GPI Atlantic

Genuine Progress Index for Atlantic Canada / Indice de progrès véritable - Atlantique

MEASURING SUSTAINABLE DEVELOPMENT

APPLICATION OF THE GENUINE PROGRESS INDEX TO NOVA SCOTIA

APPLICATION OF THE GENUINE PROGRESS INDEX APPROACH TO ANALYZING REDUCTION OF GREENHOUSE GAS EMISSIONS IN THE NOVA SCOTIA FREIGHT TRANSPORT SECTOR

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EXECUTIVE SUMMARY

The impetus for this study arose from the desire of leaders in several Nova Scotia Government Departments to 1) take a proactive stance on reduction of greenhouse gases and 2) to find a method for analyzing the impact of various GHG reduction strategies on the environmental, social and economic health of the province. The overall objective is to determine the usefulness of the Genuine Progress Index approach for analyzing and comparing costs and benefits of various greenhouse gas reduction scenarios. Specifically, the study sought to produce a Greenhouse Gas Mitigation Index, which would be a measure of the cost to reduce CO_2 emissions by one tonne in the truck and rail freight transportation sector in Nova Scotia.

The study analyzed for-hire truck traffic and mainline rail traffic along the corridor from Halifax, N.S. to Amherst, N.S. in an effort to determine the potential for GHG emissions reduction through a modal shift of freight from truck to rail. Because the study relied on available statistics, namely Statistics Canada catalogues "Rail in Canada" (which aggregates data for Atlantic Canada) and "Trucking in Canada" (which only includes for-hire trucking companies with annual income greater than $1 million), data limitations were substantial.

Costs and benefits included in the study were property tax; fuel tax; registration fees; license fees; toll fees; infrastructure costs (capital and maintenance); policing costs; administrative costs; costs of air pollution and climate change; accident costs; and costs of fossil fuel depletion. The Income and Expense Statements for Truck and Rail (below), under the Business-as-Usual Scenario and under a Modal Shift from truck to rail, summarize the net societal costs of trucking and rail for the HA-800 freight. Under the business-As-Usual Scenario, net societal costs for trucking are six times those for rail.

The current (1997) modal mix for long-haul freight between Halifax and Amherst is 67% rail and 32% truck. Because the potential for shifting freight from truck to rail is limited by the type of freight shipped, the maximum modal mix possible is 77% rail and 23% truck, which is the recommended modal mix. The change to this modal mix would save roughly $141 million over the 14 years represented here. The cumulative reduction in CO_2 emissions was estimated at 191,750 tonnes. A 10% shift of freight away from truck toward rail would result in an average annual decrease in CO_2 of 13,696 tonnes at a net average annual social benefit of $10 million.

The GHG Mitigation index is estimated at -$715 per tonne of CO_2. It is noted that the recommended modal shift would cause a decrease in total employment remuneration of 12.3%, and trucking remuneration is reduced by 30%.

The modal shift of 10% truck freight to rail is considered a "No Regrets" measure, since it results in net benefits to society. However, it is not a significant measure in the overall challenge of greenhouse gas reduction in Nova Scotia.

The GPI approach to GHG reduction strategies was found to be highly useful and applicable for many different scenarios. The GHG mitigation index allows a means of comparing the effectiveness of many different strategies.

Table ES.1. Income and Expense Statement (1997), Business-As-Usual Scenario, HA-800 Truck And Rail Freight

	Truck	**Rail**
Revenues to Society		
Government Revenues		
- Property Tax		$1,000,000
- Diesel Fuel Tax	$607,867	$321,110
- License Fees	$50,444	
- Registration Fees	$529,000	
- Toll Fees	$2,820,000	
Total Societal Income	**$4,007,311**	**$1,321,110**
Expenses to Society		
Government Costs:		
- Highway Capital Costs	$1,788,569	
- Highway Maintenance Costs	$570,469	
- Policing Costs	$3,295,900	
Administrative Costs	$14,568,200	
- External Costs		
- Accidents	$3,782,720	$1,151,864
- Air Pollution	$7,224,174	$2,357,617
- Climate Change	$1,656,996	$513,624
- Fossil Fuel Depletion	$4,921,648	$2,652,319
Total Societal Expenses	**$37,808,672**	**$6,675,752**
NET PROFIT (EXPENSE)	**($33,801,361)**	**($5,354,642)**
SUM Net Expense Rail and Truck	**($39,156,003)**	

Note: Numbers may not agree exactly with text numbers due to rounding. Total societal income and expenses refer only to those categories included in the study.

Table ES.2. Income and Expense Statement (1997), Recommended Modal Mix Scenario, HA-800 Truck And Rail Freight

	Truck	**Rail**
Revenues to Society		
Government Revenues		
- Property Tax		$1,239,084
- Diesel Fuel Tax	$424,159	$397,934
- License Fees	$35,203	
- Registration Fees	$369,131	
- Toll Fees	$1,967,761	
Total Societal Income	**$2,796,255**	**$1,637,019**
Expenses to Society		
Government Costs:		
- Highway Capital Costs	$1,248,033	
- Highway Maintenance Costs	$398,051	
- Policing Costs	$2,299,824	
Administrative Costs	$10,165,447	
- External Costs		
- Accidents	$2,639,519	$1,427,305
- Air Pollution	$5,040,907	$2,921,385
- Climate Change	$1,156,224	$636,444
- Fossil Fuel Depletion	$3,434,244	$3,286,558
Total Societal Expenses	**$26,382,250**	**$8,271,692**
NET PROFIT (EXPENSE)	**($23,585,996)**	**($6,634,673)**
SUM Net Expense Rail and Truck	**($30,220,669)**	

Note: Numbers may not agree exactly with text numbers due to rounding. Total societal income and expenses refer only to those categories included in the study.

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Needless to say, any errors or misinterpretations, and all viewpoints expressed, are the sole responsibility of the authors and ***GPI****Atlantic.*

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

APTC	Atlantic Provinces Transportation Commission
BAU	Business as Usual
CB&CNS	Cape Breton and Central Nova Scotia Railway Ltd.
CCFM	Canadian Council of Forest Ministers
CN	Canadian National
CO	Carbon Monoxide
CO_2	Carbon Dioxide
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMI	GHG Mitigation Index
GPI	Genuine Progress Index
HA	Halifax to Amherst Route
HA-800	Halifax to Amherst Route (minimum distance of 800km)
HC(s)	Hydrocarbon(s)
IPCC	Intergovernmental Panel on Climate Change
Kt	Kilotonnes
NOx	Nitrogen Oxides
PM	Particulate Matter
PM_{10}	Particulate Matter □10 Millimicrons in Diameter
RMM	Recommended Modal Mix
SO_2	Sulphur Dioxide
UNFCCC	United Nations Framework Convention on Climate Change
UV	Ultraviolet
VOC(s)	Volatile Organic Compound(s)

1. Introduction

Impetus for the Study

The impetus for this study arose from the desire of leaders in several Nova Scotia Government Departments to 1) take a proactive stance on reduction of greenhouse gases and 2) to find a method for analyzing the impact of various greenhouse gas (GHG) reduction strategies on the environmental, social and economic health of the province. In meetings among staff of **GPI***Atlantic* and officials from Nova Scotia Department of Environment, NS Department of Natural Resources, and NS Department of Transportation and Public Works, as well as Environment Canada, Atlantic Region, it was concluded that the Genuine Progress Index (GPI) might provide a broad and fairly comprehensive tool for estimating effectiveness and impacts of different strategies. To test the applicability of the GPI for this purpose, a pilot project was undertaken to determine the potential for reducing greenhouse gases through modal shifts of freight from truck to rail and to determine the impact of such shifts on the environment and the economy of Nova Scotia.

Climate Change and Greenhouse Gases

Climate change and global warming have become the number one item on the environmental agenda, both nationally and internationally. In the 20th Century average global surface air temperature has increased between 0.3 and 0.6°C, an increase that is larger and more rapid than at any other time in history (Suplee 1998). Night-time temperatures over land have increased more than day-time temperatures, and regional changes have also occurred. While recent years have been among the warmest since 1860, even with the cooling effect of the Mt. Pinatubo volcanic eruption (1991), the warming has been greatest over mid-latitude continents, with a few areas of cooling trends, including the North Atlantic Ocean. Precipitation has increased over land in high latitudes of the Northern hemisphere, and global sea level has risen by 10-25cm over the past 100 years. Although regional changes in weather extremes and climate variability are evident, inadequate data exist to detect such trends globally (IPCC 1995).

In this same time period, concentrations of GHGs in the atmosphere have risen dramatically. Since pre-industrial times (about 1750), atmospheric concentrations of CO_2 have increased by 30%, methane by 145%, and nitrous oxide by 15% (IPCC 1995). The Intergovernmental Panel on Climate Change (IPCC) (1995) predicts that maintenance of emissions at 1994 levels would cause an increase in atmospheric concentrations for the next two centuries. By 2050 alone, emissions will have reached twice the pre-industrial concentration (an increase generally referred to as “doubling of CO_2”).

It is estimated that rising CO_2 levels account for 60% of global warming, while increases in methane concentrations are thought to account for 15% of global warming. Because of the long lifetime of greenhouse gases in the atmosphere, today’s emissions can affect atmospheric concentrations for more than 100 years. (Suplee 1998).

Although uncertainties remain with models used to predict climate change, such as General Circulation Models, projections of temperature change for a doubling of CO_2 range from an increase of 1°C to an increase of 3.5°C by 2100. The mid-range estimate is a 2°C increase over 1990 temperature (IPCC 1995). Putting this into a shorter time perspective, the mid-range prediction is for an increase of 1°C to 3.5°C over the next 100 years, as compared to the increase of 0.3-0.6 °C over the past 100 years (Suplee 1998). These temperature changes are not expected to be distributed uniformly: more substantial warming is predicted over Canada, particularly in winter (Environment Canada 1997b).

Resulting warming of the oceans would lead to an increase in sea level of about 50cm from present (1995) levels by 2100. The range of sea level increase predicted by models is 15-95cm. Confidence in global model predictions is high but confidence in regional predictions is low. In both temperature and sea level, regions may differ significantly from global averages. The IPCC (1995) sums up model predictions as follows:

> *"All model simulations, whether they were forced with increased concentrations of greenhouse gases and aerosols or with increased concentrations of greenhouse gases alone, show the following features: greater surface warming of the land than of the sea in winter; a maximum surface warming in high northern latitudes in winter; little surface warming over the Arctic in summer; an enhanced global mean hydrological cycle, and increased precipitation and soil moisture in high latitudes in winter. All these changes are associated with identifiable physical mechanisms."*

Contradictions between measured surface temperatures and climate models with satellite data have been reconciled by allowing for changes in the angle of the satellite over time due to atmospheric drag (Hansen et al. 1998). These reconciliations, however, are based on a satellite record of less than two decades. Gaffen (1998) argues that the reconciliations make little difference in results based on systems that were never designed for climate monitoring. Thus the debate on global warming continues, and conclusions from the present report could be altered as increasingly accurate data and predictions become available.

Recent evidence of a cooling of the earth's upper atmosphere (stratosphere) have been cited as the latest, biggest, and most unequivocal evidence that the earth's climate really is changing (Pearce 1999). The stratosphere (50-90km above the earth's surface) has been cooling by as much as a degree every year for the past 30 years. The connection to global warming of the troposphere (the layer of the atmosphere immediately below the stratosphere) is that when the greenhouse effect causes radiant energy (heat) to be trapped in the troposphere, this heat is no longer available to warm the stratosphere, and the upper atmosphere begins to cool. This cooling is thought to be related to the decrease in the ozone layer in the stratosphere, since the degradation of ozone occurs at lower temperatures. Shindell (cited in Pearce 1999) predicts that the lower stratosphere of the arctic will be 8°C to 10°C colder by 2020 than it would have been without the greenhouse effect and ozone loss will be double what it would have been without the greenhouse effect.

Potential effects of the predicted global warming include (Suplee 1998):

- increased water vapour in air, leading to increased rainfall, more extreme weather events, and uneven distribution of rainfall;
- more serious heat waves;
- collapse of the Atlantic "conveyor belt" system that brings warm water north from the equator, resulting in arctic-like temperatures for much of Northern Europe; and
- sea level rise.

These effects translate into damages to human health, ecosystems, agriculture, fisheries, forestry, and coastal zones. Although these are effects of global climate change, no region is insulated from these impacts.

In the past 30 years, central and northwestern Canada have shown an increase in air surface temperatures up to 0.5°C, while cooling of up to 0.4°C has occurred east of the Labrador Coast (Canadian Climate Program Board and Canadian Global Change Program 1996). Canadian areas of particular sensitivity to climate change are human health, water systems, natural ecological systems, forests (especially boreal forests), coastal ecosystems and coastal zones, and agriculture.

Canada is one of the world's highest emitters of GHGs on both a per capita and a per dollar of GDP basis (Canadian Climate Program Board and the Canadian Global Change Program 1996). Canada's GHG emissions (in CO_2 equivalents) have increased from 567,000 kilotonnes in 1991 to 619,000 kt in 1995 (Jaques et al. 1997). Ninety-one percent of emissions come from stationary fuel combustion (50.6%); mobile fuel combustion (26.7%) and industrial processes (15.1%). These are the areas that offer the greatest opportunity for large reductions in GHG emissions.

Although Canada has 10% of the world's forested area, there is evidence that since the 1980s most of these forests have become a source of CO_2 emissions, rather than a sink [Canadian Council of Forest Ministers (CCFM) 1997].

In the face of potentially damaging and irreversible impacts, the United Nations Framework Convention on Climate Change (UNFCC) adopted the precautionary principle in Article 2 (IPCC 1995), which states that Parties should:

> *"...take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost effective so as to ensure global benefits at the lowest possible cost."*

In terms of mitigating GHG emissions, "No Regrets" measures are those whose benefits equal or exceed their cost to society, not counting the benefits of climate change mitigation. They are measures which are worth doing even without the pressure of mitigating climate change (Canadian Climate Program Board and the Canadian Global Change Program 1996). The IPCC (1995) has stated that "the risk of aggregate net damage from climate change provides an economic rationale for mitigation that goes beyond "no regrets."

Climate Change and Atlantic Canada

The Nova Scotia Action Plan on Climate Change (Government of Nova Scotia 1996) states:

> *"In Atlantic Canada, an enhanced greenhouse effect could lead to shifts in ocean currents resulting in a cooler, wetter climate for Nova Scotia. Implications for forestry and agriculture could be profound. Shifting ocean currents could also cause change in fish migratory patterns."*

Whereas there has been a global warming trend of 0.3-0.6°C, Atlantic Canada has shown a warming trend of only 0.2°C for the period 1895-1995 and for the period 1948-1995, a cooling trend of 0.7 °C (Environment Canada 1997c). Indeed, computer models of ocean circulation show that a cooling effect on regions bounding the North Atlantic is a possible result of global warming (Mellor 1993). Four trends have been shown in the period 1944-1990 (Environment Canada 1997c, p.19):

1) *a decreasing trend in the number of days per year with a maximum temperature above 25°C;*
2) *an increasing trend in the number of days per year with a minimum temperature below -1.5°C;*
3) *an increasing trend in the number of daily precipitation events above 20mm.;*
4) *a very slightly increasing trend in the number of daily snowfall events above 15 cm.*

The Canada Country Study (Environment Canada 1997c) outlined six major areas of climate change sensitivity in the Atlantic Region: fisheries; coastal zone; ecosystems and water resources; agriculture; forestry; and socio-economic dimensions. The conclusions presented are summarized below.

Fisheries

Changes in temperature can have effects on fish growth, spawning and reproduction, distribution, abundance and migration, and catchability and availability. Changes in migration patterns and the timing of various aspects of fish life cycles may have a great impact on productivity of the fishery. Changes in the vertical temperature gradient of the water may lead to changes in the ratio of pelagic fish to ground fish.

