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THE SOCIO-ECONOMIC IMPACTS OF ADOPTING TIGHTER MOTOR VEHICLE EMISSION STANDARDS AND FUEL REQUIREMENTS

June 11, 1996

Industry Canada

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CONTENTS

FOREWORD

This report was commissioned in order to support the development of options and recommendations for the Canadian Council of Ministers of the Environment (CCME) Task Force on Cleaner Vehicles and Fuels. The report is based on four studies which provided information on refinery upgrading costs, vehicle costs, refinery competitiveness, and health benefits that would result from various fuel and vehicle upgrading scenarios.

Because of the difficulty in completing this work, including the short time available between the availability of supporting studies and final Task Force deliberations, this particular study was not considered by the Task Force. All of the supporting work which underlies this study was fully considered and was cited in the October 23, 1995 report of the Task Force to CCME Ministers.

Since the background reports to this study were prepared in mid-1995, a number of events in the United States have occurred which support a conclusion that the incremental costs of vehicles to meet low emission vehicle (LEV) standards are expected to be small. The October 10, 1995 edition of the U.S.-Federal Register states the following:

> "[The] Environmental Protection Agency (EPA) has also analyzed the costs of the National LEV program based on currently available information. The most recent detailed assessment of the cost of LEV's was produced by the California Air Resources Board (CARB) in 1994. CARB estimated the incremental cost of $114 per car for LEV's only in California. EPA believes that the incremental cost for National LEV will be considerably less expensive than the CARB estimate for a variety of reasons. First, automotive pollution control technology has advanced since Honda recently announced the introduction of new LEV technology that will add little or no cost to vehicles. Second, the national LEV program includes numerous provisions to harmonize federal and California motor vehicle requirements. The resulting cost-savings for auto manufacturers (in areas such as vehicle design certification testing, mechanic training and inventory control) will be significant and offset at least a portion of the LEV production tests. Third, the nation-wide production of LEV's will result in economies of scale for the manufacturers. Finally, auto industry experience has consistently demonstrated rapid price decreases in successive model years for newly-introduced technology. Analysis discussed in the Regulatory Impact Analysis (RIA) yields an annual incremental cost estimate compared to current regulatory obligations of $700 million for the national LEV program, although EPA believes these costs would actually be lower, as discussed above. The total expenditure for new cars in the United States in 1993 was approximately $225 billion."

EXECUTIVE SUMMARY

Context

The Task Force on Cleaner Vehicles and Fuels of the Canadian Council of Ministers of the Environment commissioned several studies to assist in evaluating the feasibility of various air quality improvement options. Other studies commissioned by the Task Force have provided estimates of the production costs associated with meeting tighter vehicle emission and reformulated fuel standards, and the health and environmental benefits associated with those standards. This report builds upon those studies to determine the impacts on various stakeholder groups -- individuals, industry, government -- as well as the environment.

It should be noted that this is not a cost-benefit analysis. Diverse methodologies used in the studies together with budgetary and time constraints, precludes a comprehensive assessment of all the options being examined by the CCME Task Force. Nevertheless, the impacts on stakeholders are presented for two options for which relatively comprehensive information is available. The reader is invited to make an assessment regarding whether the costs and benefits can be feasibly compared. The figures should be taken as a rough order of magnitude that help to shed some light on the potential distribution of costs and health and environmental benefits, rather than being treated as precise estimates. In view of the variety of estimation techniques and assumptions and data limitations, this report should not be considered prescriptive.

Cost Impacts - Automotive

Production costs associated with adopting more stringent vehicle emission standards were extracted from **Incremental Costs of Vehicle Emissions Standards.** *Although a key element of costs is vehicle hardware, this cost may be small in relation to the potential cost of disharmony that could arise if the North American automotive market were to be fragmented through the adoption of multiple vehicle specifications. Harmonization of new vehicle standards in Canada with those in the United States is accordingly the least-cost option.*

While the size of the impacts on stakeholders varies widely depending upon which option is selected and the magnitude of the production cost estimates, the general nature of the impacts is similar -- prices rise and sales of new vehicles decline. Profits of vehicle assemblers fall without an offsetting benefit to components' manufacturers; government sales tax revenues remain fairly stable but income tax revenues fall due to *lower profits in the automotive industry. Several other industries may also be affected as demand for inputs into the automotive industry decline and consumers shift their expenditures away from other goods and services towards vehicles.*

The manner in which costs are borne by stakeholders depends upon how the vehicle manufacturers choose to price their vehicles in response to tighter emission standards. Prices may rise independently of any Canadian action if the United States tightens its standards.

Cost Impacts - Fuels

The costs of producing reformulated motor vehicle fuels were extracted from ***Cost of Upgrading Canadian Transportation Fuels.*** *The impact on refiners arising from each of the options depends upon the extent to which higher production costs can be recovered in the marketplace -- a marketplace where prices are constrained internationally. Information on the nature of such constraints was extracted from an Industry Canada study entitled* ***Recovery of Capital and Operating Costs for Fuel Reformulation.*** *The analysis suggests that all of the options under consideration will have a negative impact on after-tax industry profits. The impacts range from a profit reduction of $24 million for the 100% on-road low sulphur diesel scenario, to a profit reduction as high as $372 million under a scenario for California Phase II gasoline.*

It is estimated that consumers could face price increases of 0.5 cents per litre for low sulphur diesel, 0.7 cents per litre for reformulated gasoline under the 200 ppm scenario, and 4.2 cents per litre for California Phase II gasoline. Under some of the more stringent specifications (i.e. those requiring refiners to meet 200 ppm and lower gasoline sulphur), the economic impact arising from reduced discretionary income and potential refinery closures could be expected to result in net job losses. The long-term employment impact associated with the less stringent options is not expected to be significant.

Government tax revenues fall under each of the options due to lower refinery profits and reduced gasoline sales.

Benefits

In order to assess the overall impacts of improved air quality, it is necessary to acquire an understanding of the health and environmental benefits associated with cleaner air. Benefits estimates for two vehicle/fuel scenarios were drawn from ***Benefits of Cleaner Vehicles and Fuels.*** *The benefits from cleaner vehicles and fuels are primarily obtained from the reduction of premature deaths and of a large number of respiratory health* *effects such as chronic bronchitis, respiratory and cardiac hospital admissions and emergency room visits, asthma and acute respiratory symptoms and new cancer cases. Among these, the more than 3000 mortalities and 20,000 chronic bronchitis cases avoided over the 23 year period covered by the study provide the greatest value to Canadians.*

Premature deaths and illnesses and their associated negative values to Canadians in terms of quality of life, are not as readily quantifiable as costs where an exchange of money takes place. Therefore, techniques were used to estimate monetary values to Canadians of avoiding premature deaths and illness. An analytical tool known as "Willingness to Pay" is widely accepted and has been used in this study.

In the case of Scenario I (i.e. FEDLEV vehicles and 200 ppm sulphur gasoline), benefits to Canada (excluding British Columbia) range from $11 to $29 billion in undiscounted 1994 dollars for the period 1997 to 2020. A separate study estimating the benefits for British Columbia showed that the upper range of the benefits would increase by approximately $2 billion. The majority of the benefits occur in the areas currently affected by ambient air quality problems, specifically the Windsor-Quebec Corridor and the Lower Fraser Valley.

The benefits study did not quantitatively evaluate other environmental benefits such as improved visibility, crop yields, reduced material damage and a reduction in the production of greenhouse gases. Other factors that would tend to increase benefits, such as the characteristics of the particles and the associated contribution from vehicles, have not been included.

I. INTRODUCTION

The Task Force on Cleaner Vehicles and Fuels of the Canadian Council of Ministers of the Environment (CCME) was mandated to develop options and recommendations to the Council of Ministers on a national approach to vehicle emission and efficiency standards and fuel formulations for Canada, recognizing regional and urban concerns.

As part of the decision-making process, a number of studies were commissioned to assist the CCME in assessing the costs and benefits of adopting tighter fuel and vehicle emission standards. This report distils several of those studies and combines the results with additional information in order to provide an overall assessment of the impact on the various stakeholder groups -- individuals, industry, governments -- and the environment.

The report commences by providing background information on the Canadian automotive and fuel industries, as well as the various emission and fuel reformulation options that are under consideration. The next three sections build upon the studies on the automotive and fuel refining industries and health and environmental benefits to estimate the impact on the various stakeholder groups. The results are then combined in an overall assessment and conclusions are provided.

Because of the timing of availability of relevant background studies, this report was not available to the Task Force at the time that it provided recommendations to Ministers in October 1995. All of the basic information and background studies that support this work were, however, available to the Task Force, were cited in the Task Force report and guided the recommendations.

II. BACKGROUND
II.1 THE CANADIAN AUTOMOTIVE INDUSTRY[1]

The Canadian automotive manufacturing sector consists of two major industries -- motor vehicle assembly and components production. The assembly industry is totally foreign owned and controlled, whereas the independent parts industry is more than 50% Canadian owned and controlled. The structure of the Canadian automotive industry reflects its development under the 1965 *Canada-U.S. Automotive Products Trade Agreement* (Auto Pact). Although the U.S. and Canada each administered the Auto Pact differently, both countries allowed bilateral duty-free imports of vehicles and parts. As a result, Canadian and U.S. automotive producers operate as an integrated industry. Japanese vehicle and parts producers are also structuring on an integrated North American basis, originally supported by the FTA and now the NAFTA.

Unlike any other sector of the Canadian economy, the conditional free trade environment under the Auto Pact has led to efficient world-scale plants in Canada supplying both Canadian and the U.S. markets, and common corporate interests are deeply rooted on both sides of the border. The integrated nature of the North American automotive industry has allowed Canadian assemblers to specialize and benefit from economies of scale within the entire North American market. The NAFTA is expected to further consolidate the integration of the North American industry with the inclusion of Mexico. This trade environment allows companies to select production sites and scale based more on business factors than on the need to locate behind tariff or other trade barriers.

Contribution to GDP

The automotive sector contributes approximately 2 per cent of total Canadian GDP. When combined with the distribution and retailing, this sector is responsible for approximately 4 per cent of GDP. The industry's share of manufacturing GDP is currently over 10 per cent. Using value-added as an indicator, automotive parts manufacturing is Canada's largest manufacturing industry, and motor vehicle assembly is the second largest. The automotive sector is particularly important to the Province of Ontario, where over 80 per cent of the sites and 90 per cent of all Canadian production is located. It accounts for about 4.3 per cent of provincial GDP.

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1. The information contained in this section has been extracted from *The Current Status of the Automotive Industry* by the Automotive, Urban Transit and Rail Branch of Industry Canada.

Employment

The Canadian automotive industry is Canada's largest manufacturing sector, providing 146,800 direct manufacturing jobs and 397,800 jobs in retailing and the aftermarket. Despite expansion of assembly output since the mid 1980's, employment has remained relatively stable due to significant increases in productivity. Employment statistics, which measure the number of employees on payroll, fail to convey the variation of assembly employment. As assembly plants utilize a continuous flow process, output is varied by changing total hours worked rather than the number of persons employed per shift. Over the short term, marginal demand increases are satisfied through increased overtime or, conversely, through shift reductions or temporary plant closures.

Capital Stock and Investment

Over the past 15 years, new capital expenditures in the automotive industry have averaged over $1.7 billion per annum and continue to rise. Total investment averaged over $2 billion per year over the last decade and investment intentions for 1994 amounted to $3 billion. Although most of the investment has been in assembly, the recent economic recovery is creating a significant boost in parts facilities expenditures, some of which might find its way into markets for new vehicle emission components.

Shipments and Canadian Market

Canadian automotive shipments totalled $62 billion in 1994. In the same year, Canada produced 2.2 million vehicles, representing approximately 16 per cent of total Canada-U.S. vehicle production. Canada's share of North American production has steadily increased over the last decade from about 14 per cent to about 16 per cent.

Light duty vehicle sales in Canada amounted to 1.2 million units in 1994, a drop of 24 per cent from the 1988 level of 1.54 million. The net result is that Canada is currently producing almost twice as many vehicles as are sold domestically.

Trade

Between 85-90 percent of Canadian automotive production is exported annually, almost all of which is destined for the U.S. In 1994, Canada-U.S. bilateral automotive trade amounted to $96 billion. Automotive exports contributed 25 per cent to Canada's merchandise exports.

Canada's trade surplus in motor vehicles has improved drastically over the last 25 years -- increasing seventeen-fold in nominal terms between 1970 and 1994. In 1994, Canada had a net global automotive trade surplus of $5 billion, consisting of an assembly surplus of $20 billion and a parts deficit of $15 billion. Canada has generally had a positive automotive trade balance with the U.S. but a deficit with the rest of the world. The motor vehicle trade surplus with the United States is a direct consequence of Canada's larger-than-proportional share of assembly activity.

North American Motor Vehicle Standards

Integrated production processes and markets require a system of compatible standards to avoid adding significant costs to the design, production and testing of vehicles and parts. Accordingly, the federal government's approach to safety, emission and fuel economy standards is grounded in making Canadian standards compatible, to the greatest extent possible, with those in the U.S. In view of the integrated structure of this industry, compatibility with automotive standards in the United States, including those related to emissions, is of critical importance for the Canadian industry. Specific obligations under the NAFTA were established to encourage Canada, the U.S. and Mexico to further increase the compatibility of national standards-related measures with the purpose of reducing barriers to investment and trade.

TABLE 2.1.1
LIGHT DUTY VEHICLES MANUFACTURED IN CANADA

Assembler / Location	Product	Vehicle Type	1993 Output	1993 Capacity	1993 Employment
CAMI					
Ingersoll	Geo Metro	small	100,051	126,720	2,188
	Suzuki Swift	small			
Chrysler					
Bramalea	Concorde	large	256,754	192,000	2,743
	Intrepid LHS	large			
	NewYorker	large			
	Vision	large			
	Ram Van	large			
Pilette Rd.	Minivans	truck	84,652	111,360	1,764
Windsor		truck	301,965	264,960	5,118
Ford					
Oakville	Tempo	small	136,516	230,400	2,757
	Topaz	small			
Oakville	F-Series Truck	truck	136,247	145,920	936
St. Thomas	Crown Victoria	large	200,661	230,400	2,938
	Grand Marquis	large			
GM					
Oshawa	Lumina	middle	173,220	226,560	3,476
Oshawa	Lumina	middle	162,340	222,720	3,565
	Regal	middle			
Oshawa	C/K Truck	truck	255,546	230,400	4,027
St. Therese	Camaro	middle			
	Firebird	middle	121,773	86,400	
					3,102
Honda					
Alliston	3-door Civic	small	100,203	103,860	1,100
Hyundai					
Bromont	Sonata	middle	14,243	57,600	NA
Toyota					
Cambridge	Corolla	small	72,219	76,800	1,005
Volvo					
Halifax	700's	large	5,478	5,760	NA
	900's	large			

Research and Development

Canada's share of R&D expenditures by vehicle assemblers has historically been less than its share of production due to the standing policy of centralizing R&D at company headquarters. Although the proportion of the Big Three's engineering and R&D expenditures in the Canadian assembly industry has followed an upward trend over the past ten years, the amount is still small in relation to the total Big Three annual R&D expenditures. In 1992, the Big Three had worldwide R&D expenditures of US$ 11.3 billion, only 5.4 per cent of which was spent in Canada. Research and development by Asian and European companies is typically done in the country of origin.

Although assembler R&D in Canada is still low, it has been increasing. For example, GM undertakes R&D in niche manufacturing and product technology at its Oshawa facility, and has installed a cold-weather development centre at Kapuskasing, Ontario. Chrysler recently opened an automotive research facility in a strategic alliance with the University of Windsor, to conduct research in road simulation, advanced engine design and alternate fuels. In 1993, Ford established a Chair in aluminum casting technology at the University of Windsor, in conjunction with the establishment of an aluminum casting technology R&D centre. Windsor will become Ford's world centre for aluminum research.

