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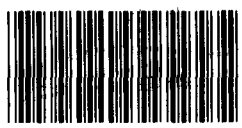
Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

May 1992

ALTERNATIVE FUELS

Experiences of Brazil, Canada, and New Zealand in Using Alternative Motor Fuels



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GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-244892

May 7, 1992

The Honorable Mike Synar
Chairman, Environment, Energy, and
Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

As you requested, this report discusses the experiences of Brazil, Canada, and New Zealand in their efforts to implement alternative fuels programs. The report also presents the results of our survey of the experiences of consumers in Vancouver, British Columbia, Canada, who converted vehicles to use compressed natural gas.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies to the Department of Energy and other interested parties and make copies available to others upon request.

Please call me at (202) 275-1441 if you have any questions about this report. Major contributors to this report are listed in appendix VII.

Sincerely yours,

Victor S. Rezendes
Director, Energy Issues

Executive Summary

Purpose

Concern about the environment and about the economic and energy security impact of this country's dependence on imported oil has increased interest in alternative motor fuels. Compressed natural gas (CNG), liquified petroleum gas (LPG), alcohol fuels such as ethanol and methanol, and electricity are examples of alternative fuels that can be substituted for or used in combination with gasoline and diesel fuels.

The Chairman of the Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, asked GAO to assess the experiences of other countries that have used alternative fuels. Specifically, he was interested in determining the lessons learned from the perspective of government, in encouraging the use of alternative fuels and vehicles; from the perspective of industry, in developing and marketing them; and from the perspective of consumers, in using them.

Background

Worldwide, ethanol, LPG (also known as propane), and CNG are the most commonly used alternative fuels. Ethanol and LPG are each currently used in about 4 million vehicles, and CNG in more than 400,000 vehicles.

Our study focused on the alternative fuel programs of Brazil, Canada, and New Zealand—countries that energy experts identified as leaders in encouraging the use of alternative fuels. In Brazil, ethanol is used in vehicles that are built to run only on that fuel. Brazil currently has about 4 million ethanol-powered vehicles, about 30 percent of its total number of vehicles. Also, almost all gasoline-powered vehicles in Brazil use a blend of gasoline and ethanol. In Canada and New Zealand, gasoline-powered vehicles are converted to run on CNG or on propane, and many of these vehicles can continue to use gasoline as well. Currently Canada has a total of 170,000 CNG and propane vehicles, or about 1 percent of its total number of vehicles, while New Zealand has a total of 105,000 CNG and propane vehicles, or about 6 percent of its total number of vehicles.

Results in Brief

The oil price and supply crises in the 1970s prompted the governments of Brazil, Canada, and New Zealand to look to domestic alternatives for their motor fuels. Their experiences, however, have shown that introducing and sustaining the use of alternative fuels will most likely not be achieved easily or quickly.

Each government was the catalyst for action on alternative fuels, and this leadership proved important in helping remove economic and

regulatory, and attitudinal changes. Real or perceived changes in the government's financial or program support had dramatic negative impacts on consumer use of alternative fuels. New Zealand, for example, experienced sharp declines in CNG use and vehicle conversions following financial incentive reductions.

Experience with alternative fuels programs also shows that government planning and cooperation with industry and other levels of government can improve program operations. Canada, for example, planned a two-phased program; it promoted propane first because that fuel was already used in some vehicles and had a distribution network, and then it phased in the CNG program by applying the lessons learned from the propane experience. Also, government-industry councils were formed that participated in cooperative efforts to prioritize, fund, and implement market and technology development projects for CNG and propane.

Industry Participation Was Vital

In all three countries, industry effort and investment was vital in introducing and sustaining the use of alternative fuels. Before entering the alternative fuels market, however, industry needed the assurance of both the government's commitment to alternative fuels and the potential for sufficient consumer demand to provide an adequate return on the investment made. Once in the market, industry's product development and marketing skills were important in attracting consumers to alternative fuels. In Canada and New Zealand, the natural gas and propane industries now lead the effort to market their fuels.

Industry involvement was essential in overcoming obstacles in making alternative fuels available to motorists. For example, the differences in the physical (gaseous or liquid) and chemical characteristics of each fuel complicated distribution and added fueling infrastructure requirements, such as new or additional storage tanks, compressors, and pumps. In New Zealand, the natural gas and propane industries had to expand their distribution networks (i.e., natural gas pipelines and propane terminals) to make the fuels accessible to fueling stations. The Canadian natural gas industry found it difficult to significantly expand its fueling infrastructure because of the high cost of fueling stations.

Industry involvement was also essential in providing vehicles that could use alternative fuels and in correcting operational difficulties these vehicles experienced. In Brazil, auto makers developed ethanol-fueled vehicles, overcoming the initial difficulties with cold starts and the

technological barriers and persuading industry and consumers that alternative fuels were important. Government planning and cooperation with industry was also important in developing technologies and marketing these fuels. But consistent long-term government commitment was somewhat difficult to maintain because of resource constraints and other reasons. Failure to maintain this commitment, in some cases, had a strong negative impact on sustaining the use of alternative fuels.

Participation by the fuel, automotive, and utility industries was vital in attracting and retaining consumers for alternative fuels and vehicles in each country. Alternative fuel initiatives struggled when industry was not actively involved in developing vehicle technologies, building a fueling infrastructure, and marketing programs.

Consumer acceptance was essential to the use of alternative fuels in these countries. A favorable price for the fuels relative to gasoline strongly influenced the ability to interest private motorists and fleet operators in using alternative fuels. Regulation, lower taxes on alternative fuels, higher taxes on gasoline, or subsidies were used to create or enlarge a price advantage. Consumer acceptance was also influenced by such factors as vehicle performance and reliability and the availability of convenient fueling. When the price of alternative fuels did not compare favorably to the price of gasoline, or when these other factors made alternative fuels less attractive, officials in each country said that their continued use was adversely affected.

GAO's Analysis

Government Was the Catalyst for Action

Government became the catalyst for action by encouraging industry to market alternative fuels and encouraging consumers to use them. In each country, the government provided incentives to consumers such as favorable prices for alternative fuels and assistance in purchasing or converting vehicles. Canada and New Zealand also provided grants, loans, and/or tax breaks to the fuel industry to help defray the installation costs of refueling facilities for alternative fuels.

In each country, GAO was told that sustained government commitment to alternative fuels was important to consumers and industry because the switch to alternative fuels requires long-term financial, technological,

corrosion of fuel and exhaust system parts. In Canada and New Zealand, continuing industry effort was needed to ensure that gasoline-powered vehicles converted to use CNG or propane performed acceptably and that conversion technology improved after both countries initially experienced poor-quality conversions.

Consumer Acceptance Was Essential

Private motorists and commercial fleets in the countries GAO studied measured alternative fuels against the price, convenience, and performance of gasoline. Consumers benefitted from government incentives—such as lower taxes and subsidies—which helped create a price advantage for alternative fuels. Brazilian consumers initially purchased ethanol at 59 percent of the price of gasoline; Canadian and New Zealand consumers purchased CNG at about 40 to 60 percent of the price of gasoline. According to government and industry officials in all three countries, saving money on fuel prices was the most important inducement for consumers to use alternative fuels. Over 90 percent of the Vancouver consumers GAO surveyed said that saving money on fuel was the major reason they converted their vehicles.

Government and industry officials in each country also emphasized that consumers needed to know that alternative fuel supplies would be reliable, easy to locate, and easy to use. The importance of a reliable fuel supply was illustrated in Brazil during a recent acute shortage of ethanol. Industry statistics indicate that as a result of the shortage, sales of new ethanol-powered vehicles within 1 year fell from about 50 percent to less than 5 percent of all new vehicle sales.

In addition, officials in each country said it was essential that consumers perceive alternative-fueled vehicles to compare favorably with gasoline-powered vehicles in terms of quality, reliability, and performance.

Recommendations

GAO is not making recommendations in this report.

Agency Comments

GAO discussed information in this report with Department of Energy officials and with current or former government officials involved with alternative fuel programs in Brazil, Canada, and New Zealand. They generally agreed with the information presented and suggested several changes that were incorporated where appropriate. However, as you requested, GAO did not obtain written comments.

Contents

Tables

Figures

Abbreviations

CATI	computer-assisted telephone interviewing
CNG	compressed natural gas
DOE	Department of Energy
EPA	Environmental Protection Agency
GAO	General Accounting Office
LPG	liquified petroleum gas

Introduction

Continuing concern about the environment, and about the economic and energy security impact of our country's increasing dependence on imported oil, has stimulated interest in the use of alternative motor fuels. The transportation sector is of special concern because it uses nearly two-thirds of all the oil consumed in the United States. Also, approximately 50 percent of all oil consumed here is imported. Other countries, however, have made greater strides in using alternative fuels for transportation. Ethanol (an alcohol), compressed natural gas (CNG), and liquified petroleum gas (LPG) have been substituted for or used in combination with gasoline and diesel fuels in more than eight million vehicles worldwide. Research and demonstrations of other motor fuel alternatives—such as methanol (also an alcohol), electricity, and hydrogen—continue in this country and around the world.

Although the Clean Air Act Amendments of 1990 and the National Energy Strategy proposals could result in the increased use of alternative fuels in certain areas of this country, the transition may not be easy. There are technical and economic obstacles to widespread marketplace acceptance of these fuels. Unlike gasoline and diesel fuels, alternative fuels and alternative-fueled vehicles are neither widely available nor familiar to the motoring public. Using alternative fuels could also require costly changes to the distribution and fueling infrastructure, since alternative fuels have physical and chemical properties—for example, some are gaseous or corrosive—that differ from gasoline or diesel fuels. Cars, trucks, and buses also must be adapted to operate on alternative fuels.

Characteristics of Alternative Fuels

Ethanol, CNG, and propane are the most commonly used alternative motor fuels in the world; about four million vehicles use ethanol, about four million use propane, and more than 400,000 vehicles are powered by CNG. The properties of these fuels vary, and each has positive and negative aspects when compared to gasoline and diesel fuels.

Ethanol: Ethanol is a liquid alcohol that makes an effective, high-octane motor fuel when blended with or substituted for gasoline. It is generally produced from renewable resources, such as corn in the United States and sugar cane in Brazil. According to the Environmental Protection Agency (EPA), ethanol offers several air quality advantages over gasoline. EPA reports that ethanol-fueled vehicles reduce carbon monoxide, hydrocarbons, and other harmful toxic emissions, but may produce higher emissions of acetaldehyde—a toxic pollutant. Ethanol is generally more expensive than gasoline. The Department of Energy (DOE) estimates the

equivalent retail price[1] for ethanol at $2.16 to $2.41 per gallon—compared to an estimated price of $1.19 to $1.45 for gasoline.

CNG: CNG, a gaseous fuel that can be produced from domestic natural gas reserves, is a high-performance, high-octane, and relatively clean-burning motor fuel. According to the EPA, CNG vehicles emit less carbon monoxide, hydrocarbons, and other toxic pollutants, but can produce higher emissions of nitrogen oxide—an ozone-forming pollutant. While the distance a CNG vehicle can travel without refueling is generally less than a gasoline-fueled vehicle, it enjoys a market price advantage over gasoline—partially due to exemptions from federal and some state motor fuel taxes. According to DOE estimates, the energy equivalent retail price for CNG is $0.99 to $1.46 per gallon, which includes federal and state motor fuels taxes.

Propane: Propane, also known as liquified petroleum gas (LPG), is a mixture of oil and natural gas converted to a liquid state by either pressure or reduced temperatures during either the processing of natural gas or the refining of crude oil. Propane provides a high-octane fuel, but vehicles using this fuel generally have a reduced driving range. While limited data are available on the air-quality effects of propane-fueled vehicles, several industry organizations state that hydrocarbon emissions from propane are lower than those from gasoline, and the California Air Resources Board reported that propane-emitted hydrocarbons have a lower ozone-formation potential. Propane is sometimes priced lower than gasoline. DOE estimates the energy equivalent retail price for propane is between $1.09 and $2.01 per gallon.

Ethanol is also sometimes blended with gasoline, a mixture that can result in less air pollution. In Brazil, for example, gasoline contains up to 22 percent ethanol. Brazil has also used methanol to blend with ethanol and gasoline. In the United States, a 10-percent ethanol/90-percent gasoline blend is sometimes used and this represents about 8 percent of the motor fuel sold here. Other alternative motor fuels include methanol, electricity, and hydrogen, which is in the earliest stages of research and development.

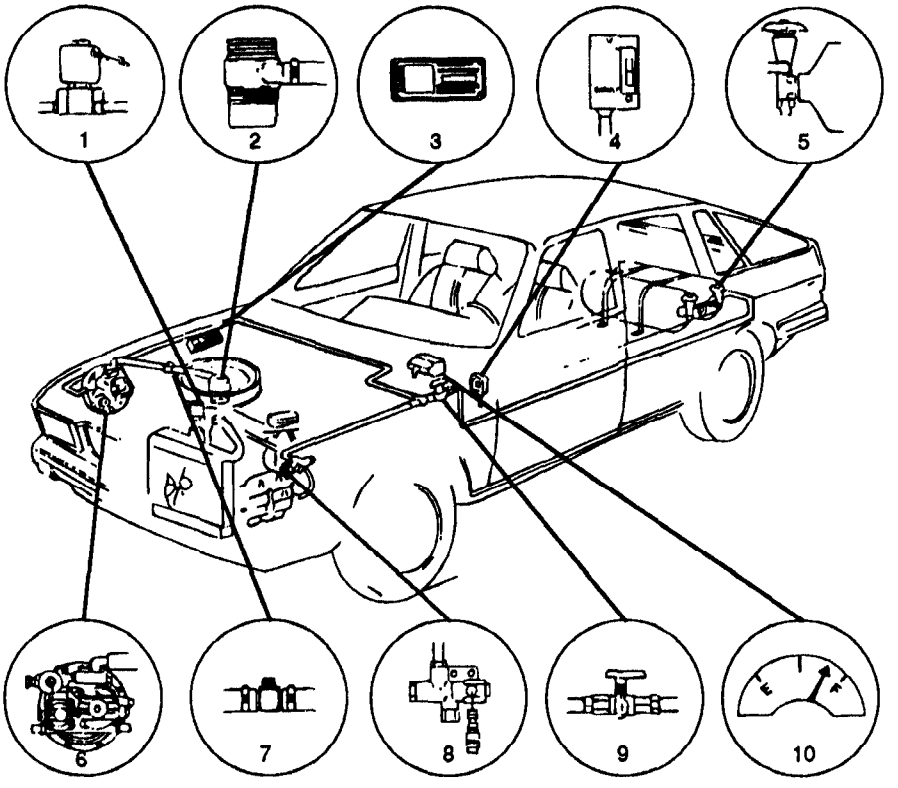
Alternative-Fueled Vehicles

Most vehicles in the world today are designed to operate on gasoline or diesel fuels, so they must be converted to operate on alternative fuels. Consequently, most alternative-fueled vehicles in operation throughout the

[1]Fuel prices in this section are estimated prices per gasoline energy equivalent, as of April 1991, assuming all fuels are taxed on a gasoline energy equivalent basis. For this analysis, DOE included 31 cents in federal and state taxes per energy equivalent gallon for each fuel.

world today were converted rather than originally manufactured to use alternative fuels—Brazil being the major exception with 4 million vehicles manufactured to use ethanol. Vehicle conversions generally involve installation of special equipment to store CNG or propane and move it through the fuel system to be ignited in the engine. Figure 1.1 illustrates the components of a vehicle converted to use CNG.