Coastal Zone

The potential effects of climate on the Atlantic coastal zone include effects of accelerated sea level rise and effects of variable storminess. Relative sea level is now rising along most parts of the Atlantic Canada coast. Increased flood risk in some areas, coastal erosion in others, and sediment redistribution and coastal sedimentation are likely effects of the rise. Variations in storminess may increase erosion, cause storm-surge flooding, and increase wave energy. Both types of effects would have serious socio-economic impacts, since the rate of coastal property development in Atlantic Canada is on the rise.

Ecosystems and Water Resources

Changes in temperature, greater variations in temperature, and seasonal time shifts may change the normal characteristics of the water cycle, creating problems for human and ecosystem users. Impacts may include habitat loss and decreases in the quantity and quality of water available for human use. Modifications of the ice regime with temperature increases may provide increased convenience to humans but could disrupt some aquatic species that depend on the ice cover for winter survival. Changes in the evapotranspiration balance may lead to lower water tables and to the loss of wetlands. Migratory birds will be particularly susceptible to climate change, through loss of habitat with sea level rise, disruption of the timing in the bird's life cycle, and changes in migratory boundaries.

Agriculture

Atmospheric warming may have both positive and negative impacts on agriculture in the Atlantic Region. Increased temperatures may expand production of corn, soybeans, tree fruits, and specialty crops. Increased precipitation will help to offset effects of drought but may increase susceptibility to foliar-type fungal diseases, which thrive under moist conditions. At the same time, it may increase leaching of nutrients from fields, increase soil erosion, and decrease the number of days available for fieldwork. Milder winters could improve the potential of alfalfa, clover, winter wheat, strawberries, tree fruits and grapes, in some areas. For 1997 and 1998, Nova Scotia experienced unusually dry conditions which led to economic losses for farmers and resulting compensation from government.

Forestry

While increased temperatures may lead to greater forest productivity, it may also lead to greater susceptibility to disease, as well as changes in disturbances such as fire frequency, insect outbreaks, and wind-storm damage. It may also lead to changes in distribution of tree species. One scenario predicts warmer winters and springs but cooler summers for the Maritimes. This could increase the growth rates of conifers, but late frosts or early extended thaws may be more damaging to hardwood species.

Socio-Economic Dimensions

Economic predictions of climate change impacts, particularly at a regional level, are fraught with uncertainties. With that in mind, predictions have been made for economic impacts on agriculture and forestry. Damage from climate change is expected to produce a decrease of 2% to 10% of the current agricultural GDP in Atlantic Canada. Forestry yields are expected to increase between 7.5% and 15%.

While predictions have not been made for the fishery, the well-known sensitivity of the Atlantic Canada fishery to environmental factors make it likely that there will be decreases in productivity and other disruptions to the fishery. Other socio-economic dimensions include impacts on marine transportation, on offshore oil and gas development, and on energy sources and demand.

Human health impacts of climate change include those caused by temperature extremes, extreme weather events, increase in vector-borne diseases, decreased water quality and quantity, and risks from increased UV radiation from the sun. Fossil fuel use also causes an increase in air pollution and increase in acid rain. Environment Canada recently announced (CBC Radio, April 15, 1999) that in the spring and summer of 1999 there will be up to a 5% greater than usual amount of UV radiation from the sun and warned citizens to take extra precautions to prevent unnecessary exposure to the sun.

Canadian Kyoto Commitments

In spite of the uncertainties related to causes, effects, and costs of global warming, the Kyoto Protocol to the UNFCC, acting on the precautionary principle, established the target of reducing overall global emissions of GHG by at least 5% below 1990 levels in the period 2008-2012, with ratifying parties agreeing to demonstrable progress in achieving their commitments by 2005. Clearly, in assessing levels of atmospheric CO_2, the issue of sinks is as important as that of emissions, as recognized in the Kyoto Protocol. The protocol states in Article 3.3:

> *"The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8."*

In this regard, it is important to note that the most recent data released from CCFM (1998) indicated that Canadian forests may be net GHG emitters rather than sinks. Although thirty six countries signed the agreement on April 29, 1998, in order for the agreement to be ratified and come into force, 55 countries, representing 50% of global GHG emissions, must make commitments to emission reductions.

Canada signed the Kyoto Agreement on April 29, 1998, agreeing to a reduction of GHG emissions to 6% below 1990 levels but will not ratify the agreement until there is an implementation plan (Bangay 1998). This translates into an annual emissions goal of 532,980 kt in Canada, a decrease of 13.9% decrease from 1995 levels. If emissions continue unabated, considering predicted economic growth, it is predicted that Canada will need to reduce its emissions by 25% in 2010 in order to meet this target. In other words, the longer the problem goes unabated, the greater the reduction that will be required.

While Environment Canada has committed to spending $150 million over three years and is starting to develop a strategy for implementation, the Commissioner for the Environment and Sustainable Development in the Office of the Auditor General has filed a report saying that the government has shown no indication it can deal with the causes of climate change and pointing out that there has been little concrete action at the federal level so far (Bueckert 1998). The report predicts Ottawa will not meet its 1992 commitment to stabilize emissions at 1990 levels by 2000 because of poor planning and ineffective management. Since the Auditor General's report, the federal government has instituted the Climate Change Process, under which are established a number of tables to determine the best options for reducing greenhouse gases in a number of sectors.

On April 24, 1998, the Canadian federal, provincial and territorial ministers of energy and environment met to discuss how to implement the Kyoto agreement. In addition to approving mechanisms for stakeholder input and strategy development, the ministers agreed to establish by 1999 a "system for crediting verifiable early action to reduce greenhouse gas emissions against any future emission obligations" (Joint Meeting of Federal, Provincial and Territorial Ministers of Energy and Environment 1998). Recognizing the strength of the Voluntary Challenge and Registry Program, they agreed to publicly recognize "good performers" in reducing GHG emissions and to instigate further incentives for voluntary action.

Nova Scotia's Greenhouse Gases Emissions

The present study examines GHG emissions, not atmospheric concentrations. Although atmospheric concentrations of GHGs are not currently measured in Nova Scotia, they are not necessarily related to emissions in Nova Scotia since Nova Scotia receives emissions from the U.S. and central Canada as a result of prevailing winds. Thus, in addressing GHG reduction, Nova Scotians are being asked to take local action to respond to a global problem. Nova Scotians will not reap immediate benefits from GHG reduction, although we might reap benefits from money that is saved as a result of GHG reduction. From an economic point of view, the advantage for Nova Scotia taking action to reduce greenhouse gases is to become a model that other jurisdictions could follow.

In 1995, Nova Scotia GHG emissions were 18,600 Kt CO_2 equivalents, compared with 18,800 in 1991 (Jaques et al. 1997). This amounts to 3% of national emissions or 19 tonnes per capita, as compared to 20 tonnes per capita nationally. Thirty percent of these emissions come from mobile sources. Rail accounts for 43 Kt and heavy-duty diesel trucks account for 818 Kt. Together these two sources comprise 16 % of mobile emissions and 4.8% of total GHG emissions in Nova Scotia. Of the total GHG emissions in Canada from the transportation sector, Nova Scotia emissions account for 3.4% (National Climate Change Process 1998).

The Nova Scotia Action Plan on Climate Change outlined initiatives for GHG abatement in provincial government, energy management, transportation, coal research and development, alternative energy, forest productivity, agriculture, pollution prevention and solid waste management.

Other studies offering options for GHG emission reduction are "Policy Tools for Combating Greenhouse Gas emissions in Nova Scotia" (CEF Consultants 1994), "Energy Strategy 1991" (Government of Nova Scotia 1991) and "Private Woodlot Management in the Maritimes" [National Round Table on the Environment and the Economy (NRTEE) 1997a].

While regional and provincial responsibilities for emission reductions have not been specifically addressed in Canada, one of the principles of the Joint Ministers Meeting was that no region should have to bear an unreasonable burden for the reductions. Therefore, even though Nova Scotia is responsible for only 3% of the GHG emissions, it is likely that the province will be asked to help offset the emission reduction requirements for provinces such as Alberta and Ontario, where emissions are much higher. This could have a significant impact on economic development in Nova Scotia, which is heavily dependent on fossil fuels. On a per capita basis, federal policies could have significant negative impact, since Nova Scotians are relatively high per capita emitters of GHG.

Principles of Full Cost Accounting

A fundamental principle of full cost accounting is that economic efficiency and accurate assessments of costs and benefits is enhanced to the degree that:

- fixed costs become variable, based on usage;
- external costs are internalized; and
- non-market costs are incorporated into market prices.

Of all methods of bringing this about, the actual accounting framework used by government (as opposed to the private sector) is most amenable to moving in the direction of fuller-cost accounting.

Three sequential steps in terms of institutional change toward full-cost accounting are:

1) changing how government keeps its accounts;
2) legislative steps by government to move the market towards fuller cost accounting through incentives and penalties related to environmental and social costs; and
3) change in market prices to reflect full social and environmental costs.

The Genuine Progress Index

The Genuine Progress Index (GPI) contributes primarily to the first step above by placing economic values on social and environmental costs and benefits of societal activities. The GPI approach holds that environmental and social costs should be built into all economic development decisions so as to favour those developments that have the least environmental and social costs.

The GPI approach is being tested in this study as a method for evaluating effectiveness and impacts of GHG reduction strategies. The GPI is a comprehensive measure of progress that integrates social, environmental, and economic factors, estimates monetary values for service flows from human and natural resources according to full cost accounting methods, and assigns a monetary value to human and natural resources, in order to link their values to conventional economic accounts. The GPI treats these resources as capital stocks and develops measures for estimating the extent of their increase or decrease on an annual basis. It accounts for depreciation or reinvestment in human and natural capital just as investment-based accounting presently assesses the value of produced capital assets.

The GPI, when fully developed, will thus provide a more complete picture of society's progress on an annual basis than short-term market statistics alone are able to do. Although the full annual GPI is in the development stage and will not be completed before the year 2000, the principles of the approach used by the GPI can be applied to any projects for which a broader analysis of the social, environmental, and economic costs and benefits is required.

The Gross Domestic Product (GDP), introduced during the Second World War for the purpose of measuring total wartime production has come to be used as a standard yardstick for measuring progress. Because the GDP excludes nonmonetary production, value of leisure time, income distribution, quality of life, and natural resource conservation and degradation, and because it fails to distinguish economic activities that contribute to well-being and prosperity form those that cause harm, it is inadequate as a measure of true, genuine progress. As Robert Kennedy has remarked, the GDP counts the cost of crime, sickness, road accidents, pollution, resource depletion, and other liabilities as contributions to economic growth and progress and therefore "measures everything, in short, except that which makes life worthwhile."

Since the early 1970's, efforts have been underway internationally to expand the scope of measuring progress. In "The System of National Accounts 1993," the United Nations, World Bank, International Monetary Fund, OECD, and the Commission of the European Committee prescribe international guidelines stating that natural resources should be incorporated into government balance sheet accounts. In 1997, Statistics Canada released the Canadian System of Environmental and Resource Accounts, which will be incorporated into Canada's national balance sheets and input-output accounts (Statistics Canada 1997a). A major goal of Statistics Canada's new Environmental Protection Expenditure Accounts is to "provide those who might be interested in calculating an environmentally-adjusted GDP along these lines with the information necessary to do so" (Statistics Canada 1997).

The Nova Scotia Strategy for Sustainable Development prepared by the Provincial Round Table on Environment and Economy clearly recognized that, until environmental “externalities” are fully incorporated into the province’s financial structure, pricing mechanisms, and economic accounting framework, these systems would continue to send misleading signals to policy makers and promote unsustainable behavior” (Nova Scotia Round Table on the Environment and the Economy 1992).

The Nova Scotia GPI integrates 22 social, economic and environmental components into a comprehensive measure of sustainable development for the province. To this end, the Nova Scotia GPI includes valuation of natural, human, and social capital for the following areas:

Time Use:

* Economic Value of Civic and Voluntary Work
* Economic Value of Unpaid Housework and Childcare
* Costs of Underemployment
* Value of Leisure Time

Natural Capital:

* Soils and Agriculture
* Forests
* Marine Environment/Fisheries
* Nonrenewable Subsoil Assets

Environment:

* Greenhouse Gas Emissions
* Sustainable Transportation
* Ecological Footprint Analysis
* Air Quality
* Water Quality
* Solid Waste

Socioeconomic:

* Income Distribution
* Debt, External Borrowing and Capital Movements
* Valuations of Durability
* Composite Livelihood Security Index

Social Capital:

* Health Care
* Educational Attainment
* Costs of Crime
* Human Freedom Index

Statistics Canada has designated the Nova Scotia GPI project as a pilot project for other Canadian provinces. Nova Scotia can lead the way not only by further developing a framework for valuing natural and human resource capital, but also by using these accounts as indicators of sustainability and by identifying data gaps or other barriers to monetizing the accounts. It should be noted that estimation of monetary values is not an end in itself but a necessary means to integrate environmental or social variables into the conventional economic accounts and eventually into pricing, taxation, and other financial structures. Monetary accounts in the GPI project are always based on physical accounts.

2. Scope of The Study and Project Objectives

Scope of the Project

Because GHG emissions result in long-term global consequences, rather than immediate local or regional impacts, emissions estimates are usually carried out on large national or international levels (Jaques 1997). Likewise, estimates of the cost of reducing emissions, or mitigating their effects, have mostly been carried out at this level. Since the most effective actions are likely to be those at a regional or provincial level, and since provincial governments will be required to respond to federal initiatives, cost effectiveness studies must also be conducted at the provincial level. The present study, using the GPI approach, applies some of the methods used in national studies to study cost effectiveness at the provincial level.

The pilot project chosen is a study of the costs and benefits of reducing greenhouse gas emissions in Nova Scotia through a shift in freight traffic from truck to rail. This study was chosen because it is well known that greenhouse gas emissions per tonne of rail freight are much lower than those for truck freight.

Since the present project is limited in scope and funding, it was approached as a case study. Since rail is competitive with truck only at distances greater than 800-1000 km (see Section 3), the shift in freight chosen for the study is long-haul freight. The freight qualifying for these terms in Nova Scotia is the freight between the Port of Halifax and Quebec (and points west). The segment of Nova Scotia rail and highway considered in this study is therefore the corridor between Halifax and Amherst, and the freight considered is freight being shipped a distance of at least 800 km. The route and the freight used are referred to as “HA-800.” This route is the only mainline rail in the province. The highway segment comprises 24 % (428 of 1,750 2-lane equivalent km) of the total km of 100-series highways in the province and 3% of two-lane equivalent km of paved road in Nova Scotia. The highway route between Halifax and Truro is said to be the most heavily traveled highway segment east of Montreal.

Additional reasons for choosing this transportation corridor are: 1) it allows use of statistics on shipping from and to Halifax (without surveying the shippers) and 2) it is small enough to be completed within the scope of the study. The importance of short-line rail to Nova Scotia is recognized but is not analyzed in this study.

This study estimates the shift in freight from truck to rail that will produce the greatest GHG reduction at the lowest social and economic cost and develops an index which can be used to compare the relative cost of different greenhouse gas mitigation measures. This ***GHG MitigationIndex*** is the net additional cost required to effect the desired market shift of freight from truck to rail, expressed as cost per tonne of CO_2[1] emission reduction. This index expresses the net cost of CO_2 reduction, taking into account both reductions in overall costs as a result of the shift and any increases in cost (based on freight demand factors) necessary to bring about this market shift.

The time frame of the study is 1997-2010. This time frame was chosen because 1997 is the most recent year for which reliable data and statistics are available and projections of market forces and increases in freight are available to the year 2010. All costs are expressed in 1997 dollars.