Each of the Big Three subsidiaries in Canada has world mandates for alternative fuel applications development projects. A number of Canadian parts companies have developed proprietary technology in alternative materials, batteries and fuel cells. There may be opportunities to encourage some of these activities related to vehicle emissions and fuel standards developments.

In 1993, the U.S. government and the Big Three entered into the Partnership for a Generation of New Vehicles (Clean Car). This agreement is aimed at strengthening Big Three competitiveness through the development of extremely efficient vehicles and more agile manufacturing methods. In order to coordinate Canada's complementary activities, the Big Three in Canada, encouraged by Industry Canada and the Provinces of Ontario, Quebec and British Columbia, have established CANCAR. This consortium has begun work on a small pre-competitive R&D project. Opportunities may exist for participating in the development of technology to comply with tighter vehicle emission requirements.

Competitiveness

The Canadian vehicle assembly industry has benefitted from strong production mandates. In the early years, trade policy and a capable work force were clearly instrumental. Luck was also a factor in some of the earlier mandates for minivans, full size cars and trucks, as many of the vehicles assembled in Canada became far more popular than originally expected. In recent years, strong performance has led to the renewal of key mandates and to massive assembly investment. However, the pressure on production mandates is relentless. Competitive demands, combined with the streamlining of product design, are leading to shorter production mandates. As today's models are replaced in the next half of the 1990s, the productivity and flexibility of Canadian plants will once again be subject to severe scrutiny. The challenge is significant as the investment is largely derived from foreign sources with no inherent commitment to Canada.

Productivity and labour costs are key measures for competitiveness in the automotive assembly industry. Labour accounts for 62 per cent of assembly costs, or 7 per cent of the costs of the total vehicle. Wage movements, therefore, play a key role in determining where the competitive edge resides. Although Canada continues to enjoy a labour cost advantage, this advantage has been eroding with the result that the value of the Canadian dollar has increased in importance. Canadian labour rates remain highly competitive at current exchange rates.

Using a standard currency, a comparison of the elements of Big Three assembly costs between the U.S. and Canada, reveals that costs are approximately identical, with the exception of labour. On the other hand, Asian-owned plants in Canada have a smaller advantage over their counterparts in the United States. Part of the reason for the smaller differential is that, unlike the U.S. Big Three, Asian-owned plants in the U.S. have younger work forces and correspondingly lower medical and pension costs.

FEATURES OF THE CANADIAN AUTOMOTIVE INDUSTRY

Consists of two industries -- vehicle assembly and components production.

Largest manufacturing industry in Canada, accounting for over 10% of manufacturing GDP.

Major employer providing 146,800 direct manufacturing jobs and another 397,800 in the retail and aftermarket sectors (1994).

Integrated Canada-U.S. Industry--NAFTA will further increase North American content.

Canada has disproportionately large share of assembly production.

Canadian competitiveness based increasingly on favourable rates of exchange as labour cost advantage declines.

II.2 VEHICLE EMISSION STANDARDS

Transport Canada is responsible for Canadian motor vehicle emission standards. Under the *Motor Vehicle Safety Act*, regulations exist for exhaust emissions of hydrocarbons, nitrogen oxides, carbon monoxide and particulates for light-duty vehicles, trucks and heavy duty vehicles. Evaporative emissions are also regulated for these vehicles. Vehicles are "self certified" by the manufacturers and audited at federal government facilities. Canadian standards are usually set in parallel with those set by the Environmental Protection Agency in the United States. Current vehicle emission standards are illustrated in Table 2.2.1.

TABLE 2.2.1
CANADIAN VEHICLE EMISSION STANDARDS

Year	HC (g/mile)	CO (g/mile)	NO_x (g/mile)	PM (g/mile)	Evaporative Emissions
1988 (Tier 0)	0.41	3.4	1.0	0.2	2
MOU* (Tier 1)	0.25	3.4	0.4	0.2	2

* ***Phased-in at 40% in 1994, 80% in 1995 and 100% in 1996. Expires in 1996.***

United States Options

For the purposes of the CCME Task Force, Transport Canada has identified three vehicle emission scenarios that might feasibly occur in the United States. Under the status quo, Tier 1 is retained throughout the United States except in California, which adopts the California Low Emission Vehicle Program (CalLEV) -- a common feature to all three scenarios. Under Scenario I, the Ozone Transportation Commission (OTC) states adopt OTCLEV with the remaining states retaining Tier 1 until the year 2004, when it would be replaced by Tier 2 requirements. Under Scenario II, non-Californian states would adopt FEDLEV, a program which ultimately results in the adoption of LEV with a different phase-in for OTC states and the remaining States[2]. These standards are discussed below.

2. Additional information can be found in *Regulation of Air Pollution from Road Vehicles in the U.S.* prepared by Transport Canada.

TABLE 2.2.2
CALIFORNIA LIGHT DUTY VEHICLE FLEET REQUIREMENTS

YEAR	NMOG (g/mile)	ZEV (% fleet)
1994	.250	-
1995	.231	-
1996	.225	-
1997	.202	-
1998	.157	2
1999	.113	2
2000	.073	2
2001	.070	5
2002	.068	5
2003	.062	10

The California Low Emission Vehicle Program (CalLEV) mandates fleet requirements for zero-emission vehicles and sets maximum hydrocarbon emissions expressed in terms of "reactivity-adjusted" non-methane organic gas (NMOG). The requirements are provided in Table 2.2.2. Leaving aside ZEVs, the NMOG average must be satisfied by certifying vehicles to one of three standards -- Transitional Low Emission Vehicle (TLEV), Low Emission Vehicle (LEV) or Ultra Low Emission Vehicle (ULEV). Manufacturers may adjust their fleets to attain these averages. The CalLEV program also provides for the carryover and trading of NMOG credits. It is worth noting that recent information suggests that the CalLEV program may be revised as the ULEV and LEV technologies are not adequately established to meet the long-range portions of the program.

TABLE 2.2.3
UNITED STATES LIGHT DUTY VEHICLE EMISSION STANDARDS
(50,000 miles)

Standard	NMOG (g/mile)	CO (g/mile)	NO_x (g/mile)
Federal Tier 0	.410	3.4	1.0
Federal Tier 1	.250	3.4	0.4
TLEV	.125	3.4	0.4
LEV	.075	3.4	0.2
ULEV	.040	1.7	0.2
ZEV	0	0	0
Federal Tier 2	.125	1.7	0.2

Note: 50,000 mile requirements of 100,000 mile standards. Vehicle tests conducted with California Phase II gasoline except Tier 2 which uses EPA certification test fuel.

Vehicle Emission Program for Ozone Transportation Committee States (OTCLEV)

The *Clean Air Act (1990)* defines the Ozone Transportation Commission States as those located in the Northeastern United States -- Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia and the District of Columbia. The OTC Low Emission Vehicle Program is basically the same as CalLEV without a federal mandated requirement for ZEVs. Any ZEV or NMOG requirements would be left up to the individual states.

Federal Low Emission Vehicle Program (FEDLEV)

FEDLEV consists of a gradual phase-out of TLEV and phasing in of LEV in the OTC states between 1997 and 2001. The LEV standard is then applied to all 49 states effective 2001. The Tier 1 requirement would apply until that time. The phase-in schedule is as follows:

TABLE 2.2.4
PERCENTAGE OF NEW VEHICLES SOLD THAT MUST SATISFY INDICATED EMISSION REQUIREMENTS UNDER FEDLEV

YEAR	OTC STATES		49 STATES	
	TLEV	*LEV*	*Tier 1*	*LEV*
1997	40	-	100	-
1998	40	-	100	-
1999	40	30	100	-
2000	40	60	100	-
2001+	-	100	-	100

Unlike CalLEV, FEDLEV does not permit manufacturers to adjust their fleets in order to meet an NMOG average. TLEV and LEV requirements are fixed so NMOG reductions operate via those standards. The program does not involve ULEVs or ZEVs.

Canadian Options

In identifying the possible options for Canada, it was assumed that Canada would adopt standards at least as stringent as those applicable in most of the United States, and that harmonization would occur with a U.S. standard -- i.e., no unique Canadian standards. The federal government's harmonization principle noted in Section II of this report was also a key factor, given the importance of the automotive industry to the Canadian economy. Similarly, it was assumed that any region within Canada that chooses to introduce its own set of standards would develop regulations at least as high as in the rest of Canada, and that it would not adopt a standard which did not exist somewhere in Canada or the United States.
On the basis of the U.S. options, Transport Canada has identified the alternatives set out in Table 2.2.5.

TABLE 2.2.5
VEHICLE EMISSION OPTIONS AND SCENARIOS

United States	*Canada*	*Region*
Status Quo California -- CalLEV OTC States -- Tier 1 Federal -- Tier 1	***Option I*** -- Tier 1	***Option I*** -- CalLEV ***Option II*** -- Tier 1
Scenario I California -- CalLEV OTC States -- OTCLEV Federal -- Tier 1 to 2003 Tier 2 in 2004+	***Option I*** -- OTCLEV ***Option II*** -- Tier 1/2	***Option I*** -- CalLEV ***Option II*** -- OTCLEV ***Option I*** -- CalLEV ***Option II*** -- OTCLEV ***Option III*** -- FEDLEV(OTC)
Scenario II California -- CalLEV OTC States -- FEDLEV Federal -- FEDLEV	***Option I*** -- FEDLEV+ ***Option II*** -- FEDLEV(OTC)	***Option I*** -- CalLEV ***Option II*** -- FEDLEV ***Option I*** -- CalLEV ***Option II*** -- FEDLEV+ ***Option III*** -- FEDLEV (OTC)

II.3 THE CANADIAN PETROLEUM PRODUCTS INDUSTRY[3]

The Canadian petroleum products industry consists of petroleum refining, product distribution and marketing operations. Thirteen companies operate 22 refineries, 17 of which produce gasoline and form the basis of this study. These refineries are identified in Table 2.3.1. Ownership of the industry is 44 per cent Canadian, 35 per cent USA and 21 per cent other (primarily European). Petroleum products are sold through a network of some 17,000 retail outlets. Canadian demand for transportation fuels is provided in Table 2.3.2.

TABLE 2.3.1
CANADIAN REFINERIES

Location	Firm	Capacity (000m³/day)
Atlantic Canada		
Saint John	Irving Oil	27
Dartmouth	Esso Petroleum	13
Quebec		
Montreal	Petro-Canada	14
Montreal	Shell Canada	19
St. Romuald	Ultramar	24
Ontario		
Nanticoke	Esso Petroleum	18
Oakville	Petro-Canada	13
Sarnia	Esso	19
Sarnia	Sunoco	13
Corunna	Shell	11
Prairies		
Regina	Co-Op/New Grade	7
Edmonton	Esso Petroleum	28
Edmonton	Petro-Canada	18.5
Bowden	Parkland	1
Scotford	Shell Canada	11
British Columbia		
Burnaby	Chevron	8
Prince George	Husky	1.5
Total		246

Source: Based on figures provided in Cost of Upgrading Canadian Transportation Fuels for Canadian Council of Ministers of Environment.

3. Based on information extracted from *The Current Status of the Canadian Petroleum Products Industry* prepared by the Manufacturing and Processing Technologies Branch of Industry Canada.

TABLE 2.3.2
1994 DEMAND FOR TRANSPORTATION FUELS
(million litres/year)

Fuel/Region	B.C./Prairies	Ontario	Atlantic Quebec	CANADA
Gasoline	11 680	12 775	10 585	35 040
Road Diesel	2 920	2 920	2 920	8 760
Other Distillate	6 205	5 840	9 855	21 900
Other Fuels	4 015	5 110	5 840	14 965
Total	24 820	26 645	29 200	80 665

Source: Based on figures provided in Cost of Upgrading Canadian Transportation Fuels for Canadian Council of Ministers of Environment.

Contribution to GDP

Petroleum products are the source of fuel for virtually all transportation modes and critical feedstocks to other important industries. Over 64 per cent of all petroleum products in Canada are used as inputs to other businesses. This equates to some $10 billion, or 2 per cent of all material inputs to these businesses. Overall, the refining sector accounts for approximately $2 billion, or 1 per cent of the Canadian manufacturing GDP -- approximately one-tenth that of the automotive industry. Accurate figures on product distribution and marketing subsectors are not available.

Employment

The petroleum products industry employs over 150,000 people, approximately 13,000 of whom are in refineries and the remainder in product distribution and marketing operations. Refinery jobs are high in knowledge intensity requirements, comparable to the high-tech electronic industry. Each refinery job has been estimated to generate up to 7 jobs in associated industries, while every distribution and retail job creates one to two additional jobs in other industries.

Capital Stock and Investment

Refining is highly capital intensive, requiring 8.7 units of capital for every unit of value-added output, as compared to the 2.5 average for manufacturing. This underlines the need for continued high levels of capital for the industry to renew its technology. In 1993, capital expenditures in refining and marketing were approximately $400 million each, for a total of $800 million. Further, the refinery workforce has one of the highest value-added levels in Canadian manufacturing, at about $150,000 of GDP per employee. The possibility exists that some of the investments required to satisfy potential reformulated gasoline requirements would need to be made for other reasons as well.

Trade

Canada is a net exporter of petroleum products, and enjoyed a trade surplus of $800 million in 1992, doubling to over $1.7 billion in 1993. In 1993, exports were $2.7 billion as compared to imports of $1 billion.

Financial Performance

Gross revenues have been relatively flat over the past decade at about $25 billion (net of taxes). The industry has also been earning low rates of return on capital (ROC), averaging about 4 per cent since 1981. The ROC in the U.S. petroleum products industry, Canada's major competitor, has been about 5½ per cent. Although the Canadian industry has under-performed relative to its U.S. counterpart, recovering demand and aggressive cost cutting have improved returns in recent years. (Operating costs have been reduced by $800 million, or 18 per cent since 1991.) The result has been an improvement from a net loss of over $600 million in 1991 to net income of $500 million (5.3 per cent ROC) in 1993 and $725 million (7.6 per cent ROC) in 1994. With total fuel output of 81 billion litres, this income represents 0.6¢/litre, and 0.9¢/litre for 1993 and 1994 respectively.

Regulatory Environment

Regulations on fuel standards are imposed at both the federal and provincial levels, with voluntary cooperation occurring through compliance with standards established by the Canadian General Standards Board (CGSB). CGSB standards cover seasonal Reid Vapour Pressure limits and performance standards such as manganese and sulphur content.

Federal Government

Canada currently has three regulations at the federal level for gasoline and diesel fuels:

- The 1978 *Fuels Information Regulation* requires fuel producers to report the sulphur content and the amount of liquid additives in fuels.

- The 1990 *Gasoline Regulations* establish limits on lead and phosphorous contents for both leaded and unleaded gasoline.

- The 1991 *Contaminated Fuels Regulations* prohibit the import or export of contaminated fuels, except for lawful destruction, disposal or recycling.

Environment Canada and the major petroleum marketing companies have signed a Memorandum of Understanding which states that after October 1, 1994, only low-sulphur diesel will be sold at service stations and truck stops, and on road cardlocks and keylocks. These outlets account for over 50 per cent of the on-road diesel fuel sold in Canada. The companies will also supply low-sulphur diesel, "as required", to on-road end-users not supplied through these facilities.

The federal government requires that its fuel purchases meet the specifications of the Canadian General Standards Board. The Department of National Defence intends to restrict its diesel purchases to the low-sulphur variety, except in remote northern locations.

A policy to prohibit the use of MMT in all gasoline was announced by the federal government in spring 1995.

The Federal Environment Minister announced in July 1995 the intention to limit the benzene content of gasoline to 1 per cent by volume.

Provincial Governments

Several provinces have regulations regarding the volatility of gasoline as measured by Reid Vapour Pressure (RVP). During the summer months, RVP is limited on a provincial basis to the levels identified in Table 2.3.3.

In late 1995, British Columbia adopted gasoline quality regulations that require the use of deposit control additives and limit gasoline formulations to control emissions of NOx and toxics.

