market for these new kinds of vehicles. Last year, the White House submitted a tax-credit bill as part of its budget proposal. The Bill would have provided tax credits to consumers ranging from $4000 for a car with three times the average fuel economy, to $3000 for a vehicle with double the fuel economy. The credits would have declined each year and disappeared by 2010. The Bill was not passed as part of the 1999 budget, but has been proposed by the White House for the budget in 2000.

Corporate Average Fuel-Economy Standards (CAFE)

Fuel-efficiency standards for new vehicles sold in the U.S. first came into affect in 1978 under the Energy Policy and Conservation Act of 1975. CAFE requires manufacturers to achieve targets for fuel consumption, computed as the average for all new passenger vehicles (cars and light trucks) sold annually. (In Canada, manufacturers have agreed to voluntarily match the U.S. fuel-economy standards).

Originally set at 18.0 miles per gallon for cars in 1978, the standard was increased annually until 1985 when it was set at 27.5 miles per gallon, where it has remained. A separate standard for light-duty trucks was implemented in 1990 at 20.0 miles per gallon, rising to its present level of 21.0 miles per gallon in 1996. Manufacturers who fail to meet the target are required to pay a special tax for each vehicle sold in the U.S. that does not meet the standard.

The U.S. is not actively considering changes to its CAFE standards at present, but rather is focusing on the PNGV initiative. In fact, the budget appropriation to the U.S. Department of Transportation for the past four years has expressly prohibited it from making any refinements to CAFE standards.

Transportation Efficiency Act for the 21st Century (TEA-21)

TEA-21 was signed into law in 1998 as a successor to the United States Inter-modal Surface Transportation Efficiency Act (ISTEA). The Bill is funded from gasoline taxes that are collected into a Highway Trust Fund. Funding for TEA-21 is forecasted to be $198-218 billion over the next six years.

Although not explicitly designed to meet climate change objectives, TEA-21 has a number of elements that will help reduce pollution from transportation, including GHG emissions. These include:

- linking federal funding to transportation plans and air quality targets, particularly in areas unable to reach national air quality goals;
- directing a minimum of 20 per cent of the funding to improvements and enhancements to public transportation;
- support for commuter rail and other projects to integrate different modes;
- a 50 per cent increase in funding to Congestion Mitigation and Air Quality initiatives, including measures to reduce transportation demand;
- support for active transportation, such as biking, pedestrian and recreational trails;
- assistance to expand the use of clean-fuel transit buses;
- an increase in the tax exemption for employer-provided transit passes;
- value-pricing pilots to reduce public funding of transportation infrastructure through road pricing, tolls, etc.; and,
- innovative approaches linking transportation and land-use planning.

1990 Clean Air Act (CAA) Amendments
Under 1990 amendments to the Clean Air Act, states with severe smog problems that are unable to meet national air quality standards must develop transportation plans and programs to restrict the growth of vehicle traffic. These standards are also used to place conditions on funding received by states and municipalities under TEA-21. States and cities have developed active transportation demand management programs, drawing from 16 possible measures identified, including:

- improvements to public transit;
- designated lanes for high-occupancy vehicles and buses;
- programs to encourage car pooling and ride sharing;
- trip-reduction programs;
- employer-based transportation and commuting programs; and,
- provision of pedestrian and bicycle paths.

European Union

Transportation Emissions[1]
Under the Kyoto Protocol, Europe would reduce its GHG emissions by 8 per cent over 1990 levels; however, this represents a reduction of 15 per cent over their forecasted emissions in 2010. Transportation represents about 26 per cent of European greenhouse

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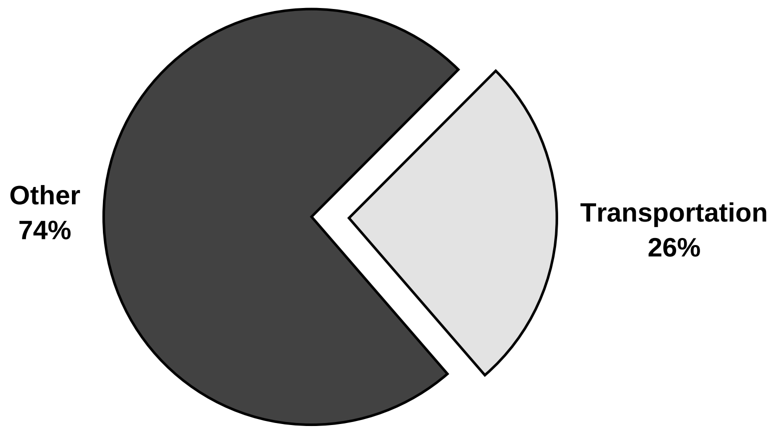
[1] Derived from: *On Transport and CO_2 - Developing a Community Approach.* Communication from the Commission of the European Communities, (COM(1998)204, 1998; The Road From Kyoto: Policy-making for Transport and CO_2 draft manuscript by R. Gorham, M. Landwehr, C. Marie-Lilliu and L. Schipper, International Energy Agency, draft manuscript 1998; and miscellaneous Internet sources.

gas emissions, similar to Canada (25 per cent). However, the on-road share is higher than in Canada, accounting for 85 per cent of all transportation sector emissions.