Project Objectives

The overall objective is to determine the usefulness of the GPI approach for analyzing and comparing costs and benefits of various greenhouse gas reduction scenarios. Specific objectives are:

1) To develop a ***GHG Mitigation Index*** for transportation modal freight shifts that can subsequently be used to compare efficacy of mitigation measures in other sectors of the economy;[2]
2) To estimate the optimal modal mix of rail and truck freight for reducing greenhouse gas emissions in Nova Scotia at the lowest total cost;
3) To estimate additional user fees that would be required to obtain the required shift of freight from truck to rail, stated in terms of costs per tonne of CO_2 reduction; and
4) To comment on the potential impact of the modal shift on employment in Nova Scotia and to suggest policies that have been effective in achieving such a modal shift in other jurisdictions.

Data Limitations

Because Nova Scotia is a relatively small province, much of the shipping data (especially in the rail sector) is confidential and is only reported at the level of the Atlantic provinces. Therefore many assumptions and extrapolations were necessary to determine estimates of tonne-km hauled along this corridor and estimates of costs per tonne-km. One of the biggest limitations of the freight tonnage data is that they do not distinguish intermodal shipments, which are thought to be steadily increasing. Data on many of the costs that were estimated were available only on a provincial level, and therefore extrapolations were used to determine the portion of the provincial estimates that should be applied to the HA-800. In each section of the report, the data limitations are made clear and the methods of extrapolating are clearly outlined. It is hoped that this transparency will allow improved updates of these results as better data become available.

[1] "CO_2" is used throughout the document to refer to "CO_2 equivalents," defined as all greenhouse gas emissions converted to the equivalent global warming of one tonne of CO_2

[2] Since the costs and benefits of GHG mitigation in other Nova Scotian sectors have not been analyzed, the comparison cannot be made in this study. Such a comparison would require additional research.

To gain a more realistic and complete picture of the potential for GHG reduction through modal shifts, it would be necessary to conduct a detailed shippers' survey. Increasing options provided by new technologies in truck, rail, and intermodal shipments make the situation much more complicated than the truck versus rail scenario presented here. Changes in shippers' behaviour as a result of these new options can only be discerned by surveys.

Nonetheless, the present study serves as a useful scoping exercise for GHG reduction in one corridor of Nova Scotia and demonstrates the usefulness of the GPI as an approach to the challenge of analyzing strategies for reduction of GHG emissions.

Structure of the Report

Section 3 of the report includes a literature review assessing the cost of climate change generally; full cost transportation studies in Canada; and the truck and rail freight transportation industries in Canada and Nova Scotia.

Section 4 presents the methodology, data sources, and input data for the study. For each parameter estimated, data sources, extrapolations used, and data limitations are explained

Section 5 presents the results of the study. It begins with a description of 1997 freight tonnage along the HA-corridor and a discussion of the potential for transferring freight from truck to rail. Next is presented a comparison of current (1997) societal and government costs (including costs of GHG emissions) for truck and rail freight along the HA-800 corridor. From these costs and emissions, the optimal modal mix of truck and rail freight is presented. Based on this modal shift, projections of costs and greenhouse gas emissions to the year 2010 [under a "business as usual" (BAU) scenario and under the modal shift scenario] are then presented.

Section 6 summarizes several conclusions that may be drawn from the results:

- the magnitude of the potential GHG reduction for the HA-800 corridor;
- the impact of such a reduction on Nova Scotia Society;
- additional user costs necessary to effect the modal shift recommended;
- the GHG Mitigation Index for the HA-800 corridor; and
- conclusions on the usefulness of the GPI approach and its potential application to other GHG reduction scenarios.

The section ends with a discussion of successful policies used in other jurisdictions to effect modal shifts, as well as recommendations for further study.

3. Literature Review

Assessing the Costs of Climate Change

Range of Cost Estimates

Assessing the costs of climate change is a subject of great controversy, even when there is agreement on the degree of predicted change. Damage costs of emissions, called "shadow prices", are based on estimates of the cost of the wide range of potential effects of global warming (Bein, 1996) and can be as high as $1,000 per tonne of CO_2 (US 1990 $). Cline (1995) found a reasonable range for the price of environmental damage from global warming to be $20-$50 per tonne of CO_2 (US 1990$). Obviously, estimates of the damage cost depend on the baseline emissions used and the time frame examined.

The challenge of trying to assess the value of projected damage is onerous, and most investigators opt for assessing the cost of controlling emissions of greenhouse gases. Even within this approach, estimates of the cost of removing a tonne of CO_2 equivalents vary from negative costs to $200 per tonne, largely depending on the assumptions held and on compatibility between new and existing technologies. This is not surprising since proposals for reducing greenhouse gases must rely on beliefs about market behaviour and political realities, both of which are functions of that unpredictable quality, human behavior.

Repetto and Austin (1997) analyzed 16 leading simulation models that estimate the cost of controlling greenhouse gases as a percentage of the GDP (U.S.). Included were top-down models and bottom-up models. The top-down models are aggregate pictures of the whole economy, based on the sale of goods and services by producers and the flow of labour and investment funds from households to industries. They include "computable general equilibrium" models that are based on market supply and demand and on the assumption that consumers and producers allocate their resources to maximize their welfare or profits. Top-down models also include optimizing models that are based on statistical behaviour in the past. The top-down models are useful for predicting long-term effects of policy options.

"Bottom-Up" models analyze the technological options for energy savings and fuel switching by industrial sector and then aggregate them to calculate the overall cost to the economy of reducing greenhouse gas emissions. The bottom-up models tend to be more optimistic, partly because they may overlook barriers to implementation, such as management and retraining time, risk-aversion, and household preferences.

Arguments for a zero cost of reducing emissions are based on offsetting benefits of the measures. Indeed there are many examples of energy savings producing financial benefits, as cited by Lovins and Lovins (1997):

- Dupont expects to save the equivalent of 18 million tonnes of CO_2 by the year 2000 through simple measures that will also save $31 million each year.
- Energy saving projects at Dow Chemical in Louisiana produced returns on investment of 204%.
- A process innovation at Blandin Paper Company saved 37,000 tonnes of CO_2 per year and more than $1.8 million.

While these examples tend to promote optimism about the cost of reducing CO_2 emissions, other studies have shown cause for caution. A top-down study that helped establish Canada's negotiating position at the Kyoto conference (Standard and Poor's DRI study, discussed in: Holling and Somerville 1998), showed that measures to stabilize emissions at 1990 levels by 2010 would depress the GDP by about 2% for the first decade, after which it would recover to "business-as-usual" levels. Several scenarios used indicated that there would be a transition cost on the economy but that the long-term productive capacity of the economy would not be significantly affected.

Holling (1997) expresses the need for caution:

> *"Optimistic forecasts imagine a clearly logical decision maker making the most logical cost/benefit choices, with the least incentive, in the most rapid way. More pessimistic forecasts imagine confused, uncertain decision makers, caught by past investments and momentum, who will only change when sharp increases in prices provide little alternative. This is not a question of science or economics but of behaviour of individuals and organizations. How can we better understand the sources of novelty and of the processes by which individuals and organizations either smother or release novelty?"*

A useful benchmark in the discussion is the marginal cost of "backstop technology," or non-carbon substitutes, which it is estimated will be available by the second half of the 21st century at a cost of $65 (US 1990$) per tonne of CO_2 replaced (cited in Cline 1996). The IPCC (1995) has not recommended a particular value for the cost of either the damage caused by CO_2 or the mitigation costs.

Table 1 presents a range of estimates of the damage costs and reduction costs of one tonne CO_2, from a variety of representative sources. Both damage and mitigation costs will increase as the delay in implementing GHG reduction measures increases. It is beyond the scope of the present study to delve into a discussion of the many types of assumptions used about the extent of global warming and the market assumptions used to derive these values. In a situation of widely varying estimates, it is perhaps best to use a range of values for the cost or reducing GHG emissions, but also to use the precautionary principle. The impacts of climate change are only beginning to be understood, and the element of surprise that could cause effects to increase or decrease by orders of magnitude must be taken into consideration.

In the long run, reducing GHG emissions requires the development of renewable energy sources, necessitated by the depletion of non-renewable sources. In the meantime, the present study takes a moderate view by choosing values that are neither overly optimistic nor pessimistic: $10; $35; and $96.

Table 1. Estimate of Damage Costs and Costs of Mitigating One Tonne of CO_2

Type of Estimate	Amount per tonne CO_2	Amount (1997$C)
Damage Costs (Cline 1996)	$20-$50 (1990$US)	$38-$96
Damage Costs (Bein 1997)	$1,000 (1995$C)	$1,040
Control Costs (IBI 1996)	$34 (1995$C)	$35
Control Costs; Klein (1998)	$10 (1997$C)	$10
Backstop Technology (Cline 1995)	$65 (1990$C)	$124

Discounting

The second controversial area in assessing the cost of climate change is the ratio of present value to future value. Discounting is the process by which total social costs and benefits in different years are converted to a common metric so that they can be properly compared to one another. Based on the assumption that a dollar in-hand now is worth more to people than a dollar received in the future, economists often apply a discount rate to future values in order to show the costs of changing climate over time in present day dollars. The question of discount rates is controversial and depends on how the future is valued by decision-makers in the present. The discount rate is an expression of society's willingness to trade the future for the present. If the needs of the present generation are considered paramount, then the future value of costs and benefits is correspondingly low and the discount rate is high. If a high value is placed on costs and benefits for future generations, the discount rate is low.

It can be argued that the discount rate for environmental studies should be zero, if we wish to leave behind environmental resources for future generations (Environment Canada 1997b). This is especially true when project impacts may lead to irreversible outcomes. The discount rate chosen can have an enormous impact on the outcome of studies, particularly those with a long time range (50 years or longer). The Treasury Board of Canada recommends a 10% discount rate for economic studies that involve future projections based on present-day costs or benefits.

Full-Cost Transportation Studies in Canada

For the purposes of this study it is understood that any recommended modal mix of rail and truck freight must be sustainable, which according to NRTEE (1997) means that it:

- allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health and with equity within and between generations;
- is affordable, operates efficiently, offers a choice of transport mode, and supports a vibrant economy; and

- limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise.

Full cost accounting is based on the idea that the economy would benefit if each enterprise recovered all its costs from consumers (Lee 1995). The question of whether highway users pay their way, when environmental and social costs are taken into account has spawned many studies on full-cost accounting for highways, more on passenger traffic than on freight traffic.

Full cost accounting for transportation includes not only traditional costs but also costs that have been termed "external", which are a result of transportation activities and affect the welfare of the general public without any compensation or payment being made (Button 1993). Although these costs are often difficult to quantify and monetize, by ignoring them, a monetary value of zero is placed on them. This practice gives an inaccurate picture of the real costs of transportation. Some external costs related to transportation include the costs of accidents, pollution, noise, traffic congestion, land use, and the costs of transportation's contribution to global warming. Lee (1995) summarizes four categories of transportation costs: expenditures, opportunity costs of capital assets, externalities, and social overhead.

Litman (1997) studied the following internal (borne by user) and external (borne by others) costs for passenger transportation:

Internal

- Vehicle ownership
- Vehicle operating
- Travel time
- Internal accident
- Internal parking

External

- Operating subsidies
- External accident
- External parking
- Congestion
- Road facilities
- Roadway land value
- Municipal services
- Opportunity loss of equity
- Air pollution
- Noise
- Resource consumption
- Barrier effect (increased travel time and inconvenience)
- Land use impacts
- Water pollution
- Waste disposal
- Climate change

This classification of transportation costs includes both market and non-market costs.

Six studies were reviewed in detail that are related to full-costing of freight transportation in Canada:

- Royal Commisssion on Passenger Transportation 1991. "*Directions: The Final Report of the Royal Commission on National Passenger Transportation*."
- Khan, 1991. "*Energy and Environmental Factors in Freight Transportation*."

- IBI Group 1995. "*Full Cost Transportation and Cost-Based Pricing Strategies*."
- Transmode Consultants Inc. 1995. "*Ontario Freight Movement Study*."
- Transport Concepts 1993. "*External Costs of Truck and Train*."
- Bein 1997 (B.C. Ministry of Environment). "*Monetization of Environmental Impacts of Roads*."

Royal Commissison Report

The Royal Commission Report is an exhaustive, four- volume study that focused primarily on passenger transportation but did include some analysis of freight transportation. Two recommendations related to freight costs were that provincial and territorial governments institute axle weight and distance taxes for trucks and that conventional tolling systems be considered in new or expanded highways. In terms of emissions, the Commission recommended that regulations be set so as to impose similar obligations in terms of costs per unit of emission abatement on each mode.

The study examined road costing practices, taking into consideration that the principle pavement used in Canada is a flexible pavement, whereas rigid pavements are more common in the U.S., where many of the road costing studies have been done. In Atlantic Canada the poor quality sub-grades require thicker pavements than in some other provinces. Generally flexible pavement in Canada will be resurfaced twice in 40-50 years before a decision is made to reconstruct the pavement.

In order to apportion road costs among different transportation modes, it is necessary to estimate the relative costs of damage caused by the mode.

The principle mechanisms contributing to deterioration of pavements are the stresses posed by heavy axle loads and by freeze-thaw cycles. Using the concept of load equivalency, the report states that one 10,000kg truck axle (the maximum load limit in three Canadian jurisdictions) does 160,000 times as much damage to a flexible pavement as a car axle load of 500kg. The relative contribution of heavy axle loads and environmental conditions to the deterioration of pavements depends on several factors, including the harshness of the environment, the average axle loads, the volume of traffic, and the type of pavement constructed. Generally, where traffic volume is light, environmental factors are thought to be the major contributor to deterioration, and where traffic volume is heavy, axle-weight is a more important contributor. The study concludes that even on high-volume roads, environmental conditions may account for up to 50% of road deterioration.

Generally the costs of road deterioration are distributed among different modes of transportation based on their relative volumes. Small et al. (1989) state categorically that it is the weight per axle that matters in the amount of damage inflicted on roads. They report on studies that conclude a) that time and weathering merely exacerbate the damage done by traffic loadings and b) that climate has an effect independent of traffic load, especially in moist freezing climates. According to discussions with engineers in the Nova Scotia Department of Transportation, almost all the damage done to asphalt pavements is from heavy trucks.

Ontario Freight Movement Study

Transmode Consultants (1995) examined three options for improving energy efficiency and emissions of truck and rail freight in Ontario. The options included technology improvements; changes in operating prices; and modal shifts. The study used a life-cycle costing method for GHG emissions, which adjusted emission totals to account for emissions created during the extraction, refinement and distribution of the fuels. Previously reported fuel efficiency estimates in the literature varied by a factor of 12. The Transmode Study calculated energy efficiency of inter-city diesel trucks at 61.4 tonne-km per litre. A shift of one-third of truck shipments to intermodal caused a decrease in emissions of 19% between 2000 and 2010. The study found that combinations of all options analyzed could not offset the impact of increased growth in freight transportation. With more moderate growth in freight, a combination of all options examined would allow Ontario to meet its emission reduction targets.

Full Cost Transportation and Cost-Based Pricing Strategies

The study by IBI (1995) examined the extent to which users of each transportation mode in Canada and Ontario bear the full cost of each mode and assessed the implications of pricing and related initiatives to encourage use of more sustainable modes in Ontario. User charges were defined as the sum of fares and tariffs paid by users to transportation carriers and the full capital and operating costs borne by the users (such as car and fuel costs). While the study focused on passenger transportation, some aspects of freight transportation were included. IBI considered three categories of costs for inter-city freight in Canada: user fees, government subsidies, and external costs (which include accidents and airborne emissions (including carbon dioxide). Government subsidies are defined as government transportation expenditures (such as infrastructure costs) minus government revenues. For government expenditures plus external costs, IBI calculated a cost of 2.88 cents per tonne-km. for intercity truck freight and a cost of 0.424 cents per tonne-km. for intercity rail freight.