Figure 1.1: Illustration of a Natural Gas Vehicle System



Components of a CNG Conversion

1. An automated shut-off valve to cut off fuel to the engine when it is not running.
2. An air/gas mixture and carburetor combination suitable for dual-fuel use.
3. Ignition system adjustment.
4. A fuel selector switch to permit the selection of CNG or gasoline.
5. The fuel cylinders to store the CNG, including a pressure relief device.
6. A pressure regulator to reduce the pressure of the CNG for supply to the carburetor.
7. Supply lines which connect the above components.
8. A refueling connection to receive the probe of the refueling hose.
9. A master shut-off valve.
10. A fuel gauge to indicate the remaining fuel quantity.

Source: Natural Gas Vehicle Coalition

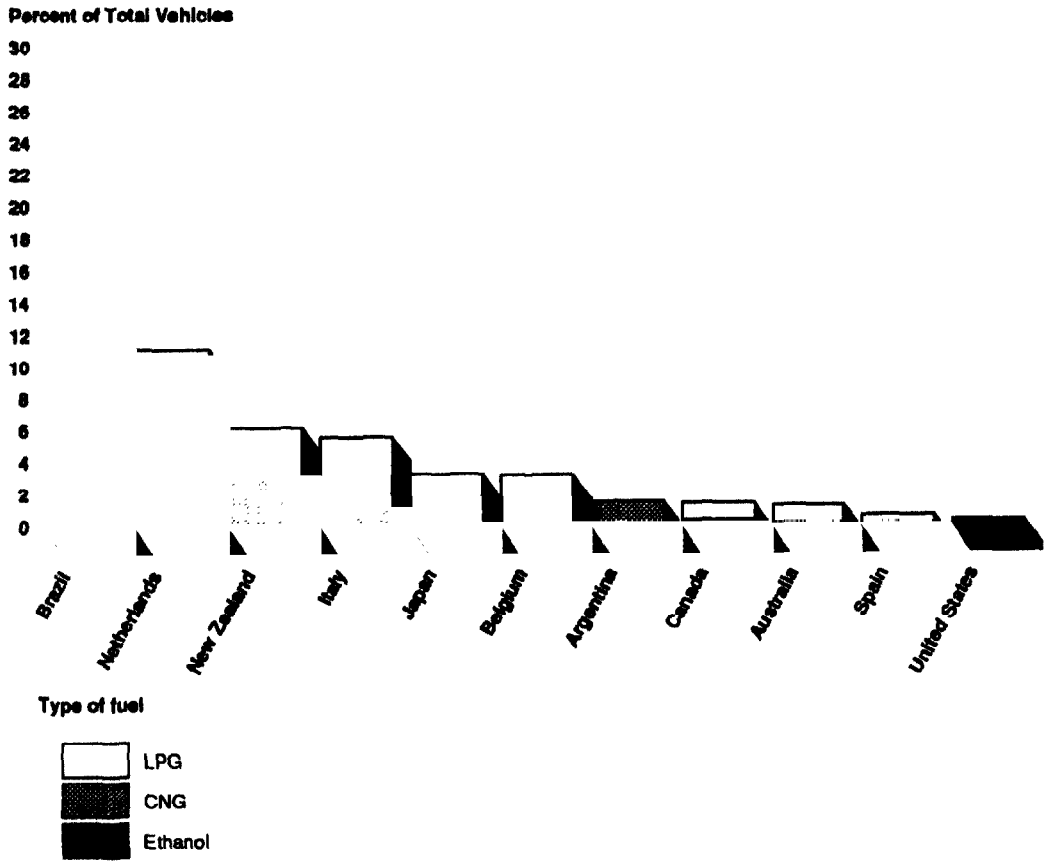
The technologies for converting gasoline-fueled vehicles to operate on CNG and propane have been widely used in Europe, Asia, and the South Pacific for many years.

There are many types of alternative-fueled vehicles, each with cost and performance advantages and disadvantages. Vehicles can be built or converted to operate on one fuel (a dedicated-fuel vehicle), two fuels (a dual-fueled vehicle), or a combination of fuels mixed in various ratios (a flexible-fueled vehicle). Whether converted or manufactured to operate on alternative fuels, alternative-fueled vehicles generally cost more for the consumer. Government and industry sources estimate that, in the U.S., the additional costs for CNG and propane vehicles will range from $500 to $2,500 for conversions, and from $150 to $800 for a newly manufactured vehicle at mass production levels. Dual-fueled and flexible-fueled vehicles allow motorists to use either an alternative fuel or gasoline, an important advantage where fueling stations with alternative fuels are not readily available. However, these vehicles do not offer all of the performance and emission benefits that dedicated-fuel vehicles can provide because they are not designed to take advantage of the benefits of each fuel.

Auto makers have produced and continue to develop alternative-fueled vehicles. In the early 1980s, both Chrysler and Ford produced propane vehicles but found that there was not enough demand for these vehicles. Auto makers are currently producing flexible-fueled methanol vehicles for sale to federal and state fleets and to the public. General Motors has recently started producing a light-duty CNG truck—and Chrysler is producing dedicated CNG vans—for sale to fleets. Chrysler, Ford, and General Motors also are developing electric vehicles that are currently targeted for fleet use. In addition, research and demonstration of alternative fuels for heavy-duty vehicles—buses and trucks—continues and is concentrating on methanol and CNG engines.

Worldwide, over eight million vehicles use alternative fuels. Outside of Brazil, propane and CNG are the most commonly used fuels. The worldwide use of alternative-fueled vehicles is illustrated in figure 1.2, which compares the use of alternative-fueled vehicles to the overall total number of vehicles in each country.

Figure 1.2: Alternative-Fueled Vehicles as a Percentage of Total Number of Vehicles, by Country and Fuel Type



Source: DOE

Alternative Fuel Programs in Brazil, Canada, and New Zealand

The 1970s oil crises, with their resulting gasoline price increases and supply shortages, prompted the governments of Brazil, Canada, and New Zealand to look for opportunities to use domestic resources to reduce their dependence on imported oil. The programs that these three countries developed, though varied in approach, provide examples of organized national efforts to encourage the use of alternative fuels. The characteristics of the alternative fuel programs in these countries are shown in the following table.

Table 1.1: Characteristics of Alternative Fuel Programs in Brazil, Canada, and New Zealand

	Brazil	Canada	New Zealand
Objectives	Reduce oil imports Help sugar industry Create jobs	Reduce oil imports Use domestic energy	Reduce oil imports Use domestic energy
Methods	Vehicle purchase incentives, e.g., reduced taxes Fuel price regulation Fuel production facility loan	Vehicle conversion grants Fueling station grants Fuel tax incentives	Vehicle conversion grants and loans Fuel price regulation and subsidies Fuel station grants, loans, and tax breaks
Fuels	Ethanol	Natural gas Propane	Natural gas Propane
Targets	Private drivers	Private drivers Fleets	Private drivers Fleets
Total vehicles	14 million	14 million	1.8 million
Alternative fueled vehicles	4.2 million ethanol	30,000 CNG 140,000 propane	50,000 CNG 55,000 propane

Brazil

In 1975, faced with heavy dependence on imported oil and a depressed sugar market, the Brazilian government began a program to convert domestic sugar cane into ethanol for use as a motor fuel. The government provided substantial subsidies for ethanol production, used the government-owned oil company to control much of the ethanol distribution, ensured that ethanol was consistently priced lower than gasoline, and reduced taxes on ethanol vehicles. Although consumers experienced vehicle performance and fuel supply problems that adversely affected their use of ethanol, about 30 percent (4.2 million vehicles)[2] of Brazil's current passenger vehicles operate only on ethanol. Appendix I contains a more detailed description of Brazil's experiences with ethanol as a motor fuel.

Canada

Canada began a national energy program in 1980 to improve its energy security and self-sufficiency through conserving energy, substituting alternative motor fuels for gasoline, and using domestic energy resources. In 1981, the Canadian government began providing grants to consumers who converted their vehicles to run on propane. Vehicle conversions increased through 1985, when removal of government incentives and low gasoline prices contributed to a leveling-off in the number of conversions.

[2]The available vehicle and fuel use estimates for Brazil, Canada, and New Zealand are neither precise nor consistent, and therefore we are presenting estimates that seem to best indicate the general extent of use in each country.

Today, about 140,000 vehicles (1 percent of Canada's total number of vehicles) use propane; 85 percent of these vehicles can operate only on propane, and 15 percent can operate on propane or gasoline, according to an industry official. Beginning in 1983, the government provided grants for consumers to convert vehicles to use CNG and for industry to install CNG equipment at fuel stations. Currently, there are about 30,000 CNG vehicles in Canada, according to an industry official; 97 percent are dual-fueled vehicles and 3 percent can use only CNG. Appendix II contains a more detailed description of Canada's experiences with CNG and propane as motor fuels.

New Zealand

New Zealand began its alternative fuels program in 1979 to reduce its dependence on imported oil and gain energy self-sufficiency. The government provided financial incentives to consumers for converting vehicles to run on CNG or propane, and to industry for developing a fueling network. More than 140,000 vehicles had been converted to use CNG or propane through 1985. In 1985, government austerity moves reduced incentives to consumers. Since then, the number of conversions and use of alternative fuels decreased steadily, with only a temporary resurgence during the Persian Gulf War. Currently, about 105,000 converted vehicles (6 percent of the total fleet) are operating in New Zealand. Appendix III contains a more detailed description of New Zealand's experiences using CNG and propane as motor fuels.

U.S. Alternative Fuels Initiatives

The use of alternative fuels in the United States has been developing slowly. Recent federal and state initiatives that could promote greater use of alternative fuels have focused on reducing environmental problems and enhancing energy security, and tend to rely on regulatory compliance, sometimes coupled with economic incentives.

Federal Initiatives

The Alternative Motor Fuels Act of 1988 encourages the development and use of vehicles powered by alcohol (ethanol and methanol) and CNG. The act requires that the maximum practical number of alternative-fueled vehicles be acquired for federal government use, and it provides fuel economy credits to vehicle manufacturers that build alternative-fueled vehicles. The Clean Air Act Amendments of 1990 will require, beginning in 1998,[3] both the use of "clean alternative fuels" in areas with severe air

[3]Under the Clean Air Act, as amended in 1990, "clean alternative fuels" mean methanol, ethanol, CNG, propane, hydrogen, electricity, as well as reformulated gasoline and diesel fuels used in a clean-fuel vehicle that complies with emission standards established by the act.

quality problems and the purchase of clean-fueled vehicles by certain fleets. At this time, it is not certain whether the clean alternative fuel provisions of the act can be met using reformulated gasoline—where the composition of gasoline is changed to improve its emission characteristics—or with alternative fuels and alternative-fueled vehicles.

Federal and state incentives also have encouraged the use of ethanol fuel blends. Gasoline blended with at least 10 percent ethanol produced from renewable resources, for example, is eligible for a 5.4 cent per gallon exemption from federal motor fuel excise taxes. Several states also subsidize ethanol used for gasoline blending.

The National Energy Strategy, issued on February 20, 1991, and various bills before the Congress would encourage the use of alternative fuels through a variety of initiatives. Examples of such initiatives include

- increases in the number of alternative-fueled vehicles used by the federal government,
- purchases of alternative-fueled vehicles by fleets in certain urban areas with air quality problems,
- tax incentives and credits to spur development of a fueling infrastructure for alternative fuels,
- financial incentives to encourage state and local governments and the private sector to purchase or convert to alternative-fueled vehicles, and
- training and certification for technicians converting vehicles.

State Initiatives

California has been the leader in U.S. efforts to use substitutes for gasoline and diesel fuels. The 1970s oil shortages provided the impetus for California's initiatives, which have evolved to focus on the state's severe air quality problems. California is adopting progressively more stringent standards to reduce motor vehicle emissions. To meet these standards, motorists during the next 10 years may have to use alternative fuels, reformulated gasoline, or vehicles with advanced engine technology. The most stringent standards may require the use of electric vehicles or other emerging technologies. Working with U.S. auto manufacturers and oil companies, California is conducting a major demonstration of methanol-fueled vehicles by purchasing 5,000 flexible-fueled methanol vehicles by 1993 and developing a fueling infrastructure.

Other states have also initiated programs that require the use of alternative fuels. Texas, Louisiana, and Colorado, for example, have adopted

legislation that mandates the purchase of alternative-fueled vehicles for government fleets in the mid-1990s. Oklahoma's legislation provides government funding to convert school and government vehicles and provides tax credits for both propane and CNG vehicles. The Clean Air Act authorizes states to either comply with the emission control requirements of the act or adopt California's standards.

Objectives, Scope, and Methodology

The Chairman of the Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, asked us to assess the practical experiences of other countries that have begun alternative fuel programs. The Chairman expressed particular interest in determining the lessons learned from the experiences of government, industry, and consumers with the programs, fuels, and vehicles.

In conducting this review, we drew on information from studies and energy experts on the worldwide use of alternative fuels and alternative-fueled vehicles. Based on this information, the alternative fuel programs in Brazil, Canada, and New Zealand were chosen as case studies in consultation with Subcommittee staff. These countries offered the opportunity to observe different types of programs with different characteristics. Brazil emphasized newly manufactured vehicles while Canada and New Zealand relied on vehicle conversions. Ethanol was used in Brazil and CNG and propane were used in Canada and New Zealand.

In reviewing the Brazil, Canada, and New Zealand programs, we collected information from a wide range of sources. In each country, we contacted government officials, fuel producers and distributors, fuel and vehicle retailers, vehicle manufacturers and converters, taxi and bus company officials, equipment suppliers, energy consultants, research organizations, and consumers to learn about their experiences with alternative fuels and vehicles. We also observed operations at fueling stations and vehicle conversion shops. To obtain additional information about consumer experiences in using alternative-fueled vehicles, we conducted a telephone survey of 475 consumers in Vancouver, British Columbia (Canada), who recently converted their vehicles to use CNG. Appendixes IV and V provide information on the telephone survey and results.

We conducted our work from July 1990 through February 1992 in accordance with generally accepted government auditing standards. Information in this report has been discussed with DOE officials and current or former government officials involved with alternative fuel

programs in Brazil, Canada, and New Zealand. They generally agreed with the information presented and suggested several changes that were incorporated where appropriate. As the Chairman's office requested, we did not obtain written agency comments on a draft of this report. In July 1991, we testified before the Subcommittee, providing the preliminary results of this review.[4]

[4]Alternative Fuels: Experiences of Countries Using Alternative Fuels (GAO/T-RCED-91-85, July 29, 1991).

Government Played an Important Role

When the price and supply of imported oil became serious concerns during the 1970s, the governments of Brazil, Canada, and New Zealand responded with programs substituting alternative motor fuels for imported oil. Although each country's program differed, they had many similar experiences and characteristics—all were government-initiated and used government financial and non-financial incentives to attract industry and consumers to the alternative fuels market. A decade of experience with these alternative fuel programs indicates that government initiative was important to start these programs, and that continuing government commitment was needed to retain industry and consumer confidence in alternative fuels and vehicles. Experience with these programs also shows that planning and cooperation with industry and other levels of government can improve alternative fuel programs.