Effective April 1, 1995, only low-sulphur diesel may be sold in British Columbia. This requirement, however, has been in effect in the Lower Fraser Valley since September 1994. Diesel regulations do not exist in the other provinces.

TABLE 2.3.3
PROVINCIAL REID VAPOUR LIMITS

Province	RVP (psi)
British Columbia	9.0
Alberta	11.0
Ontario	10.5
Quebec	10.5
New Brunswick	10.5
Nova Scotia	10.5
Newfoundland	10.5

Manitoba, Saskatchewan and Prince Edward Island do not have any requirements for gasoline or diesel fuels.

Competitiveness

Canadian refiners are price takers for both crude purchases and product sales. Canadian crude oil prices are established in the U.S. Midwest market relative to competing feedstocks. Canadian wholesale product prices are strongly influenced by U.S. prices, adjusted for transportation costs. Accordingly, refinery margins (the value of the product slate less feedstock and operating costs) are heavily influenced by access to low-cost feedstocks, the ability to process the inexpensive heavy sour crudes, economies of scale and control of operating costs.

Canadian refineries are largely built to process light-sweet crude. Unlike U.S. refiners, Canadian refiners have not made the investments in desulphurization and heavy crude upgrading needed to process the lower cost, heavier, more sour crudes. The combined effect of previous federal energy policies and the current low price spread between light and heavy crudes, has meant that little new investment has occurred. To date, the Canadian industry has not been competitively disadvantaged, but remains vulnerable should the light/heavy crude spread increase substantially (e.g. in excess of $6 per barrel). It is not clear whether investment in crude slate flexibility will assist Canadian refiners in competitively complying with possible new reformulated fuel requirements.

Rationalization has led to a reduction in the number of refineries, from 36 in 1980 to 21 at present, and increased refinery utilization rates on a more competitive scale with plants in the northern U.S. Higher utilization rates have reduced the operating costs per unit of output. The refinery utilization rate has increased to just under 85 per cent in 1993, still below the U.S., but higher than the pre-1993 rate. With the closures of the Ultramar Eastern Passage Refinery in Nova Scotia in 1994 and the Esso IOCO refinery in B.C. in 1995, utilization rates could approach 90 per cent.

Rationalization has also taken place in the marketing subsector, with the number of retail outlets falling from 24,000 in 1980 to the current level of 17,000. Despite closures, the number of service stations remains high -- Canada has proportionately twice as many stations as the U.S., pumping 75 per cent of the volume. The structure of this subsector, with about 44 per cent of facilities owned by small independent business people, makes further rationalization beyond the control of major suppliers. Retail margins are under extreme competitive pressures. A typical example is the Toronto rack-to-retail margin for regular unleaded gasoline dropping from 10¢/litre in 1988 to about 3.5¢/litre in 1994. Lower margins are forcing a major change in the gasoline retailing business. Non-petroleum merchandising in the form of convenience stores and fast food outlets are growing as owners seek to maximize revenues.

Environmental challenges are also an important factor in assessing future competitiveness. The industry has spent approximately $2 billion on environmental protection since the early 1970's, a large part of which was expended on sulphur recovery. Future environmental requirements are anticipated to be more numerous and much more costly. Preliminary analysis by Industry Canada suggests that, on a unit basis, Canadian refiners' costs for environmental improvements are less than U.S. costs by a factor of two to three. On the basis of environmental costs alone, Canadian refineries have a competitive advantage relative to the U.S. This is because of the higher density of industrial activity, in the U.S. than in Canada, resulting in the U.S. opting for more costly environmental measures that would not need to be considered in Canada. Areas of Canada that can access products from off-shore however, may be vulnerable to increased competition from large refineries in the Caribbean, Persian Gulf and Northwest Europe, as these competitors may not face similar investments for on-site environmental protection. The high investment requirements in both Canada and the U.S. could shift economic activity to off-shore refineries. Environmental costs which affect product specifications are more likely to be recoverable in the marketplace than environmental costs needed for local site operations, since all refiners, domestic and foreign, would be required to meet fuel specification requirements.

FEATURES OF CANADIAN PETROLEUM PRODUCTS INDUSTRY

Price taker for crude purchases and product sales.

Capital intensive with $150,000 of GDP per employee.

Trade surplus of $1.6 billion in 1993.

Employs 150,000 people.

Overcapacity in the past, resulted in low utilization rates and poor rates of return. Rationalization and aggressive cost-cutting have been instituted, and returns are increasing.

Vulnerable as the capability to process heavy sour crude lags that of U.S. competitors (not a problem at current differentials).

II.4 FUEL REFORMULATION OPTIONS

Unlike the automotive industry, fuel options in Canada need not necessarily be linked to choices made in the United States. Accordingly, a summary of fuel regulations and standards in the United States is not provided.[4]

The work presented in this report is based on a report by Kilborn which examines several fuel scenarios. These include low-sulphur diesel (LSD) for 100 per cent on-road use and eight gasoline reformulation options. With the exception of CARB Phase II gasoline, each of the gasoline reformulation options are incremental to the preceding option.[5] The options are as follows:

- eliminate the use of methylcyclopentadienyl manganese tricarbonyl (MMT) as an additive[6];
- reduce Reid Vapour Pressure (RVP) in the Windsor-Quebec City Corridor to 9.0 psi;
- reduce benzene content in gasoline to a maximum of 1 per cent or reduce toxic air pollutants by 15 per cent[7];
- reduce toxic air pollutants by 20 per cent;
- reduce RVP to 8.1 psi in the Windsor-Quebec City Corridor and Lower Fraser Valley;
- establish maximum average sulphur levels of 200 ppm;

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4. A full explanation of these requirements may be found in *Approaches to Reformulating Gasoline and Diesel by U.S. and Canadian Jurisdictions* prepared by Environment Canada for the CCME Task Force.

5. It should be noted, however, that investments under one option may affect other options. For example, the investment required to reduce toxins can reduce or eliminate the investment required to lower the sulphur content of gasoline.

6. Since the CCME Task Force has commenced its work, both the federal government and British Columbia have announced intentions to prohibit the addition of MMT to gasoline.

7. The Federal Minister of the Environment announced in July 1995 the intention to limit the benzene content of gasoline to 1 per cent by volume.

- establish maximum average sulphur levels of 50 ppm; and
- use California Air Resource Board (CARB) Phase II reformulated gasoline.

CARB Phase II gasoline must either meet the strict specifications set out in the following table or achieve equivalent emissions reductions using California's predictive model.

TABLE 2.4.1
SPECIFICATIONS FOR
CARB PHASE II REFORMULATED GASOLINE

Property	Limit
Benzene	0.8 LV %
Aromatics	22 LV%
RVP	7.0 psi (summer)
Sulphur	30 ppm
Olefins	4 LV%
Oxygen Content	1.8-2.2 wt%
T50	200°F
T90	290°F

An approximation of the costs associated with the proposal of the Canadian Petroleum Products Institute (CPPI) is also being presented to the CCME. The CPPI proposal comprises the following components:

- Cap gasoline properties at a 1994 Canadian industry or at individual refiner's baseline (MMT retained);
- Reduce summer RVP to 9.0 in Windsor to Montreal corridor and to 8.5 psi in the Lower Fraser Valley (or an equivalent reduction in VOC's);
- Reduce benzene content in gasoline to 1 LV per cent (or an equivalent reduction in toxins) unless science provides the basis for a "safe" level; and
- Implement 100 per cent on-road low-sulphur diesel if justified by market demand.

III. COSTS OF LIGHT VEHICLE EMISSION STANDARDS

The primary input for this section of the report is *Incremental Costs of Vehicle Emissions Standards* prepared by Sypher: Mueller International. The study provides an indication of two types of costs. The first, vehicle emission control hardware, draws upon several studies that have attempted to estimate these costs. The second is the cost of disharmony which would arise in the case of market fragmentation caused by multiple requirements.

Vehicle Emission Hardware

Table 3.1 provides four estimates of the costs of vehicle hardware, a discussion of which is provided in the Sypher report. Although debate exists over the "correct" figures, the Sierra Research figures fall between the CARB and manufacturer figures and result from a study done across several representative vehicle manufacturers. Accordingly, the Sierra figures will be used as the basis for the central quantitative estimates provided in this report. Estimates based upon the CARB and manufacturer figures are also shown in order to provide a range. A brief description of the Sierra methodology is provided below. It should be noted that technological advances since 1991, when the estimates were produced, may reduce the figures somewhat.

TABLE 3.1
INCREASE IN LIGHT VEHICLE PRICES BY CONTROL MEASURE*

Control Measure	CARB Estimates	Sierra Estimates		Manufacturer Estimates		Sypher 1991
		California	*National*	*California*	*National*	
TLEV	94	489	306	903	603	583
LEV	175	1,342	967	2,171	1,561	705
ULEV						
Small	339	1,557	714	2,774	2,139	1,027
Mid-Size	339	2,040	1,844	3,873	3,525	1,027
ZEV	2,202	32,031	19,081	86,430	51,937	6,440

*Relative to Tier 1. Figures converted at $Cdn = $US .75 (includes PST and GST)

Sierra utilized data provided by the Big Three, one European manufacturer and one Japanese manufacturer to estimate the costs of more stringent vehicle emission requirements. All direct costs that affect regulated parties and consumers were included and distinguished from inconvenience costs and other secondary effects which are more speculative in nature. The estimates include costs relating to research and development, vendor-supplied components and materials, tooling, assembly labour and overhead, corporate overhead and profit, dealer markup and maintenance. The estimates do not include costs associated with any additional weight reduction or other modifications that may be needed to maintain fuel economy in light of the additional emission equipment. Inconvenience and other indirect costs, such as those associated with additional inspection and maintenance procedures, were not examined. Warranty costs were also excluded because of a lack of data availability.

Sierra assumed that the minimum cost system under development by any vehicle manufacturer would be adopted by all manufacturers. From this system, a weighted average estimate was then developed. The estimates reflect average discounted costs over the 1993-2010 period and incorporate a learning curve effect. The learning curve effect reduces variable costs by 5 per cent per year and for each new product cycle (every five years), engineering costs and equipment, tooling and facilities costs would all decline by 50 per cent. The study also assumed that new vehicle dealers were able to realize only 50 per cent of their standard price markups for the marginal components.

Disharmony Costs

Sypher's discussion of the implications of not harmonizing with U.S. standards is based upon information gathered at a meeting with motor vehicle manufacturers. Specific cost estimates of non-harmony were not provided. However, the Sypher report does suggest that "the cost per vehicle of non-harmonization ... is potentially more significant than the average vehicle hardware costs". In this regard, doubling the hardware estimates may provide an indication of minimum total costs should disharmony occur.

It is extremely important to understand the relationship between a "harmonization with the U.S." scenario and a "disharmony" scenario. As a result of tighter requirements for enhanced vehicle emissions equipment in the United States, the costs of manufacturing new vehicles and their market price will increase in Canada. The production cost and price increases could be expected to be proportional on both sides of the border and will occur irrespective of actions taken in Canada.

Harmonization with U.S. standards represents the least-cost alternative for Canada. If standards are established in Canada independent of changes in the United States, automobile manufacturers would be faced with relatively higher manufacturing costs to produce unique vehicles for the Canadian market. The costs of disharmony would arise from the disintegration of the North American automotive market that has developed since the signing of the Canada/U.S. Auto Pact 30 years ago. These costs fall into four categories: design and testing of specific models; plant logistics and scheduling; marketing and sales; and, servicing. The higher costs would likely be passed on to consumers in the form of higher prices.

Over the longer term, the potential for some disruption of the vehicle production and distribution network in Canada under a disharmony scenario has been identified as being of higher importance than the risk of immediate potential retail price increases. Given the integrated nature of the North American vehicle production and distribution network, and the benefits of that system to Canada, the potential disruption which may result from fragmentation of the North American market is a serious concern. While an assessment of this potential risk is beyond the scope of this paper, it is accurate to state that the likelihood of some form of disruption is greater under a disharmony scenario.

A summary of the impacts of "disharmony" is provided in Table 3.2. Greater detail is provided in the Sypher-Mueller report.

TABLE 3.2
IMPACTS OF NON-HARMONIZATION

Costs to Design Specific Models	Plant Complexity Costs	Marketing and Sales Implications	Servicing
Special vehicle specifications Possible Canadian/ regional emission certification Additional testing for severe Canadian weather conditions	Separate ordering and separation of parts for assembly Additional assembly plant space for parts Special assembly work orders and scheduling; possible batch production Quality control to ensure proper build to special specifications	Reduced consumer choice Special dealer training and order guides Special owners' manuals Reduced dealer sales assuming price increases Vehicle inventory costs Strong consumer preference for out-of-province, new and old cars Resale value of unique vehicles	Special service training, parts supplies and tools Servicing of "out-of-province" vehicles Warranty exposure with unique models and severe Canadian weather

Source: *Incremental Costs of Vehicle Emission Standards*, Sypher:Mueller International (1995).

SOCIO-ECONOMIC IMPLICATIONS

The figures presented in Table 3.1 do not provide estimates of the costs to the automotive industry of adopting more stringent emission requirements. Rather, they provide an indication of the pre-tax price increases that could be faced by consumers as a result of higher automobile emission standards if common standards were adopted throughout most of Canada and the United States and if expenses (plus markup) of the automobile industry were fully flowed through to consumers. The figures do not likely provide the true costs or benefits to any stakeholder group. The distinction between costs and transfers is particularly important.

A price elasticity of demand can be used to provide insight into the potential impact on stakeholders. A literature survey for the United States reported in the Sierra study found the average price elasticity of demand for new vehicles to be in the neighbourhood of -1.0. This means a 10 per cent increase in price results in a 10 per cent decrease in vehicle demand, with overall expenditures remaining unchanged. Assuming a comparable elasticity for Canada, combining this figure with the estimated price increase and additional market data makes it possible to acquire a rough indication of the change in quantity of vehicles sold and hence the financial impacts on vehicle assemblers, consumers and government. A qualitative assessment is provided where quantification is not possible.

In order to make use of the elasticity, it is necessary to have information on changes in prices. At any given point in time, the new fleet composition for the options under consideration comprises a mix of vehicles meeting the standards identified in Table 2.2.4. It is, therefore, possible to estimate the average pre-tax retail price equivalent for a "typical" North American automobile by multiplying the estimated incremental vehicle price changes set out in Table 3.1 by the appropriate percentage. As the phase-in schedule for each of the options would result in a different value for each year, estimates for the mature system (2003) are provided. An interim year of 1998 is also provided to indicate the near-term impact. Using the notional phase-in schedule provided in Exhibit 2 of the Sypher report, Table 3.3 provides potential manufacturing cost increases for the various options for the years 1998 and 2003.

As discussed in the previous section, the costs of a disharmony scenario would be greater than under a harmonization scenario, thereby leading to a relatively higher price for new vehicles in Canada than would otherwise have been the case. Based upon Sypher's assessment that the costs of disharmony could exceed vehicle hardware costs, a very rough estimate of the incremental increase in the price for new vehicles in Canada can be derived by doubling the estimates of average hardware costs. This rough cost estimate only pertains to the potential increase of costs to the manufacturers, and does not consider the social costs of any disruptions to the existing production network in Canada which may occur under a disharmony scenario.

TABLE 3.3
ADDITIONAL HARDWARE COSTS
OF MANUFACTURING "TYPICAL" VEHICLES*
($)

Year	FEDLEV			OTCLEV			CALLEV		
	CARB	*Sierra*	*Mfg.*	*CARB*	*Sierra*	*Mfg.*	*CARB*	*Sierra*	*Mfg.*
1998	33	106	210	85	448	750	135	757	1,604
2003	152	840	1,357	188	909	1,878	350	2,457	5,904

* National figures relative to Tier 1. FEDLEV for 1998 uses requirements for OTC States. ULEV (average, small and mid-size) substituted for ZEV in OTCLEV.