Strategies for GHG reduction examined involved increased user charges, reducing basic subsidies, and reducing external costs. Long term (1994-2015) strategies relevant to freight transportation included fuel/tailpipe emissions premiums, a weight-distance tax, and promotion of intermodal freight transportation. With the long-term strategies, taking ionto consideration projected growth in freight transportation, a decrease of 26% CO_2 , compared with projected base case scenario, could be accomplished by 2015. In comparison to 1994 levels, however, this represents a 26% *increase* in CO_2 emissions. As in the Transmode study, it was concluded that while various strategies can reduce overall emissions, no strategy or combination of strategies was able to offset the effect of growth in vehicle-km in the longer term (1994-2015).

Energy and Environmental Factors in Freight Transportation

Khan (1991) developed energy efficiency estimates for different modes of freight transportation and examined impacts of modal shifts and changes in weights and dimensions regulations. Over the Montreal-Toronto route, a comparison of intermodal options with all-highway options showed that the intermodal is more than twice as efficient as truck transport alone. The study examined energy and emissions implications for 1) BAU (1988); 2) inclusion of weight and dimension regulations (that were not in place at the time); 3) a 10% reduction in the cost of rail freight; and 4) a combination of #2 and #3. Three markets were examined: Ontario-Quebec; Ontario-B.C.; and Ontario-Manitoba. The study also examined the effect of emissions controls expected to be in effect in 1995. The weight and dimension regulations were expected to lower trucking costs and thereby cause some shift of freight from rail to truck. The magnitude of the modal shift would depend on the commodity and the length of haul. In terms of modal share, it was found that the combination of #2 and #3 would restore the original balance of rail and truck freight, after the predicted decrease in truck rates. This scenario would decrease total freight costs by 27-30% and would decrease CO_2 emissions by 28%, as compared with the 1988 base case (BAU).

External Costs of Truck and Train

The Transport Concepts (1993) study examined the following external costs of truck and rail freight: accidents; pollution; congestion; infrastructure; cash subsidy; fuel taxes and license fees; and property taxes on rail corridors. Internal costs included vehicle costs, own accident risk, and accident costs covered by insurance. Overall average external costs of inter-city trucking were estimated at $.0215 per tonne-km. and for rail freight, $0.0051 per tonne-km. Road infrastructure costs due to big trucks was estimated at $0.0069 per tonne-km.for tractor-trailers and $0.0052 per tonne-km.for double trailers. The study concluded that a shift of 10% of truck freight to rail in Canada would save $230 million annually; a 20% shift would save $459 million; and a 30% shift would save $689 million. A U.S. study cited apportioned 41% of highway infrastructure costs to heavy trucks. The authors recommend increasing user fees and subsidizing rail infrastructure to help effect such a shift.

Monetization of Environmental Impacts of Roads

The B.C. Monetization Study (Bein 1997) sought to establish appropriate and defensible per unit costs for different environmental impacts of transportation and to identify the values that cannot be monetized. The study examined costing of greenhouse gases; air pollutants; noise and vibrations; land use impacts; resources and energy (does not include opportunity cost of non-renewable fossil fuel); waste disposal; water pollution; barrier effects (increased travel time, etc.); and impacts on biodiversity. These costs are expressed as dollars per kilometre driven, per person affected, per hectare of land, or per tonne of greenhouse gases and pollutants.

The author points out that, since average alternative use of resources in other industrial or public projects is rarely known, transportation project costs are usually assessed in terms of comparison to a “do nothing” or “business as usual” scenario. Criticism of a market-based approach to transportation costing is that it fails to take into account the uncertainty of ecosystem functioning; the irreversibility of some natural resource degradation or loss; and the critical nature of some natural components for which man-made capital cannot be substituted. The author argues for a damage cost approach to environmental impacts of transportation, stating that control cost estimates are usually inappropriate for determining total environmental impact costs.

Newer methods of discounting to account for intergenerational equity are discussed. Emissions calculations are based on those presented by Khan (1991) and Transport Concepts (1991). Shadow pricing for one tonne of CO_2 shows that the shadow price is heavily dependent on discounting rate and on value judgments, such as the monetary value of a human life. Using a precautionary approach and a worst-case scenario, the cost of damage incurred from one tonne of CO_2 is set at $1,000 (C$ 1989). Overall, this study points out the inadequacies of previous methods to account for total environmental impact of transportation.

Rail and Truck Freight Industries in Canada and Nova Scotia

Over the past 20 years, the Canadian transportation system has undergone massive changes, including [Atlantic Provinces Transportation Commission (APTC) 1996a]:

- Privatization of CN Rail;
- Sale of branch lines to independent operators;
- Abandonment of rail lines;
- Increase in intermodal systems;
- Double-stacking on rail cars; and
- Trucking industry becoming a strong competitor for long-haul movements.
- Trucking industry now handling majority of freight in Atlantic Canada.

Free trade, deregulation, loss of freight subsidies, and technological innovations have all contributed to these changes.

Canadian Trucking Industry

The Canadian trucking industry consists of three types of carriers:

- *For-Hire Carriers*: firms that maintain their own fleets; account for about 50% of all commercial truck freight movements in Canada ;
- *Private Carriers*: firms that maintain their own fleets; and
- *Owner Operators*: can work for private or for-hire carriers.

Most private trucking is local. Companies with private fleets are usually retail distributors of consumer goods, chemical products producers, pulp and paper companies, beverage distributors, and wholesale distributors of agricultural products (Industry Canada 1998). Beyond distances of 500 km, for-hire trucking captures 90% of the market share of shipping. Some private fleets, however, are extending their range of operations and have substantial intercity operations.

The trucking industry in Ontario, Quebec, and the Atlantic Provinces is more dependent on inter-regional trade and transborder trade with the U.S. than on domestic trade with western Canada (APTC 1996a).

Atlantic Canada Rail Industry

Only the Halifax-Montreal corridor remains as a long-haul line in Atlantic Canada. When system costs are included in financial accounting, the Atlantic Region is viewed as CN's weakest region, with the lowest priority in terms of investment and improvements (APTC 1996b). CN's official position is that it intends to continue at least the core line between Montreal and Halifax. On May 7, it was announced that the Port of Halifax would not be the site of the new post – Panamax terminal. Although one newspaper account stated that CN may close the Halifax-Montreal line if the Port of Halifax does not win the bid for the terminal (Chronicle Herald, March 3, 1999), after the post-Panamax terminal announcement, CN reaffirmed its commitment to the Port of Halifax and its ability to attract new container traffic destined for the U.S. midwest (Hayes 1999). CN stated that it has made investments in its Halifax intermodal terminal, the St-Clair tunnel linking Sarnia, Ontario and Port Huron, Michigan, and Gateway Intermodal Terminal at Chicago to help position the Port of Halifax as a point of entry to the midwest.

In contrast to the CN line, short-lines have been very successful. The Cape Breton and Central Nova Scotia Railway Ltd. (CB&CNS) increased traffic by 20% in its first year of operation and the Windsor-Hantsport Railway showed a 60-70% increase in traffic over the amount handled by the former CN line in this area (APTC 1996b). Local operators are able to keep costs down and to be more flexible in responding to shippers' needs.

The APTC (1996b) has recommended formation of a regional railway for Atlantic Canada, which would consist of the Halifax-Montreal line combined with the short-line feeders. Such a system should be able to have lower base costs and more efficient operations than the current system.

Competition Between Truck and Rail

Rail is the dominant mode for transporting crude materials over all distances. Under 1500 km, truck dominates in the carriage of food, feed, beverages, and tobacco (Khan 1991). Truck has advantages over rail in delivering perishable items and for time-sensitive deliveries. The two commodity groups which offer the most opportunity for rail to gain an increased share of the freight are fabricated materials and end products.

The top three factors emphasized by shippers in carrier choice are (Industry Canada 1998):

1) price;
2) service frequency; and
3) carrier response to customer needs.

A 1996 survey of North American shippers by KPMG (Bowland 1997) revealed the following factors as important in choice of modal and carrier choice:

- reliable delivery (99% of shippers);
- freight rates (98%);
- total transit time (90%); and
- door-to-door service (84%).

Competition has forced for-hire trucking to add services such as (Industry Canada 1998):

- contract logistics;
- air and marine freight forwarding;
- customs brokerage;
- intermodal rail services;
- warehousing and distribution;
- documentation;
- insurance;
- expedited and zero inventory distribution systems; and
- just-in-time inventory deliveries.

Freight Demand Factors

Changes in rail freight tonnage brought about by changes in the cost of truck freight are estimated by using cross elasticities and freight demand factors. These factors estimate the degree to which freight tonnage of one mode is dependent on prices of a second mode. They predict the percent impact on rail freight tonnage of a given percent increase or decrease in trucking price. Recent trends in this field of study have produced models that measure impact in both the short-term and the long-term (Yevdokimov and Prentice 1999). While the study of freight demand models is beyond the scope of the present study, a rough estimate shows that rail freight is likely to increase by 0.5 for every 1% increase in trucking costs (Cambridge Systematics Inc. 1995). This is the factor that is used in the present study to estimate increases in trucking rates necessary to produce a modal shift of freight from truck to rail.

Freight Transportation Studies in Nova Scotia

Three studies that included freight transportation in Nova Scotia were reviewed. Two of these (ADI 1989 and Peat Marwick et al. 1989) included surveys of shippers in order to fill in data gaps. Although these studies provide a useful background, they were conducted before the privatization of CN Rail and before the opening of the CN Intermodal Terminal in Halifax. The ADI study is based on data from 1984 and 1986, while the Peat Marwick study includes 1987 data. Because of the small size of the transportation industry in Nova Scotia, much of the data collected by Statistics Canada is confidential, and therefore surveys are the only way of obtaining an accurate picture of the sector. A recent study (Gardner Pinfold 1997) has provided provincial analysis of some Statistics Canada data.

In general, the trucking industry showed rapid increases in freight between 1984 and 1986 (79% increase), primarily due to the growth in the service sector, whereas the freight volume for rail showed only a 19% increase (ADI 1989). In 1989, trucking accounted for virtually all the freight moved within the province, except for crude products. Trucking predominates in the movement of food products and end products, whereas rail dominates shipment of crude materials. Since rail tends to move the lower revenue bulk commodities, such as gypsum, rail accounts for a higher percentage of the tonnage but a lower percentage of the revenues for freight transportation within, to and from Nova Scotia (ADI 1989). Industries with the greatest dependence on rail are shipping lines, automotive product companies, and building supply firms. In 1989, private trucking accounted for approximately 45% of freight moved within Nova Scotia and 20% of that moved to and from the province.

Gardner Pinfold (1997) provides the following information:

- The Port of Halifax was said to operating at 68% of its capacity.
- Approximately two thirds of the 1995 container traffic was associated with mainline rail transfer.
- The CN mainline is operating at about 30% capacity, offering opportunities for growth for the Port of Halifax.
- In 1996, rail in Nova Scotia handled 15 million tonnes of cargo, while truck handled 8.5 million tonnes.
- Overall cargo demand (marine, air, rail and truck) is expected to increase 37% from 56 million tonnes in 1998 to 77 million tonnes in 2007.
- Of the projected increase in cargo, rail cargo is expected to increase from 16.8 million tonnes in 1998 to 23 million tonnes by 2007; truck cargo is predicted to increase from 9.5 million tonnes in 1998 to 13.2 million tonnes in 2007.

The study also provides a breakdown of freight at the Port of Halifax. In 1996, total cargo handled was 13 million tonnes, of which 3.2 million (25%) was containerized; 0.4 million tonnes (3%) was general; and 9.3 million tonnes (72%) was bulk. Of the bulk cargoes, 3.6 Mt was crude oil; 3.3 Mt gypsum; 2.0 Mt refined oil; and 0.4 Mt grain and other commodities.

Although it has now been announced that the Port of Halifax will not be the site of a new post-Panamax Terminal, port authorities have stated that container traffic at the port is up 70% in the first quarter of 1999 (Hayes 1999). Personal Communication (Jill Vandersand, Halifax Ports Corporation) indicated the increase was 17%, not 70%.

4. Methodology and Data Sources

General Approach

This section describes methods of deriving estimates in cents per tonne-km. for 1997 rail and truck freight on HA-800 for the following parameters:

- Government Revenue and Expenditures
  - Government Revenue
    - Property Tax
    - Fuel Tax
    - Registration Fees
    - License Fees
    - Toll Fees
  - Government Expenditures
    - Infrastructure Costs (capital and maintenance)
    - Policing Costs
    - Administrative Costs
- Additional Environmental and Social Costs
    - Air Pollution and Climate Change
    - Accident Costs
    - Cost of Fossil Fuel Depletion

In addition, estimates were made of the contribution rail and truck freight make to employment in Nova Scotia. With the exception of employment, all estimates were entered into a simple model to determine the overall cost and the overall emissions of greenhouse gases for different modal mixes. Employment income was also a consideration in choosing the desired modal mix of rail and truck freight. Clearly there are other external costs which could be taken into account but are not included here because of the limited scope of the project.

After the most satisfactory modal mix was determined, a freight demand factor was applied to determine the additional cost necessary to produce the desired shift in freight. This cost was then translated into dollars per tonne of reduction of CO_2, which is called the "GHG Mitigation Index."

For a province the size of Nova Scotia, many types of data required for this type of study are not routinely collected, and much of the data collected is confidential. The only way to increase accuracy of such a study is to collect new data through a survey of shippers. Within this limitation, the study used available data and pro-rated them where necessary. The data sources and use of data have been made completely transparent, so that readers can judge for themselves the reliability of the data.

Every effort was made to obtain specific data for Nova Scotia or for the Halifax-Amherst Route. When this was not possible, efforts were made to determine reasonable percentages or ratios to allow derivation of the parameters for the HA-800 Route. Table 2 summarizes the basis on which various costs and types of income were allocated to HA-800 freight.

Table 2. Basis of Apportioning For-Hire Trucking Costs and Income to HA-800

Cost	Statistical Base	Percent Used	Derivation of Percent
Maintenance Costs	Hfx-Amh. Route	47%	HA-800 tonnes/Hfx-Amh. tonnes
Capital Costs	Hfx-Amh. Route	47%	HA-800 tonnes/Hfx-Amh. tonnes
Toll Fees	Hfx-Amh. Route	47%	HA-800 tonnes/Hfx-Amh. tonnes
Heavy Truck Registration	NS	23%	HA-800 tonnes/total tonnes in NS
Class I license fees	NS	23%	HA-800 tonnes/total tonnes in NS
Policing Costs	NS	23%	HA-800 tonnes/total tonnes in NS
Accident Costs	Heavy trucks NS	23%	HA-800 tonnes/total tonnes in NS
Administrative costs	NS	23%	HA-800 tonnes/total tonnes in NS

Note: Hfx-Amh. Route = Halifax to Amherst Route

Only for capital and maintenance costs, and for toll fees, were statistics available for the Halifax-Amherst 102-104 route. For these statistics, costs were allocated by the ratio HA-800 freight tonnage: Halifax-Amherst tonnage, which is 47% (detailed below). Other statistics were available only on a provincial level and were allocated to HA-800 by the ratio HA-800 tonnage: total Nova Scotia tonnage, or 23%. All ratios are based on for-hire trucking only, since these are the only data available. Truck registration income is based on weight and distance, so the tonnage ratio is quite appropriate. While it is not as applicable to income from Class I license fees, it is probably more appropriate than a ratio based on kilometres. Because tonnage reflects the intensity of traffic, it is considered an appropriate means of apportioning policing, accident, and administrative costs. Again, these statistics are available only on a provincial basis, so they are allocated to HA-800 at 23%.

In the remainder of this section of the report, methods and input data are described in detail.