Government Was the Catalyst in Starting Programs

In the three programs that we studied, the government was the catalyst for action on alternative fuels because of concern about both the effect of oil imports on the national economy and the transportation sector's dependence on petroleum products. Brazil and New Zealand were hit particularly hard by the oil price and supply shocks of the 1970s. In Brazil, which depended on imports for 80 percent of its petroleum needs at the time of the 1974 world oil shock, energy experts explained that mounting foreign debt had cut economic growth, making oil imports a critical problem throughout the 1970s and 1980s. New Zealand's dependence on imported oil also affected its balance of trade. According to government officials there, the cost of oil imports grew to 21 percent of total export earnings by 1980.

The Brazil and New Zealand governments each began ambitious programs to rapidly substitute domestically-produced alternative fuels for imported oil. Although Canada was not a major oil importer then, nor as adversely affected by the 1970s oil shocks because of its domestic oil reserves, its government was concerned that future oil imports would be expensive and unreliable, so it began initiatives to conserve energy and substitute alternative fuels for gasoline.

According to government and industry officials in each country, government action was needed because there was a national problem—dependence on imported oil. Government action was also needed because both industry and consumers, in changing from gasoline

[4]Alternative Fuels: Experiences of Countries Using Alternative Fuels (GAO/T-RCED-91-85, July 29, 1991).

to alternative fuels, faced obstacles that were national in scope—particularly given industry's investment in a gasoline fueling infrastructure and consumers' familiarity with gasoline vehicles. To deal with the psychological, financial, and technological obstacles facing alternative fuels, each government tried to create advantages for industry and consumers in the production or use of alternative fuels. These advantages included direct financial incentives (such as grants for converting vehicles to alternative fuels and expanding fueling infrastructure) and indirect financial incentives (such as tax breaks or favorable financing to expand production of alternative fuels), as highlighted in the following table and discussed in more detail below.

Table 2.1: Government Incentives to Use Alternative Fuels

	Brazil	Canada	New Zealand
Incentives to Industry			
Grants, tax breaks		X	X
Fuel subsidies/price controls	X		X
Loans	X		X
Incentives to Consumers			
Conversion grants		X	X
Loans			X
Reduced fuel taxes		X	X
Reduced vehicle taxes	X	X	

Note: For more detailed information on the incentives offered in each country, see appendices on the Brazil, Canada, and New Zealand case studies.

Each government took steps to create positive public perceptions of alternative fuels and vehicles by publicizing their importance and the incentives for using them. The governments of Brazil and New Zealand were particularly active in promoting alternative fuels. The Brazilian government began its ethanol fuel program with a major publicity campaign that appealed to the public's patriotic instincts to use "the Brazilian fuel" (domestically produced ethanol). According to government and industry officials, this received a positive, rapid response.

Incentives to Industry

Each government provided incentives to encourage industry to enter the alternative fuels market and reduce the financial risks of market entry. These incentives included low-interest loans to expand alternative fuels

production, grants for installing alternative fuels at local stations, and funding for technology development.

Since Brazil's ethanol program had ambitious targets for fuel production and use, government incentives centered on encouraging industry to develop an adequate, reliable fuel supply. To increase the fuel supply, the government offered very low interest loans for constructing distilleries that produced ethanol from sugar cane. A World Bank study indicated that distillery owners who received loans also benefitted because the loans were repaid during a period when annual inflation averaged about 190 percent. The government also guaranteed it would pay favorable prices for all ethanol produced. The government did not provide incentives to develop the fueling infrastructure because the national government-owned oil company supplied motor fuels to distributors and retailers in Brazil, and could control the fuels that were sold to consumers.

In Canada and New Zealand, developing an alternative fuels distribution system was a major government concern. For example, when the Canadian government's CNG program began, no fueling stations were equipped to sell CNG for vehicles. Installing CNG fueling equipment at existing stations was costly—approximately $310,000,[1] according to government officials. Government and industry officials said that government grants of about $45,000 encouraged local gas utilities to work with oil companies to develop the fueling infrastructure. The 119 local fuel stations that were selling CNG by late 1991 all took advantage of the government grant. In New Zealand, the government sought to stimulate development of the fueling infrastructure by offering a grant covering 25 percent of CNG and propane fueling equipment costs as well as loans and tax write-offs for CNG and propane stations. The fueling infrastructure grew to about 400 stations offering CNG and 600 offering propane. Industry and government officials in New Zealand acknowledged that government support, including incentives, helped expand the fueling system.

Incentives to Consumers

In each country, government provided incentives to consumers who purchased alternative fuels and vehicles. Governments helped make alternative fuels attractive to consumers by creating a significant price differential between gasoline and alternative fuels through tax policies, regulations, or subsidies.[2] Governments also offered conversion grants as

[1]All prices throughout the report are shown in U.S. dollars that have been converted from other currencies using the rates reported for October 29, 1991 in The Wall Street Journal.

[2]See chapter 4 for additional information.

well as tax reductions and favorable financing for converted or new vehicles. When combined with favorable fuel prices, these incentives allowed consumers to at least partially recover their purchase or conversion costs. According to government and industry officials, these incentives also helped offset some of the disadvantages of alternative-fueled vehicles, such as limited driving range, power loss, reduced trunk space, and cold-starting problems.

Government and industry officials in the three countries, as well as the consumers in Vancouver that we surveyed, confirmed that the price difference between gasoline and alternative fuels was the most important factor in consumers' decisions to use alternative fuels. The Brazilian government initially set a ceiling on ethanol prices at no more than 65 percent of gasoline. Later, the ethanol price ceiling was changed to 59 percent of gasoline, and has recently been at about 75 percent of gasoline. The New Zealand government pledged that CNG prices would be advantageous for consumers, and indirectly influenced the price through its management of natural gas production and distribution. From 1979 through 1985, the price of CNG varied between 42 and 65 percent of the price of gasoline; in 1991, it was about 60 percent of the price of gasoline. In Canada, limited or no taxes on CNG and propane have kept their prices at about 40 to 60 percent of gasoline.

The importance that consumers place on the gasoline-alternative fuel price differential has also been demonstrated in Italy. Although GAO did not review Italy's experiences in detail, energy experts there indicated that gasoline prices in Italy are among the highest in Europe, with government taxes representing about 60 percent of the price of gasoline. Italian fuel industry officials told GAO that high gasoline prices have been a major factor in shaping Italy's current situation, where over one million Italian vehicles use propane and 240,000 vehicles use CNG.

The Brazilian, Canadian, and New Zealand governments also provided incentives to consumers who purchased or converted their vehicles to use alternative fuels. Canada and New Zealand provided grants to consumers who converted their vehicles to run on CNG or propane. The Canadian government offered grants ranging from about $350 to $440 to reduce the $1,300 to $2,200 cost of vehicle conversion, and it also reduced taxes on converted vehicles. Canadian officials indicated that although the government expected vehicle conversion grants to provide some financial benefits for consumers, they viewed the principal importance of the grants as symbolizing government commitment to alternative fuels. An energy

expert observed that grants were important in making vehicle conversions attractive, since conversions declined when grants ended, but promotional efforts, low propane prices, and provincial government tax incentives also were important because many consumers converted their vehicles without the grant. In New Zealand, the government offered grants, loans, and tax write-offs to offset some vehicle conversion costs that ranged from about $670 to $1,230. Government and industry officials told us that the government's low-interest, no-down-payment loans were important incentives for consumers to finance vehicle conversions. In Brazil, auto makers and car dealers indicated that taxing ethanol vehicles at 35 percent, rather than the 45 percent rate for gasoline vehicles, was important to consumers.

Government Program Costs

Government costs varied in the three countries that we studied, reflecting differences in the scope of each alternative fuels program. Government officials and independent experts estimated that the total cost of Brazil's ambitious ethanol program ranged from $7 billion to $10 billion, largely due to fuel subsidies. By contrast, Canadian government officials estimated they spent about $45 million in direct incentives and $13 million for research and development to promote propane and CNG vehicle use. Provincial governments also provided incentives to encourage the use of each fuel. New Zealand government officials estimated that their CNG program cost about $28 million (no estimates were available for New Zealand's propane program expenditures).

Sustained Government Commitment Was Needed

According to government and industry officials, a decade of experience with alternative fuels in Brazil, Canada, and New Zealand has shown that, once involved, government needed to demonstrate continuing, consistent commitment to alternative fuels. A Canadian energy consultant pointed out that it takes a long time for industry and consumers to make the extensive, costly changes required to move from gasoline to alternative fuels, and emphasized that government needed to show the same long-term commitment that it encouraged from industry and consumers. Governments did show commitment in many ways, such as providing incentives, supporting research and development, and promoting alternative fuels. In the countries we studied, however, governments found that their commitment to alternative fuels became closely identified with financial incentives. When the government reduced or eliminated conversion grants, for example, industry and consumers interpreted such

changes to mean that using alternative fuels was no longer important, according to government and industry officials.

The importance and difficulty of sustaining government commitment was highlighted in New Zealand. According to government and industry officials there, consumer confidence in alternative fuels was severely shaken when the government reduced its incentives. Government had taken the lead in introducing CNG, providing both financial incentives and strong promotional efforts —including television appearances in which the Prime Minister urged drivers to use alternative fuels for the good of the country. Officials explained that government incentives were scheduled to end in 1987, but when a new administration abruptly reduced these incentives in 1985 as part of a general austerity program, consumers became concerned. As a result of the government's aggressive promotion, consumers perceived CNG as "belonging to the government" whose support gave respectability to CNG as a motor fuel, government and industry officials said. According to these officials, when incentives were reduced, consumers concluded that something was wrong with CNG fuel and vehicles. Officials attributed both the drop in CNG vehicles from a total of about 110,000 in 1986 to a total of 45,000 in 1989, and the 50 percent drop in CNG sales between 1985 and 1990, at least in part to the abrupt change in government policy.

Brazil also demonstrated that changes in government incentives and policy can affect the use of alternative fuels. In order to restrain inflation, the government began reducing the price at which it purchased ethanol from producers, although price was its principal tool to guarantee the ethanol supply, according to government officials. In a highly inflationary economy, this meant that producers were paid about 50 percent less for ethanol by 1990 than in 1983. Government officials said that some growers stopped growing sugar cane because the growers could not cover their costs; others diverted sugar cane from ethanol production to the international sugar market to take advantage of rising sugar prices. Ethanol demand, however, continued to grow and outpace production until Brazilian consumers faced a 1 billion liter ethanol shortage in late 1989. At that point, consumer preference changed rapidly and convincingly to gasoline as the public lost confidence in the government's commitment to provide adequate ethanol supplies, according to government and industry officials as well as energy experts. The shortage affected new ethanol car sales, which dropped from over 50 percent of the 1988 market to less than 4 percent of the market in mid-1990. By late-1991, however, ethanol vehicle sales rebounded to 26 percent of vehicle sales. Industry

analyses attributed this renewed interest in ethanol vehicles primarily to concern about gasoline supplies as a result of the Persian Gulf War.

Planning and Cooperation Can Help Government Programs

The three governments' experiences with alternative fuel programs suggested that planning and cooperation with industry and other levels of government can improve program implementation and operation. Government and industry officials in these countries pointed out that planning can help anticipate and prepare for problems that are likely to occur, and involving industry and other government levels can contribute support and stability to the program.

Both the Canadian and New Zealand governments, for example, found that devoting resources to planning their alternative fuels programs was useful. In Canada, the government began by analyzing how propane and CNG could be promoted effectively in the national energy market. Government officials indicated that this analysis led to the planning of a two-phased program. Propane promotion began first because it was already being used in some vehicles and had a distribution network. CNG promotion became the second phase because at that time CNG was not used in vehicles, lacked a distribution system, and needed research and development to adapt its conversion technology to the Canadian climate. Government officials said that the two-phased program allowed them to apply experience from propane to the CNG initiative. However, that experience also showed that propane program objectives had been too short-term. Industry officials indicated that government support may have ended before the propane market was self-sustaining.

In New Zealand, the government established groups to evaluate alternative fuels and use of the country's natural resources. After considerable research, planning groups recommended that CNG, propane, and synthetic gasoline made from natural gas be used for vehicle fuel. Although planning helped the government to make major decisions about the program, planning did not extend to program implementation and operation. The result was what one government official described as a "shotgun" approach in which the government tried to maximize both the number of vehicle conversions irrespective of quality and the number of fueling stations no matter where they were located. Without further planning, the government did not anticipate problems that had a major impact on the program, such as poor-quality vehicle conversions and insufficient fuel supply in some areas. As a result, an effective response to these problems was delayed for several years.

Brazilian industry officials agreed that planning for the ethanol program was limited, and therefore little was done to ensure that it complemented the nation's overall energy policy. They emphasized that better planning could have helped identify and prepare for problems that they experienced. For example, industry officials pointed out that as ethanol began to displace gasoline, a significant diesel fuel shortage developed. This shortage occurred because diesel fuel is a by-product of gasoline refining, and reduced demand for gasoline resulted in less diesel being refined. Government officials explained that the diesel fuel shortage has been serious because Brazil depends on diesel-fueled vehicles to distribute goods throughout the country and provide public transportation in urban areas. To compensate, Brazil now refines more gasoline than the market needs to meet its diesel fuel requirements, and exports surplus gasoline. Industry officials and energy experts concurred that planning could have minimized these fuel supply problems.

In Canada, cooperation among various levels of government and industry was an integral and beneficial part of the alternative fuels program. Government and industry officials agreed that their cooperation throughout the program added support, resources, and stability to the program. Government officials explained that they solicited industry involvement and funding soon after the alternative fuels initiative was announced, and that cooperation had tangible results. For example, natural gas producers in the province of Alberta agreed that they would contribute to federal conversion grants for CNG vehicles in return for reduced federal natural gas taxes and access to new markets. Government-industry councils also were formed to coordinate federal government, industry, and provincial governments' efforts for CNG and propane. According to government and industry officials, fuel councils have been beneficial because all parties participated in prioritizing, funding, and implementing market and technology development projects for each fuel. Interested provincial governments and the federal government also have jointly funded technology development and other initiatives.

GAO Observations

The U.S. government is considering various ways to encourage the use of alternative motor fuels. Such ways include regulatory mandates as well as an array of financial incentives. In developing and implementing these actions, it may be useful to draw on the experiences of Brazil, Canada, and New Zealand.

Lessons learned from these countries show that it is likely the government will need to play a key role in articulating why the use of alternative fuels is necessary. Also, government will probably need to build a consensus with industry and consumers to overcome the financial, technological, and perception-related barriers involved in initiating an alternative fuels program.

Sustained government commitment may be needed for a long period of time to encourage the use of alternative fuels and vehicles. This could be costly for the government, particularly if financial incentives are used. The experiences of Brazil and New Zealand also showed that any government wavering in financial or other commitments may lead to a negative response from consumers and industry.

The success of an alternative fuels program will likely be enhanced if federal and state governments and the fuel and automotive industries cooperate in setting the scope and pace of the efforts that are needed. Comprehensive plans that integrate the many aspects of this undertaking, such as the potential impact of changing world oil prices, would help to ensure that all factors have been considered and provide a framework for action by government and industry.