While it is not possible to provide a definitive estimate of the costs of a disharmony scenario, it is clear that the costs to the manufacturers, and the subsequent price of new vehicles in Canada, will be relatively higher under a disharmony scenario than under a harmonization scenario. It is also more likely that disruptions to the production network in Canada will occur under the disharmony scenario than under a harmonization scenario.

Impact on the Automotive Industry

In order to determine the costs to the automotive sector, it is important to distinguish between the two segments of the industry -- vehicle assembly and components production.

For vehicle assemblers, it follows that the greater the vehicle price increase, the greater the risk of market distortion. The change in new vehicle sales could take the form of an absolute reduction in vehicles sold (motorists retain their vehicles longer, purchase used vehicles or use alternative transit) or a shift in the composition of purchases (motorists select cheaper models to offset price increases stemming from emission technology). While the unitary elasticity suggests revenues would remain unchanged, increased costs per vehicle, a reduction in the number of vehicles sold, or shifts towards the purchase of less expensive vehicles, would serve to decrease after-tax profits for the industry. The magnitude of the profit decline depends on which vehicle hardware estimates are used. The central estimates of reduced profit range from around $33-35 million under FEDLEV to almost three times that level under a mature CalLEV program.

It must be remembered that the estimated profit impacts are calculated by holding everything constant except for the price of vehicles. Factors such as population growth and increased income levels would serve to alleviate this impact, although vehicle sales would still be expected to be lower than in the absence of tighter emission requirements. Profits would be further reduced in the presence of disharmony. Again, the harmonization scenario is the least cost option for Canada.

The component production segment of the automotive industry has the theoretical potential to benefit from increased emission requirements as it is firms in this segment that will supply the new parts to the vehicle assemblers. In order to determine the impact on Canada, it would be necessary to identify suppliers with the potential capacity to provide the parts that are expected to be needed (e.g. catalytics, electric air pump, fuel preparation system, etc.). An analysis of suppliers prepared by the Automotive Branch of Industry Canada suggests that Canadian capacity in this area is limited, and that the creation of additional capacity would likely occur elsewhere. Accordingly, Canadian components manufacturers are not likely to reap many benefits from tighter vehicle emission standards, although some scope for R&D may exist as part of the CANCAR initiative. To the extent that the required parts are imported, the parts deficit with the U.S. will increase.

Higher prices for new vehicles will also have an impact on vehicle retailers. The Sierra study assumed that dealers would be able to realize only 50 per cent of their usual markup on the additional costs associated with tighter vehicle standards. Under this assumption, the rate of return on invested capital for dealers would decline. In addition, more capital would be required to maintain inventories of higher-priced vehicles. As it is not possible to disaggregate the Sierra figures, quantitative estimates of the financial impacts on vehicle dealers are not available. Certain dealers could be expected to increase their service business on the assumption that some consumers would choose to retain and maintain their old vehicles rather than buy new ones. Used vehicle dealers could experience increased sales.

Impact on Other Industries

Other industries may be affected by tighter vehicle emission requirements through their role as suppliers to the automotive industry, users of automotive products, and suppliers of complementary products (e.g. steel, taxis and petroleum products). Estimating the direct and indirect impacts of new vehicle standards, increased production costs and price increases on such industries is beyond the scope of this study.

To the extent that consumers -- both household and commercial -- spend more to purchase the same number of vehicles, this income is not available for either saving or consumption of other items. The aggregate impact of this reduction in discretionary income would decrease demand for the goods and services of other industries. An estimate of the impact of this reduction in discretionary income is beyond the scope of this study.

Impact on Individuals

Individuals are affected by tighter vehicle emission standards via their role as consumers, taxpayers (see government section), suppliers of labour and capital, and as users of air.

For all of the options under consideration, consumer satisfaction would decline due to both higher prices and, in certain cases, possibly reduced selection. In response to higher vehicle prices, consumers may choose not to purchase an automobile, defer the purchase, purchase a used automobile, or purchase a lower-priced new automobile. Consumer satisfaction would also decline if manufacturers chose to supply fewer choices as a means of cost containment. Increased prices may have a different impact on consumers depending on their socio-economic characteristics.

The extent to which prices may increase is difficult to ascertain as vehicle assemblers would presumably price their products in such a way as to maximize profit. This may result in shifting some of the costs from one particular vehicle or geographic area to another market in order to generate the most beneficial financial results. Prices could further increase to the extent that overhead expenses must be distributed across a lower volume of vehicles. Any region that chose to adopt standards tighter than the rest of the market could face even higher prices if the cost recovery efforts of vehicle assemblers were concentrated in that region.

The impact on workers depends, to a large extent, on the share of costs borne by Canadian vehicle assemblers. As noted in Section II of this report, Canadian vehicle manufacturers tend to adjust labour inputs through changes in labour hours as opposed to number of workers employed. Only where significant changes in demand occur would the actual number of employed individuals vary. Although it is difficult to forecast the potential employment impacts arising from tighter vehicle emission standards in light of the many other changes taking place in the market, only a long-run decrease in the sale across both Canada and the U.S. of vehicles produced in Canada would be expected to result in employment impacts. Under a disharmony scenario, however, the potential disruption of the integrated North American production system is greater, as is the potential impact on employment in Canada. The extent of this relatively higher risk is unknown.

The impacts on individuals as users of air include both health and environmental impacts. Health benefits are assessed in a separate study and are summarized in Section V of this report.

Impact on Government

The costs to governments arise on three fronts -- through their role as consumers, regulators and tax collectors. As current data on annual light duty vehicle purchases by governments is not available, it is not possible to provide a quantitative estimate of these costs. However, the impact on government procurement would not be different from that of other consumers.

Costs per vehicle could exceed the price increase in a "typical" vehicle if governments were required to purchase the lowest emitting type of any vehicle.

The Sypher report did not provide estimates of administrative costs associated with increased vehicle emission standards. These costs would be significant only if Canada chose to adopt a standard different from those adopted in the United States. They may, however, be an important consideration, particularly during a period of fiscal constraint.

Assuming a unitary price elasticity, price increases will be exactly offset by quantity decreases so that total expenditures would remain unchanged. Under these conditions, sales tax revenues from new automobiles would not be affected. Excise tax revenues may decline to the extent that reduced automobile demand translates into fewer vehicles on the road. Income tax revenues from the automotive industry would decline proportionately with profits. Other tax revenues would change to the extent that higher vehicle prices influence economic activity in various sectors.

Summary

The harmonization scenario would be the least-cost option for all stakeholders and have the least potential impact on the Canadian economy overall. The impact of harmonization with the United States will ultimately depend on exactly what standards both Canada and the U.S. adopt, and the schedule for the introduction of lower emission vehicles into Canada. The production of lower emission vehicles will increase production costs for vehicle manufacturers and, to the extent these costs can be passed on to consumers, higher prices for new vehicles can be expected. Under a harmonization scenario, these price increases will be proportionally equivalent on both sides of the border, and there is expected to be no change to the existing production and distribution networks in Canada.

While the harmonization scenario will likely lead to higher new vehicle prices in Canada, these price increases, and the subsequent negative impacts on stakeholders, will be significantly less than under a disharmony scenario. The disharmony scenario, and the higher costs associated with producing a unique vehicle for the Canadian market, will lead to relatively higher new vehicle prices for Canadian consumers. Most importantly, disharmony might cause disruption to the production and distribution system in Canada.

The potential annual long-term impacts on each of the stakeholder groups associated with the emission packages under consideration are summarized in Tables 3.4, 3.5 and 3.6. It is important to stress that the estimates contained therein are based strictly on hardware costs and are measured relative to Tier 1 standards.

TABLE 3.4
ANNUAL COST-ASSOCIATED IMPACTS OF FEDLEV[8]

Price Change	Industry		Individuals	Government
	Automotive	Other		
2003: L - $175 C - $ 966 H - $1,561 1998: L - $38 C - $122 H - $242	Reduced vehicle sales: L - 10,700 C - 57,000 H- 89,000 After-tax profit of assemblers declines: L - $6 m C - $33 m H - $52 m Limited potential for R & D or parts production associated with pollution technology developments Negative impact on new vehicle retailers Potential benefit for used vehicle dealers	Vehicle prices increase for commercial users Potential for reduced sales in related industries Net impact on fuel sales unknown	If expenditures unchanged, 10,700-89,000 fewer new vehicles purchased Employment impact uncertain -- long run job losses unlikely	Increase in vehicle expenditures No additional administrative costs unless Canada not harmonized with US federal program Sales tax revenues unchanged Change on fuel excise tax revenue unknown Income tax revenues decrease: L - $5 m C - $25 m H - $39 m

8. The values given in this table resulted from an elasticity analysis of potential increases in the price of new vehicles. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in vehicle prices. The resulting figures are directional and rough orders of magnitude.

The table is based on a Canada - U.S. harmonization scenario. A disharmony scenario could be expected to result in disruption to the industry with significantly greater impact on stakeholders. If the U.S. adopts more stringent emission standards, new vehicle prices in Canada would likely increase independent of Canadian policy action.

TABLE 3.5

TABLE 3.5
ANNUAL COST-ASSOCIATED IMPACTS OF OTCLEV[9]

Price Change	Industry		Individuals	Government
	Automotive	Other		
2003: L - $216 C - $1,045 H - $2,160 1998: L - $98 C - $515 H - $863 Any region adopting OTCLEV when rest of market is less stringent could face greater price increases	Vehicle sales decline: L - 13,000 C - 61,300 H - 120,300 After-tax profit of assemblers declines: L - $8 m C - $35 m H - $70 m Limited potential for R & D or parts production associated with pollution technology developments Negative impact on new vehicle retailers Potential benefit for used vehicle dealers	Vehicle prices increase for commercial users Potential for reduced sales in related industries Net impact on fuel sales uncertain	If expenditures unchanged, 13,000-120,300 fewer new vehicles purchased Costs associated with smaller volumes of vehicles would force assemblers to consider limiting vehicle choice Potential impact on automotive employment uncertain - depends on vehicle choice/output	Increase in vehicle expenditures -- may be required to purchase lowest emission vehicles Additional administrative costs due to need to monitor entry of vehicles below OTCLEV standards if U.S. federal standard lower Sales tax revenue unchanged Change in fuel excise tax revenues unknown Income tax revenues fall: L - $6 m C - $27 m H - $53 m

9. The values given in this table resulted from an elasticity analysis of potential increases in the price of new vehicles. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in vehicle prices. The resulting figures are directional and rough orders of magnitude.

The table is based on a Canada - U.S. harmonization scenario. A disharmony scenario could be expected to result in disruption to the industry with significantly greater impact on stakeholders. If the U.S. adopts more stringent emission standards, new vehicle prices in Canada would likely increase independent of Canadian policy action.

TABLE 3.6
ANNUAL COST-ASSOCIATED IMPACTS OF CALLEV[10]

Price Change	Industry		Individuals	Government
	Automotive	Other		
2003: L - $403 C - $2,826 H - $6,790 1998: L - $155 C - $872 H - $1,845 Prices rise further in the case of market fragmentation Any region adopting CalLEV when most of market selects lower standard could face greater price increases	Vehicle sales decline: L - 24,300 C - 172,600 H - 313,000 After-tax profits of assemblers declines: L - $14 m C - $100 m H - $181 m Limited potential for R & D or parts production associated with pollution technology developments Negative impact on new vehicle retailers Potential benefit for used vehicle dealers	Vehicle prices increase for commercial users Motor vehicle fuel sales decrease Potential for reduced sales in related industries Opportunities for alternate technology vehicle manufacturers	If expenditures unchanged, 24,300-313,000 fewer vehicles new vehicles purchased Potential reduction in new vehicle choice Employment uncertain but the greater the decline in vehicle sales, the greater the risk of production disruption	Increase in vehicle expenditures -- may be required to purchase lowest emission vehicles Additional administrative costs due to need to monitor entry of vehicles below CALLEV standards if U.S. federal standard lower Automobile sales tax revenue unchanged Fuel excise tax revenues would likely decline - extent unknown Income tax revenues decline: L - $11 m C - $74 m H - $137 m

10. The values given in this table resulted from an elasticity analysis of potential increases in the price of new vehicles. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in vehicle prices. The resulting figures are directional and rough orders of magnitude.

The table is based on a Canada - U.S. harmonization scenario. A disharmony scenario could be expected to result in disruption to the industry with significantly greater impact on stakeholders. If the U.S. adopts more stringent emission standards, new vehicle prices in Canada would likely increase independent of Canadian policy action.

IV. COST IMPACTS OF REFORMULATED FUEL REQUIREMENTS

The reformulation of motor vehicle fuels may have an impact on a number of stakeholders -- refiners, individuals, governments and the environment. Intermediate industries -- both suppliers of equipment and fuel additives, and users of fuel -- will also likely be affected. This section of the report attempts to provide an indication of the potential impacts on stakeholders.

There are two primary inputs for the analysis. The first, a study entitled *Cost of Upgrading Canadian Transportation Fuels,* prepared by Kilborn Inc., examined the additional capital and operating costs to refiners associated with meeting the reformulated fuel specifications under consideration by the CCME. The study did not assess the costs or benefits to any stakeholder group; nor did it address emissions that result from the refining or distribution of fuels.

The financial information in the Kilborn study was gathered directly from participating refiners who used internal planning methods to estimate the costs of the fuel reformulation cases. For non-participating refiners, a mathematical technique called "linear programming" was utilised. Linear programming permits the maximization or minimization of a function subject to a number of inequality constraints (e.g. minimize plant production costs subject to constraint that benzene and sulphur content must not exceed specified levels).

The calculations assume a reference year of 1994 with demand, prices and costs set equal to the nominal amounts prevalent in that year. The target year for producing the upgraded fuels is 1998. The study assumed a crude oil barrel price of US$17.20 (Marker crude, West Texas Intermediate) and natural gas costs of $1.25 kcf (Alberta field gate) and $2.80 kcf (Ontario). Prices per barrel for MTBE, Methanol (Gulf Coast), Ethanol (Iowa/Illinois) and Ethanol (Gulf Coast) were set at US$39.90, US$27.30, US$26.88 and US$29.82 respectively. An exchange rate of C$=US$0.75 was utilised. Operating cost accuracy is reported to be ±25 per cent.

In computing the annual capital charges, the Kilborn report used a figure of 1.18 for a location factor (relative to U.S. Gulf Coast), a construction period of one to two years, a depreciation period of 7 years, an economic life of 15 years, an after-tax cost of capital of 10 per cent, a property tax/insurance rate of 1 per cent, land costs equal to 0.2 per cent of total investment, and a series of combined federal-provincial corporate income tax rates. Kilborn reports that the accuracy of the capital cost figures is ±40 per cent.

Like the estimates for the automotive sector used in Section III of this report, the Kilborn analysis is based directly on industry-supplied data. However, the estimates differ from Sierra Research's "least-cost approach" to estimating vehicle hardware costs as they simply aggregate figures supplied directly by refiners. Kilborn's figures may, therefore, be more comparable to the vehicle manufacturers' estimates of the cost of adopting more advanced emission technology as indicated in Table 3.1. On the other hand, Kilborn has verified the reasonableness of the refinery data. The reader is invited to make his own assessment of the importance of this difference in data source. The overall accuracy of the annualized figures is reported to be ±35 per cent.

The second input study, *Recovery of Capital and Operating Costs for Fuel Reformulation*, was completed by the Manufacturing and Technologies Branch of Industry Canada. This study analyses potential cost recovery based on an examination of market prices for baseline and reformulated gasoline in the United States. Although U.S. requirements do not exactly correspond to the specifications under consideration for Canada, adjustments were made to the U.S. data to match Canadian specifications as closely as possible. It is important to emphasize that prices have fluctuated markedly as the rapid pace of regulatory change has resulted in uncertainty and market disequilibrium. The figures for maximum recoverable costs should, therefore, be treated with caution.