Data Sources, Assumptions, and Estimations

Estimation of Total HA-800 Freight by Truck and Rail

Freight chosen for analysis in this study is all freight that is carried along the corridor between Halifax and Amherst and that is potentially competitive between truck and rail. It is assumed that any long-haul freight with southern or western destinations or origins will travel along this corridor. Although distance is not the only factor determining whether rail and truck are competitive, it is the factor that allows us to choose *potentially* competitive freight. In terms of the minimum length of haul that is considered competitive, Khan (1991) states that freight travelling more than 1500 km is potentially competitive, while Industry Canada (1998) states that for distances greater than 500 km, 90% of the freight is hauled by rail. For the purposes of this study, it seemed safe to assume that freight hauled for distances of at least 800 km is potentially competitive between truck and rail. The freight analyzed, then, is all Nova Scotia interprovincial freight travelling distances of 800 km or more in a southerly or westerly direction. This segment of freight, and the corridor is referred to as HA-800. Tonnage was translated into tonne-km by multiplying tonnes X total km on the route.

Rail Freight

Rail freight data for 1997 for the Atlantic Region were obtained from Statistics Canada, and the percent of freight entering and leaving Nova Scotia was estimated by applying a ratio of Nova Scotia: New Brunswick freight published by Statistics Canada from 1989-1991. HA-800 rail freight may be overestimated since data on distance hauled were not available and it was assumed that all tonnage was hauled 800 km or more.

Table 3 shows estimated rail freight for HA-800 in 1997, and Table 4 presents relative tonnage of major commodities. A total of 3,153,581 tonnes is hauled along this corridor, representing 37% of rail freight in Atlantic Canada in 1997. Tonne-km are calculated on the basis of a total track length of 267 km, which includes spurs, but does not include switching and yard track. The greatest percentage of freight (mixed carload; freight forwarded; other) is essentially unclassified. The largest imports, after the unclassified, are petroleum products and paper and forestry products. Unclassified freight comprises a smaller portion of exports, and paper and forestry products are the major export.

Table 3. Estimated 1997 Tonnes and Tonne-km of Rail Freight for HA-800

To/From Atlantic Region	To/From Atlantic Region	Percentage To/From Nova Scotia	Tonnes To/From Nova Scotia	HA-800 Tonne-km To/From Nova Scotia @ 267km Total Route
Import	4,211,164	42.3%	1,781,323	475,613,241
Export	4,328,891	31.7%	1,372,258	366,392,886
Total	8,540,055		3,153,581	842,006,127

Source: Statistics Canada 1999.

Table 4. Relative Tonnage of Commodities Shipped by Rail on HA-800

Commodity Group	Imports		Exports	
	Tonnes	% of Total	Tonnes	% of Total
Mixed carload; freight forward; other	980,846	53.9%	636,004	46.4%
Petroleum products	142,641	8%	17,850	1.3%
Paper and forestry products	162,396	9%	516,267	37.6%
Clay, cement, sand	108,880	6%	29,570	2.2%
Feeds, grains, and non-perishable food preparations	116,334	6.5%	7,605	0.55%
Automobiles, engines, parts	81,103	4.6%	17,733	1.3%
Chemicals	117,762	6.6 %	28,168	2%
Ore, plastics and metal building materials	69,604	3.9%	90,940	6.6%
Total percent of tonnage		98.5%		98%

Source: Statistics Canada 1999.

Truck Freight

Truck freight data were obtained from Statistics Canada, Transportation Division (Statistics Canada 1999) from the 1997 For-Hire Trucking Survey (Table 5). This is a quarterly survey of non-local shipments by for-hire trucking companies having annual inter-city revenues of $1 million or more. It is unknown what percentage of total truck freight is represented by the For-Hire Trucking Survey, but approximately 90% of long-haul truck freight is thought to be included. The limitations of the data were presented in Section 2. Table 5 presents HA-800 tonnage and tonne-km.

Table 5. Estimated Freight Tonnage by For-Hire Trucking in Nova Scotia, 1997

Import/ Export	Total for NS (tonnes)	Total Halifax-Amherst (tonnes)	Total for HA-800 (tonnes)	HA-800 % of Total for NS	HA-800 Tonne-km @ 214 km for route
Import	2,264,705		1,173,579	51.8%	251,145,906
Export	2,209,334		747,754	33.8%	1 60,019,356
Total	4,474,039	4,075,970	1,921,333	42.9%	411,165,262

Source: Statistics Canada 1999

The total tonnes of import/export freight travelling in a western or southern route (and presumed to travel along Hwy 102-104) was 4,075,970. This represents 91% of the for-hire import and export freight traffic. Of this total, freight hauled 800 km or more was 1,921,333 tonnes. This HA-800 freight represents roughly 42.9% of the total for-hire trucking imports and exports in

Nova Scotia and 47% of estimated total of all for-hire Halifax-Amherst traffic. The HA-800 freight represents 23% of the total Nova Scotia for-hire trucking freight, including intra-provincial freight.

Relative tonnage of major commodities is shown in Table 6. For imports, the three largest commodity groups are unclassified freight, non-perishable food products, and fabricated materials. For exports, the three largest groups are non-metallic minerals and products, rubber tires and tubes, and fabricated materials.

Table 7 presents major destinations for HA-800 export freight. Seventy-five percent goes to Canada and the Northeast U.S, and 20 percent goes to other U.S. regions.

Table 6. HA-800

Commodity Group	Imports		Exports	
	Tonnes	% of total	Tonnes	% of Total
General or Unclassified Freight	193,117	16.5%	82,133	12.3%
Rubber Tires and Tubes			109,505	16.5%
Non-metallic minerals/products	49,445	4.2%	124,097	18.6%
Pulp, paper, crude wood materials			77,132	11.6%
Non-perishable food products	312,074	26.6%	67,012	10 %
Perishable Foods/food products	39,456	3.4 %	74,678	11%
Fabricated Materials	182,180	15.5%	103,166	15.5%
Crude materials, waste and scrap	24,771	2%		
Metals and metal fabricated products	146,611	12.5%		
Chemicals and related products	34,393	2.9%		
Machinery and Equipment	29,942	2.6%		
Vehicles and parts	22,713	1.9%		
Equipment	25,722	2.2%		
Medical supplies	16,887	1.4%		
Total percent of tonnage		92%		95.5%

Source: Statistics Canada 1999.

Table 7. Major Destinations: For-Hire Trucking HA-800 Exports

Region	Tonnes	Destinations Receiving Largest Amounts
Canada	403,683	Quebec (52%); Ontario (45%)
Northeast US	161,154	MA (37%); NY (31%); ME (15%)
West US	68,681	South Dakota 93%
South US	59,272	TN (67%); TX (11%); Georgia (6%)
Midwest US	19,359	82% to Michigan, Indiana, Wisconsin

Statistics Canada 1999.

Rail

Since privatization of CN Railways, the only government revenues from CN Rail operations are from locomotive fuel tax, property tax and "Other Sales & Excise Tax." Grants in lieu of property taxes are paid to municipalities on commercial buildings and rail yards. The right-of-ways are not taxed. Roger Cameron (Railway Association of Canada, pers. comm.) estimates the total property taxes paid by CN in Nova Scotia in 1997 to be in the range of one million do1lars, which translates into 0.118 cents per tonne-km.

"Other sales and excise taxes" (listed in Railway Association of Canada 1998) are not included in this study's total government revenues, either for truck or for rail. Locomotive fuel taxes paid by CN for operations along HA-800 are estimated from fuel taxes reported in Railway Trends (Railway Association of Canada 1998) and from statistics on diesel fuel usage in Nova Scotia from Rail in Canada 1996 (Statistics Canada 1997). Rail in Canada 1996 reports that 65% of diesel fuel used in Nova Scotia was used by CN Rail. Total diesel tax reported in Nova Scotia in 1997 was $494,000. Diesel tax paid for HA-800 freight was therefore estimated at 65% of this total, or $321,110. With 842, 006,127 tonne-km., this amounts to a fuel tax rate of .038 cents per tonne-km. Property tax and diesel fuel tax paid result in a total government revenue rate of 0.157 cents per tonne-km.

Truck

Vehicle registrations for interprovincial trucking are regulated by the Canadian Agreement on Vehicle Registration under the Motor Vehicle Act. This agreement allow provinces to prorate vehicle registration based on kilometres and tonnage transported by province. The total collected for vehicle registrations in Nova Scotia for all heavy commercial trucks (>5001 kg) travelling interprovincially in 1997 was $2.3 million for 3,506 vehicles (pers. comm., Nancy Craig-Noddin, N.S. Department of Business and Consumer Affairs).

Since it is not possible to obtain this figure for trucks travelling only the Halifax-Amherst Route, this figure is pro-rated according to the estimated proportion of tonnes of freight transported along the Halifax-Amherst route to the total estimated tonnes of freight in all of Nova Scotia. Total freight transported by for-hire trucking in Nova Scotia in 1997 (Statistics Canada 1997) is estimated at 8,332,452 tonnes, and total freight on the HA-800 is 1,921,333 tonnes. As shown in Table 8, the percentage of Nova Scotia freight that is HA-800 is therefore 23%, and the vehicle registration fees for HA-800 are estimated at $529,000.

In June 1997, a total of 15,893 Class I drivers were registered in Nova Scotia. The fee for this class of license is $69 for a five year-period, or $13.80 per year. Based on this number of drivers registered, total income from Class I licenses is estimated at $219,323. Based on the above proportion of freight, the proportion of this fee relevant to the Halifax-Amherst Route is $50,444, as shown in Table 8.

Table 8. Government Revenue from HA-800 Trucks: Registration and License Fees

	All of Nova Scotia: For-hire trucking	HA-800: For-hire Trucking	HA-800 percent of total	HA-800 Cents per tonne-km
Total Freight (tonnes)	8,332,452	1,921,333	23%	
Vehicle Registrations	$2,300,000	$529,000	23%	0.12
Class I Licenses	$219,323	$50,444	23%	0.01

Diesel fuel taxes paid by commercial trucks along this route are based on the 1996-97 Nova Scotia rate of $.154 per liter. The number of liters consumed is based on rates of diesel fuel usage of 52.02 tonne-km per litre (Khan 1991). In the absence of data, it was assumed that 50% of this diesel fuel is purchased in Nova Scotia. On this basis, the estimated amount paid for diesel fuel tax on HA-800 in 1997 is $607,867, or 0.148 cents per tonne-km (Table 9).

Table 9. Government Revenues from HA-800 Trucks: Diesel Fuel Tax

Diesel Fuel Usage Rate (Khan 1991) = 0.0192 litres per tonne-km	
Total Diesel Fuel Usage for HA-800: 411,165,262 tonne-km.	7,894,373 litres
Estimated Diesel Fuel Purchased in N.S. (50%)	3,947,187
Estimated Diesel Fuel Tax for HA-800 @0.154 per litre	$607,867
Estimated Diesel Fuel Tax for HA-800: cents per tonne-km	0.1478

Toll fees paid by trucks on the Halifax-Amherst Route are estimated at $6,000,000 per year, based on 600,000 truck trips per year and a charge of $2 per axle, or, on average, $10 per truck. The number of truck trips reported amounts to an average of 32 trucks per hour, which would indicate a heavy burden of truck traffic on this highway. The average truck is a five-axle truck, and 2% of the fleet are B-trains with eight axles (Highway 104 Western Alignment Corp., pers. comm.). Toll charges were apportioned for HA-800 at 47% of the total (percent of western imports/ exports that travel over 800 km). This produces an estimate of $2,820,000 for 1997, or 0.686 per tonne-km. This estimate is high, since it does not consider the trucks travelling within the province that pay toll fees. A summary of provincial government revenues for HA-800 truck and rail freight is presented in Table 10. For trucks, toll fees represent 71% of total government income.

Table 10. 1997 Estimated Provincial Government Revenue for HA-800 Truck and Rail Freight (cents per tonne-km)

Type of Revenue	Rail	Truck
Property Tax	0.118	
Diesel Fuel Tax	0.038	0.1478
License Fees		0.01
Registration Fees		0.12
Toll Fees		0.686
TOTAL	**0.157**	**0.974**

Provincial Government Costs

Rail

Because of privatization of rail, provincial governments bear no costs for operations or maintenance of Right-of-Ways. Although in 1997 there were federal grants of $169,400 to improve safety at two Nova Scotia crossings (Railway Association of Canada 1998b), these expenditures were not routine and were not made by the provincial government.

Truck

Infrastructure

Capital costs for the relevant highways for 1974-1976 were obtained from Mr. Kent Speiran, N.S. Department of Transportation and Public Works. While the length of time before re-paving of Nova Scotia 100-series highways is estimated at 12 years, the lifetime of a highway (time before reconstruction) is estimated at 20-25 years. The capital costs must also include the cost of borrowing on the capital (Litman 1997). The primary reason for including borrowing costs (Lee 1995) is that there is an opportunity cost to capital sunk into highway investments, which could be earning interest. The Nova Scotia Government, however, expenses its capital expenditures and therefore does not show the exact rate of borrowing on the capital expenditures. In order to estimate the cost of borrowing, it was assumed that the government does borrow on highway capital expenditures for a 20-year term. Mr. Roy Spence (NS Department of Finance) recommended that since the Nova Scotia borrowing rates are very complicated, it would be more feasible to use Government of Canada long-term borrowing rates. These rates were available from 1976 to present. Total capital costs per year and estimates of the cost of borrowing are shown in Table 32 in the Appendix. The average annual payment of capital expenses for the Halifax-Amherst route is $9,259,023.

Maintenance costs average $6,900 per 2-lane km for 100-series highways (pers. comm., Kent Spearin, N.S. Dept. of Transportation and Public Works), or a total of $2,953,200.

As mentioned in Section 3, the procedure for apportioning infrastructure costs to vehicle type is a subject of controversy. This study apportions 41.1% of these costs to heavy trucks (from U.S. study, cited in Transport Concepts 1993). Table 11 summarizes estimated annual provincial government costs for infrastructure for HA-800.

Policing Costs

Policing costs for HA-800 were calculated using a percentage of total provincial policing costs for 1997. The total policing bill was $143,300,000 (Statistics Canada 1999a and b). Based on Transport 2001 (Litman 1997) estimates, 10% of this figure is apportioned to traffic costs. The result is further apportioned to HA-800 by multiplying by 23%, which is the ratio of HA-800 tonnage to total Nova Scotia tonnage. Table 12 shows the results: a value of 0.8 cents per tonne-km for HA-800.

Table 11. Annual Average Provincial Costs for Infrastructure on HA-800

MAINTENANCE COSTS:	
Total 2-lane km on HA-800	428
Tonne-km Hauled on HA-800 in 1997	411,165,262
Average Maintenance Cost per 2-lane Km of 100-series Highway	$6,900
Total Maintenance Cost for Halifax- Amherst Series 100 Hwy	$2,953,200
Maintenance Costs Attributable to Trucks (@ 41.1%)	$1,213,765
Highway Maintenance Costs Attributable to HA-800 Trucks (@ 47%)	$570,469
Maintenance Costs for HA-800 Trucks: cents per tonne-km.	0.139
CAPITAL COSTS:	
Average Annual Payments on Capital Expenditures for Halifax-Amherst 100-Series Hwy	$9,259,023
Payments on Capital Exp. Attributable to Truck (@ 41.1%)	$3,805,458
Payments on Capital Expenditures Attributable to HA-800 Trucks (@ 47%)	$1,788,565
Annual Payments on Capital Expenditures for HA-800 Trucks: cents per tonne-km.	0.435

Table 12. Estimates of Annual Policing Costs for HA-800

Total cost of policing for Nova Scotia, 1997	$143,300,000
Amount apportioned to Traffic costs (10%)	$14,330,000
Amount apportioned to HA-800, based on 23%	$3,295,900
Total annual cost of policing on HA-800 (cents per tonne-km)	0.802

Administrative Costs

Because in Nova Scotia transportation and public works are combined into one department, it is difficult to accurately determine total administrative costs for transportation. A rough estimate has been made, however, based on Main Estimates for the Fiscal Year 1998-99, which included actual year-end figures for 1996-97 (Government of Nova Scotia 1998). Table 13 shows the totals and the estimates for HA-800. Administrative expenses which likely were included in the above infrastructure expenses were omitted. Expenses of the Department of Transportation and Public Works related to highways are listed in Table 13 (pers. commun. Kevin Malloy, NS Dept. of Transportation and Public Works). Allocating on the basis of 23% of total costs, the cost for HA-800 is 3.54 cents per tonne-km.