Industry Participation Was Vital

Introducing alternative fuels and vehicles poses the challenge of making them available and convincing consumers to use them. In the three countries we studied, industry's technical, financial, and marketing skills were essential to meet this challenge. However, before entering the market, industry needed assurances that the market for alternative fuels was potentially profitable and sustainable. Once industry decided to go ahead, it faced many difficulties in entering and remaining in the market. In each country, aggressive industry product and market development was critical in expanding the alternative fuels and vehicles market.

Industry Needed Assurance About Market Potential

In the countries we reviewed, industry was reluctant to invest in developing, producing, and marketing alternative fuels and vehicles without some assurance of consumer demand and profit potential. A Canadian government official said that, at the outset, industry lacked an economic incentive for entering the limited alternative fuels market. Industry officials indicated that their assessment of market potential was a major consideration in their decision to enter the market, and that evidence of the government's long-term commitment to alternative fuels also influenced their decisions.

In Brazil, for example, auto makers' decisions to begin producing ethanol vehicles was influenced by assurances that there would be adequate ethanol supplies and that the government was committed to the ethanol program, according to energy experts. When ethanol was introduced, auto makers' production decisions were crucial to ensure that vehicles able to use ethanol would be in the market. However, auto makers were reluctant to begin production because of concern about whether adequate, reliable ethanol supplies would be available to make ethanol cars viable and attractive to consumers, according to energy experts. They were also concerned about whether government was committed to the ethanol program. Auto makers were encouraged when initial ethanol production targets were met as a result of government assistance to sugar cane producers and distillers, and government policies that provided attractive ethanol fuel prices and ethanol car purchase incentives for consumers.

New market opportunities also influenced industry's willingness to enter the motor fuels market. In Canada, for example, propane and natural gas industry officials told us that when the government alternative fuels program was announced, they were facing a home-heating market with limited growth prospects. Both groups were attracted by the motor vehicle market because it offered opportunities for expanding year-round sales.

Brazilian auto industry officials said they were influenced to enter the ethanol car market by slumping gasoline car sales that resulted from gasoline price increases and uncertainty about future supplies following the 1970's oil shocks.

Industry Found It Difficult to Enter and Remain in the Market

Once the fuel and automotive industries in the three countries decided the market had potential, they faced difficulties in the market. The most significant obstacles were developing a fueling infrastructure, ensuring the quality of alternative-fueled vehicles, meeting price and performance competition from gasoline products, and responding to regulatory disincentives.

Difficulties in Developing Alternative Fueling Infrastructure

Each country's fuel industries faced unique problems in developing an infrastructure for delivering alternative fuel to consumers. The principal challenges were developing national production and distribution systems, expanding the local fuel station network, improving methods for dispensing fuels, and learning how to handle alternative fuels. As discussed in Chapter 2, the Canadian and New Zealand governments offered incentives to encourage fueling infrastructure development. In Canada, government and industry officials differed on the extent to which incentives influenced infrastructure growth.

New Zealand industry faced a limited distribution network in developing a CNG fueling infrastructure. Existing gasoline stations were owned by independent retailers who generally were not willing to risk the installation of costly natural gas compressors and pumps, according to government and industry officials. Also, New Zealand oil companies were unwilling to invest in a fuel that they did not control and that competed with gasoline even when government grants, loans, and tax incentives were offered to install CNG equipment. A breakthrough occurred after a large oil company decided to install CNG at its stations. Officials from that firm said their motivation was to remain competitive with other oil companies not offering CNG because drivers would fill their dual-fueled vehicles with both gasoline and CNG. The company's aggressive marketing also brought CNG to areas not served by natural gas pipelines. It developed a system to compress natural gas in large storage cylinders, and then transports them by trucks to remote stations not served by the pipelines. Subsequently, other oil companies also installed CNG equipment and by 1986 there were about 400 CNG stations in operation. About 350 stations currently sell CNG. The reduction has occurred because of insufficient or

declining demand at some stations, but it has not had serious impact on the availability of CNG to consumers, according to industry officials.

The propane fueling infrastructure in New Zealand expanded slowly because the propane industry initially was not organized to develop a national production and distribution system, according to government and industry officials. At the beginning of the program, the propane industry consisted primarily of small distributors selling propane for cooking and recreational use and to small industrial users. A government loan and other incentives, along with financial support from industry participants, helped establish a propane fueling infrastructure, according to government and industry officials. Later, major oil companies with an interest in propane provided additional funding and leadership in organizing industry efforts. By 1985, most of the propane distribution network was in operation, and there currently are about 600 propane stations on the North and the South Islands.

In Canada, the propane and natural gas industries faced different problems than New Zealand in developing their fueling infrastructure. According to industry officials, the relatively low cost (about $27,000 to $45,000) of equipping stations to dispense propane was important in expanding the fueling infrastructure to about 5,000 public stations located primarily in four provinces. No government incentives were provided to these fuel stations. The propane industry's challenge, however, has been to develop propane fueling equipment that would be easy for consumers to use. As a Canadian researcher pointed out, fueling with propane is noticeably different from gasoline because some provinces require licensed attendants to dispense propane. As a result, propane cannot be offered at self-service pumps. Industry officials indicated that their research and development is directed toward making propane fueling as much like self-service gasoline fueling as possible.

For Canada's natural gas industry, the principal challenge has been expanding its local fueling network. Despite having a gas pipeline system that serves areas where about 85 percent of the nation's vehicles are located, expansion of the fueling infrastructure has been slow. The government set a target to finance 125 public CNG fueling stations by 1986, offering station owners a $45,000 grant to install CNG equipment. The grant program has been extended to 1994, and expanded to include fleet fueling facilities and financial incentives for small natural gas compressors that provide overnight vehicle refueling at homes or business locations. Currently, 119 public stations sell CNG and are concentrated in three

Canadian provinces, according to an industry official. Government officials and an energy expert agreed that their efforts have been hampered by the high cost of equipping existing fuel stations to dispense CNG—about $310,000, according to government officials, depending on station size and area of the nation. Gas utility officials described oil companies' willingness to install CNG at their stations as "critical" to developing the market since constructing a new CNG station at a prime location would be very costly and oil companies have the best locations, customers, and billing systems.

To interest Canadian oil companies and their retail stations in installing CNG, a variety of incentives have been offered. In addition to the federal grant for installing CNG equipment at stations, at least one provincial government offered additional funds and lending programs. Local gas utilities offered incentives such as guaranteed fuel sale volume and financing. They also offered technical assistance to design fuel stations to accommodate compressors and prevent backups at gasoline and CNG pumps, as well as to maintain compressors.

There was disagreement on the extent to which the Canadian government CNG fuel station grant program encouraged infrastructure development. While federal officials described the government grant as "critical," utility officials saw it as helpful but "not sufficient." One oil company said its decision to enter the CNG market was based on owning natural gas reserves, potential for developing CNG vehicle use, and federal and provincial government incentives. Company officials said it took a "huge capital investment" for the company to enter the market in a substantial way. A utility official pointed out that oil companies most interested in CNG stress sales volume than what fuel they sell, and see their investment in a group of customers, rather than a product line.

Although Brazil had advantages in developing its ethanol fueling infrastructure, industry officials confirmed that learning to handle ethanol was a factor in distribution delays. Its principal advantage was that Brazil's government-owned oil company had considerable control over motor fuel supplies. The oil company handled more than half of the ethanol distribution through its pipelines and ships, owned 28 percent of the country's 22,000 fuel stations, and accounted for 25 percent of all fuel sales. In addition, industry officials indicated that pumps became available for ethanol at stations in Brazil because the government had discontinued refining premium gasoline. Despite these advantages, industry officials explained that it took 2 to 4 years for substantial amounts of ethanol to

reach most stations, and learning how to handle ethanol was a factor in this delay. When ethanol was transported through the national gasoline pipeline system, ethanol's cleansing properties tended to clear pipelines of all residues, creating blockages and exposing metal surfaces to corrosion. To minimize these problems, the government-owned company shipped ethanol and gasoline in batches, and used corrosion-retarding products in the pipelines.

Early Problems in Vehicle Quality Had to Be Overcome

Early converted vehicles in Canada, New Zealand, and Brazil performed poorly, a situation that had immediate and long-term consequences for alternative fuels and vehicles. In New Zealand, government and industry officials reported that many early propane and CNG conversions were trial-and-error operations performed by mechanics with inadequate training and experience. These converted vehicles had up to 30 percent less power than before conversion, had difficulty starting in cold weather, and had required frequent tune-ups. Many frustrated drivers switched back to gasoline, and their experiences deterred others from converting their vehicles. Industry and government officials confirmed that negative impressions of alternative fuels and vehicles persisted long after the conversion problems were corrected. These officials attributed the steady decline in CNG conversions after 1985 in part to the poor quality of early conversions. In Canada, industry and government officials also agreed that shoddy early vehicle conversions created negative perceptions of alternative-fueled vehicles among consumers. In one large fleet, vehicles were converted back to gasoline. Early in Brazil's program, a market for vehicle conversions developed and unqualified installers entered the market when government-certified mechanics could not keep pace with demand. Some poor-quality conversions resulted that had a negative effect on both converted and factory-produced ethanol cars because, as energy experts pointed out, consumers and the media did not distinguish between them.

Industry and government in Canada and New Zealand cooperated to improve vehicle conversion quality. In Canada, industry participated in quasi-governmental bodies that developed standards for vehicle conversions, installations, and programs to train installers. These standards have been adopted and enforced by the provincial governments, which regulate vehicle conversions and their use, according to industry officials. Local utilities also improved conversion quality by using qualified conversion shops and monitoring their work. In New Zealand, industry and government collaborated in developing standards, identifying and

promoting good installers, and providing installers with information and training about converting late-model vehicles.

Initial problems with Brazil's factory-produced ethanol cars adversely affected the new vehicle market. After ethanol vehicles reached local dealers in late 1979, sales were good and this resulted in ethanol vehicles capturing 73 percent of the market by the end of 1980. However, auto industry officials told us that consumers had problems with starting these vehicles in cold weather and with corrosion of fuel and exhaust system parts. They explained that the government's decision to move rapidly to ethanol fuel reduced the time available for product development. The resulting quality problems and concurrent ethanol price increases caused new ethanol vehicle sales to fall to less than 10 percent of total vehicle sales by July 1981. To restore consumer confidence, a major auto maker said it (1) ensured that all ethanol vehicle warranty claims were fully satisfied, (2) improved ethanol engines and materials, and (3) upgraded ethanol vehicle warranties to match or exceed those for gasoline vehicles. As new ethanol vehicles improved, public confidence increased steadily. By 1985, they accounted for 95 percent of all new vehicle sales. As discussed previously, from late 1989 to early 1990 an acute shortage of ethanol resulted in a major drop in ethanol vehicle sales. Ethanol vehicles represented less than 4 percent of total vehicle sales by mid-1990, and accounted for about 26 percent of total vehicle sales in October 1991.

Competition From Gasoline Products

Alternative fuel and vehicle producers have found that competing against gasoline products has been risky and continues to be difficult. The experience of a Canadian company established to sell CNG vehicles illustrates the risks involved. A former company official explained that the company entered the market in the early 1980's because it owned natural gas reserves and expected gasoline prices to rise, creating considerable demand for CNG vehicles. It also was aware of New Zealand's experience with CNG vehicles. As industry and government officials agreed, the company was the principal force in Canada's early CNG vehicle initiative. It developed a wide-ranging strategy that included providing incentives for fuel stations to install CNG, providing vehicle conversion incentives, setting up conversion and fuels operations, and lobbying the government to support CNG vehicles. However, consumer demand did not materialize—in part because of low gasoline prices—and the company went out of business in 1988.

In both Canada and New Zealand, it is difficult for CNG- and propane-converted vehicles to compete with factory-produced gasoline vehicles. For example, a Canadian fleet manager noted that despite recent improvements in vehicle conversion technology, gasoline technology has also improved. Also, a Canadian utility official indicated that conversion installers may lack experience to deal with the wide variety of vehicle types and technologies to be converted. A conversion shop owner added that conversions can be difficult because each conversion must be customized to meet specific vehicle requirements and individual consumer preferences about vehicle appearance. A Canadian energy consultant pointed out that consumers also may find it more difficult to keep a converted vehicle properly tuned than a gasoline vehicle. New Zealand officials recalled that converters were asked to convert a wide variety of vehicle makes and models of different ages at the start of their program, and they found it very difficult to fit available conversion parts on these vehicles.

Regulatory Disincentives

Government regulation can be a disincentive to industry efforts to build an alternative fuel and vehicle market unless there are consistent standards and regulations for these products. In Canada, government officials and an energy expert stressed the importance of having the same standards for alternative fuels across the nation in order to assure product integrity, satisfy consumers, and allow these products to compete in the entire market. For example, some provinces do not allow propane vehicles to park inside public garages. An energy expert pointed out that this can be a significant deterrent to propane use in Canada's relatively cold climate. Government officials also explained that one auto maker's decision to stop producing new propane vehicles was influenced by concern that its future vehicles would need to meet emission standards, while converted propane vehicles would not. A Canadian energy consultant pointed out that having a consistent regulatory framework for alternative fuels and vehicles is important to industry. The consultant also explained that producers and retailers always feel threatened, especially during development of a new market, that new regulations can wipe out their efforts.

Product Development and Marketing Were Important

In all three countries, industry's ability to develop products and create consumer interest in alternative fuels and vehicles was essential to attracting and retaining consumers in the alternative fuels market. Alternative fuel and vehicle producers, however, found that it is difficult to compete against sophisticated, reliable, high-performance gasoline fuel

and vehicles that enjoy wide consumer acceptance. Industry officials emphasized that aggressive, creative effort is needed to develop and sell alternative fuels and vehicles.

Product Development

Continuing industry efforts to develop and improve alternative fuels and alternative-fueled vehicle technology have been important to keep pace with improvements in gasoline fuel and gasoline vehicles. In Brazil and Canada, industry attention toward improving the supply and delivery of alternative fuels has been important. In Brazil, increasing production to meet substantially higher demand for ethanol fuel was a challenge for the agricultural industry. Industry officials explained that sugar cane growers improved their productivity by developing higher-yield sugar cane varieties and more efficient distilling processes to increase ethanol supplies. In Canada, industry officials indicated that development work focused on making refueling as similar to gasoline as possible so that alternative fuels would be more acceptable to consumers. For example, retail fuel stations have been equipped with CNG pumps that resemble gasoline pumps and can be operated on a self-service basis, allowing consumers to refill their vehicles in three to five minutes.

Product development has also been important to improving the quality of converted and factory-produced vehicles. A Canadian government official observed that alternative fuels and vehicles are always compared to gasoline or diesel, and urged that research and development focus on removing consumers' concern about getting "second best." To improve their products, the propane and natural gas industries in Canada, for example, have worked with government to improve conversion technology by supporting development of a gaseous fuel injection system for converted vehicles. In Brazil, industry officials indicated that auto makers developed fuel-injection systems and improved materials used in ethanol cars. In New Zealand, the gas industry has been adapting vehicle conversion equipment so it can be used on vehicles equipped with new electronically-controlled fuel injection systems.