Chart A6-2
Transportation's Share of Total GHG Emissions - E.U.



GHG emissions from transportation are increasing much more rapidly than in Canada. They increased 37 per cent in the 10 years from 1985 to 1995 and are expected to increase 40 per cent from 1990 levels by 2010. Road vehicles and aviation are the two fastest-growing sources of emissions. Road emissions grew by 36 per cent in the 10 years to 1995 due to increases from cars and truck freight. The aviation sector represents only 12 per cent of European transport emissions, but increased 57 per cent in the 10 years to 1995.

Measures with the most potential across Europe are summarized in Table A 6-1. In addition, a few European and country-specific initiatives are worth noting.

Voluntary Agreement with Automobile Manufacturers

The European Union has established a goal of improving the fuel economy of new cars by 30 per cent. As a result, it has negotiated an agreement with automobile manufacturers to voluntarily reduce greenhouse gas emissions from new cars by an average 25 per cent by 2010. This agreement will be complemented by a program of increased consumer awareness and vehicles taxes as a means of encouraging consumers to buy more fuel-efficient vehicles.

Encouraging Modal Shift in Freight

Europe relies more on truck transport for its freight than North America does, and has expressed its goal of moving more freight by rail and ship. Options being considered include a reduction in railway freight tariffs, deregulation of rail, promoting more open access across national boundaries, and greater technical harmonization of railway standards among countries.

Pricing

The European Union has adopted an objective that prices should reflect the full underlying costs to society that would otherwise not be taken into account by transport users. These include costs related to transportation infrastructure, air and water pollution, GHG emissions, the costs of time delays due to congestion, accident costs and noise pollution. It is estimated that a policy of internalizing all external costs of transportation would reduce CO_2 emissions by 11.5 per cent, with an overall net benefit of between 28-78 billion ECU per year.

Table A6-1. Potential of European Measures to Reduce Transportation Emissions

ACTIONS	MEASURES	ESTIMATED REDUCTIONS (% age of transport emissions in 2010)
Increase fuel-efficiency of cars and light-duty trucks.	Voluntary agreement to reduce GHG emissions in new cars 25% by 2010.	4 - 8%
Passenger transportation	Demand management measures and enhancing public transportation	10-14%
	ITS and traffic flow	3%
	Air charges and taxes	1%
Improve efficiency in freight	Promote modal shift to rail, marine	5%
	Improve road freight logistics, operating efficiencies, technologies	10-14%
Transportation pricing	Higher fuel taxes and/or full-cost pricing of transportation	11%
TOTAL		**35-50% ***

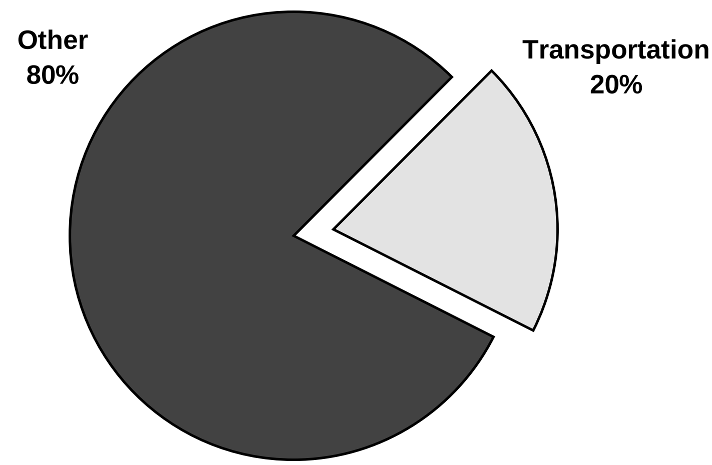
* Note: Totals do not add. Reductions are illustrative and are not necessarily additive.

Japan

Transportation Emissions[2]

Under the Kyoto Protocol, Japan would reduce its GHG emissions by 6 per cent over 1990 levels; however, this represents a reduction of only 12 per cent over its forecasted emissions for 2010. Transportation represents about 20 per cent of Japanese greenhouse gas emissions, somewhat less than in Canada (25 per cent). However, the on-road share is higher than in Canada, accounting for 90 per cent of all transportation sector emissions. GHG emissions from transportation are increasing more rapidly than in Canada, growing by 19 per cent between 1990 and 1996, and expected to be 40 per cent above 1990 levels by 2010 (versus 32 per cent for Canada).