Table 13. Estimated Annual Administrative Expenses for HA-800

Government Administrative Costs 1996-97 (from Provincial Estimates)		
Category	TOTAL	HA-800 share @ 23%
Senior Management	$1,046,000	$240,580
Corporate Services Unit	$7,648,000	$1,759,040
Policy and Planning	$914,000	$210,220
Field Administration	$20,779,000	$4,779,170
Contract Employee Benefits	$7,341,000	$1,688,430
Specialized Support Services	$4,130,000	$949,900
Capital Development & Engineering	$4,990,000	$1,147,700
Registry of Motor Vehicles	$16,492,000	$3,793,160
TOTAL	$63,340,000	$14,568,200
HA-800 cents per tonne-km		3.54

Air Pollution Costs and Climate Change Costs

The major air pollutants from the burning of diesel fuel are carbon dioxide (CO_2); nitrogen oxides (NOx); volatile organic compounds (VOC); sulphur dioxide (SO_2); carbon dioxide (CO_2), and particulate matter (PM). The environmental impacts of carbon dioxide are discussed in "Costs of Climate Change." Nitrogen oxides are a health problem, primarily in urban areas, where they contribute to smog and cause respiratory irritation and increased susceptibility to respiratory infections. VOCs react with NOx to produce ground-level ozone, a major constituent of smog. Some VOCs, such as benzene, are carcinogenic. SO_2 emissions cause respiratory irritation, reduced visibility, reduced agricultural production, and acid rain. CO converts to ground-level ozone and also converts to methane, a very strong greenhouse gas. Exposure to high concentrations can cause impaired perception and thinking, slow reflexes, drowsiness, and unconsciousness. Particulate matter of a size range of less than 10 millimicrons (PM_{10}) can penetrate human, animal, and plant tissue.

Previous estimates of emissions per tonne-km of these pollutants for rail and truck are shown in Table 14. These figures are based on a 1995 study of freight emissions in Ontario (Transmode Concepts 1995), which included the following steps:

1) baseline goods movement by vehicle type were established;
2) energy consumed by vehicle type was assessed;
3) emissions were calculated based on unit emissions per unit of energy consumed;
4) emission totals were adjusted to account for the emissions created during the extraction, refinement and distribution of the fuels to produce life cycle estimates of emissions.

Over the years, emissions from rail freight have improved considerably. Hydrocarbons (HCs) are reported, rather than VOCs. Since VOCs are included in HCs, the values for HC is used as that for VOC. This results in a conservative estimate - higher than actual estimate for VOCs. To some degree, the improvements in emissions are a result of fuel efficiency , which increased from 175 tonne-km per litre in 1993 to 187 tonne-km per litre in 1997 (calculated from Railway

Association of Canada 1999). In addition, the maximum allowable axle load is being increased on many lines, which improves efficiency of freight movement. Low-idle applications, which allows the diesel engine to idle at reduced speed, and automatic start/stop systems, which automatically shut down and restart the diesel when it is not in use, have also contributed to lowered emissions.

Total emissions (Table 14) were calculated by multiplying the tonne-km by the emission rates. According to Jaques (1997), the CO_2 emissions calculated here for trucks amount to six percent of total 1995 emissions from heavy-duty diesel vehicles. Emissions from rail amount to 40% of total 1995 emissions from rail. On the assumption that improvements in fuel efficiency and emission control technologies will be comparable in rail and truck in the period 1995-2010, projections of future emissions were based on the emission rates in Table 14.

Table 14. Total Estimated Emissions (kilotonnes) from Truck and Rail: AH-800 in 1997

TRUCK		**CO_2**	**NOx**	**VOC**	**SO_2**	**PM**
Grams per Tonne-km. →		115.2	1.99	0.2	0.24	0.13
	Tonne-km	Tonnes				
Imports	251,145,906	28,932	500	50.2	60.3	33
Exports	160,019,356	18,434	318	32.0	38.4	21
TOTAL	411,165,262	47,366	818	82.2	98.7	53
RAIL						
Grams per Tonne-km. →		17.38	0.353	0.018	0.016	0.009
	Tonne-km	Tonnes				
Imports	475,613,073	8,266	168	8.6	7.6	4.3
Exports	366,393,005	6,368	129	6.6	5.9	3.3
TOTAL	842,006,127	14,634	297	15.2	13.5	7.6

Sources: IBI Group 1995 and Railway Association of Canada 1999.

Cost of emissions

The second step in estimating the cost of emissions is to apply costs to each of the air pollutants. With the exception of CO_2, discussed in Section 2, the costs of one tonne of each of the air pollutants is fairly straightforward. The IBI Group considered five studies that estimated these costs, based upon the cost of controlling, or reducing, the emissions. IBI chose values in the middle of the ranges presented by the other studies. They also used a value of $100 per tonne. Klein (1997) used generally lower values to cost these externalities for a study of gas turbine cogeneration and district energy plants on the prairies in Western Canada. He does point out that these values may change with location and geography. Since air pollution is a much more serious problem in Atlantic Canada than on the prairies, it is reasonable to choose higher values for Atlantic Canada. Klein also mentions that as society's concern over the effects of climate change rises, higher externality values in the $20-$40 per tonne range may be more appropriate. The current study used the IBI values, as well as additional values for CO_2, converted to C$1997

(Table 15), as discussed in Section 3. Table 16 summarizes values used in the current study in terms of cents per tonne-km.

Table 15. Comparison of Environmental Externality Values (dollars/tonne)

Pollutant	Royal Commission on National Passenger Transportation (1991)	Ontario Externalities Collaborative (Tellus Institute 1994)	Klein (1997)	IBI Group (1995)
Carbon Dioxide	$32.7	$40	$10	$34
Carbon Monoxide	-	$1,400		0
Sulphur Oxides	-	$2,100-4,800	$1,000	$6,000
Nitrogen Oxides	$5,000	$8,500-$15,000	$1,000	$7,000
Volatile Organic Compounds	$5,000	$3,000-$7,500		$5,000
Particulate Matter	-	$13,200-$16,400	$2,000	$4,000

Source: IBI 1995, p. 4.3.

Table 16. Cost of Emissions Used in Present Study (1997 C$ per Tonne)

Pollutant	Cost Per Tonne	Cost in 1997 C$ Per Tonne	Cents Per Tonne-km	
			Rail	Truck
CO_2	$34 C$1995 (IBI)	$35	0.061	0.403
	$20-$50 US$1990 (Cline 1996)	$96	0.167	1.106
	$10 C$1997 (Klein 1997)	$10	0.017	0.115
SO_2	$6,000 C$1995 (IBI)	$6,240	0.010	0.150
NOx	$7,000 C$1995 (IBI)	$7,280	0.257	1.449
VOC	$5,000 C$1995 (IBI)	$5,200	0.009	0.104
PM	$4,000 C$ 1995 (IBI)	$4,160	0.004	0.054

Costs of Accidents

Truck

Accident rates for trucks were taken from the 1996 Nova Scotia Traffic Safety Report. Rates for trucks over 5000kg and semi-trailer power units were used (Table 17). The proportion of truck accidents in Nova Scotia that should be attributed to AH-800 was estimated at 23%, the ratio of HA-800 tonnage to total Nova Scotia tonnage. As mentioned earlier, this ratio was chosen on the assumption that accident costs are related to traffic intensity and that tonnage is a reflection of traffic intensity. Estimated compensation costs per accident were based on those listed in

Transport Canada's 1997 Annual Report (Transport Canada 1997). The results are shown in Table 17.

Table 17. Estimated Annual Accident Costs for Trucks HA-800

1996 Only	Property Damage	Personal Injury	Fatality	Total
Est. Cost Per Accident (1997$) (Transport Canada 1997)	$5,712	$28,560	$1,591,200	
Trucks over 5,000kg.	308	93	3	404
Semi-Trailer Power unit	190	48	3	241
TOTAL	498	141	6	645
Portion attributable to HA-800 (23%)	114.54	32.43	1.38	148.35
Total Cost HA-800	$654,252	$926,201	$2,195,856	$3,776,309
Cents per tonne-km HA-800				0.92

Source: Nova Scotia Traffic Safety Report 1996.

Rail

Because rail accidents are so infrequent, a three-year average of rail accidents in Nova Scotia was used. The same costs were applied that were used for truck. The results are shown in Table 18.

Table 18. Estimated Annual Accident Costs for Rail HA-800

Average 1995-1997	1995	1996	1997	Average	Estimated Cost
Total	7	20	11	12.67	
Fatal	0	2	0	0.67	$1,060,800
Serious Injury	0	1	2	1.00	$28,560
Assumed Property Damage	7	17	9	11	$62,832
TOTAL					$1,152,192
Cost per tonne-km					0.14

Transportation Safety Board of Canada 1998.

Cost of Fossil Fuel Depletion

To determine an estimate for the cost of fossil fuel depletion, a proxy value is based on the estimate of the cost to replace fossil fuel with alternative energy sources. As mentioned in Section 3, a value of $124 per tonne of CO_2 has been estimated, although this estimate is for energy sources not currently available (Cline 1996). The U.S. G.P.I. Group has estimated a value of $100 per barrel of ethanol fuel derived from corn (value was $75 1988 US $). At 158.9 litres per barrel of diesel, the fuel usage rate allows the calculation of the replacement cost per tonne-km.

Table 19. Cost of Fossil Fuel Depletion Based on Value of $100 per Barrel (or $0.63 per liter) of Corn-based Ethanol

Mode	Tonne-km Per Liter Diesel Fuel	Liters Diesel Fuel Per Tonne-km	Replacement Cost (cents per tonne-km)
Rail	187	0.005	0.315
Truck	52.02	0.019	1.197

Employment Benefits From Truck and Rail Freight

Exact figures on numbers of employees and remuneration in the rail and truck freight industries in Nova Scotia were not obtainable from either the employment by Industry figures of from the employment by occupation figures Statistics Canada 1996 Census). While estimates of numbers of employees were not available, estimations of remuneration rates per tonne-km were made from estimates in Trucking in Canada and Rail in Canada for 1996, as shown in Table 20.

Table 20. Estimates of National Rates of Remuneration per Tonne-km

Mode	Estimated Total Annual Compensation (1996)	Estimated Total Annual Tonne-km (1996)	Estimated Rate of Compensation (cents per tonne-km)
Truck (for-hire >$1million annual revenue)	$3,472,100,000 (Trucking in Canada 1996, p. 23)	120,459,000,000 (Trucking in Canada 1996 p. 34)	
Converted to 1997 dollars	$3,541,542,000		2.9
Rail (CN)	$2,491,734,000 (Rail in Canada, 1996 p. 13)	282,488,814,000 (Rail in Canada 1996, p. 13)	
Converted to 1997 dollars	$2,541,568,680		.9

Although trucking employs nearly one-third of all transportation sector workers, the average annual wage is less than that in the rail industry. While an average annual wage was not available for the trucking industry as a whole, in 1995 in Nova Scotia, 6,585 truck drivers were employed (3,090 full-time and 3495 part-time), at an average annual wage of $24,082 ($29,446 full-time; $19,340 part-time) (Statistics Canada 1996 Census).

CN Rail has increased productivity and decreased numbers of employees but increased average rate of remuneration (CN Rail 1998). In 1997, the rail industry employed an average of 46,174 people, with an average annual wage of $54,580 (Railway Association of Canada 1997).

Projections to 2010

Discount Rate

As discussed in Section 2, no discount rate is used for this study, which infers that in terms of environmental concerns, the future value of the dollar is equal to the present value. To demonstrate the impact of discount rates on the calculations, cost projections for a 10% discount rate were determined and are presented in the Results section.

Freight Projections

Projections of tonnage to the year 2010 are based on percentage increases cited in "Freight Transport Trends & Forecasts to 2010 (Transport Canada 1998). Overall freight shipments in Canada are expected to increase by an annual average of 1.4% between 1996 and 2010. Canadian exports to the U.S. are expected to grow by an annual average of 1.4% during this period, much of which will be driven by an intermodal component from ports in Eastern Canada. Imports are expected to increase by an annual average of 2.3%.

Table 21 summarizes projected annual increases in rail and truck freight in Nova Scotia. Rail loadings (exports) in Nova Scotia are expected to increase by an average annual rate of 1% between 1998 and 2005, and by 1.1% between 2006 and 2010. Interprovincial truck loadings are expected to increase by an average annual rate of 2.3% between 1998 and 2005 and by 1.7% between 2006 and 2010. These projections are low, compared with those of Gardner-Pinfold (1997) for cargo demand. For the period 1998-2007, Gardner-Pinfold predicted an increase of 36.9% for rail and 38.9% for truck, whereas the cumulative increases over this same time period calculated from Transport Canada projected rates of increase are 9.96% increase for rail and 16.3% increase for truck. It is not known whether the Gardner-Pinfold estimates were based on the addition of the post-Panamax Terminal at the Port of Halifax.

Table 21. Average Annual Percentage Increases in Freight Tonnage in Nova Scotia 1998-2010

Import/Export	Truck		Rail	
	1998-2005	2006-2010	1998-2005	2006-2010
Import	1.4	0.6	1.1	1.1
Export	2.3	1.7	1.0	1.1
Average	1.85	1.15	1.05	1.1

Transport Canada 1998.

Table 22 demonstrates how CO_2 emissions will increase if these freight projections are accurate. For truck, this amounts to a cumulative increase of 22% and for rail, 19%.

Table 22. Projected CO_2 Emissions 1997-2010 from HA-800 Truck and Rail Freight

Year	Rail			Truck			Total
	tonnes	tonne-km	tonnes CO_2	tonnes	tonne-km	tonnes CO_2	
1997	3,153,581	842,006,127	14,634	1,921,333	411,165,262	47,366	62,000
1998	3,186,694	850,847,191	14,788	1,956,878	418,771,819	48,243	63,030
1999	3,220,154	859,781,087	14,943	1,993,080	426,519,098	49,135	64,078
2000	3,253,965	868,808,788	15,100	2,029,952	434,409,701	50,044	65,144
2001	3,288,132	877,931,281	15,258	2,067,506	442,446,281	50,970	66,228
2002	3,322,658	887,149,559	15,419	2,105,755	450,631,537	51,913	67,331
2003	3,357,545	896,464,629	15,581	2,144,711	458,968,220	52,873	68,454
2004	3,392,800	905,877,508	15,744	2,184,388	467,459,132	53,851	69,595
2005	3,428,424	915,389,222	15,909	2,224,800	476,107,126	54,848	70,757
2006	3,466,137	925,458,503	16,084	2,250,385	481,582,358	55,478	71,563
2007	3,504,264	935,638,547	16,261	2,276,264	487,120,556	56,116	72,378
2008	3,542,811	945,930,571	16,440	2,302,441	492,722,442	56,762	73,202
2009	3,581,782	956,335,807	16,621	2,328,919	498,388,750	57,414	74,036
2010	3,621,182	966,855,501	16,804	2,355,702	504,120,221	58,075	74,879
Cumulative			219,587			743,088	962,675

5. Results

Summary of Input Data

Table 23 presents a summary of the values used to estimate revenue, costs, and emissions of rail and truck freight. The values demonstrate that, when external costs are included, truck freight is almost 13 times more expensive than rail freight, on a per tonne-km basis. The values are compared with those from the IBI (1995) report. Government Revenue values for rail and freight are higher than those of IBI because 1) government revenues in the IBI study only included fuel taxes and license fees, whereas in the current study, property taxes, registrations, and toll fees are also included. Government costs are lower than those of IBI for rail are and higher than IBI for truck. When the IBI study was done, there was still some government subsidy to railways, whereas in the current study, there is none.