Market Development

Aggressive industry marketing of alternative fuels and vehicles has been important in each country. For example, the Canadian natural gas industry developed a business plan to actively market CNG vehicles. In carrying out that initiative, Vancouver's gas utility developed a one-stop shopping conversion package designed to simplify consumers' decisions about switching to CNG and appeal to their interest in price, quality, and

convenience. A utility official explained that the utility provides a single contact person for information, for the vehicle conversion, and for a one-year warrantee. It combines low-interest financing and other financial incentives provided by the utility and the government. As a result, the consumer pays about $1,250 for a conversion that actually costs $2,200, according to a utility official. To provide this package, the utility developed active marketing and advertising campaigns, a sales staff to provide individualized attention to consumers throughout the conversion process, and experts to monitor conversion quality and provide technical assistance to private drivers and fleets. According to utility sales officials, consumer response has been strong—there have been as many as 1,000 vehicles on the conversion waiting list.

By contrast, industry and government officials stated that New Zealand's industry initially relied on government to develop, promote, and sustain the CNG vehicle market. When the government reduced its financial support for the program in 1985 because it needed to reduce its deficit and did not believe the program would be impaired, the natural gas industry and oil companies did not step in to replace government support for the market, according to industry and government officials. Without promotional support and with falling gasoline prices, they said CNG sales and vehicle conversions declined steadily. As a result, oil industry officials also said that some oil companies are phasing out CNG at some stations. The natural gas industry, however, has recently begun an aggressive marketing campaign to improve the CNG image by advertising CNG as a clean, high-performance motor fuel and by targeting fleets for vehicle conversions.

GAO Observations

Industry's experiences with alternative fuels and vehicles in Brazil, Canada, and New Zealand has shown that, like government, industry's involvement in developing and sustaining an alternative motor fuels program is vital. Absent regulatory mandates or other incentives, however, industry is unlikely to take the lead with alternative fuels and vehicles if it is not convinced that it can make as much profit selling alternative fuels and vehicles as with gasoline products. A profitable and sustainable market potential needs to exist if industry is to make the necessary investment to produce and distribute fuels and vehicles.

Because of industry's substantial existing investment in the current gasoline infrastructure and the potential high costs of an alternative fuel system, government and industry should agree on realistic expectations

with respect to how quickly alternative-fueled vehicles and the required fueling infrastructure can be developed. The development of fuel and vehicle standards, training, and certification requirements that are needed to ensure acceptable performance levels will also affect how quickly alternative fuels can be introduced. Industry experience in Brazil, Canada, and New Zealand showed that when consumers had fuel supply or vehicle performance problems with alternative fuels, they developed negative perceptions that persisted long after the problems had been resolved.

Finally, industry needs a consistent regulatory framework that will allow alternative fuels and alternative-fueled vehicles to be competitive in the marketplace. Within that framework, to remain competitive, industry will need to continuously develop and improve alternative fuels and vehicle technology, and aggressively and creatively market alternative-fueled vehicles and fuels in order to attract and retain consumers.

Consumer Acceptance Was Essential

Brazil, Canada, and New Zealand's experiences demonstrated that consumer acceptance was essential for alternative fuels to succeed, and that the potential for consumer acceptance was greater if consumers received tangible advantages for moving to alternative fuels and vehicles. Consumers using alternative fuels and vehicles indicated that favorable fuel and vehicle prices, fuel availability, and vehicle performance were major considerations in their decisions to use alternative fuels and vehicles. Experience in all three countries also indicated that reducing consumers' apprehension about, and creating consumer interest in, alternative fuels and vehicles remains a major challenge.

Favorable Prices Were an Important Incentive

The price of alternative fuels relative to the price of gasoline played an important role in consumers' decisions to switch from gasoline to alternative fuels. The opportunities to purchase alternative fuels at prices substantially below those of gasoline, and to receive price incentives for purchasing or converting to alternative-fueled vehicles, were important to consumers.

Fuel Prices

Saving money on fuel prices was the most important inducement for consumers to use alternative fuels, according to government and industry officials, energy experts, and consumers. Consumers found alternative fuel prices particularly attractive because they had been paying high gasoline prices that reflected substantial taxes and, in the early 1980s, high oil prices. High gasoline taxes combined with government subsidies, fuel price regulations, or lower taxes on alternative fuels helped create a price difference between alternative fuels and gasoline in the countries that we studied. As discussed in chapter 2, Brazilian consumers initially purchased ethanol fuel at prices that the government set not to exceed 65 percent of the price of gasoline. In late 1991, consumers could purchase ethanol at 75 percent of gasoline prices. As a result of tax exemptions in Canada and government control of fuel supplies in New Zealand, consumers in those countries have been able to purchase CNG at prices that range from 40 to 65 percent of the price of gasoline. A Canadian energy expert pointed out that the difference between propane and gasoline prices was important enough so that about 50 percent of vehicles that Canadians converted to propane did not use the government's conversion grant.

In our 1991 survey of 475 Vancouver consumers who recently converted vehicles to run on CNG, over 90 percent said that saving money on fuel was a major reason for their decision. When asked if they would convert their

vehicles if the prices of alternative fuels and gasoline were similar, less than half (47 percent) of those surveyed said that they would be likely to do so.

Saving money on fuel purchases helped consumers offset disadvantages associated with some alternative-fueled vehicles, such as reduced driving range before refueling, cold-starting problems, engine power loss, and reduced trunk space. A 1991 New Zealand gas industry survey of 500 consumers (both private drivers and businesses) using CNG found that "the economic advantage of CNG is the major motivation for usage of this fuel, and this attribute is considered by most CNG users to outweigh the perceived disadvantages of power loss that affects the vehicle." Lower fuel prices also allowed consumers to recover at least some of the costs of purchasing or converting vehicles to use alternative fuels.

Canadian commercial and government vehicle fleet managers reported experiences that underscored the relationship between consumers' ability to realize financial benefits and willingness to use alternative fuels and vehicles. Fleet managers pointed out that their drivers, who do not receive fuel price savings or conversion grants but face the disadvantages of alternative fuels and vehicles, are less likely than private drivers to use these fuels. A utility official who worked with fleets observed that private drivers make better customers than fleet drivers because they accept the drawbacks of alternative-fueled vehicles in exchange for fuel savings. Without financial benefits that can compensate for vehicle limitations, fleet managers reported that drivers tend to use gasoline in dual-fueled vehicles, unless fuel use is carefully monitored.

Vehicle Prices

Consumers responded favorably to vehicle purchase and conversion incentives in each country we studied. As discussed in Chapter 2, when Brazil moved to ethanol fuel, consumers were able to purchase ethanol cars at lower prices than they would have paid for gasoline cars because of lower vehicle purchase taxes. Auto industry officials confirmed that the price difference was an important consideration in Brazilian consumers' purchase decisions. It contributed to ethanol vehicle sales, accounting for 95 percent of vehicle sales by 1985, according to government officials.

Incentives that reduced Canadian and New Zealand consumers' initial capital costs for vehicle conversions influenced their decisions to convert their vehicles. Incentives, such as conversion grants, tax rebates on conversion equipment, and low-interest, extended-term loans to finance

conversions were important in consumers' conversion decisions, as discussed in chapter 2. Research conducted for the British Columbia natural gas industry found that many consumers cited initial conversion cost as a reason for not considering alternative fuels and vehicles. An industry consultant confirmed that many motorists and small businesses could not afford the lump sum payment of a conversion and the additional fees to purchase fuel storage cylinders. A Canadian utility official, however, reported that favorable financing and low-cost cylinder rentals reduced initial costs for consumers and created more interest. In New Zealand, where CNG conversions cost between $670 and $1,230, a consumer marketing survey found that low-interest government loans to finance vehicle conversions were an important factor in 75 percent of consumers' conversion decisions.

Reliable, Convenient Fueling Was Needed

Experience in these countries indicated that consumers attached considerable importance to knowing that alternative fuel supplies were reliable, easy to locate, or easy to use. Since CNG and propane vehicles have a shorter driving range that requires more frequent fueling than gasoline vehicles, having enough fuel stations at accessible locations was important to consumers, according to government and industry officials.

The importance that consumers place on reliable fuel supplies was demonstrated in Brazil, as discussed in chapter 3. The reactions of Brazilian consumers to ethanol supply shortages in 1989 and 1990 demonstrated that an unreliable fuel supply can have a serious impact on the alternative fuel and vehicle market. Inability to obtain ethanol fuel prompted consumers to switch from ethanol to gasoline vehicles, and ethanol vehicle sales dropped to less than four percent of vehicle sales by mid-1990. Government and industry officials as well as energy experts predicted that it may require considerable effort to regain consumer confidence in ethanol. A fuel industry official stated that if were not for the Iraqi crisis that created consumer concern about gasoline supplies, sales of ethanol vehicles could have continued to fall. As discussed in chapter 2, ethanol vehicle sales rebounded to 26 percent of vehicle sales in late-1991.

The importance that consumers place on having adequate fueling stations has been demonstrated in Canada. Although over 40 percent of all Canada's CNG stations are located in British Columbia and heavily concentrated in the Vancouver area, the Vancouver consumers GAO surveyed expressed more dissatisfaction with the convenience of CNG fuel

stations than with any other aspect of using their converted vehicles. Concern with fuel availability also prompted a number of these consumers and the manager of a large fleet to express interest in a residential CNG fueling appliance. A 1987 survey conducted for the British Columbia natural gas industry indicated that consumers who were aware of CNG vehicles cited the lack of CNG stations and limited fuel availability among their principal reasons for not converting their vehicles.

Fuel availability was an important issue for Canadian fleets. We discussed this issue with three commercial fleet managers whose fleets ranged from 75 to 4,500 vehicles, and with two government fleet managers whose fleets ranged from 5,000 to 12,000 vehicles. They indicated that they want the financial and time savings associated with owning their own fueling equipment. For this reason, these fleet managers did not expect introducing alternative fuels through fleets would greatly expand the fueling infrastructure for other consumers.

Consumers also wanted fueling their alternative-fueled vehicles to be as easy as it is with gasoline, according to industry officials in Canada and New Zealand. As described in chapter 3, Canada's propane industry has been concerned that consumers dislike not having propane available on a self-service basis, and has been developing pumps that can be operated safely and easily by consumers. In New Zealand, industry officials indicated that CNG fueling resembles gasoline fueling except that consumers dislike the difficulty of comparing CNG and gasoline prices, because CNG is sold in kilograms and gasoline is sold in liters, making price comparisons very difficult.

Vehicle Performance Was Important

Technology was important to consumers, and their acceptance of alternative-fueled vehicles depended, to a great extent, on their perception that alternative-fueled vehicles compared favorably to the quality, reliability, and performance of gasoline vehicles. As discussed in chapter 3, consumers' problems with early factory-produced and converted alternative-fueled vehicles in all three countries had a significant impact on immediate and long-term consumer purchase and conversion decisions. A Canadian official described the transportation market as demanding and pointed out that minor problems can result in losing customers. When Brazilian consumers became aware of quality problems with the first factory-produced ethanol cars, fuel and purchase price incentives were not sufficient to keep them in the ethanol car market. Industry action was needed to win back consumers' confidence in the quality and reliability of

ethanol cars. According to government and industry officials, Canadian and New Zealand consumers' perceptions of alternative-fueled vehicles were also influenced by early conversion problems.

In Canada and New Zealand, where conversion was the principal option for obtaining alternative-fueled vehicles, government and industry officials questioned whether conversions provided the technology, quality, and reliability to satisfy consumers. For example, fleet officials and consumers surveyed in Vancouver indicated that they view factory-produced alternative-fueled vehicles or gasoline vehicles converted on an auto maker's assembly line as preferable because of better product quality control and warranties. Canadian government and fuel industry officials also cited this preference. A Canadian fleet manager described conversions as putting old technology on a new car. One fleet manager also found that negative views of converted vehicles made them difficult to resell, and that used fleet vehicles often were converted back to gasoline before resale or valued below comparable gasoline vehicles. Studies conducted by the New Zealand government and fuel industry during 1989 also found that used car dealers removed conversion equipment from vehicles in order to sell them as gasoline vehicles.

Other Factors in Consumer Decisions

Alternative fuels and vehicles pose actual and perceived risks to consumers, and reducing apprehension about these risks has been important in attracting and retaining customers, as a Canadian industry official and an energy consultant pointed out. Since a vehicle is one of a consumer's largest purchases, many consumers may perceive the purchase of unfamiliar fuels or a vehicle with some performance limitations as a considerable risk. This has made it difficult, as a Canadian utility official pointed out, to convince consumers who are satisfied with gasoline vehicles to switch to an alternative-fueled vehicle.

Consumers perceive using alternative fuels and vehicles as less risky if their use appears to be socially acceptable, if they are satisfied about fuel and vehicle safety, and if they receive accurate information about performance characteristics of converted and new factory-produced alternative-fueled vehicles. Consumers can be reluctant to use alternative fuels and vehicles unless it appears to be socially acceptable, a Canadian energy consultant indicated. A high-ranking British Columbia government official, by advocating CNG vehicles in the early 1980s, helped make using alternative fuels and vehicles acceptable in the province. Government and industry officials explained that this official's support proved very

important in giving consumers positive impressions of alternative-fueled vehicles. An energy consultant pointed out that the British Columbia official's role demonstrated the need to have an influential advocate for alternative fuels, and noted that the leader of the Quebec taxi drivers' union played a similar role in stimulating the use of alternative fuels in Quebec taxis. In New Zealand, government officials indicated that consumers felt that using CNG vehicles was "respectable" because of the Prime Minister's strong support for using the fuel.

Consumers needed accurate safety information to feel comfortable with alternative fuels and vehicles and would avoid alternative fuels if they had any safety concerns, according to government and industry officials in each country. When Brazil decided to introduce methanol into its gasoline blend, there was considerable public controversy about possible adverse health effects. Based on this experience, a government official cautioned that when consumers develop negative perceptions about an alternative fuel because they do not have accurate information, it is very difficult to change their opinions. Similarly, Canadian government and industry officials stated that several local zoning boards have voted against installation of alternative fuel dispensers at local stations because they were concerned about risk of explosions. A Canadian fleet manager indicated that some alternative-fueled fleet vehicles were converted back to gasoline because of drivers' safety concerns. New Zealand government officials were aware of consumer safety concerns, and told us that they tried to reassure consumers about safety issues by organizing a preventive inspection program to ensure that components, such as CNG cylinders, were structurally sound.

In both Canada and New Zealand, industry officials and conversion shop owners emphasized that consumers feel more comfortable if they understand the advantages and disadvantages of alternative fuels and vehicles. Since consumers cannot test how their car will operate after conversion, Canadian industry officials pointed out that giving consumers complete, accurate information about what to expect after a vehicle conversion has made consumers' decisions easier and increased consumer satisfaction.

Expanding Consumer Interest Remains a Major Challenge

Expanding consumer interest in alternative fuels and vehicles is a major challenge, as was evident in the countries we reviewed. Only a small percentage of Canadian and New Zealand consumers use alternative fuels and vehicles. There is, however, little information about why the majority

of consumers do not use alternative fuels and vehicles or respond to incentives designed to encourage their use, according to a Canadian energy consultant.

Lack of consumer awareness of alternative fuels and vehicles remains an important obstacle to expanding their use. In Canada, government officials pointed out that after more than 10 years of promotion, many consumers are not aware of alternative fuels and vehicles, and cited this as a very difficult problem that requires considerable attention. A utility official agreed that creating consumer awareness is a major challenge, but reported that consumer interest in conversions can be increased through local advertising and marketing.