SOCIO-ECONOMIC IMPLICATIONS

The analysis in this section of the report commences with the estimated increase in the cost to produce fuels provided in the Kilborn report. This cost is compared with the maximum potential recoverable costs provided in the Industry Canada analysis. The lower of these two figures is then combined with elasticity estimates and additional market data to approximate the decrease in consumption of fuel. Finally, the financial impact on several stakeholder groups is estimated based on the above.

A survey of the literature on gasoline demand elasticities[11] found that short-term price elasticities ranged from -0.41 to -0.08, with a fairly stable average of around -0.26. Longer term price elasticities varied more widely, with figures from -1.05 to -0.28 and an average of -0.86. Elasticities for diesel fuel were not readily available, but demand could be expected to be inelastic given that the majority of demand is for commercial purposes.

Impact on the Petroleum Industry

The potential impact of reformulated fuels on the petroleum industry is two-fold: increased capital and operating costs and changes in revenue. The additional costs of manufacturing various types of reformulated gasoline are provided in the Kilborn report and are adjusted for reduced volume sold. Changes in revenues can be derived from changes in price and quantity sold. These figures can be combined with the cost savings of reduced crude purchases to estimate the change in profit for the industry.

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11. *Analysing Gasoline Demand Elasticities: A Survey*. Energy Economics, July 1991.

A key factor in determining the impact of reformulated fuel on the industry is the degree to which refineries are able to pass new production costs on to consumers in the form of gasoline price increases. For all reformulated gasoline scenarios, it is anticipated that the industry will experience reduced profits per litre of gasoline. Combined with reduced demand associated with higher fuel prices, the net effect on the companies will be reduced profits. In the case of low-sulphur diesel, higher costs and constant demand (commercial consumers) are not expected to result in a significant adverse impact on company profits. Details of the impacts of the various proposed fuel reformulation parameters are outlined below.

An important consideration is the distribution of the aggregate costs to meet the new fuel standards amongst Canada's 17 refineries. Each refinery is somewhat unique. As a result, each refinery will be faced with a different set of problems in the face of new fuel specifications. The corresponding cost implications will vary considerably from refinery to refinery. Similarly, refineries will have varying abilities to recover some or all of their costs in the market through price increases.

As identified in the Kilborn study, the industry will be faced with both an initial capital cost and an increase in annual operating costs to produce reformulated fuels. If refineries chose to close rather than make the necessary investment, this could significantly alter the Kilborn numbers which aggregate costs for all existing refineries. The closure of a refinery would serve to reduce the total costs to the industry of fuel reformulation and the estimated profit impact on petroleum refining companies. In addition, it may be possible under such a scenario for the remaining refineries to benefit by increasing the utilization rate and/or expanding capacity, thereby becoming more competitive and profitable.

If MTBE is to be used as an oxygenate to replace lost octane, about 70,000 barrels per day will be required. With existing Canadian capacity of about 12,000 bpd, Canada must either import the additive or build 3 world-scale oxygenate plants. The Kilborn estimates of the costs associated with the removal of MMT and for CARB Phase II gasoline include the expansion or construction of new facilities to produce MTBE as an additive to enhance octane levels. The anticipated locations for such facilities are Montreal, Sarnia and Edmonton.

Refiners in Quebec and Atlantic Canada have historically been victims of the dumping of "off-spec" gasoline destined for the United States. According to industry estimates, margins for conventional gasoline, particularly in Quebec, have been curtailed by as much as 2¢ per litre. The figures presented in the cost recoverability study adopted in this report are based on the assumption that national fuel standards will eliminate this practice by establishing a level playing field for domestic and foreign producers. The elimination of this situation represents a direct economic benefit of national fuel standards to the affected refiners.

Impact on Other Industries

The impact on other industries flows in large part from benefit to Canadian suppliers of petroleum equipment arising from the refiners' increased investment, and the reduction in income that domestic and commercial consumers have available to spend on other items because of the increased cost of gasoline or diesel.

In recent years, because of the lower value of the Canadian dollar versus the U.S., Canadian refiners have largely favoured Canadian suppliers to procure materials necessary for the upgrading of refineries. As a result, there would be positive spin-offs during construction, in Canada, from the industry's capital expenditures needed to produce the reformulated fuels. It is estimated that in excess of 50 per cent of the capital investments would be made in Canada. Technology licensing, R&D, and procurement of high pressure or specialty equipment would largely be out-sourced. Operating cost dollars would be expected to be spent in Canada as well. Over the long term, it is anticipated that the impacts on the economy would be small.

The impact arising from the use of motor vehicle fuel as an input to other industries is not expected to be significant. The exception may be in the area of commercial transportation. For example, increased gasoline prices would have an impact on the taxi industry and may result in increased fares. Higher diesel fuel prices are likely to have the largest impact on commercial consumers -- primarily the trucking industry which accounts for the majority of the 8.76 billion litres of road diesel consumed annually in Canada. Determination of the extent to which these costs might be passed on to consumers of transportation services would require further investigation.

Increased fuel prices may also have an impact on complementary industries. As higher fuel prices would increase the overall costs of owning/operating a motor vehicle, an increase in gasoline prices, if high enough, could have a depressing effect on automobile sales. Automotive manufacturers might be able to offset this impact by increasing the fuel efficiency of their vehicles or by reducing the prices of the vehicles available to the market. Any increase in vehicle fuel efficiency would, of course, have an adverse impact on the petroleum industry sales. It is important to note that the likely increases in gasoline prices for the gasoline reformulation scenarios being evaluated here, are not sufficient to have a significant impact on auto related sales.

Impact on Individuals

Individuals are directly affected by reformulated fuels in the same three ways as when vehicle emission hardware is altered -- as consumers, as suppliers of labour and capital and as users of air.

The impact of reformulated gasoline requirements on consumers operates via higher prices. As noted below, the expected increase in gasoline prices ranges from 0¢ per litre for the elimination of MMT to 4.2¢ per litre for CARB Phase II gasoline. Reformulated gasoline, which has similar properties to the U.S. federal RAG, will increase gasoline prices to consumers by about 0.7¢ per litre. Similarly, low-sulphur diesel will cost consumers around 0.5¢ per litre more than at present. If personal income remains constant, higher expenditures on fuels would reduce personal disposable income, thereby having an effect on the demand for other goods and services. Demand for fuel would decline in response to these price increases. The direct and indirect impacts of higher fuel prices on consumer spending will vary spatially and between social groups. Specific details of these effects will require further analysis; however, the net aggregate effects on the Canadian economy are expected to be minimal.

Employment impacts are expected to be minor, unless one or more refineries chose to close. Refinery closure becomes more likely as gasoline reformulation requirements become more stringent, particularly the reduction of sulphur content to the 200 ppm level and beyond. On average, a refinery closure would result in the loss of 600 direct refinery jobs, with attendant indirect employment losses of 4,300 jobs, based on the application of an indirect employment multiplier [12]. This would be the case if the individuals affected could not be employed elsewhere. Depending on its location, the regional impacts of a closure could be significant. Offsetting employment opportunities in the refinery industry are not expected, nor are significant spin-offs resulting from the increased level of investment. Some jobs may be created in the short term during the construction of the necessary refinery modifications. The creation of new MTBE production facilities would create approximately 100 direct jobs per facility. Additional associated indirect jobs may also be created.

As refineries close, decreased demand for labour could exert downward pressure on wages. Estimates of the wage impact are not available.

The impact on individuals as the breathers of air is examined in Section V of this report.

Impact on Governments

The overall cost impact on the governments is, *ceteris paribus*, an increase in the deficit. This impact arises from its role as a consumer, a regulator, a tax collector and a supplier of social services. The macroeconomic impact of any changes in the budgetary position of governments is not addressed in this report.

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12. *Employment in the Canadian Petroleum Industry 1985-1994*, Canadian Energy Research Institute, December 1994.

Governments of all levels will have to pay higher prices for the fuels they purchase with an associated budgetary impact. However, this impact is not expected to be significant. Even for CARB Phase II fuel, increased expenditures net of tax would be in the neighbourhood of only $5 million.

Administrative costs will rise as it would be necessary to monitor gasoline and diesel fuel to ensure that they comply with the requirements. Quantitative estimates of these administrative impacts are not available. They are not, however, likely to be significant, and would, in all probability, be passed on to the industry .

Income, sales and excise tax revenues will all be affected. A decline in unit consumption of gasoline in response to increased prices would result in decreased excise tax revenues. Sales tax revenues (e.g. GST) would increase as expenditures increase. However, this increase is not sufficient to offset the loss of excise tax revenue. Reduced refinery earnings, potential job losses and downward pressure on wages would all serve to reduce income tax revenues. Job losses may also necessitate an increase in social support expenditures.

Summary

The subsections that follow are based on Industry Canada's cost recovery analysis. They address the same fuel reformulation steps as that study: namely, low-sulphur diesel (100 per cent on-road), MMT removal, RAP reduction to 8.1 psi, the sulphur reduction steps (200 ppm and 50 ppm), California Phase II gasoline and the CPPI proposal. They provide an indication of the cost impacts on the various stakeholder groups. Benefits are addressed separately. Where quantitative information is not available, a qualitative assessment is provided.

The Kilborn study also examined gasoline reformulation scenarios, other than those identified above. The cost impacts of these are shown for completeness in Annex VIII-1.

Low-Sulphur Diesel

Low-sulphur diesel (LSD) has a sulphur content under 500 parts per million (ppm) -- one-fifth of the Canadian average for regular diesel of 2,500 ppm. The latest heavy-duty diesel emission control technology requires LSD in order to operate reliably. A reduction in sulphur content would reduce emissions of particulate matter.

TABLE 4.1
COSTS OF PRODUCING 100% ON-ROAD LOW-SULPHUR DIESEL

	B.C. & Prairies	Ontario	Atlantic Quebec	CANADA
Capital Investments ($ m)	81	168	15	264
Annual Operating Costs ($ m)	2	11	17	29
Annual Capital Costs ($ m)	13	28	2	43
Total Annual Costs ($ m)	15	38	19	72
Annual Volume (bl)*	2.0	2.0	2.0	6.0
Annual Costs (¢/l)	.73	1.9	0.93	1.2
Recoverable Costs (¢/l)	0.48	0.48	0.48	0.48
Estimated New Volume (bl)	2.0	2.0	2.0	6.0
Reduction in Earnings ($ m)	3	16	5	24

* Note: Figures are below those indicated in Table 2.3.1 because refiners already produce some LSD.

Increased prices for diesel fuel are not expected to alter demand and consumption patterns in Canada. Commercial consumers account for the largest portion of on-road diesel sales (approximately 70 per cent) and their demand price elasticity is relatively inelastic in the short term. Refining industry profits may fall by $24 million per year. The distribution of the costs and the resulting potential decline in profits will vary considerably from refinery to refinery, with the majority of the impact expected in Ontario.

Consumers could be expected to pay up to 0.5¢ per litre more for low-sulphur diesel fuel. This will have a direct impact on the commercial transportation and related sectors, and could have an indirect impact on the price of goods and services which rely on the transportation sector. Increased transportation prices may be passed on to consumers in the form of relatively small price increases, which would influence demand and consumption patterns. These specific impacts are beyond the scope of this paper. It should be noted that 0.5¢/l in the commercial price of diesel fuel represents an increase of approximately 1 per cent.

TABLE 4.2
ANNUAL COST-ASSOCIATED IMPACTS OF 100% ON-ROAD DIESEL[13]

Industry		Individuals	Government
Petroleum	Other		
After tax profit decrease of $24 m (likely less since 0.5 ¢ per litre increase might apply to total on-road volumes)	Trucking industry and other commercial users pay 0.5¢ more for their fuel ($31 m) -- road transportation costs could increase Capital investment will benefit Canadian producers of petroleum equipment during construction phase (approx. $132 m or more one time investment), resulting in some short term jobs. Majority of refiner operating costs will be spent in Canada	Small impact as most road diesel purchases are by commercial sector Consumers could pay up to 0.5¢ more per litre ($13 m) for LSD Price of goods and services with significant transportation component may rise marginally	Increased expenditure on-road diesel Minimal tax revenue impact --sales taxes increase slightly, excise taxes largely unchanged, income tax revenues fall by $19 m Long-term incremental administrative costs are small

13. This table is a summary of expected cost-associated impacts. Please refer to the text in this chapter for the full discussion, and to Chapter 5 for a discussion of benefits. The values given in this table resulted from an elasticity analysis of potential increases in the price of fuels. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in fuel prices. The resulting figures are directional and rough orders of magnitude.

Elimination of MMT

The first gasoline formulation change being examined is the elimination of MMT -- an octane-enhancing fuel additive that has been used by Canadian petroleum refiners in almost all unleaded gasoline since 1977. A policy to prohibit the use of MMT in all gasoline was announced by the federal government in spring 1995. As such, the removal of MMT from gasoline is not being considered by the CCME Task Force. Nevertheless, as estimates are provided in the Kilborn report, the distribution of costs is provided in this report. The estimated costs to the industry are set out in Table 4.3.

The results of the cost recoverability analysis indicate that Canadian refiners will not be able to recover any of the costs associated with the elimination of MMT from gasoline in the marketplace. This is primarily due to the possibility of MMT-free fuel being imported into Canada from abroad. As a result, industry will be required to absorb all of the costs, translating into a decline of industry profits of almost $40 million annually. The costs and subsequent profit losses will be unequally distributed amongst the refiners, with refiners in B.C. and the Prairies facing the largest share of the costs.

TABLE 4.3
COSTS OF PROHIBITING THE USE OF MMT

	B.C. & Prairies	Ontario	Atlantic Quebec	CANADA
Capital Investments ($ m)	97	2	16	115
Annual Operating Costs ($ m)	14	21	15	50
Annual Capital Costs ($ m)	16	0	3	19
Total Annual Costs ($ m)	30	21	18	69
Annual Volume (bl)	11.7	12.8	10.6	35.0
Annual Costs (¢/l)	0.26	0.16	0.17	0.20
Recoverable Costs (¢/l)	0	0	0	0
Estimated New Volume (bl)	11.7	12.8	10.6	35.0
Annual LT Profit Decline ($m)	16	12	11	39

TABLE 4.4
ANNUAL COST-ASSOCIATED IMPACTS OF PROHIBITING THE USE OF MMT[14]

Industry		Individuals	Governments
Petroleum	Other		
After tax profit decrease of $39 m MMT supplier loses approximately $10-30 m in sales Increased income for manufacturers of any MMT replacement	Minimal impact Capital investment will benefit Canadian producers of petroleum equipment during construction phase (approx. $58 m or more one time investment), resulting in some short term jobs. Majority of refiner operating costs will be spent in Canada	No impact on consumers as gasoline prices do not rise	No change in gasoline expenditures Minimal administrative costs Income taxes fall by $30 m, sales and excise tax revenues unchanged

14. This table is a summary of expected cost-associated impacts. Please refer to the text in this chapter for the full discussion, and to Chapter 5 for a discussion of benefits. The values given in this table resulted from an elasticity analysis of potential increases in the price of fuels. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in fuel prices. The resulting figures are directional and rough orders of magnitude.

Kilborn Scenario 5 - Reduction in Reid Vapour Pressure to 8.1 psia

This scenario assesses the cumulative cost-associated impact of the first 5 Kilborn scenarios; that is, up to and including reducing RAP to 8.1 psi in the WQC corridor to include the Lower Fraser Valley. The costs provided in Table 4.9 indicate that the cumulative impact of changes to this point could reduce industry profits by $56 million on an annual basis. Roughly 80 per cent of the impact is borne by the Ontario industry ($46 million). In contrast, the impact on the BC/Prairies refineries is not expected to be significant. Indeed, the modern refineries in Alberta might be able to increase profits ($12 million) by increasing prices to the maximum the market can withstand. Annual profit losses in Atlantic Canada and Quebec are in the order of $22 million.