Chart A6-3
Transportation's Share of Total Emissions in Japan



Japan has set a target of reducing the growth in emissions from transportation from 40 per cent to 17 per cent. This will require a reduction of 13 Megatonnes of carbon from a forecast of 81 Mtto 68 Mt of carbon by 2010. In 1998, Japan published its *Guidelines of Measures to Prevent Global Warming* and introduced legislative changes to promote these measures and encourage greater energy efficiency. The measures proposed for transportation are summarized in Table A6-2 and are described below. Information on the costs of different measures is not available.

[2] Derived from a presentation by Shuji Fukumoto, Ministry of Transport, Japan, to the Transportation Research Board conference, Washington D.C., January 1999.

Table A6-2. Summary of Japanese Measures to Reduce Transportation Emissions

ACTIONS	MEASURES	ESTIMATED REDUCTIONS (Megatonnes of Carbon)
Increase fuel efficiency of cars and light-duty trucks.	Targets to increase fuel efficiency 22.8% from 1995 by 2010 Feebates - incentives and taxes based on fuel efficiency.	4.1
Increase fuel efficiency of air, rail and marine	Provide incentives to increase efficiency	0.5
Improve efficiency in freight	Promote modal shift to rail, marine Increase truck loading and size	2.5
Improve public transportation	Improve service Facilities to better integrate modes	1.6
Improve traffic management	Demand management measures Improve traffic flow Intelligent transportation systems Change driver behaviour	4.0
TOTAL		**12.7**

Automobile Efficiency

Japan has established more strict fuel-efficiency targets for automobile manufacturers under 1998 changes to its Law Regarding the Rationalization of Energy Use. Under a "Top-Runners Approach" targets are set higher than the most efficient vehicle in each class. Fuel-efficiency targets(based on 1995 levels) to be achieved by 2010, are:

- a 22.8 per cent increase in fuel efficiency for gasoline cars;
- a 13.2 per cent increase for gasoline light- and medium-duty trucks;
- a 14.9 per cent increase for diesel cars; and,
- a 6.5 per cent increase for diesel light- and medium-duty trucks.

In addition, Japan is studying feebates as a means of reducing consumers' growing demands for larger-sized vehicles. This would include financial incentives to purchase high-efficiency vehicles and a tax on less efficient vehicles.

Opportunities in Freight

Japan also hopes to reduce emissions by about 3.0 Mt in the freight sector. The bulk of this will come from improving the efficiency of trucking by increasing load efficiency from 47 per cent to 50 per cent, and promoting larger trailers sizes. Efficiency improvements in air, rail, and marine, along with measures to shift freight from truck to marine and rail, account for the balance.

Opportunities in Passenger Travel

Japan hopes to reduce emissions by 1.6 Mt by encouraging a shift from automobile use to rail, bus and public transit. This will be achieved by improving rail service, reducing fares, expanding park-and-ride facilities and an expansion of rail and transit lines in cities.

Finally, it hopes to achieve significant savings of 4 Mt through traffic management policies. This includes demand management programs to encourage ride sharing and reduce peak demand, promoting intelligent transportation systems and electronic toll collection, improving traffic flow with changes to signals, and encouraging walking, biking and telecommuting.

Appendix 7

Glossary of Abbreviations

AAGR	Average Annual Growth Rate
AFV	Alternate Fuel Vehicle
BC	British Columbia
CAA	United States Clean Air Act
CAFC	Company Average Fuel Consumption
CCA	Capital Cost Allowance
CN	Canadian National
CNG	Compressed Natural Gas
CMA	Census Metropolitan Area
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CP	Canadian Pacific
DDI	Diesel Direct Injection
GDI	Gasoline Direct Injection
GDP	Gross Domestic Product
CTI	Truck Central Tire Inflation devices
ENGO	Environmental Non-government Organization
FCC	Fuel Consumption Credit
FEM	Fuel- Efficiency Model
GHG	Greenhouse Gases
GHG grams/ pass-km	Grams of Greenhouse Gases per Passenger-Kilometer
GST	Goods and Services Tax
HC	Hydrocarbons
HOV	High- Occupancy Vehicle
HST	Harmonized Sales Tax
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
ITS	Intelligent Transportation Systems
km	Kilometers
LCVs	Long combination Vehicles (a.k.a. long trucks)
LNG	Liquefied Natural Gas
LPG	Propane
LRR	Truck Lower Rolling Resistance tires
MERC	Mobile Source Emission Reduction Credit
MOU	Memorandum of Understanding
Mt	Megatonnes
NAFTA	North American Free Trade Agreement
NEMS	US Department of Energy's National Energy Modelling System
NG	Natural Gas
No_x	Nitrogen Oxides

N_2O	Nitrous Oxide
NPV	Net Present Value
NWT	North West Territories
OHV	Over-Head Valve
PM	Particulate matter
R&D	Research and Development
SO_2	Sulphur Dioxide
SAE	Society of American Engineers
USA	United States of America
US DOE	United States Department of Environment
U.S. PNGV	United States Partnership for a New Generation of Vehicles
VKT	Vehicle Kilometers Traveled
VIA	VIA Rail
VOC	Volatile Organic Compounds
YT	Yukon Territories