Opinions differed about the extent to which fleet use could help improve general consumer awareness of alternative fuels and vehicles. Several Canadian government officials cited fleet use as one way to promote public awareness. Two of the commercial fleet managers who we talked with, however, saw limited potential for fleet use to increase public awareness because they did not believe that private drivers consider fleets as relevant to their experience, or that information about alternative fuels is likely to move from fleet to private drivers. Government and fleet officials agreed that education was critical for both private and fleet drivers.

Even when consumers are aware of alternative fuels and vehicles, however, many do not proceed with conversions. In Canada and New Zealand, government and industry officials said that many consumers do not find gasoline prices unacceptably high and this is an important obstacle in expanding interest in alternative fuels. A Canadian energy consultant concluded that, even with consumer research, it is difficult to learn why consumers will not switch from gasoline to alternative fuels. In general, the consultant indicated that consumers who are apprehensive about alternative fuels and vehicles identify strongly with their vehicles, making it unattractive to "tamper" with their vehicle through conversion. Interviews conducted for the Canadian gas industry indicated that 80 to 90 percent of 310 consumers contacted who were aware of alternative fuels did not consider converting to either CNG or propane. Among their principal reasons for not considering CNG, for example, were the high initial cost of conversion, not enough fuel stations, and the length of time to recover conversion costs.

GAO Observations

From the consumer's perspective, some of the most important lessons learned from the experiences of Brazil, Canada, and New Zealand are that consumers want (1) alternative fuels and alternative-fueled vehicles to be price competitive with gasoline, (2) alternative fuels to be conveniently available, and (3) alternative fuels and vehicles to offer performance that compares favorably to that of gasoline fuels and vehicles. Even if these conditions are met or exceeded, however, there is still no guarantee that alternative fuels will be widely used because consumers may be apprehensive about switching to an unfamiliar product with unproven performance records. Social acceptability may also be a factor influencing the use of alternative fuels, at least in the early stages of their introduction into the market place. Providing consumers with accurate information concerning performance and safety and demonstrating government and industry support may help alleviate some of these concerns.

The National Energy Strategy and several proposals introduced in the Congress call for introduction of alternative-fueled vehicles into government and commercial fleets rather than the general public. It is hoped that this in turn will lead to greater interest in and use of alternative fuels by the general public. Opinions of government and industry officials in the countries we studied differed as to whether this fleet use will lead to greater awareness or use of alternative fuels by the general public. The extent to which the general public will see fleet use as relevant to their needs is not known. In addition, an extensive public fueling infrastructure may not develop if fleet vehicles are refueled centrally, and lack of widespread convenient refueling is a major concern of consumers.

Finally, on the basis of the overall experiences of Brazil, Canada, and New Zealand, it could take years for alternative fuels to displace significant amounts of gasoline, and it may not happen without setbacks.

Case Study: Brazil's Alternative Fuel Program

Brazil's ethanol program is the world's largest and most ambitious government initiative supporting alternative motor fuels. In 1979, Brazil's passenger car fleet was comprised almost exclusively of gasoline vehicles; a decade later, about 30 percent of its vehicles are built to run on ethanol fuel. Brazil was chosen as a case study to examine how it made rapid progress in encouraging consumers to use an alternative fuel.

Background

Government officials and energy experts indicated that the 1974 world oil price and supply shock jeopardized Brazil's economic expansion, and set the stage for the National Alcohol Program (Proalcool). Since over 80 percent of Brazil's oil was imported and the transportation sector was about 98 percent dependent on oil derivatives, oil price increases had an immediate, profound effect on its balance of payments position. To deal with this economic threat, the government took actions to reduce its dependence on imported oil by searching for domestic oil sources and using ethanol primarily made from domestic sugar cane to increase the motor fuel supply. This action reflected both the government's desire to protect Brazil's large sugar industry, which had been hurt by falling world sugar prices, and Brazil's decades of experience using ethanol distilled from sugar cane as a gasoline blending agent.

An international energy expert explained that Brazil's strong centralized government played a dominant role throughout the program. Its considerable control over the national economy ensured that the program was implemented throughout this large country. (Brazil is among the largest nations in the world, with an area the size of the continental United States, excluding Alaska. It has a population of 154 million, and about 14 million vehicles.) In addition to controls and incentives for sugar cane planting, distillery construction, sugar and ethanol prices, and motor fuel prices at the pump, the government also exercised a monopoly in fuel exploration and production, and controlled much of the fuel distribution through the government-owned oil company, Petrobras.

Brazil's privately-held agriculture, auto and fuel distribution industries played important roles in the ethanol program. Industry officials agreed that support from the influential sugar and alcohol producers was important in starting and continuing the program. As energy experts pointed out, sugar has always been one of Brazil's main exports, and the sugar industry's stability was important to its economy. The auto industry also was important because its combined annual production of about 800,000 cars figured prominently in Brazil's economy and exports,

according to an industry official. General Motors, Fiat, and Autolatina (a joint venture of Volkswagen and Ford) are Brazil's major vehicle producers. In addition to Petrobras, Brazil's fuel distributors and retailers include major international oil companies and a Brazilian company. Of the 22,000 local fuel stations in Brazil, industry officials said Petrobras operates about 6,200 stations that represent 25 percent of all fuel sales.

Consumer acceptance was critical throughout the ethanol program. Brazilian consumers had experience using ethanol-gasoline blends, and had been accustomed to high gasoline prices before the ethanol program. They were characterized by an automobile trade association as interested in vehicles that offered acceptable prices, and good quality performance and handling.

Implementation of the Alternative Fuel Program

The government's ethanol program has had three stages: 1975 to 1979, when ethanol was blended with gasoline as a fuel extender; 1979 to 1985, when ethanol was used as a fuel in cars that were built to run on ethanol; and after 1985, when ethanol use was affected by an imbalance between the supply and demand for ethanol.

1975 to 1979: Ethanol Used in a Gasoline Blend

The first stage of the ethanol program began in 1975 when the government issued a Presidential decree that had wide-ranging objectives. Its most important objective was to substitute domestic fuel for imported oil, but it also was to support the depressed sugar market, offer agricultural employment, and stimulate agricultural technology improvements. By 1979, the target was to produce 3 billion liters of ethanol at distilleries adjacent to sugar mills so that production could be switched between ethanol and sugar as needed. Ethanol was to be used in a 20 percent ethanol/80 percent gasoline blend to be sold throughout Brazil. Substituting ethanol for some gasoline in a blend had advantages, since it could be used in existing gasoline vehicles and sold to consumers through the existing retail fuel network.

The government's principal concern during this period was to increase ethanol supplies by giving incentives for production and demand, according to an energy expert. Energy experts pointed out that Brazil's sugar growers faced falling international sugar prices and underutilized distillery capacity. The government offered incentives for ethanol production, by making ethanol prices attractive, purchasing all ethanol produced, and providing very low-interest loans to expand existing

ethanol distilleries at sugar mills. To stimulate demand, the ethanol blend was attractively priced for consumers. As a result of these incentives, ethanol production rose from .6 billion liters in 1976 to 3.4 billion liters in 1979, exceeding the production target, according to industry officials.

1979 to 1985: Ethanol Fuel and Ethanol Vehicles

The second stage of the ethanol program began in 1979, when Brazil plunged into an even more serious economic crisis, according to government officials. The crisis occurred when the oil-producing countries announced oil prices increases of 37 percent and sharp increases in international interest rates raised the cost of servicing Brazil's foreign debt. Government officials explained that substituting domestic energy resources for oil imports became crucial because 85 percent of Brazil's oil was imported. The government began several initiatives to find substitutes for imported oil including increased coal production as well as domestic oil exploration and production. It also decided that a new fuel—96 percent ethanol—was needed to replace gasoline at the fastest possible rate. Since the situation was so critical, the ethanol program was begun hastily without adequate analysis or planning, according to industry officials and energy experts.

The government's decision to move to ethanol fuel meant that new fuel and automotive infrastructures were required. A 150 percent expansion of ethanol production capacity was needed to meet the government's new target of 10.7 billion liters by 1985. According to industry officials and energy experts, this changed the cost and character of the program: until 1979, ethanol production was increased by using distilleries at existing sugar refineries; the 1985 ethanol production target could only be met by building free-standing distilleries dedicated to producing ethanol. There also were new demands on the fuel distribution system. For example, local fuel stations needed pumps dedicated exclusively to dispensing ethanol fuel.

Brazil's automotive infrastructure was also affected by the government decision to use ethanol fuel. The decision to produce dedicated ethanol vehicles meant that auto makers would need to produce two types of engines—one for gasoline/blends and one for ethanol. Production and sales strategies also were needed to reach the government's target that ethanol vehicles comprise 50 percent of new vehicle sales by 1985.

To develop ethanol supply and demand that would substitute for imported oil, ethanol fuel production and sales were heavily subsidized, as the following table indicates.

Table I.1: Alternative Fuel Incentives in Brazil

Type of incentive	Incentive Provided
Government incentives to consumers	
Vehicle purchases	Smaller down-payments, extended repayment terms, lower registration fees for ethanol vehicles
Fuel prices	Ethanol prices capped at 59 to 75 percent of gasoline price
Vehicle taxes	35 percent purchase taxes on ethanol vehicles compared to 45 percent on gasoline vehicles
	No vehicle taxes on taxis
Government incentives to industry	
Fuel production	Favorable loans for ethanol distillery construction
	Favorable purchase prices for ethanol

To stimulate production, the government continued its low-interest loans for distillery construction and favorable prices for purchasing ethanol. Low-interest loans for distillery construction played a major role in increasing ethanol production. A World Bank study indicated that distillery owners, who received loans also gained because the loans were repaid during a period when annual inflation averaged about 190 percent.

To create consumer demand for ethanol fuel, the government began a major advertising campaign in which it offered consumers incentives for purchasing ethanol fuel and vehicles. The government guaranteed that ethanol would be available and priced at no more than 65 percent of the gasoline-ethanol blend. The government gave ethanol vehicles a significant advantage by placing a 35-percent tax on their purchase, compared to a 45-percent tax on gasoline vehicles. Auto makers and dealers said that these incentives were important in consumers' purchasing decisions. Ethanol vehicle purchasers were also offered lower registration fees, smaller down payments, and extended payment terms. The government promoted the program by appealing to consumers' patriotic instincts to use "the Brazilian fuel." Of these incentives to consumers, industry officials stated that favorable ethanol prices were the most important.

Although Brazil had advantages in developing its ethanol fueling infrastructure, industry officials confirmed that there were problems in learning how to handle ethanol in the gasoline distribution system. The government had the advantages of controlling more than half of all ethanol distribution through Petrobras pipelines and ships, 28 percent of local fuel stations, and 25 percent of fuel sales. According to oil company officials, the government decreed that every fueling station in Brazil would have an ethanol pump, and they became available because the government had discontinued refining premium gasoline. By 1980, over 5,000 ethanol pumps were operating in Brazil. By 1987, about 18,000 of Brazil's 22,000 fuel stations carried ethanol.

Despite these advantages, industry officials pointed out that learning how to handle ethanol contributed to a two- to four-year delay in supplying substantial amounts of ethanol to fuel stations. The government oil company reported that when ethanol was transported through pipelines, its cleansing properties tended to clear pipelines of all residues, create blockages, and expose metal surfaces to corrosion. The company minimized this problem by shipping ethanol and gasoline in batches and using corrosion-retardants in the pipelines. A private oil company also reported that ethanol initially damaged equipment at fuel stations, but found that corrosion retardants controlled the problem.

Although ethanol vehicles were vital to the government's ethanol program, and the government issued resolutions encouraging ethanol car production, auto makers were reluctant to begin production. Despite research indicating that dedicated ethanol vehicles were feasible, auto makers did not commit to production until 1979 because of concern about the reliability of ethanol supplies and government commitment to the program, energy experts reported. The fact that initial ethanol production targets were met and government support for the ethanol program remained strong between 1975 and 1979 proved important to auto makers. In addition, when the second phase of the ethanol program began in 1979, the government extended its commitment by offering consumers attractive ethanol fuel prices and ethanol vehicle purchase incentives. Industry officials added that their decision to enter the ethanol vehicle market was influenced by these factors as well as by a slump in gasoline car sales that resulted from gasoline price increases and supply uncertainties following the 1970's oil shocks.

There were several additional factors in the auto makers' decision to produce dedicated ethanol vehicles. An auto makers' trade association

indicated that one such factor was that dedicated vehicles were consistent with the government's goal of increasing ethanol use. One auto maker, however, reported that it considered flexible-fueled ethanol vehicles until company engineers concluded that these vehicles could not match the performance of dedicated vehicles.

After strong initial sales, problems with ethanol vehicles and changes in government fuel price policy had a negative impact on the ethanol vehicle market. When the new factory-produced ethanol vehicles went on sale in late 1979, consumer response was stronger than expected. Stimulated by favorable ethanol prices and vehicle purchase incentives, consumer purchases of ethanol vehicles were about 73 percent of vehicle sales by the end of 1980. By that time, however, consumers were experiencing fuel and exhaust system corrosion and cold-starting problems with ethanol vehicles. An auto maker indicated that, under considerable pressure from the government, it did not have enough time to adequately develop ethanol vehicles. This meant that the first ethanol vehicles were essentially gasoline models modified to use ethanol, with fuel and exhaust system materials that could not accommodate the corrosiveness of ethanol fuel.

Consumers who converted vehicles to take advantage of ethanol prices also encountered problems. According to energy experts, this occurred when government-certified mechanics were overwhelmed by demand for conversions, and unlicensed mechanics moved into the market. Industry officials and energy experts described these conversions as "disastrous" because they resulted in consumer distrust of ethanol fuel and factory-produced ethanol vehicles, since neither consumers nor the media distinguished between poorly-converted ethanol vehicles and newly-manufactured ethanol vehicles.

Consumers also faced higher fuel prices when the government increased ethanol prices from as low as 40 percent of the price of gasoline toward the government's 65 percent cap, according to energy experts. The government increased ethanol prices in an attempt to reduce the inflationary effect of program subsidies, and to reflect supply shortages that resulted from strong ethanol vehicle demand and reduced government subsidies to ethanol producers. Consumers reacted rapidly, and ethanol vehicle sales fell to less than 10 percent of total vehicle sales by July 1981.

Faced with consumer defections from ethanol fuel and vehicles, government and industry acted to regain consumer confidence. The government renewed its support for the program in 1981 and 1982 by

holding ethanol prices at 59 percent of gasoline prices for two years and extending ethanol vehicle purchase incentives. Ethanol producers also received more attractive credit to increase ethanol production. A major auto maker said that it honored warranties to repair corrosion problems on ethanol vehicles. It also improved ethanol vehicles by using chrome plating on carburetors to prevent corrosion problems, adding a small pump to inject gasoline to reduce cold starting problems, and increasing ethanol vehicle warranties to meet or exceed those of gasoline vehicles. Public confidence in ethanol vehicles steadily increased, with purchases peaking in 1985 at about 95 percent of vehicle sales, according to government officials. Industry officials pointed out that this experience underscored the need for adequate time to develop products that are reliable from the outset.

After 1985: Imbalance in Ethanol Supply and Demand

The third stage of the ethanol program began in 1985 and was characterized by growing imbalance between ethanol demand and supply. Consumer incentives continued and demand for ethanol grew, but producer incentives steadily decreased and supplies diminished. According to government and industry officials, this led to the 1989-90 ethanol shortages that dramatically reversed the program's earlier successes.