Beginning with this scenario, refiners, principally in Ontario, will begin to evaluate investments of sufficient magnitude to consider options other than upgrading facilities. When the cost of LSD is included, the profit decline for Ontario refiners is $62 million per year. It is possible that one or more refiners may consider closure.

TABLE 4.5
CUMULATIVE COST ANALYSIS OF KILBORN SCENARIOS UP TO REDUCING RAP TO 8.1 PSIA IN WQC AND LFV

	B.C. & Prairies	Ontario	Atlantic Quebec	CANADA
Cumulative Capital Investment ($ m)	163	318	261	741
Cum. Operating Costs ($ m/yr)	29	117	65	211
Cum. Capital Costs ($ m/yr)	27	52	42	121
Total Annual Costs ($ m)	56	169	107	332
Annual Volume (bl)	11.7	12.8	10.6	35.0
Annual Costs (¢/1)	0.47	1.3	0.97	0.95
Recoverable Cost (¢/1)	.7	.7	.7	.7
Estimated New Volume (bl)	11.6	12.6	10.5	34.7
Annual LT Profit Decline ($m)	-12	46	22	56

TABLE 4.6
ANNUAL COST-ASSOCIATED IMPACTS OF GASOLINE REFORMULATION STEPS UP TO REDUCING RAP IN WQC AND LFV[15]

Industry		Individuals	Governments
Petroleum	**Other**		
Cumulative after tax profit decrease of $56 m Potential for one or more refineries to consider closure Retail profits decline $7 m	Lower discretionary consumer income results in decreased sales Higher prices for commercial users Capital investment will benefit Canadian producers of petroleum equipment during construction phase (approx. $370 m or more one time investment), resulting in some short term jobs. Majority of refiner operating costs will be spent in Canada	Increased gasoline prices reduce discretionary expenditures by $36 m in long term If a refinery closes, direct job losses of 600 and indirect job losses of 4,300. Potential for reduced investor confidence due to reduced industry profit	Marginal increased expenditure on gasoline Federal sales excise tax revenues decrease $35 m Provincial excise tax revenues decrease $53 m Income tax revenues decline $43 m Increased administrative costs (potential to pass costs on to the industry)

15. This table is a summary of expected cost-associated impacts. Please refer to the text in this chapter for the full discussion, and to Chapter 5 for a discussion of benefits. The values given in this table resulted from an elasticity analysis of potential increases in the price of fuels. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in fuel prices. The resulting figures are directional and rough orders of magnitude.

Kilborn Scenarios 6 and 7 - Sulphur Reductions in Gasoline

Canadian gasoline had an annual average sulphur content of between 360 ppm in 1994, approximately 7 per cent higher than the 1990 U.S. baseline gasoline (338 ppm). Reducing the sulphur content of gasoline is the principle means of reducing NOx emissions, a precursor to the formation of ground-level ozone. This action would also decrease emissions of fine particulates, VOCs and toxic air pollutants.

TABLE 4.7
CUMULATIVE COST ANALYSIS OF KILBORN SCENARIOS UP TO REDUCING SULPHUR IN GASOLINE

	B.C. & Prairies		Ontario		Atlantic Quebec		CANADA	
	50	200	50	200	50	200	50	200
Cumulative Capital Investment ($ m)	499	232	515	370	794	326	1807	927
Cum. Operating Costs ($ m/yr)	59	43	126	125	60	74	245	241
Cum. Capital Costs ($ m/yr)	81	38	85	61	125	52	291	151
Total Annual Costs ($ m)	140	81	211	186	185	125	536	392
Annual Volume (bl)	11.7		12.8		10.6		35.0	
Annual Costs (¢/l)	1.17	.68	1.62	1.43	1.68	1.14	1.53	1.12
Recoverable Cost (¢/l)	>.7	.7	>.7	.7	>.7	.7	>.7	.7
Estimated New Volume (bl)	11.6		12.6		10.5		34.7	
Annual LT Profit Decline ($m)	<35	2	<70	56	<68	33	<173	90

Reducing the sulphur content in gasoline is a relatively high-cost procedure for the refining industry, with the impacts on individual refineries varying widely, depending upon the limit for sulphur selected. Imposing a cap on sulphur content of 200 ppm would decrease industry profitability by about $90 million annually, with more than 60 per cent being borne by the refiners in Ontario. The impacts of 200 ppm sulphur limit on specific refineries will vary considerably; a small number of refineries may be faced with difficult investment decisions, and could choose to close.

The costs and subsequent impacts on the industry increase as sulphur content standards become more stringent. Estimates of cost recoverability for gasoline with maximum 50 ppm sulphur content will likely be somewhat higher than the 0.7 ¢/l shown in the table. Using 0.7 ¢/l as a low end cost recoverability figure generates a maximum profit decrease for Canadian refiners of around $173 m -- almost 50 per cent greater than the 200 ppm requirement.

A 50 ppm sulphur content limit would be a more difficult standard to meet for a larger number of refineries in Canada, with potential for closures becoming increasingly likely.

It is beyond the scope of this study to assess with precision individual refinery viability. The refining industry is highly competitive and new fuel standards would impact refineries to a varying degree. Nevertheless, given the magnitude of the cost impacts of these sulphur reduction scenarios, it is estimated that 1 to 3 refineries will have to make difficult investment decisions, and could close.

TABLE 4.8

ANNUAL COST-ASSOCIATED IMPACTS OF GASOLINE REFORMULATION STEPS UP TO REDUCING GASOLINE SULPHUR TO LEVELS OF 200 & 50 PPM[16]

Industry		Individuals	Governments
Petroleum	**Other**		
Cumulative after tax profit decrease of $90 m (200 ppm) and up to $173 m (50 ppm) Potential for 1 to 3 refineries to consider closure Profit decline for retailers of up to $8 m	Decreased sales due to reduced economic activity Capital investment will benefit Canadian producers of petroleum equipment during construction phase (one time investment of approx. $463 m or more for 200 ppm: $903 m or more for 50 ppm), resulting in some short term jobs. Majority of refiner operating costs will be spent in Canada	Long-term discretionary expenditures reduced by $37 m Potential job losses if refineries close: - direct: 600-1,800 - indirect: 4,300-13,000 Potential for downward pressure on wages due to decreased demand for labour Potential for reduced investor confidence due to reduced industry profit	Increased expenditures on gasoline Federal sales/excise tax revenues decreased $36 m Provincial excise tax revenues fall $53 m Income tax revenues fall $68 m (200 ppm) and up to $130 m (50 ppm) Potential for increased social support spending resulting from job losses Increased administrative costs (potential to pass costs on to the industry)

16. This table is a summary of expected cost-associated impacts. Please refer to the text in this chapter for the full discussion, and to Chapter 5 for a discussion of benefits. The values given in this table resulted from an elasticity analysis of potential increases in the price of fuels. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in fuel prices. The resulting figures are directional and rough orders of magnitude.

California Phase II Reformulated Gasoline

The impacts of a CARB Phase II fuel scenario would greatly exceed those of the other options under consideration. The costs to the industry to produce the fuel are outlined below.

TABLE 4.9
COST ANALYSIS OF CALIFORNIA PHASE II GASOLINE

	B.C. & Prairies	Ontario	Atlantic Quebec	CANADA
Capital Investments ($ m)	1,500	1,700	1,600	4,800
Annual Operating Costs ($ m)	360	395	435	1190
Annual Capital Costs ($ m)	250	280	260	790
Total Annual Costs ($ m)	610	675	695	1,980
Annual Volume (bl)	11.7	12.8	10.6	35.0
Annual Costs (¢/l)	5.08	5.19	6.32	5.66
Max. Cost Recoverable (¢/l)	4.0/4.20	4.20	4.20	4.20
Estimated New Volume (bl)	10.9	11.9	9.9	32.7
Annual LT Profit Decline ($m)	93-104	107	174	372

The impacts of California standards on the petroleum industry would be significant. The costs to the industry are estimated at an initial capital investment of $4.8 billion, and increased annual operating costs of $1.2 billion. This translates into some 5.0 to 6.0¢ per litre. It is estimated that the industry could recover some 4.2¢ per litre in the marketplace. The resulting after-tax profit loss to the industry is estimated to be $372 million, more than 50 per cent of recorded 1994 profits. It would be likely that a number of refineries would close under these conditions. As many as 3 to 5 refineries could be affected. The subsequent economic and social costs to Canadian society of this decision would be significant. Likewise, the direct and indirect impacts on other industries, services, consumers and government would be severe under a CARB Phase II scenario.

TABLE 4.10

ANNUAL COST-ASSOCIATED IMPACTS OF CALIFORNIA PHASE II GASOLINE[17]

Industry		Individuals	Governments
Petroleum	**Other**		
After tax profit decrease of $372 m Potentially 3-5 refinery closures Retail profit decline of $43 m	Potential for 3 MTBE plants to be constructed providing direct gain of 300 jobs, plus associated indirect job gains Capital investment will benefit Canadian producers of petroleum equipment during construction phase (approx. $2.4 b or more one time investment), resulting in some short term jobs. Majority of refiner operating costs will be spent in Canada General fall in profits due to reduced economic activity -- impact not insignificant	Decreased discretionary income of $213 m - short-term impact more severe Potential job losses: - direct: 1,800-3,000 - indirect: 13,000-21,600 - induced: unknown Downward pressure on wages resulting from decreased demand for labour Potential for reduced investor confidence due to reduced industry profit	Substantially increased expenditures on gasoline Federal sales/excise tax revenues fall $201 m Provincial excise tax revenues decline $302 m Income tax revenues from petroleum sector fall $282 m--income taxes from other sources also decline Increased social support expenditures resulting from job losses Higher administrative costs (potential to pass costs on to industry)

17. This table is a summary of expected cost-associated impacts. Please refer to the text in this chapter for the full discussion, and to Chapter 5 for a discussion of benefits. The values given in this table resulted from an elasticity analysis of potential increases in the price of fuels. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in fuel prices. The resulting figures are directional and rough orders of magnitude.

Kilborn estimated the costs for a reformulated fuel scenario proposed by the Canadian Petroleum Products Institute (CPPI). The costs for the CPPI specifications for reformulated gasoline and LSD (along with MMT removal costs) are provided in Table 4.11.

TABLE 4.11
COSTS TO MANUFACTURE CPPI PROPOSAL

	B.C. & Prairies	Ontario	Atlantic Quebec	CANADA
Capital Investments ($ m)	63	51	52	186
Annual Operating Costs ($ m)	14	41	31	86
Annual Capital Costs ($ m)	10	9	8	27
Total Annual Costs ($ m)	24	50	39	113
Annual Volume (bl)	11.7	12.8	10.6	35.0
Annual Costs (¢/l)	0.21	0.39	0.37	0.32
Recoverable Cost (¢/l)	0.2	0.2	0.2	0.2
Estimated New Volume (bl)	11.6	12.7	10.5	34.7
Annual LT Profit Decline ($ m)	1	14	11	26
Annual LT Profit Decline from MMT removal ($ m)	16	12	11	39
Annual LT Profit Decline from 100 % on-road LSD ($ m)	3	16	5	24
Net Annual LT Profit Decline ($ m)	20	42	27	89

The incremental cost of the CPPI gasoline proposal is 0.32¢ per litre, the same as the 15 per cent reduction in toxics scenario (net of MMT removal) which was considered by Kilborn (see Annex VIII-1). The cost recovery potential for that scenario was estimated by Industry Canada to be 0.2¢ per litre. Since on the basis of cost, the 15 per cent toxic scenario (net of MMT removal) and CPPI's proposal are essentially the same, 0.2¢ per litre will be used to estimate the cost recovery potential for the CPPI proposal on gasoline.

The results, which are not incremental to any of the other options presented in this section of the report, indicate that refiners would be unable to recover most of their costs in the marketplace, and would suffer an after-tax profit decline of $89 m, with Ontario refineries bearing close to half of the burden.

TABLE 4.12
ANNUAL COST-ASSOCIATED IMPACTS OF CPPI PROPOSAL[18]

Industry		Individuals	Governments
Petroleum	Other		
After tax profit decrease of $89 m Retail profits decline $2 m	Increased fuel costs of $31 m for trucking industry and other commercial users Minimal impact outside of transportation sector Capital investment will benefit Canadian producers of petroleum equipment during construction phase (approx. $93 m or more one time investment), resulting in some short term jobs. Majority of refiner operating costs will be spent in Canada	Modest increase in gasoline and diesel prices -- discretionary income falls by $33 m Price of goods and services with significant transportation component may rise Minimal impact on wages and employment	Marginal increased expenditures on gasoline and diesel purchases Federal excise and sales tax revenues fall $7 m Provincial excise tax revenues decline $15 m Income tax revenues decrease $69 m Modest increase in administrative costs (likely to be passed on to the industry)

18. This table is a summary of expected cost-associated impacts. Please refer to the text in this chapter for the full discussion, and to Chapter 5 for a discussion of benefits. The values given in this table resulted from an elasticity analysis of potential increases in the price of fuels. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in fuel prices. The resulting figures are directional and rough orders of magnitude.

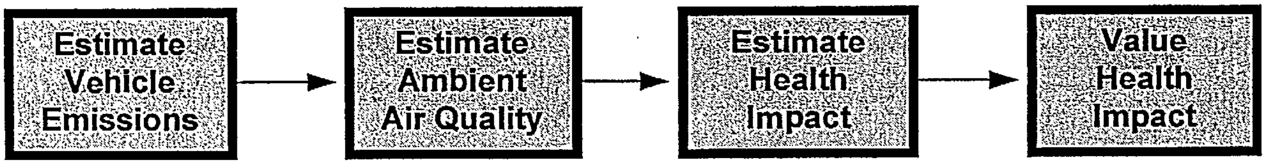
V. HEALTH/ENVIRONMENTAL BENEFITS

The previous two sections of this report examined primarily the costs to individuals, governments and industry associated with adopting various vehicle emission or fuel reformulation standards. However, in order to assess the overall merits of the options under consideration, it is necessary to acquire an understanding of the health and environmental benefits associated with cleaner air. The primary source of information for this section of the report is *Benefits of Cleaner Vehicles and Fuels* by Hagler-Bailly Consulting Inc. and ENVIRON International Corporation which assesses two cleaner vehicles and fuels scenarios for Canada, exclusive of British Columbia. Comparable information for that province is provided in a separate study that was not available at the time this report was written.

Methodology

The environmental/health impacts associated with cleaner air are in some ways more difficult to estimate than some of the financial costs described in the preceding two sections of this report, due to their non-financial nature. The Hagler-Bailly/ENVIRON (HBE) study employs a commonly used estimation methodology referred to as the "damage function approach" where damages refer to adverse effects on health or the environment. Benefits are measured as reductions in such damages. The methodology consists of four key stages as indicated in Figure 5.1.

FIGURE 5.1
"DAMAGE FUNCTION" APPROACH TO ESTIMATING HEALTH BENEFITS



The first step is to estimate tailpipe emissions for a given vehicle/fuel combination. Annual emissions changes were estimated using three EPA computer simulation models. Changes in NO_x, VOCs and CO were calculated using the Mobile5c model. The Complex model was used to estimate air toxins, while PM_{10} changes were estimated through the use of the PART5 model. Details of these calculations are provided in two reports by Environment Canada.[19]

The estimates of vehicle emissions must then be translated into changes in ambient air quality. The Hagler-Bailly/ENVIRON study does this through the adoption of atmospheric simulation modelling techniques drawn from the Auto/Oil Air Quality Improvement Program.

Health endpoints were estimated through concentration-response relationships developed on the basis of Canadian and U.S. literature. Where U.S. estimates were used, they were adjusted to correspond to Canadian health data and demographics. Health endpoints included factors such as hospital admissions for cardio-respiratory symptoms, emergency room visits, acute and chronic respiratory symptomology, cancer and mortality.