Government costs for truck are higher because costs were allocated to trucks at 41.1% of total road costs, whereas IBI allocated 25% of total road costs to truck. With regard to accident costs, it is difficult to analyze why present study costs are so much higher than those of IBI. The present study uses specific provincial accident records and therefore produces a more accurate value than a national value. Other studies (Transport Concepts 1993) have produced a range of values for accident costs from 0.06 to 0.23 cents per tonne-km for rail and 0.59 to 4.52 cents per tonne-km for truck (all 1994 dollars). Fossil fuel replacement costs were not included in the IBI study. Costs of air emissions are very similar between the two studies, since the same costing methods were used. IBI did not analyze the contribution of the two modes to employment remuneration.

Table 23. Input Values for Estimating Costs and Emissions for HA-800

Parameter	Values			
	Rail		Truck	
HA-800 1997 Freight (tonnes)	3,153,581		1,921,333	
HA-800: Total km in route (including spurs)	267		214	
HA-800: Total Tonne-km Freight	842,006,127		411,165,262	
	Cents/Tonne-km.			
		IBI 1995		IBI 1995
GOVERNMENT REVENUE	0.1569	0.06	0.97462	0.36
GOVERNMENT COSTS				
Government Capital Costs	0		0.43500	
Government Maintenance Costs	0		0.13874	
Policing Costs			0.80160	
Administrative Costs			3.54315	
TOTAL GOVERNMENT COST	0	0.014	4.91849	0.76
NET GOVERNMENT COSTS	-0.1569		3.94387	
EXTERNAL COSTS				
Accidents	0.1368	<0.01	0.92000	0.04
Fossil Fuel Replacement Costs	0.315		1.19700	
Climate Change and Air Pollution Costs				
CO_2	0.061	0.07	0.40300	0.39
NOx	0.257	0.3	1.44900	1.39
VOC	0.009	0.01	0.10400	0.1
SO_2	0.01	0.02	0.15000	
PM	0.004	0.01	0.05400	0.05
Total External Cost of Emissions	0.341	0.41	2.160	2.08
TOTAL EXTERNAL COSTS	0.7928	0.41	4.27700	2.12
TOTAL NET COSTS	0.6359		8.2209	
EMPLOYMENT BENEFITS				
Employment Remuneration	0.82		2.90	

Costing of HA-800 Rail and Truck Freight Transportation for 1997

The input values shown in Table 23 were used to estimate total transportation costs for the current situation and for different modal mixes of truck and rail freight for 1997. The effect of varying the discount rate and the value used for one tonne of CO_2 were examined. Finally the impact of modal freight shift on employment remuneration was considered, and a new modal mix was recommended. Table 24 shows the total transportation costs for the existing situation. External costs account for the majority of the costs. Table 25 shows the total emissions for the current situation.

Table 24. Total Transportation Costs for HA-800 Freight in 1997

	Rail	Truck	Total
Kilotonne-km	842,006.13	411,165.26	1,253,171.40
Percent of total Kilotonne-km	67.19%	32.81%	
COSTS: C$ 97 (' 000)			
A. Government Costs			
- Government Revenues	1,321.11	4,007.31	5,328.42
- Government Costs	0	20,223.138	20,223.13
NET GOVERNMENT COSTS	-1,321.11	16,215.828	14,894.72
B. External Costs			
- Local Air Pollution	2,357.62	7,224.17	9,581.79
- Climate Change (@ $35/ tonne CO_2)	513.62	1,656.99	2,170.16
- Accident Costs	1,151.86	3,782.72	4,934.58
- Fossil Fuel Depletion Costs	2,652.32	4,921.65	7,573.97
TOTAL EXTERNAL COSTS	6,675.42	17,585.54	24,260.96
TOTAL NET TRANSPORTATION COSTS	$5,354.31	$33,801.36	$39,155.67

Table 25. Total Air Emissions for HA-800: Existing Situation (1997)

Pollutant	Tonnes		
	Rail	Truck	TOTAL
CO_2	14,634.06	47,366.27	62,000.33
NOx	297.23	818.22	1,115.45
VOC	15.16	82.23	97.39
PM	7.58	53.45	61.03

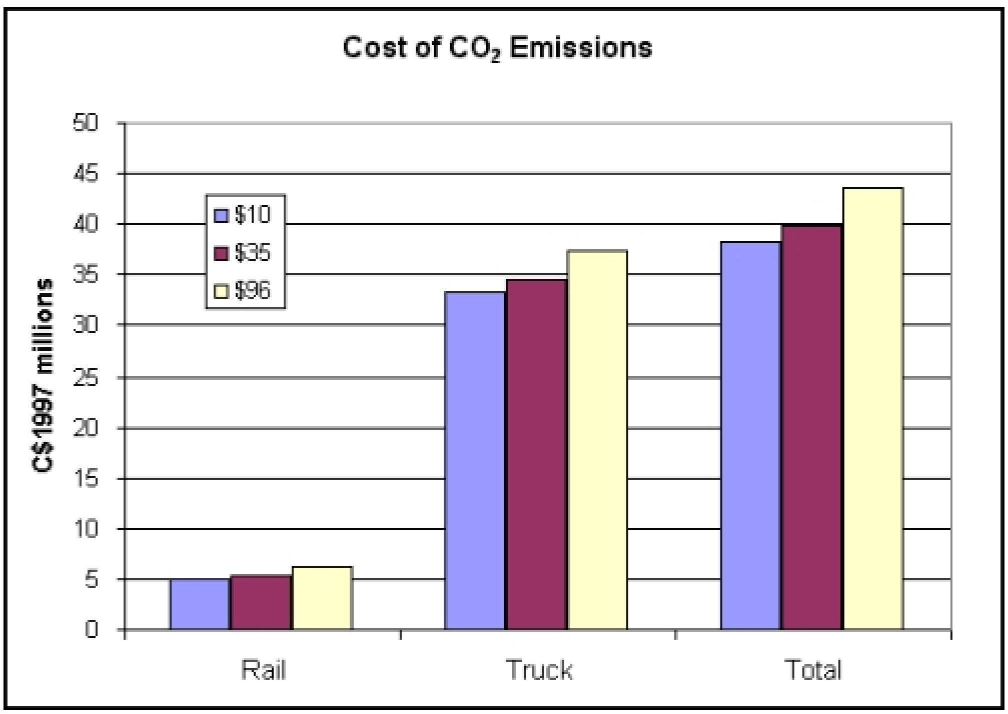
Effect of Varying Dollar Value of CO_2

Three values for the cost of one tonne of CO2 were used: $10; $35; and $96. Table 26 and Figure 1 show how the total costs change when different values are used. The difference in total transport costs between the $10 value and the $96 value is $5.3 million annually. The impact on rail freight is much less than that on truck freight. The current study uses the $35 figure in all subsequent calculations.

Table 26. Effect of Value of One Tonne CO_2 on Total Transportation Costs for HA-800: Current Situation (1997)

CO_2 Cost/tonne	Total Cost (C$97 ' 000)		
	Rail	Truck	Total
$10	$4,990	$33,300	$38,290
$35	$5,353	$34,485	$39,839
$96	$6,250	$37,370	$43,620

Figure 1. Costs of Carbon Dioxide Emissions



Effect of Varying Discount Rate

The decision to use a zero discount rate is a philosophical one, based on intergenerational equity.

Recommended Modal Shift

Table 27 presents the potential export tonnage that would be suitable for a shift from truck to rail. The maximum potential transferable is 578,903 tonnes, which represents 77% of HA-800 truck and rail exports and 30 % of total HA-800 freight. These are commodities that are not perishable or particularly time-sensitive. Very small shipments were excluded, as were the unclassified, mixed cargo, and freight forwarding commodities. Since specific origin and destination were not considered in the scope of the study, there may be other reasons why certain shipments cannot be transferred to rail.

Table 27. Potential Export Truck Freight to be Shifted to Rail for Ha-800 (1997)

Commodity Group	Truck (tonnes)	Rail (tonnes)
Potentially Transferrable to Rail:		
Forestry Products: lumber, newsprint, building materials,		
Pulp	77,132	516,267
Rubber tires and tubes	109,505	
Non-metallic minerals: crude and basic products	124,097	
Base metals, iron & steel, ores	21,306	88,074
Fabricated Materials	103,166	
Equipment & Machinery	18,079	
Household and personal equipment	14,888	
Motor Vehicles, engines, parts, aircraft, ships, boats	9,876	17,733
Food preparations and feeds	12,212	7,605
Non-perishable food & beverage products; oils, fats, waxes	67,973	
Containers & Closures	8,681	
Crude animal & Vegetable products and waste	3,699	
Chemicals	5,104	28,168
Photographic goods and office supplies; printed matter	1,847	
Miscellaneous end products, firearms, apparel, rec. equip.	1,338	
Total Potentially Transferrable to Rail	578,903	
Commodities Probably Not Transferrable to Rail:		
Plastics		2,866
Fertilizers, potash		28,122
Gypsum, sand, clay, cement, rock salt		29,570
Unclassified; mixed carload; freight forwarder; and other	91,525	636,004
Medical Supplies	2,069	
Perishable food products	74,678	
Petroleum Products	232	17,850
Small retail items	347	
Total Commodities Probably Not Transferrable to Rail	747,754	1,372,259
Total Potential Transfers	**578,903**	
Potential Transfer: Percent of Total	**77.42%**	

Table 28 presents the total transportation costs, CO_2 emissions, and employment remuneration for different modal mixes. The maximum potential transferable tonnage results in a mode mix of 77% rail and 23% truck freight. This mix is recommended as the best modal mix for decreasing total costs and decreasing CO_2 emissions. This modal shift will bring about a decrease in overall employment remuneration, however. Total remuneration is reduced by 12.3%, and trucking remuneration is reduced by 30%.

Table 28. Total Transportation Costs, CO_2 Emissions, and Employment Remuneration with Different Modal Mixes (HA-800, 1997)

Percent of Total Tonne-Kilometres		CO_2 Emissions (Tonnes)	Total Transportation Costs (C$97 '000)	Total Employment Remuneration (C $97 '000)
Rail	Truck			
67.19 (current)	32.81 (current)	62,000.33	$ 39,136.5	$ 18,828.2
77	23	49,913.43	$ 30,260	$ 16,258.14
75	25	52,426.43	$ 32,250	$ 16,792.50
73	27	54,878.13	$ 34,200	$ 17,313.82
71	29	57,329.83	$ 36,140	$ 17,835.14
69	31	59,781.54	$ 38,080	$ 18,356.45

Costing of HA-800 Rail and Truck Freight Transportation, 1997-2010

Based on the projected annual percent increases in freight described in Section 4, total transportation costs and CO_2 emissions were calculated for the years 1997-2010. Table 29 shows the contribution of the recommended modal shift to the GHG reduction target for Nova Scotia, based on the Kyoto agreement. (*The targets presented are proportional to a six percent decrease from 1990 levels, as stated in the Kyoto Agreement. It should be emphasized that Nova Scotia has not set actual GHG reduction targets*.) By 2010, the modal shift would provide a decrease of 2.1 Kt from 1997 levels, which is 0.23% of the Nova Scotia target. Compared with the Business-as-Usual Scenario, the RMM provides an average reduction of 14.99 Kt annually by 2010.

Table 30 shows CO_2 emissions and total transportation costs for the Business-as-Usual scenario, assuming no change in modal mix and for the Recommended Modal Mix (77/23). According to these calculations, the recommended modal mix (RMM) would save roughly $150 million over the 14 years represented here. Figure 4 shows the projected total freight costs, and Figure 5 shows the projected CO_2 emissions for the "business as usual" scenario vs. the "recommended mode mix" scenario. The cumulative reduction in tonnes of CO_2 is estimated at 191,750. It is estimated that the annual CO_2 reduction would range from 12 kt to almost 15 kt. This would represent a decrease in total Nova Scotia GHG emissions (18,600 kt in 1995) of 0.23% of the targeted decrease. This means that a 10% shift of freight away from truck toward rail would result in an average annual decrease in CO_2 of 13,696 tonnes at a net average annual social benefit of $10 million.

Table 31 presents a comparison of predicted transportation cost savings obtained through the recommended modal shift when varying costs per tonne of CO_2 are used. In this case, the climate change damage estimate of $1,000 recommended by Cline is also used. A roughly two-fold annual difference is observed between savings when CO_2 is valued at $10 per tonne vs. $1,000 per tonne. With the valuation of $1,000 per tonne, which considers a range of climate change damages, the cumulative savings with this measure from 1997-2010 is predicted to be $303 million.

Table 29. HA-800 Recommended Modal Mix: Contribution to Nova Scotia Target Annual GHG Emissions (2010), Based on Kyoto Agreement

Section	Annual Emissions	Target 2010 Emissions	Change	% Change
Nova Scotia 1995	18,600	17,672	-928.00	-5.0%
HA-800 BAU (1997)	62.00	74.88	12.88	20.8%
HA-800 RMM (1997)	62.00	59.89	-2.10	-3.4%
HA-800 RMM : percent of 2010 target		0.23%		

Table 30. Projected Transportation Costs and CO_2 Emissions for HA-800 Freight for Business-As-Usual (BAU) and for Recommended Modal Mix (RMM) 1997-2010

Year	Total Annual Costs (C$97 ' 000)			Total Annual CO_2 Emissions (tonnes)		
	BAU	RMM	Difference	BAU	RMM	Difference
1997	39,156	30,221	8,935	62,000	49,910	12,090
1998	39,837	30,727	9,111	63,030	50,070	12,960
1999	40,531	31,242	9,289	64,080	51,500	12,580
2000	41,237	31,765	9,472	65,140	52,320	12,820
2001	41,956	32,298	9,658	66,230	53,150	13,080
2002	42,687	32,840	9,847	67,330	53,990	13,340
2003	43,432	33,392	10,040	68,450	54,850	13,600
2004	44,190	33,953	10,237	69,600	55,720	13,880
2005	44,961	34,524	10,437	70,760	56,610	14,150
2006	45,475	34,918	10,558	71,560	57,250	14,310
2007	45,995	35,316	10,680	72,380	57,900	14,480
2008	46,521	35,718	10,803	73,200	58,550	14,650
2009	47,053	36,125	10,928	74,040	59,220	14,820
2010	47,591	36,537	11,055	74,880	59,890	14,990
Cumulative Difference			141,048			191,750
Average Annual Difference			10,075			13,696

Figure 2. Projected Total Freight Costs for Business as Usual and Recommended Modal Mix Scenarios