Although many factors caused ethanol demand to outpace supply, government and industry officials agreed that government unwillingness to increase prices it paid ethanol producers and crop subsidy reductions had the greatest impact. Government officials explained that the price the government paid for sugar and ethanol was the principal means for guaranteeing the supply of ethanol. As oil prices fell and foreign debts accumulated throughout the 1980's (the government borrowed to support the ethanol program), prices paid to producers were reduced in an attempt to control inflation. According to government officials, producers' costs have exceeded the prices they received for their products since 1985, and this resulted in reduced sugar cane planting. An official of a large agricultural trade association estimated that by 1990, producers received 50 percent less for ethanol than in 1983. Government officials also pointed out that the government's 1985 suspension of subsidies to sugar cane growers and low-interest loans to distillers affected supplies.

As sugar growers switched to more profitable crops, distilleries began to have difficulty in buying enough sugar to produce ethanol. Growers who continued to grow sugar cane were deeply in debt and unable to

modernize their equipment. The situation worsened as international sugar prices rebounded from a long-term slump, and gave sugar growers an alternative to producing for the domestic motor fuels market.

Brazil began to experience what a government official described as "a reverse oil shock" as ethanol demand began to outstrip production as early as 1986. Demand continued to rise even after ethanol prices were increased to the cap of 75 percent of the price of gasoline, and the difference between the taxes on ethanol and gasoline vehicles was reduced to 3 1/2 percent. From late 1989 to early 1990, there was an acute shortage of ethanol that government and industry officials described as a crisis for the program. As a result, consumers with dedicated ethanol vehicles waited in long fuel lines. The situation was so desperate that executives of a major oil company recalled stopping at a pharmacy to purchase alcohol for an ethanol vehicle.

The ethanol shortage had an adverse impact on auto makers. Industry sales records demonstrated that consumer preference again changed rapidly and convincingly to gasoline vehicles. Ethanol vehicle sales dropped from over 50 percent of the 1988 market to less than 4 percent of vehicle sales in mid-1990. Government officials stated that some consumers also converted their ethanol vehicles to gasoline. An industry official observed that one failure, such as the ethanol shortage, undermined the entire program, and that consumer support collapsed when the government was unable to ensure adequate fuel supplies.

Government officials indicated that the government was forced to consider options for dealing with the fuel shortage—rationing or finding a substitute fuel. With support from ethanol producers who were anxious to support alternative fuels, it decided to import methanol to extend fuel supplies, and a blend (60 percent ethanol/33 percent methanol/7 percent gasoline) was introduced in several areas. One government official described it as having "an alternative for the alternative fuel." However, government and industry officials explained that there was considerable public controversy about the safety of handling methanol. One fuel producer indicated that "misinformation" developed about methanol during the controversy. As a result, the methanol blend was prohibited in some major markets such as Rio de Janeiro, but was sold in the Sao Paulo area. According to a government official, experiences throughout the ethanol program showed that when any new fuel is introduced, people need clear information about its advantages and disadvantages because when people assimilate incorrect information, it is difficult to change their

perceptions. Later, the government also imported ethanol to relieve the domestic ethanol shortage.

During 1990, the Brazilian government announced actions to stabilize and expand the ethanol program. It promised to begin (1) raising prices paid to ethanol producers during 1991 until these prices reflected world prices, (2) renegotiating producers' debt, and (3) providing credits to expand sugar cane planting. Although sugar and ethanol prices had increased by late 1991, they were still about 20 percent below world prices. Debt renegotiations were to begin in late 1991, but it was uncertain if government credits would be available to producers for the sugar cane planting in January through March 1992. In addition, new ethanol vehicle sales began a recovery that industry analyses attributed to renewed concern about gasoline supplies as a result of the Persian Gulf War. New ethanol vehicle sales rose throughout 1991 and accounted for about 26 percent of October 1991 vehicle sales. One manufacturer's 1992 ethanol vehicles featured a fuel injection system, the world's first use of this technology in ethanol vehicles.

Results

Government and industry officials and energy experts agreed that the ethanol program has generally met its objectives. They indicated that its positive results include making it possible for Brazil to move impressively from gasoline to ethanol fuel and vehicles, and significantly increase sugar cane and ethanol production and efficiency. Although increased domestic oil production has made Brazil about 60 percent self-sufficient in oil, ethanol consumption has also improved Brazil's balance of payments position by providing a substitute for 200,000 barrels per day of imported oil. The program created new business for the sugar and auto industries, led to new employment in the agricultural sector, and stimulated capital investment in agriculture and auto technology. Although environmental protection was not a concern when the program began, government and industry officials reported that in urban areas such as Sao Paulo, ethanol use has improved air quality. Government and industry officials stated that the ethanol program stimulated the development of a three-stage national emission control program that, in 1997, will bring Brazil's air pollution requirements to current U.S. levels.

These positive results, however, were achieved at considerable cost. Industry officials and energy experts estimated that the government invested a total of $7 billion to $10 billion from its $400 billion annual economy and international borrowing. The World Bank estimated, for

example, that the collapse of oil prices in 1986 and the loss of revenues from reduced gasoline-ethanol blend sales resulted in a $900 million program loss in 1988. A government official also cited the subsidies required to support the ethanol program as a factor in Brazil's high inflation.

According to government and industry officials, the ethanol program had undesirable side-effects as well. For example, they concurred that ethanol shortages put the credibility of the ethanol program and ethanol at risk with the public, and forced the government to spend funds for ethanol and methanol imports. Industry officials and energy experts also agreed that the ethanol program created a significant imbalance in Brazil's energy market by contributing to a gasoline surplus and diesel fuel shortage. The shortage occurred because diesel fuel is a by-product of refining gasoline, and reduced demand for gasoline resulted in less diesel being refined. Government officials explained the diesel shortage has become serious because Brazil is highly dependent on diesel-fueled vehicles to distribute goods throughout the country and provide urban transportation. Diesel fuel represented about 50 percent of the 1990 motor fuel market, and demand is increasing at 3 percent annually. To compensate, Brazil now refines more gasoline than the market needs to meet its diesel fuel requirements, and exports surplus gasoline. Industry officials and energy experts pointed out that long-range analysis and better planning by the government would have helped to minimize the fuel distribution and ethanol supply problems that occurred, and to provide more realistic forecasts of program costs and effects of oil prices on these costs.

The Future

The ethanol program's future is unclear because of uncertainty about government policy, program cost, and consumer responses to ethanol. Although ethanol is widely used as a motor fuel in Brazil and about 30 percent of their vehicles are built to run on ethanol, industry officials and energy experts agree that the program faces major questions. It is not clear whether the government will provide the consistent support for the ethanol program. Questions have been raised about whether the program's benefits justify its costs, since increasing sugar cane and distillery production will require major investment.

Government and industry officials and an energy consultant point out that consumer acceptance is key to an alternative fuel program. Auto industry officials are concerned as to whether consumers will overcome their skepticism about the reliability of ethanol supplies. Recent rapid shifts in

consumers' perceptions of ethanol and gasoline supply outlook have made it difficult to estimate future ethanol and ethanol vehicle demand. However, since air quality is a growing issue in urban areas, some officials suggest that environmental concerns may support the program. Government and industry officials conclude that ethanol has a strategic role in Brazil's energy plan and is important as a clean fuel, but the extent of government continuing support is uncertain.

Case Study: Canada's Alternative Fuels Program

As a net oil exporter, Canada appeared an unlikely candidate for an alternative fuels program after the 1970s oil shocks. The Canadian government, however, was concerned about future dependence on imported oil, and concluded that alternative fuels could help increase energy self-sufficiency by using domestic energy resources. Currently, alternative-fueled vehicles are estimated to represent about 1 percent of the nation's vehicles. Canada was chosen as a case study because it illustrates how alternative fuel use developed in a country whose market and political organization has many similarities to the U.S.

Background

After the two world oil and price supply shocks in the 1970s, Canadian government officials indicated that the government was concerned that oil imports would become expensive and unreliable as domestic oil supplies were depleted. As part of Canada's 1980 energy program to reduce energy consumption and dependence on imported oil, the government decided to promote propane and CNG as motor fuels since they were available domestically and close to being economically and technologically viable, according to government officials. Canada had been a propane exporter (although propane is a limited resource) and had extensive proven and potential natural gas reserves with a pipeline system that could serve 85 percent of the nation's 14 million vehicles. Motor fuels are important in Canada, since its considerable land area makes the transportation network important to its population of 26.5 million people.

Canada's alternative fuels program has been characterized by cooperation between the federal government, provincial governments, and industry. Cooperation began soon after the alternative fuels initiatives started when the federal government solicited industry ideas and funding for the program, according to government officials. Cooperation developed through councils that were formed to support technology, markets, and demonstration programs for each fuel. The federal government, interested provincial governments, and the propane and natural gas industries participated in decisions and funding, according to government and industry officials.

The federal government initiated the alternative fuels program and planned to help fund and promote alternative fuels until the program was stabilized and industry could take leadership, according to government officials. Provincial governments actively supported alternative fuels by providing incentives such as research and development funds, fuel tax breaks, and sales tax rebates on vehicle conversions.

Industry involvement and fuel industry leadership has been important in Canada's alternative fuels program, according to government officials. The fuel industry took an active role in promoting vehicle use of propane and CNG because it offered opportunities for new markets. Industry officials indicated that they were attracted to this market because the home heating oil market had limited growth prospects and were seasonal. According to government and industry officials, some major international and independent oil companies in the Canadian market have been selling alternative fuels at their local fueling stations and participate in an alternative fuel industry association. Auto makers, however, played a limited role in the alternative fuels program. They currently do not produce alternative-fueled vehicles, making conversions the principal option for Canadians to obtain these vehicles. However, Ford sold factory-produced propane vehicles between 1982 and 1984, and Chrysler sold them from 1982 until 1988. (The reasons for these auto makers leaving the propane market are discussed later in this appendix.) According to a government official, General Motors has plans to produce CNG trucks for the Canadian market.

Canadian consumers have been the focal point of government and industry efforts in the alternative fuels program. Before the government program began, consumers had some experience with propane vehicles, particularly in Alberta, where some fleets had been using propane for as long as 30 years. By contrast, general consumer awareness of CNG as a motor fuel was very limited prior to government promotion efforts.

Implementation of the Alternative Fuels Program

Government analyses conducted before the program was implemented concluded that there were regulatory, information, acceptance, technology, supply, and cost barriers to alternative fuels. To reduce these barriers, officials indicated that the federal and provincial governments cooperated to develop industry and consumer financial incentives, vehicle technology, consumer awareness, and a fueling infrastructure. Government officials explained that their analyses of how to promote propane and CNG in the national market led to a two-phased alternative fuels program. Propane promotion came first because its existing fuel delivery infrastructure used for heating and other purposes could also serve vehicles. In addition, some propane vehicles were already in use, vehicle conversion equipment was available, and standards existed for propane vehicles, according to government and industry officials. Since CNG use in vehicles was very limited and there was no vehicle fueling infrastructure, its promotion was planned as the second phase of the

program so that a fueling infrastructure, vehicle conversion technology suited to the Canadian climate, vehicle safety standards, and consumer awareness could be developed. Government officials also said that they decided to promote alternative fuels and vehicles with both the public and fleets in order to generate sufficient demand.

The federal and provincial governments offered a variety of incentives to interest industry and consumers in alternative fuels, as indicated in table II.1. Government officials indicated that although they expected vehicle conversion grants to provide financial benefits to consumers, the grants were also intended to symbolize government commitment to alternative fuels and attract consumer attention. The propane and natural gas industry also provided incentives to consumers and other industries. Government officials indicated that they wanted the marketplace to decide which alternative fuels would be used. They regarded initial government support as necessary for those fuels most likely to be economically viable by reducing barriers to industry investment in those fuels, making gasoline more expensive in order to encourage the use of alternative fuels, and funding the alternative fuels program until industry could assume leadership.

Table II.1: Alternative Fuel Incentives in Canada

Type of incentive	Incentive Provided
Government incentives to consumers	
Vehicle conversions	Federal grants of $350 for a propane conversion, $440 for a CNG conversion, or $1300 for a CNG conversion with a vehicle refueling appliance
Fuel prices	Propane and CNG exempted from federal excise taxes and some provincial fuel taxes
Vehicle taxes	Two provinces offered sales tax rebates on conversions
Government incentives to industry	
Public fueling stations	Up to $45,000 grants for CNG equipment
Fleet fueling facilities	Up to $45,000 grants for CNG compressors
Technology/market development	Federal and provincial government funding or support
Industry incentives to consumers/businesses	
Vehicle conversions	Gas utilities provided conversion grants, low-interest financing, CNG cylinder rental option, conversion warranties Propane industry provided conversion incentives
Fueling stations	Natural gas industry provided incentives for oil companies to offer CNG

The Propane Program

When the federal government's propane program began in 1981, its target was to expand Canada's existing fleet of 10,000 propane-powered vehicles to 90,000. To reach this target, the government offered grants of about $350 to help reduce the $1,300 to $1,800 cost of converting a commercial vehicle to run solely on propane, according to industry officials. Government officials explained that commercial conversions were expected to make propane sales about 1 to 2 percent of the motor fuel market, an amount anticipated to lead to a self-sustaining market. By 1984, the government expanded its conversion grant program so that dual-fueled and non-commercial vehicles also were eligible.

The federal and provincial governments also began promotional and tax initiatives that, according to government officials, were more important than vehicle conversion grants in promoting propane. The federal government encouraged its fleets to use propane and eliminated excise taxes on propane, according to government officials. The province of

Ontario exempted propane from road taxes and offered up to $670 in sales tax refunds on vehicle conversions. These exemptions were important because Ontario accounted for one-third of all Canada's vehicles, according to government officials. All provinces except Manitoba and Quebec exempted propane fuel from road taxes, and several also reduced or removed sales taxes on conversions or factory-produced vehicle purchases.

Industry officials indicated that propane retailers developed the market by targeting high-mileage vehicles such as taxi and commercial vehicle fleets for conversion to increase fuel sales. This strategy produced a steady increase in propane use as owners of propane vehicles took advantage of the difference between propane and gasoline prices, which now is 40-to 60-percent, according to an industry official.

Since propane was available at many locations, the government did not offer financial incentives to expand the fueling infrastructure. Propane retailers, however, acted to expand the fueling infrastructure because industry officials said they regarded fuel availability as necessary to convince consumers to purchase or convert vehicles. Retailers offered vehicle fueling at some propane outlets, and worked with gasoline fuel stations to encourage them to install propane dispensing equipment at a cost ranging from $27,000 to $45,000 (depending on station size). By targeting fleets, propane retailers were able to minimize their investment in infrastructure development because it costs less to install the fueling infrastructure for fleets than for the general public. However, since provincial governments require propane dispensing equipment to be operated by trained personnel, self-service pumps have not been available for consumers.

Problems occurred with both converted and factory-produced propane vehicles during the program. Government and industry officials agreed that the poor quality of early conversions and the continuing need to keep propane conversion technology current with gasoline vehicle technology presented problems in expanding the propane market. For factory-produced propane vehicles, officials indicated that the problem was keeping auto makers in the market. Although the federal and Ontario provincial governments provided financial incentives for auto makers to produce dedicated propane vehicles, production ended by 1988, according to government officials. Government officials and an energy expert cited possible reasons for this, including insufficient demand, concern about propane supplies, the fact that conversion shops could perform

conversions cheaper and faster, and auto makers' concerns about the feasibility of dual-fueled vehicles meeting emission standards. The costs of meeting emissions standards and providing warranties (costs not incurred by conversion shops) were disincentives for auto makers to remain in the market, according to government officials.