Quantifying the economic impacts of the health benefits makes use of "willingness-to-pay" (WTP) and "cost-of-illness" (COI) methodologies. COI estimates provide an indication of the direct financial costs associated with illness, such as medical costs and work loss. WTP measures are somewhat broader and provide estimates of the amount individuals would be willing to pay to avoid an increase in certain health risks. Due to their more comprehensive nature, WTP-based estimates are used wherever feasible.

The data for the estimates were extracted from U.S. and Canadian economic literature. Hagler-Bailly applied expert judgement to the range of available estimates to determine what figures would be most appropriate to use in the current context. Where WTP estimates were not available, COI estimates were revised upwards through use of a WTP/COI ratio derived through available evidence. The estimated WTP ratios were then aggregated over the appropriate number of individuals to determine the "value of a statistical life" (VSL). The paper provided a range of VSL estimates between $3m-$10m in 1994 for individuals under the age of 65. The central estimate provided was $5 million. Greater detail on the methodology is provided in the HBE report.

Options under Consideration

The HBE study evaluated benefits for only two vehicle/fuel combinations. These combinations, and the benchmark against which they are assessed, are provided in Table 5.1.

19. *Emissions Reductions from Changes in Vehicles and Fuels* and *Estimating Changes in Emissions for Various Gasoline Formulations Using the Complex Model* (Environment Canada, 1995).

TABLE 5.1
VEHICLE/FUEL COMBINATIONS EXAMINED IN HEALTH STUDY

	Vehicle	Fuel
Status Quo	Tier 1 commencing 1996	No MMT Summer RAP 10.5 psi, 1.9% benzene, 400 ppm sulphur average 50% on-road LSD use
Scenario I	Canadian LEV program commencing 2001 (approximately same as FEDLEV)	Commencing 1998, Summer RAP of 8.1 psi in WQC, 1% benzene, 200 ppm sulphur average 100% on-road LSD in 1997
Scenario II	CalLEV program commencing 1999	CARB Phase II gasoline in 1998 (7% summer RAP, 1% benzene, sulphur limit 40 ppm) 100% on-road LSD in 1997

Results

The study evaluates the health impacts associated with the two vehicle/fuel combinations identified in Table 5.1. Quantitative estimates, in terms of the health effects and in terms of the value Canadians assign to these effects, are provided where adequate scientific and economic literature exists and the benefits are large. A qualitative assessment is otherwise provided. Table 5.2. displays the benefit categories and pollutants by the type of estimate used.

TABLE 5.2
BENEFITS OF REDUCED VEHICLE EMISSIONS

Quantitative Estimates		**Qualitative Estimates**	
Benefit Category	*Pollutant*	*Benefit Category*	*Pollutant*
Mortality/Morbidity	Ozone	Crop Yield	Ozone
Mortality/Morbidity	PM_{10}	Forest Yield	Ozone
Cancer Risk	Toxics	Ecosystems	Ozone, PM_{10}, Toxics
		Materials Damage	PM_{10}
		Visibility	PM_{10}
		Non-Cancer Health Effects	Toxics

The inputs used to quantify the benefits typically have a range of values. To determine the cumulative effect of those ranges, the HBE study used a Monte Carlo technique to calculate the probability distribution of the results. The low and high estimates reported represent values for the 20th and 80th percentile of the distribution of possible total benefits. The central values are described as the "best estimates" as they make use of the central values for all variables.

Tables 5.3 and 5.5 report the incidence of various health effects for all of Canada, with the exception of British Columbia, for the period 1997 to 2020 for Scenarios I and II respectively. The central estimates of Scenario I report more than 3,000 mortalities and 20,000 incidents of chronic bronchitis.

Large monetary values are assigned, by the numerous valuation studies available in the literature and used in the HBE report, to an incidence of the two health effects noted above. Therefore, the monetary value derived from those incidents account for the majority of the quantified benefits. The value of all the effects is shown in Tables 5.4 and 5.6 for Scenarios I and II respectively. These are the aggregate undiscounted totals for the period 1997 to 2020. Point estimates are also available at 5 year intervals in the HBE study.

It is important to note that the estimates do not include British Columbia, which has been the object of a separate study. The monetary values provided in Tables 5.4 and 5.6 also do not include other environmental benefits such as improvements to visibilty and crop yields, reduced material damage and a reduction in the production of greenhouse gases. These benefits often amount to 15 per cent to 20 per cent of the value of the health benefits. Other factors that would tend to increase benefits, such as the characteristics of the particles and the associated contribution of vehicles, have also not been considered.

It should also be noted that Canada will experience health benefits even if it does not alter its vehicle or fuel regimes. These benefits will occur because of improved air quality in the United States and the reduced trans-boundary movement of pollutants.

Table 5.3
Decreased Incidence of Health Effects for Scenario 1 for all of Canada (excl. British Columbia)

	WQC			Rest of Canada			TOTAL		
Health Effect	**Low**	**Central**	**High**	**Low**	**Central**	**High**	**Low**	**Central**	**High**
Particulate Matter									
Mortality	1176	2503	3047	443	943	1148	1619	3446	4195
Chronic Bronchitis	10735	17045	21816	3842	6101	7809	14577	23146	29625
Respiratory Hospital Admissions	488	1084	2154	184	409	812	672	1493	2966
Cardiac Hospital Admissions	413	918	1823	155	345	686	568	1263	2509
Emergency Room Visits	39765	88367	174963	14989	33310	65951	54755	121677	240914
Asthma Symptom Days	470477	1045504	2070099	177344	394098	780315	647821	1439602	2850414
Restricted Activity Days	6964992	15477761	30645970	2492991	5539980	10969162	9457983	21017741	41615132
Acute Respiratory Symptoms	21435818	47635152	94317598	8219762	18266137	36166950	29655580	65901289	130484548
Bronchitis in Children	73063	162362	321471	31366	69703	138009	104429	232065	459480
Ozone									
Mortality	0	30	50	0	4	7	0	34	57
Respiratory Hospital Admissions	103	178	246	14	25	34	118	203	280
Asthma Emergency Room Visits	371	639	882	51	87	120	421	726	1002
Asthma Symptom Days	75582	130653	181428	10280	17771	24677	85862	148424	206106
Minor Restricted Activity Days	325442	562612	781217	44265	76523	106256	369707	639135	887473
Acute Respiratory Symptoms	776136	1341746	1863096	105565	182496	253407	881701	1524242	2116503
Toxics									
New cancer cases			53			7			60

Source: Hagler-Bailly/ENVIRON (1995)

TABLE 5.4
QUANTITATIVE ESTIMATES OF TOTAL BENEFITS (1997-2020) FOR SCENARIO 1 FOR ALL OF CANADA (excl. British Columbia) - $1994 MILLIONS

	WQC			Rest of Canada excl. B.C.			TOTAL Benefits		
Category	Low	Central	High	Low	Central	High	Low	Central	High
Particulate	**$7,650**	**$16,690**	**$21,160**	**$3,130**	**$6,190**	**$7,480**	**$10,780**	**$22,870**	**$28,640**
Mortality	$3,990	$10,060	$11,650	$1,700	$3,730	$3,950	$5,690	$13,790	$15,600
Chr. Bron.	$2,510	$4,710	$6,880	$980	$1,740	$2,580	$3,490	$6,450	$9,460
Morbidity	$1,150	$1,920	$2,620	$450	$710	$950	$1,600	$2,630	$3,580
Ozone	**$20**	**$160**	**$250**	**$0**	**$20**	**$30**	**$30**	**$180**	**$280**
Mortality	$0	$120	$190	$0	$20	$20	$0	$130	$210
Morbidity	$20	$40	$60	$0	$10	$10	$30	$50	$70
Air Toxics									
Cancer			$140			$20			$160
TOTAL	**$7,680**	**$16,850**	**$21,550**	**$3,130**	**$6,210**	**$7,530**	**$10,810**	**$23,050**	**$29,080**

Source: Hagler-Bailly/ENVIRON (1995)

Table 5.5
Decreased Incidence of Health Effects for Scenario 2 for all of Canada(excl. British Columbia)

	WQC			Rest of Canada			TOTAL		
Health Effect	**Low**	**Central**	**High**	**Low**	**Central**	**High**	**Low**	**Central**	**High**
Particulate Matter									
Mortality	1479	3217	3856	579	1260	1510	2059	4477	5366
Chronic Bronchitis	13806	21911	28049	5136	8152	10435	18942	30063	38484
Respiratory Hospital Admissions	611	1394	2745	239	546	1075	850	1940	3820
Cardiac Hospital Admissions	518	1180	2323	203	462	911	721	1642	3234
Emergency Room Visits	49983	113595	223778	19585	44510	87682	69568	158105	311460
Asthma Symptom Days	591353	1343984	2647647	231707	526606	1037413	823060	1870590	3685060
Restricted Activity Days	8754419	19896405	39195920	3256891	7402025	14581990	12011310	27298430	53777910
Acute Respiratory Symptoms	26943214	61234586	120632130	10739733	24408489	48084720	37682948	85643075	168716850
Bronchitis in Children	91838	208718	411172	40990	93158	183521	132828	301876	594692
Ozone									
Mortality	0	70	114	0	13	21	0	83	135
Respiratory Hospital Admissions	245	422	582	45	77	106	289	499	688
Asthma Emergency Room Visits	878	1511	2085	160	275	379	1038	1786	2464
Asthma Symptom Days	195899	308998	427705	35703	56315	77949	231602	365313	505654
Minor Restricted Activity Days	777988	1330592	1841759	141790	242503	335664	919777	1573095	2177423
Acute Respiratory Symptoms	1855399	3173264	4392327	338150	578334	800510	2193549	3751598	5192837
Toxics									
New cancer cases			95			23			118

Source: Hagler-Bailly/ENVIRON (1995)

TABLE 5.6
QUANTITATIVE ESTIMATES OF TOTAL BENEFITS (1997-2020) FOR SCENARIO 2 FOR ALL OF CANADA (excl. British Columbia) - $1994 MILLIONS

	WQC			Rest of Canada excl. B.C.			TOTAL Benefits		
Category	Low	Central	High	Low	Central	High	Low	Central	High
Particulate	**$9,840**	**$21,450**	**$27,200**	**$4,180**	**$8,270**	**$9,990**	**$14,020**	**$29,710**	**$37,190**
Mortality	5,130	$12,930	$14,980	$2,270	$4,980	$5,280	$7,400	$17,920	$20,260
Chr. Bron.	$3,220	$6,050	$8,850	$5,130	$2,330	$3,400	$4,530	$8,380	$12,290
Morbidity	$1,480	$2,470	$3,370	**$3,220**	$950	$1,270	$2,080	$3,420	$4,650
Ozone	**$60**	**$380**	**$610**	**$10**	**$70**	**$110**	**$70**	**$450**	**$710**
Mortality	$0	$280	$470	$0	$50	$80	$0	$330	$550
Morbidity	$60	$100	$140	$10	$20	$30	$70	$120	$170
Air Toxics									
Cancer			$250			$60			$310
TOTAL	**$9,900**	**$21,830**	**$28,060**	**$4,190**	**$8,340**	**$10,160**	**$14,090**	**$30,170**	**$38,220**

Source: Hagler-Bailly/ENVIRON (1995)

VI. OVERALL IMPACTS

The three primary input studies used in this report -- *Incremental costs of Vehicle Emissions Standards*, *Costs of Upgrading Canadian Transportation Fuels* and *Benefits of Cleaner Vehicles and Fuels* -- used different methodologies and technical assumptions to evaluate the costs and benefits associated with tighter motor vehicle and fuel requirements. The benefits were computed for two vehicle/fuel combinations, while the fuel costs were also computed for several additional intermediate scenarios. It is therefore only possible to provide an indication of the net impact on stakeholders of the two benefits scenarios computed.

In order to be able to compare the cost and benefit figures, it would be necessary to:

- ensure that all figures are measured in the same type of currency (Sierra figures are 1991 dollars, Kilborn and HBE are 1994 dollars);
- measure costs and benefits over a comparable time period (e.g. HBE estimates aggregate 23 years of benefits from 1997-2020, while the annual automotive estimates generated by Sierra are based on the 17-year period 1993-2010;
- ensure that other technical assumptions are consistent and put cost-benefit figures in perspective;
- attempt to reconcile the differing methodologies (the HBE study uses a "willingness-to-pay" approach, while the Sypher-Mueller and Kilborn studies use the more traditional engineering cost estimates);
- consider evaluating the vehicle/fuel scenarios against the next best use of funds.

Notwithstanding the limitations of the data and analyses, it is possible to present the available information in an organised fashion for the two scenarios for which benefit estimates are available. Readers are invited to reach their own conclusions about the suitability of combining the figures provided in Tables 6.1 and 6.2.

TABLE 6.1
LONG-TERM ANNUAL IMPACTS OF SCENARIO I*

Industry			Individuals	Government
Automotive	Refining	Other		
Costs	*Costs*	*Costs*	*Costs*	*Costs*
After tax profit decrease of \$6-52 m Some profit impact may occur independent of any changes in Canada if U.S. increases standards	After tax profit decrease of \$114 m Retail profits decline by up to \$8 m Potential for one or more refineries to consider closure	Reduced profits since consumers have less discretionary income Potential for materials suppliers to automotive industry (e.g steel) to lose sales Higher operating costs for trucking industry Higher costs for commercial users of automobiles	Reduced discretionary income of \$37 m -- gasoline price rises less than 1¢ Price of average vehicle increases \$175-\$1,561 Potential for direct/indirect job losses of 5,000 per refinery closure (associated downward wage pressure)--regional focus Potential for reduced investor confidence due to reduced industry profit	Higher expenditures on vehicles and fuel Possible increase in regional social support expenditures Marginal additional administrative costs to monitor fuel (potential to pass costs on to industry). No additional costs to monitor auto standards if harmonized with federal US program Excise, income and sales tax revenues decline \$181-215 m Potential for increased deficit (due to higher expenditures, lower revenues)
Benefits	***Benefits***	***Benefits***	***Benefits***	***Benefits***
Potential higher revenues for used vehicle dealers and repair shops	Increased competitiveness for some refiners Reduced vulnerability to off-spec gasoline being dumped in Canada	Increased revenues from capital and operating expenditures Improved crop yield Improved forest yield Reduced materials damage Potential savings from healthier labour force	Reduced mortality and improved respiratory health; benefits of \$1 billion (excluding B.C.) Increased visibility Healthier ecosystems	Health care savings

* Note: Quantitative estimates for costs and benefits are not comparable with each other due to differing methodologies in the input studies. Figures presented are not discounted. For greater detail, the reader should consult the relevant sections of this report.

TABLE 6.2
LONG-TERM ANNUAL IMPACTS OF SCENARIO II*

Industry			Individuals	Government
Automotive	Refining	Other		
Costs After tax profit decrease of $14-181 m Some profit impact may occur independent of any changes in Canada if U.S. increases standards ***Benefits*** Potential higher revenues for used vehicle dealers and repair shops	***Costs*** After tax profit decrease of $396 m Retail profits decline by up to $43 m Potential for 3-5 refineries to consider closure ***Benefits*** Increased competitiveness for some refiners Reduced vulnerability to off-spec gasoline being dumped in Canada	***Costs*** Reduced profits since consumers have less discretionary income Potential for materials suppliers to automotive industry (e.g steel) to lose sales Higher operating costs for trucking industry Higher costs for commercial users of automobiles ***Benefits*** Increased revenues from capital and operating expenditures Improved crop yield Improved forest yield Reduced materials damage Potential savings from healthier labour force	***Costs*** Reduced discretionary income of $213 m -- gas price increases 4.2¢ Price of average car increases $403-$6,790 Reduced choice of automobiles Direct/indirect job losses of 5,000 per refinery closure (associated downward wage pressure)-- regional focus May face higher taxes or reduced services to cover government costs and revenue losses Potential for reduced investor confidence due to reduced industry profit ***Benefits*** Reduced mortality and improved respiratory health; benefits of $1 billion (excluding B.C.) Increased visibility Healthier ecosystems	***Costs*** Higher expenditures on vehicles and fuel Possible increase in regional social support expenditures Marginal additional administrative costs to monitor fuel (potential to pass costs on to industry). No additional costs to monitor auto standards if harmonized with federal US program Excise, income and sales tax revenues decline $815-941 m Potential for increased deficit (due to higher expenditures, lower revenues) ***Benefits*** Health care savings

* Note: Quantitative estimates for costs and benefits are not comparable with each other due to differing methodologies in the input studies. Figures are not discounted. For greater detail, the reader should consult the relevant sections of this report.