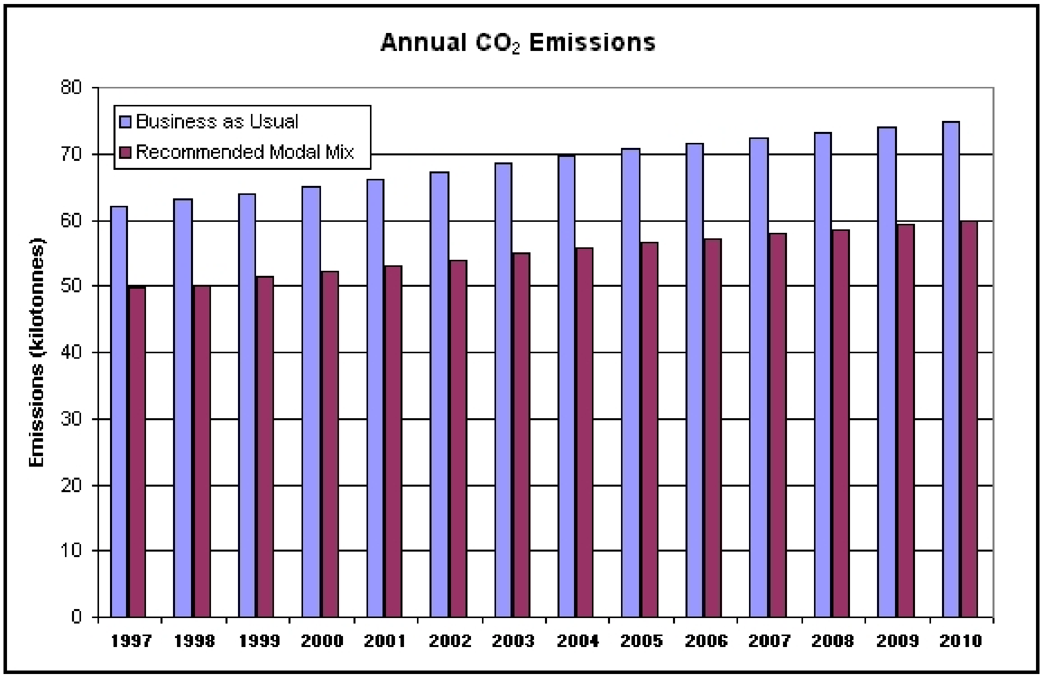


Figure 3. Projected Total Carbon Dioxide Emissions for Business as Usual and Recommended Modal Mix Scenarios

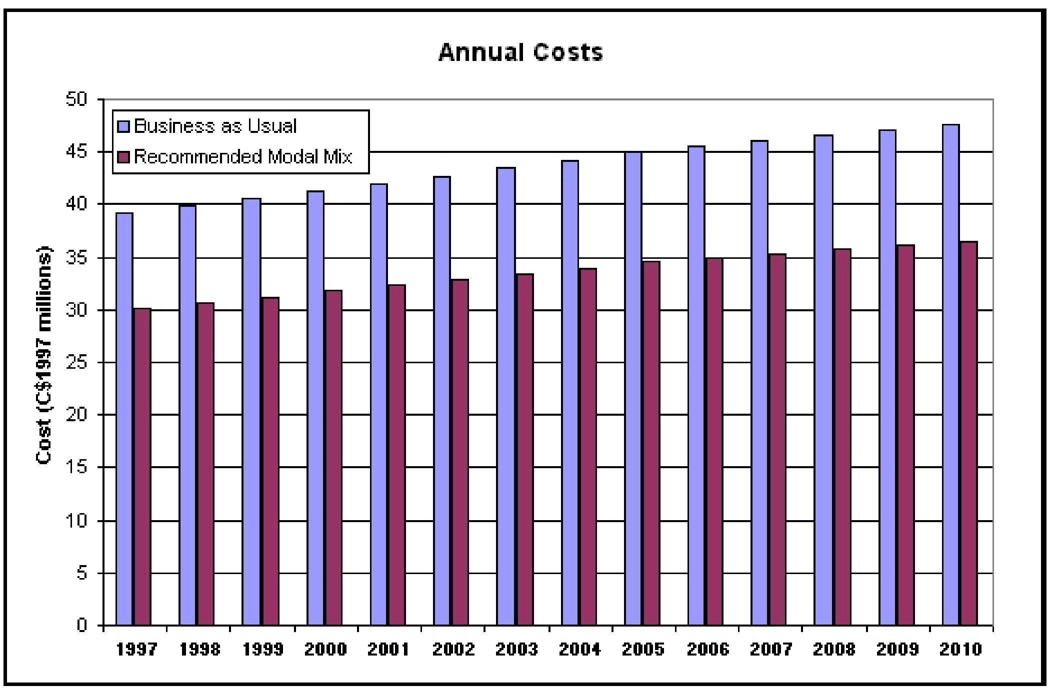


Table 31. Total Transportation Costs Savings with RMM with Varying Values for Cost of CO_2 per Tonne (C$97 million)

CO_2 $/tonne	1997	2010	Cumulative (1997-2010)
$10	8.66	10.71	145.30
$35	8.93	11.05	141.05
$96	9.59	11.87	151.47
$1,000	19.37	24.12	307.20

Additional User Costs Required to Implement Modal Shift

Based on the freight demand factor discussed in Section 3, an increase in trucking costs of 1% is required to effect an increase in rail tonnage of 0.5%. This amounts to a 2:1 ratio in that a 2% increase in trucking costs would result in a 1% increase in rail freight. The required increase in rail tonnage for the recommended modal mix is 577,339 tonnes, or an 18% increase over the current rail tonnage. If the shift is effected by additional user costs, this would require an increase in trucking costs of 36% over current costs.

Since it is assumed this government would implement the shift, the costs to be increased would be the government revenues. Current total government revenue from HA-800 truckers is estimated at $4,007,311. Increasing the costs by 36% would produce a total annual cost to truckers (in the form of government revenue) of $1,442,632.

GHG Mitigation Index for HA-800 Freight

The GHG Mitigation Index is a measure of the cost to reduce CO_2 by one tonne. The GHG Mitigation Index (GMI) as defined here is the extra cost required to bring about the reduction minus the costs or benefits that result from the reduction. A negative GMI indicates a net social benefit for a given proposed GHG reduction option. In this case it does not include any government administrative costs that may be incurred in increasing the cost of trucking. In the case of the long-haul freight transportation industry in Nova Scotia, the total annual reduction of CO_2 in 1997 resulting from the recommended modal shift is 12,090 tonnes, and the cost is estimated at $1,426,910, which is a cost of $118 per tonne). The average annual economic benefit of the modal shift is $10,074,863, or $833 per tonne of CO_2. Therefore, the GMI for the HA-800 Route is $118 minus $833, or $-715, or a net social benefit of $715 for every tonne of CO_2 reduction.

6. Conclusions

Because of the nature of the data on which the study is based, caution must be applied in drawing conclusions from the study. General conclusions that can safely be drawn are discussed here.

Magnitude of CO_2 Reduction Available

In order to meet the Kyoto commitments, Nova Scotia would need to reduce its GHG emissions to six percent below the 1990 level, which would result in a target of 17,672 Kt per year. This would require a reduction of 928 Kt from the 1995 levels of 18,600 Kt. The HA-800 freight modal shift allows the reduction of CO_2 by 2100 tonnes by the year 2010, or 0.23 percent of the overall annual target. While this is a modest share of the overall reduction target, in terms of the cumulative impact, it should be emphasized that this reduction is accompanied by a reduction in overall transportation costs of $11 million annually by 2010. Even without including the costs of climate change, savings in 1997 from the modal shift would have been $8.5 million. As compared with the "Business-as-Usual" scenario, the CO_2 reductions are more dramatic, resulting in a decrease of 191.7 Kt by 2010. While it is clear that a modal shift alone will not accomplish the required reduction in GHG emissions for Nova Scotia, it would make a significant contribution. The modal shift would have significant economic benefits and therefore may be considered a "No Regrets" measure.

Usefulness of GPI Approach in Analyzing GHG Reduction Strategies

This study has shown that the GPI approach is quite useful in analyzing the potential benefits and costs of a general type of GHG reduction strategy. By including "externalities", a more complete picture of costs and benefits is obtained. The GHG Mitigation Indices would be extremely helpful in comparing strategies across different sectors to determine the greatest reductions at the least cost.

Successful Strategies in Other Jurisdictions

In Sweden, environmental costs have been partly included in the tax on petrol and diesel fuel (Kageson 1993). A 1988 policy which substantially increased mileage tax on heavy vehicles has been somewhat eroded by subsequent measures to harmonize Sweden's taxes with other EU countries.

No jurisdictions in Canada have implemented user fees specifically to include environmental costs or to encourage use of rail freight over truck freight. The Ontario Freight Movement Study (Transmode Consultants 1995) did analyze in great detail options for GHG reduction in the Ontario freight transportation sector. New technologies providing greater customer service and efficiency may attract more freight to intermodal. If all long-haul freight in Ontario were shifted to intermodal, this would accomplish a reduction of 2% below 1990 levels in 2005 and an increase of 6% over 1990 levels in 2010. This is compared with an increase of 35% over 1990 levels under a business-as-usual scenario. The authors concluded that there are not enough options in the freight transport industry to reduce GHG emissions to a degree that would offset increased emissions from projected increases in traffic growth. They suggest that the answer to reducing GHG emissions in the freight transport industry may be more regionalized production facilities, leading to a lower demand for freight transport. In order to implement an intermodal shift, the authors recommend pricing of energy use to reflect environmental cost of emissions and improved response of rail to customer service demands.

An Australian study (BTCE 1996) examined the effect of rail infrastructure improvement to decrease rail freight transit time, increase operating efficiencies, decrease overall rail freight cost, and thereby effect a shift of freight traffic from truck to rail. The study concluded that although shifting of freight from truck to rail is only of minor significance in its potential to reduce GHG emissions, this strategy remains a "No Regrets" measure.

Recommendations for Nova Scotia

In light of the limited scale of GHG reduction in the HA-800 freight, the conclusions drawn by Transmode Consultants (1995) merit particular consideration. Their recommendation of regionalization of manufacturing leading to lower freight demand may be applicable to the Atlantic Region. One option would be for provincial governments to encourage investment in industries that are less freight intensive.

While a modal shift of freight from truck to rail in Nova Scotia may not be the most efficient method of reducing GHG emissions, it is a "No Regrets" measure, as demonstrated by the Net GHG Mitigation Index of -$715 per tonne of CO_2. Considering the poor performance of the CN line in Nova Scotia as compared to lines in Canada and the U.S., it may be necessary for the provincial government to provide a business environment that encourages rail freight. Otherwise, the province may lose the line altogether. The suggestion by the APTC of establishing a regional rail network may be worthy of further consideration. Because the Highway 104 Toll fee has only been recently implemented, it may be wise to determine the impact of this change on the trucking industry before initiating other changes. The impacts of any shift of freight from truck to rail on competitiveness of Nova Scotia and of Canada must be considered. In addition, the upheaval caused by a decrease in trucking employment would have to be addressed. This situation may require new ways of thinking about the trucking industry in Nova Scotia and Atlantic Canada so that new means of employment could be found within the trucking industry through intermodal and regional centres.

Recommendations for Further Study

Enhancement of Present Study

1) Conduct a Shippers' and Receivers' Survey to determine
   a. Actual freight being shipped on HA-800
   b. Shippers' willingness to pay for alternate modes
   c. Degree of intermodal shipments already occurring
   d. Freight and mode projections based on shipper's plans
   e. Analyze structure of shipping rates for truck, rail, and intermodal shipments
2) Obtain cooperation of CN Rail for more exact figures and projections based on their market and their plans
3) Use current model for price cross-elasticities to more accurately determine increases in trucking rates required to effect a particular modal shift
4) Examine future of CN Rail Halifax-Montreal line.
5) Obtain data from Statistics Canada input-output database to determine impacts on the economy as a whole (including spin-offs) of a modal shift.

Studies of Other GHG Reduction Strategies

It is recommended here that future cost-benefit studies of GHG reduction strategies focus on those strategies most likely to produce net benefits for society. Such "no regrets" measures are those that can reduce net greenhouse gas emissions levels, but whose total social cost is zero or negative over a specified time period. This does not mean that some individuals or groups do not incur losses, but that society, as a whole, will gain, which allows compensation for those with losses.

Additional Transportation Studies

Before delving into policy initiatives, it may be worthwhile to look at various transport combinations of modal transportation shifts in order to determine which combinations provide the greatest GHG reductions at the least cost. These could include shifts from car to bus; car to rail; and truck to rail.

In the transport sector, previous studies internationally have focused on the following areas as potential "no regrets" measures. Nova Scotia may wish to examine the implications of these for local conditions and circumstances:

1) Road user charges
2) Reduced urban public transit fares and improved public transit services
3) City-wide parking charges
4) Fuel-efficiency labelling of cars
5) Carbon taxes on fuels.

An Australian study (BCTE 1996) found that introduction of all five of these measures would reduce total transport sector emissions between 1996 and 2015 by up to 10%. The measures would also produce substantial social benefits in reduced congestion, accidents, noxious emissions, and other costs. The framework of the present study on modal freight shifts is particularly applicable to an examination of the potential for modal shifts in passenger transportation and to transportation in the entire province.

Forest Sector

A further area for future study, which is in accord with the GPI natural resource accounts, is exploration of the potential for enhancing carbon sinks. Investments in restorative forestry and tree planting were found by the Australian study (BCTE, 1996) to be a low cost measure capable of absorbing all CO_2 emissions from the transport sector in the long term.

Energy Sector

The GPI approach would be applicable to the study of renewable energy sources and for comparing total costs of existing energy sources.

In sum, because the GPI approach attempts to assess the economic costs and benefits of social and environmental variables as well as direct inputs on the economy, it may be a helpful tool for future studies assessing the viability of different GHG reduction strategies.

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8. Appendix

Table 32. Annual Capital Costs for HA-800

Yr.	Average Annual Rate	Total Capital Hwy 102	Annual Payments New Loans	Annual Cumulative Payments	Total Capital Hwy 104	Annual Payments New Loans	Annual Cumulative Payments
1976	9.61	$7,243,500	$828,283	$828,283	$35,600	$4,071	$4,071
1977	9.15	$2,169,500	$240,207	$1,068,490	$74,200	$8,215	$12,286
1978	9.57	$1,235,000	$140,829	$1,209,319	$457,600	$52,181	$64,467
1979	10.5	$8,631,900	$1,048,718	$2,258,036	$325,300	$39,522	$103,989
1980	12.82	$2,839,200	$399,806	$2,657,842	$878,500	$123,707	$227,696
1981	15.59	$5,198,800	$857,806	$3,515,648	$0	$0	$227,696
1982	14.75	$3,963,600	$624,485	$4,140,133	$61,600	$9,705	$237,401
1983	12.08	$4,336,200	$583,439	$4,723,571	$593,900	$79,910	$317,311
1984	12.92	$2,184,100	$309,421	$5,032,992	$1,787,300	$253,206	$570,517
1985	11.2	$3,385,100	$430,658	$5,463,651	$2,079,300	$264,532	$835,049
1986	9.3	$2,359,300	$264,001	$5,727,652	$691,900	$77,422	$912,472
1987	9.75	$142,500	$16,453	$5,744,105	$359,100	$41,462	$953,934
1988	10.05	$1,843,600	$217,288	$5,961,394	$798,000	$94,053	$1,047,987
1989	9.66	$4,287,600	$491,983	$6,453,377	$2,589,400	$297,122	$1,345,109
1990	10.69	$1,204,300	$148,176	$6,601,553	$4,357,200	$536,105	$1,881,214
1991	9.72	$2,155,300	$248,340	$6,849,892	$8,700,700	$1,002,519	$2,883,734
1992	8.77	$200,800	$21,638	$6,871,530	$22,263,600	$2,399,055	$5,282,788
1993	7.86	$100,000	$10,079	$6,881,609	$38,374,400	$3,867,886	$9,150,675
1994	8.69	$1,076,700	$115,355	$6,996,964	$35,861,300	$3,842,075	$12,992,750
1995	8.41	$8,961,750	$940,799	$7,937,762	$16,619,900	$1,744,746	$14,737,496
1996	7.75	$2,362,100	$236,127	$7,345,606	$30,466,200	$3,045,545	$17,778,971
1997	6.66	$4,431,950	$407,354	$7,512,753	$28,047,900	$2,577,971	$20,348,726
Average Annual Payments				$5,081,007			$4,178,015
Total Average Annual Payments				$9,259,023			

Note: Assumes 20-year lifetime & 20-year loan term at Govt. of Canada Benchmark Bond Yields. Long-Term Rates (Bank of Canada 1999)