VII. CONCLUSIONS

Diverse methodologies used in the input studies, together with budget and time constraints, prevented comprehensive assessment of the overall costs and benefits associated with the improved air quality options being examined by the CCME. Notwithstanding these limitations, there are a number of key findings identified in this report that should be emphasized:

- Given the integrated nature of the North American automotive industry, harmonization with new vehicle standards in the United States is the least-cost option for Canada. However, should Canada establish standards which are different from those in the U.S., and thereby require vehicle manufacturers to produce unique vehicles for the Canadian market, manufacturing costs and subsequent consumer prices will be higher than under a harmonization scenario. There is little expectation for Canadian parts sourcing or R&D associated with the emission control technology applicable to these scenarios.

- The fuel refining industry produces a homogeneous good which is highly susceptible to foreign competition. The introduction of fuel reformulation requirements that are not cost recoverable in the marketplace will reduce industry profits. Although ability varies from refinery to refinery, on average, Canadian refiners should be able to recover a significant portion of their costs through price increases. The scenarios for tighter gasoline sulphur requirements (i.e. 200 ppm and 50 ppm sulphur) indicate, however, that potentially one to three refineries would face difficult strategic decisions and could close, with attendant job losses in the affected regions. Refinery investments required to meet tighter standards will largely be made in Canada, and therefore benefit Canadian equipment suppliers during construction phases. Employment is expected to increase during the construction period. The net effect from such investment on employment over the long term is not expected to be significant.

- It is estimated that consumers will be faced with an increase of approximately 0.7 cents per litre for gasoline under the 200 ppm sulphur scenario, and 4.2 cents per litre under the California Phase II scenario. The price of diesel fuel is estimated to rise by 0.5 cents per litre. The introduction of lower emission vehicles into the North American market will increase the price of new vehicles proportionally on both sides of the border. This price increase will occur irrespective of action in Canada in the event that the U.S. adopts tighter vehicle standards.

- In the absence of refinery closures, the overall impact of the less stringent gasoline reformulation option (i.e. 200 ppm sulphur) on the Canadian economy is expected to be small. However, the closure of a refinery would have significant regional impacts. Similarly, provided price increases on new vehicles are such that they do not result in major market distortion, the harmonized vehicle scenario is not expected to have a major overall economic impact.

- Governments may face a decrease in tax revenues and an increase in expenditures resulting from the direct and indirect effects of the costs and price increases for fuels and new vehicles. These effects would increase if one or more refineries were to close or if vehicle standards were not harmonized.

- The health benefits of improved ambient air quality in Canada have been estimated on a "willingness-to-pay" basis. The benefits from cleaner vehicles and fuels are primarily obtained from the reduction of premature deaths and of a large number of respiratory health effects such as chronic bronchitis, respiratory and cardiac hospital admissions and emergency room visits, asthma and acute respiratory symptoms and new cancer cases. Among these, the more than 3,000 mortalities and 20,000 chronic bronchitis cases avoided over the 23-year period covered by the study provide the greatest value to Canadians.

- The benefits to Canada associated with Scenario I (i.e. FEDLEV vehicles plus 200 ppm sulphur gasoline) range from $11 to $29 billion from 1997 to 2020. These benefits exclude the Province of British Columbia. A separate study estimating the benefits for British Columbia showed that the upper range of these benefits would increase by approximately $2 billion. The majority of the benefits will occur in areas currently affected by ambient air quality problems, specifically the Windsor-Quebec Corridor and the Lower Fraser Valley.

- The benefits from reduced damage to crops and materials, and improved visibility could be expected to be 15 per cent to 20 per cent of the health benefits. Further environmental and health benefits (e.g. reduced damage to ecosystems; non-cancer health effects) are also expected, although the extent of these benefits is not known.

- The potential benefits associated with Scenario II (i.e. California LEVs and fuel) are higher than Scenario I, but so too are the estimated economic and social costs. In particular, the costs to the refining industry would likely result in the closure of a number of refineries. Society would have to bear the costs of this dislocation. The direct and indirect impacts on the Canadian economy and the affected regions would be significant, although the specific effects are beyond the scope of this study.

VIII. ANNEXES

VIII.1 THE OTHER KILBORN SCENARIOS

The remaining Kilborn scenarios for gasoline reformulation are analyzed here for completeness. Cost recovery for these scenarios in the marketplace has been estimated using the following approach.

It was estimated by Industry Canada that 0.7¢ per litre was recoverable in the marketplace for Kilborn Scenario 5 (i.e. RVP reductio to 8.1 psia in WQC and LFV). The scenarios considered in this annex are less severe than Scenario 5, and consequently cost less to produce. By reducing the 0.7¢ per litre cost recovery by the difference between Scenario 5 and these lesser scenarios, an estimate of cost recovery can be made. The results are:

KILBORN SCENARIO		COST RECOVERY POTENTIAL
2.	9 psia RVP in WQC	0.05 ¢ per litre
3.	1 LV% Benzene or 15% toxics reduction	0.2 ¢ per litre
4.	20% toxics reduction	0.6 ¢ per litre

Kilborn Scenario 2 - Reduction in Reid Vapour Pressure

The second incremental option being considered is the reduction of RVP in the Windsor-Quebec City Corridor (WQC) -- the most heavily populated part of Canada -- to 9.0 psia. Lower Reid Vapour pressure reduces VOC emissions and hence ground-level ozone.

TABLE 8.1
CUMULATIVE COST ANALYSIS OF KILBORN SCENARIOS UP TO 9 PSIA RVP REDUCTIONS IN WQC

	Ontario	Atlantic Quebec
Cum. Capital Investment ($ m)	19	23
Cum. Operating Costs ($ m/yr)	45	23
Cum. Capital Costs ($ m/yr)	4	3
Total Annual Costs ($m)	48	26
Annual Volume (bl)	12.8	10.6
Annual Costs (¢/1)	.37	.24
Recoverable Costs (¢/1)	.05	.05
Estimated New Volume (b1)	12.8	10.6
Annual LT Profit Decline ($m)	24	12

The results of the cost recoverability study indicate that only a minimal portion of the costs of this option are recoverable in the marketplace due to the availability of foreign sources of fuel which satisfy the RVP requirement at current prices. As a result, industry profits may decline up to $24 million in Ontario and $12 million in Quebec/Atlantic Canada. Specific impacts will vary from refinery to refinery.

TABLE 8.2
ANNUAL COST-ASSOCIATED IMPACTS OF GASOLINE REFORMULATION STEPS UP TO REDUCTIONS OF RVP TO 9.0 PSIA IN WQC[20]

Industry		Individuals	Government
Petroleum	Other		
Cumulative after tax profit decrease for gasoline reformulation steps, of $52 m. (incl. $24 m in Ontario and $12 m in Quebec)	Lower aggregate consumer demand may lead to reduced expenditure in many industries -- impact small Capital investment will benefit Canadian producers of petroleum equipment during construction phase (approx. $16 m or more one time investment), resulting in some short term jobs. Majority of refiner operating costs will be spent in Canada	Pay marginally more for gasoline	Marginally increased expenditure on gasoline Sales tax increase outweighed by reduced excise and income tax revenues -- federal loss of $1 m, provincial loss of $1.5 m Income tax revenues fall $41 m Minimal, if any, incremental administrative impact

20. This table is a summary of expected cost-associated impacts. Please refer to the text in this chapter for the full discussion, and to Chapter 5 for a discussion of benefits. The values given in this table resulted from an elasticity analysis of potential increases in the price of fuels. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in fuel prices. The resulting figures are directional and rough orders of magnitude.

Kilborn Scenarios 3 & 4 - Reduction in Toxic Air Pollutants

For the purpose of this study, "toxic air pollutants" (TAPS) are distinguished from the "common air pollutants" of nitrogen oxides, particulates, carbon monoxide (CO) and hydrocarbons which include volatile organic compounds (VOCs) and non-methane organic gases (NMOGs). Perhaps the most serious toxin is benzene which is deemed by Environment Canada and Health Canada to be a non-threshold carcinogen. 1,3-butadiene has been classified as a probable human carcinogen, while acetaldehyde and formaldehyde have been referred to as possible carcinogens. The other toxin is polycyclic organic material. The options being assessed are (i) to reduce benzene content in gasoline to a maximum of 1 per cent or a 15 per cent reduction in toxins, and (ii) to reduce emissions of these toxic substances by 20 per cent.

TABLE 8.3
CUMULATIVE COST ANALYSIS OF KILBORN SCENARIOS UP TO TAPS REDUCTION

	B.C. & Prairies		Ontario		Atlantic Quebec		CANADA	
	1/15	20	1/15	20	1/15	20	1/15	20
Cum. Capital Investment ($ m)	157	157	53	308	69	182	279	647
Cum. Operating Costs ($ m/yr)	26	26	62	99	46	66	134	191
Cum. Capital Costs ($ m/yr)	26	26	9	51	11	29	46	106
Total Annual Costs ($ m)	52	52	71	149	57	95	179	296
Annual Volume (bl)	11.7		12.8		10.6		35.0	
Annual Costs (¢/l)	.45	.45	.56	1.2	.54	.90	.51	.85
Recoverable Costs (¢/l)	.2	.6	.2	.6	.2	.6	.2	.6
Estimated New Volume (bl)	11.6		12.7		10.5		34.9	34.7
Annual LT Profit Decline ($ m)	16	-8	26	43	22	20	64	55

The results suggest that refinery profits could fall by $64 million for the 1/15 option, and by $55 million for a 20 per cent reduction in toxic substances. This paradoxical result occurs because B.C. experiences zero incremental costs in moving from the 1/15 to the 20 per cent option, and because refiners in all regions except Ontario can recover a greater proportion of costs under the 20 per cent option than under the 1/15 alternative.

TABLE 8.4
ANNUAL COST-ASSOCIATED IMPACTS OF GASOLINE REFORMULATION STEPS UP TO 1/15 AND 20% TOXINS CASE[21]

Industry		Individuals	Governments
Petroleum	Other		
Cumulative after tax profits fall \$64 m (1/15) or \$55 m (20%) Profits of retailers fall \$2 m (1/15) or \$6 m (20%) from reduced sales flowing from lower aggregate demand	Higher prices for commercial users Capital investment will benefit Canadian producers of petroleum equipment during construction phase (one time investment of approx. \$140 m or more for 1% Benzene or 15% toxics red'n; \$322 m or more for 20% toxic red'n), resulting in some short term jobs. Majority of refiner operating costs will be spent in Canada	Reduced discretionary income of \$10 m/yr (\$31 m/yr -- 20%)	Increased expenditure on fuel Reduced sales/excise tax revenues -- federal \$10 m (\$31 m -- 20%), provincial \$15 m (\$46 m -- 20%) Income tax revenues from petroleum sector decline by up to \$48 m (1/15), \$42 m (20 %) Increased administrative costs (potential to pass these costs on to industry)

21. This table is a summary of expected cost-associated impacts. Please refer to the text in this chapter for the full discussion, and to Chapter 5 for a discussion of benefits. The values given in this table resulted from an elasticity analysis of potential increases in the price of fuels. Based on a number of underlying assumptions (see Annex VIII.2), the analysis provides a static view of a dynamic process as industry, consumers and governments respond to changes in fuel prices. The resulting figures are directional and rough orders of magnitude.

VIII.2 EXPLANATION OF CALCULATIONS

Elasticity

Estimates of the costs borne by industry and consumers were computed using an elasticity as follows:

$$\epsilon = \frac{\text{percentage change in quantity}}{\text{percentage change in price}}$$

$$= \frac{(Q_2 - Q_1) / (Q_1 + Q_2)/2}{(P_2 - P_1) / (P_1 + P_2)/2}$$

The variables P_1, P_2, Q_1 and ϵ are all determined from outside sources. Rearranging for Q_2 provides:

$$Q_2 = Q_1 \frac{(1 - \epsilon\rho)}{(1 + \epsilon\rho)}$$

where P_1 = initial price
P_2 = new price
Q_1 = initial sales
Q_2 = new sales
ϵ = elasticity
$\rho = (P_2 - P_1)/(P_2 + P_1)$

Supplementary Calculations and Data

Changes in revenue were determined by the formula $P_2Q_2 - P_1Q_1$. Changes in profit were calculated as the change in revenue less the additional costs provided in the input studies adjusted for the fact that $Q_2 < Q_1$.

Corporate income taxes were computed using a combined federal/provincial tax rate weighted according to refiners' capacity. A rate of 43per cent was used for analysis of the automobile industry. Gasoline excise tax rates were set at 10¢ per litre federally and 14¢ per litre at the provincial level. Sales tax rates equal 7per cent federally (GST).

Discount rate of 10 per cent

VIII.3 GLOSSARY OF ACRONYMS

Acronym	*Full Title*	*Description*
CAFE	Corporate Average Fuel Economy	U.S. Fuel economy standards. Applied to the fleet of a manufacturer.
CAFC	Corporate Average Fuel Consumption	Canadian counterpart to CAFE. Vehicle manufacturers comply on a voluntary basis.
CalLEV	California Low Emission Vehicle	Program to reduce automotive emissions. Manufacturers must meet NMOG averages through sale of TLEVs, LEVS ULEVs and ZEVs. Only ZEVs are mandated.
CGSB	Canadian General Standards Board	Board that establishes various standards including those for diesel and gasoline.
CO	Carbon Monoxide	Air pollutant.
EPA	Environmental Protection Agency	United States Department of the Environment.
FEDLEV	Federal Low Emission Vehicle	Phase-in of LEV. Same as LEV after 2000.
HC	Hydrocarbons	Ozone precursor emitted from automobile exhausts.
LDV	Light Duty Vehicle	Cars, vans and light trucks.
LEV	Low Emission Vehicle	See Table 2.2.4.
LSD	Low Sulphur Diesel	Diesel fuel with a maximum of 500 ppm of sulphur.
MMT	Methylcyclopentadienyl Manganese Tricarbonyl	Gasoline additive used to enhance octane.
MTBE	Methyl Tertiary Butyl Ether	Oxygenate.
NMOG	Non-Methane Organic Gas	A measure of hydrocarbons, an ozone precursor.

Acronym	*Full Title*	*Description*
NO_x	Nitrogen Oxide	Ozone precursor emitted from automobile exhausts.
OBD II	Second Generation On Board Diagnostic System	System built into car to continuously monitor emission-related defects during operation.
ORVR	On-Board Vapour Recovery	Automotive system designed to absorb vapours while refuelling vehicles.
OTC	Ozone Transportation Commission	States in northeastern USA identified by Clean Air Act (1990).
OTCLEV	Ozone Transportation Commission Low Emission Vehicle	Program for OTC States. See page 15.
PM	Particulate Matter	Air Pollutant.
RFG	Reformulated Gasoline	Generic term for gasoline standards which exceed those in baseline gasoline.
RVP	Reid Vapour Pressure	Measure of gasoline volatility.
SO_2	Sodium Sulphur Dioxide	
TAP	Toxic Air Pollutant	Include benzene, 1,3-butadiene, acetaldehyde, formaldehyde and polycyclic organic material.
TLEV	Transitional Low Emission Vehicle	See Table 2.2.4.
ULEV	Ultra Low Emission Vehicle	See Table 2.2.4.
VOC	Volatile Organic Compounds	Contributor to ground-level ozone.
WQC	Windsor-Quebec City Corridor	Geographical region between indicated cities.
ZEV	Zero Emission Vehicle	Electric Vehicles.