The government's propane vehicle conversion target was met when the grant program ended in 1985. Between 1980 and 1985, grants were used to convert about 71,000 vehicles. However, an additional 30,000 vehicles were converted without government support. An energy expert observed that grants were important in making vehicle conversions attractive, since conversions declined when grants ended, but promotional efforts, low propane prices, and provincial tax incentives also were important because many consumers converted their vehicles without the grant.

After the government program ended, federal and provincial governments worked with the propane industry on market development, vehicle demonstrations, and federal fleet promotion. In addition, the propane industry offered incentives for vehicle conversions and fuel stations, according to a government official. Currently, there are approximately 140,000 propane vehicles on the road (about 1 percent of the total number of vehicles), of which about 80 percent are commercial vehicles, and the public fueling station network has expanded to about 5,000 stations, according to industry officials.

The CNG Program

Before beginning the CNG initiative, actions were taken to prepare CNG for the marketplace. The federal and British Columbia governments funded research to improve vehicle conversion technology, adapt it to Canadian weather, and develop safety standards for CNG vehicles.

When the CNG program was announced in 1983, it had two major parts—grants for vehicle conversions and grants for fuel infrastructure development. To interest consumers in conversions, the federal government offered $440 grants for dual-fueled vehicles. Alberta's natural gas producers contributed funds for federal conversion grants in return for reduced federal taxes on natural gas and the opportunity to develop this new market. Industry officials stated that they regarded the grant as crucial because consumers faced higher costs for a CNG conversion (totaling about $2,200) than for propane, and consumers saw it as a tangible endorsement of CNG by the government. CNG users also benefitted from a price difference between CNG and gasoline that, according to an

industry official, currently gives CNG a 40 to 42 percent pump price advantage. Other benefits included exemption from the federal excise tax on CNG and elimination of provincial road taxes on CNG. The federal government set a target of 35,000 conversions by 1987, although officials acknowledged that there was concern that this might not be adequate for a self-sustaining market. The provinces of Alberta, British Columbia, Ontario and Quebec also provided support for the CNG program. For example, Ontario offered up to $900 in sales tax refunds for vehicle conversions.

To develop a CNG fueling infrastructure, the federal government offered up to $45,000 toward the capital costs of installing CNG equipment at public fueling stations. According to government and industry officials, this grant was begun because the cost of equipping an existing fuel station to dispense CNG (about $310,000) was much higher than for propane. Since the cost of constructing a new CNG station at a prime location would have been substantially higher, and since oil companies had the best locations on major traffic routes, customers, and billing systems, a utility official described oil companies' willingness to install CNG at their stations as "critical." At least one provincial government offered generous lending programs for oil companies to install CNG equipment, according to an industry consultant. The government's target was to help finance 125 public CNG fueling stations by 1986.

Government and industry officials pointed out that individuals and a private company were important in creating positive perceptions of CNG fuel and vehicles with consumers. British Columbia's efforts to promote CNG were advanced because a high-ranking provincial government official advocated CNG vehicles. An energy consultant explained that the leader of the Quebec taxi drivers' union played a similar role in urging CNG use in taxis. During the early 1980s, a private Canadian company provided leadership in marketing CNG vehicles. A former company official explained that the company entered the market in the early 1980s because its parent company owned natural gas reserves, and the company saw opportunities for vehicle use to increase demand for its product. The expectation of high oil prices was also important to its plans. The company provided incentives to consumers and fuel stations, set up vehicle conversion and fueling operations, and promoted CNG vehicles with the government. According to government and industry officials, the company demonstrated the sales potential of CNG vehicles. However, the company went out of business in 1988 because (1) low gasoline prices limited consumer demand and (2) developing a CNG fuel infrastructure and vehicle use proved far more expensive than anticipated.

Like propane, shoddy vehicle conversions performed early in the program created negative impressions of CNG vehicles. Industry officials indicated that some private drivers and fleets converted back to gasoline because of performance problems.

Utilities began to take an active role in promoting CNG vehicles, according to government officials. A 1985 natural gas industry business development plan set a target of 150,000 CNG vehicle conversions supported by 600 public fueling stations by 1989. To reach this target, marketing was directed to small commercial fleets and high-mileage private vehicles. To make conversions simpler for consumers, industry and government agreed that local utilities would administer the federal conversion grant, and utilities added their own incentives to make conversions even more attractive, utility officials indicated. Local utilities also offered incentives to make selling CNG more attractive for oil companies. For example, utility officials stated, some utilities guaranteed to re-purchase equipment if stations failed to reach specific sales volumes, maintained equipment, provided advertising or offered financing to install CNG equipment. Since CNG compressors and dispensers take up space, one utility offered technical assistance in designing stations to optimize space use and reduce backups at gasoline and CNG pumps, according to a utility official. Industry and government also jointly funded development of new CNG technology, such as fuel injection systems for vehicle conversions.

In implementing its business plan, the industry found that aggressive local CNG marketing was needed, according to a utility official. For example, Vancouver's gas utility developed a one-stop shopping conversion package designed to simplify consumers' decisions about switching to CNG and appeal to their interest in price, quality, and convenience. A utility official explained that the utility provided a single contact for information, vehicle conversion, and a one-year warranty. It combined low-interest financing and other utility and government financial incentives so that the consumer paid about $1,250 for a conversion that actually cost about $2,200. The utility developed active marketing campaigns, a sales staff to provide individualized attention throughout the conversion process, and experts to monitor conversion quality and provide technical assistance to private drivers and fleets, according to a utility official. A utility official stressed this has been necessary because selling a vehicle conversion is complicated, and consumers often require considerable time to reach a decision. According to government officials, the Vancouver utility, unlike others, has been successful in the private market. Consumer response has been strong—about 1,000 vehicles have been on the conversion waiting

list and conversion shops have been booked for 6 months, according to a conversion company official.

Despite government and industry efforts, 30,000 CNG vehicle conversions (about 0.2 percent of Canada's total number of vehicles), rather than the 1987 target of 35,000 conversions, had been performed by 1990, according to an industry official. All but 2,000 conversions used the government grant, a government official stated. The poor quality of early conversions affected conversion rates, but government officials and energy experts also attributed the shortfall to high conversion costs, low gasoline prices, and the limited number of fuel stations. The conversion grant program was extended to 1994 with a target of 35,000 conversions.

The government's 1986 target of 125 CNG fuel stations has not been met either, although CNG is sold to the public at 119 fuel stations, according to an industry official. Government officials, an energy expert, and consumers that GAO surveyed agreed that there are not enough fueling stations. They explained that the high cost of equipping fueling stations to sell CNG hampered efforts to expand the fueling infrastructure.

The role of the federal grant in CNG fueling infrastructure expansion is not clear. While Federal officials described the government grant as "critical", utility officials saw it as helpful but "not sufficient." Federal officials expressed concern that utilities emphasized increasing CNG profitability for retailers, rather than expanding CNG stations. Utilities, however, cited the importance of structuring deals to interest gasoline retailers in CNG, noting that a retailer could install substantial gasoline pumping capacity for an established market for only slightly more than the cost of installing CNG for a less established market. An oil company official described the company's decision to enter the CNG market as based partly on owning natural gas reserves and seeing the market for CNG vehicle use, and partly on both federal and provincial government incentives. Company officials said it took a "huge capital investment" for the company to enter the market in a substantial way, but described it as a long-range decision for additional business. A government official characterized the problem as a lack of economic incentive for oil companies to invest in a new product, compounded by the companies not seeing a need for change. An industry official pointed out that the oil companies most interested in CNG were more interested in sales volume than what fuel they sold. An energy consultant said these companies saw their investment in a group of customers rather than in a product line.

Consumers, who were encouraged to forgo the familiar gasoline-fueled vehicles for CNG or propane vehicles, had a major impact on New Zealand's program. Their willingness to convert their vehicles and use CNG or propane helped encourage the private sector to develop vehicle conversion facilities and a network of fueling stations. Industry officials indicated that mobility and vehicles are very important to New Zealand motorists.

Implementation of the Alternative Fuels Program

New Zealand's alternative fuel program evolved from the oil supply and price disruptions of the mid-1970s, when motorists faced rising gasoline prices, weekend closings of gasoline stations, and restrictions on the use of their vehicles. The government established organizations to assess New Zealand's overall energy situation and find alternative motor fuels that would use domestic natural gas resources. By the time of the second oil shock in 1979, high oil prices were taking a toll on New Zealand's economy (the cost of oil imports rose from $52 million in 1972 to $709 million by 1980). The government decided that CNG, propane, and synthetic gasoline should be developed as replacements for gasoline, and set a 1990 goal of 50 percent self-sufficiency using these fuels. The government invested more than $800 million in a plant to produce synthetic gasoline from natural gas.

At the start of the alternative fuels program in 1979, the government set goals of (1) 150,000 CNG vehicles in operation by 1985 and (2) about 50,000 propane vehicles in operation at an unspecified date. There were, however, serious obstacles to achieving these goals. As discussed above, vehicles in New Zealand were not designed to use these fuels and had to be converted, there was limited infrastructure to fuel these vehicles, and motorists' acceptance of these fuels was uncertain. A government official said that consumers initially were hesitant to spend money converting their vehicles without assurances of convenient fueling, and the fuel industry was hesitant to invest in distribution unless there was a market. To rapidly implement its program, the government concluded that incentives would be needed to encourage consumer use and develop a CNG and propane fueling infrastructure. Table III.1 shows the incentives that have been provided by government and industry.

advantage of CNG savings. These consumers generally were very satisfied, especially with money they saved on fuel purchases (see appendix IV for additional details). These consumers were less satisfied with vehicle operating characteristics such as reduced driving range and power. Although an industry official stated that over 40 percent of Canada's CNG stations are located in British Columbia and are heavily concentrated in the Vancouver area, even Vancouver consumers were more dissatisfied with the convenience of CNG fuel stations than any other aspect of using their converted vehicles. For this reason, consumers expressed interest in the CNG residential fueling appliance.

Many Canadian consumers, however, do not consider using alternative fuels and vehicles. In interviews conducted for industry, consumers cited initial conversion costs, length of time to recover conversion costs, and not enough fuel stations (for CNG) as reasons for not considering alternative fuels and vehicles. An industry consultant confirmed that many motorists and small businesses cannot afford the initial costs for conversion and fuel storage cylinders.

Consumers may also view alternative fuels and vehicles as risky if they are not satisfied that vehicle use is socially acceptable or have safety concerns. An energy consultant identified consumer concern about doing something outside accepted behavior as an important obstacle to consumers entering the market. In British Columbia, for example, a respected provincial official's support for alternative fuels made using them "respectable" for consumers, according to the consultant. A utility official emphasized that it is difficult to approach consumers who are satisfied with gasoline vehicles and propose that they switch to alternative fuels and vehicles. Officials also noted that consumers will avoid alternative fuels if they have any safety concerns. One fleet manager indicated that some fleet vehicles were de-converted because of drivers' safety concerns. After being involved in consumer research, an energy consultant concluded that it is difficult to learn why consumers will not use alternative fuels, but that many who are apprehensive about them dislike conversion because it represents "tampering" with their vehicle, and perceive vehicle conversions as behavior outside the mainstream.

Developing consumer awareness of alternative fuels remains a difficult obstacle, according to government and industry officials. Utility officials agreed, but one pointed out that local advertising and marketing increases consumer interest in conversions. Opinion differed about the extent to which fleet use could help improve general consumer awareness of

allocated over $22 million to improve CNG vehicle technology—such as fuel injection systems for conversions.

Government officials and an energy expert pointed out that it will be necessary to ensure there are consistent standards and regulations for alternative fuels and vehicles in order to assure product integrity, satisfy consumers, and allow these products to compete in the nation-wide market. Provincial governments regulate vehicle conversions and use based on standards developed by government-industry groups, but they have adopted different regulations concerning alternative fuels, according to industry officials. For example, some provinces do not allow propane vehicles to park inside public garages. An energy expert pointed out that this can be a significant deterrent to propane's use in Canada's relatively cold climate. A Canadian energy consultant pointed out that developing a consistent regulatory framework will be important to industry in expanding the market.

Other alternative fuels may have roles in Canada's future. Canada is one of the largest methanol-producers in the world, and the government has been funding methanol light- and heavy-duty vehicle demonstrations, in cooperation with industry. It also has been encouraging the use of ethanol as an octane booster blended with gasoline, and supporting research on hydrogen and electric vehicles.

Government and industry officials cited their continuing cooperation on alternative fuels initiatives as important, and has added support, resources, and stability to the program. For example, the federal government now funds only about 20 percent—while private industry funds the remainder—of alternative fuels research, in contrast to 1981, when the government provided all research funds. Officials also underscored the significance of building the consensus on alternative fuels' importance and ensuring that their program will continue to have clear objectives that can provide a stable environment for market development. They pointed out that long-term government commitment will be needed because, as an energy consultant observed, it takes a long time for industry and consumers to make the extensive, costly changes associated with moving from gasoline to alternative fuels.

Although factory-produced propane and CNG vehicles were not available in Canada, fleet managers said they preferred factory-produced vehicles over conversions. One manager described conversions as putting old technology on a new car. Another manager pointed out that negative views of converted vehicles make them difficult to resell, and that used fleet vehicles are often converted back to gasoline before resale or valued below comparable gasoline vehicles. Government and industry officials agreed that factory-produced vehicles are preferable, and that consumer awareness and confidence is increased by having manufacturers' quality controls and warranties. Some of the Vancouver consumers that we surveyed also indicated interest in factory-produced alternative-fueled vehicles.

Industry officials acknowledged that it can be difficult to make vehicle conversions attractive and acceptable to consumers. A utility official indicated that installers may lack experience to deal with the wide variation in vehicle types and technologies. In addition, it is difficult to ensure consistent quality because each conversion must be customized to meet individual consumer preferences elements such as fuel tank placement and dashboard appearance. An industry consultant also indicated that consumers may find it more difficult to keep a converted vehicle properly tuned than a gasoline vehicle.

The Future

Canadian officials agreed it is difficult to predict the future of alternative fuels because (1) the market is evolving, (2) propane and CNG face continuing challenges, and (3) environmental issues are becoming more important in considering alternative fuels and vehicles. Government officials emphasized that their experience demonstrates the need not only for direct incentives, but also for simultaneous market development, consumer research, technology development, and fuel infrastructure expansion.

Propane and CNG face common obstacles—competing against gasoline and improving technology—in becoming more viable in the market. Government and industry officials pointed out that both actual gasoline prices and the differential between gasoline and alternative fuels prices will be important. Officials emphasized that the actual level of gasoline prices will be a significant obstacle to expanding consumer interest because many consumers do not find current gasoline prices unacceptably high. This will continue to make it very difficult to attract consumers to alternative fuels.

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The CNG Program

The government took a very active role in promoting CNG as a motor fuel at the beginning of the program in 1979. The government stressed the importance of CNG to New Zealand's energy and economic security, and the Prime Minister appeared on television to promote CNG. While the financial incentives (see Table III.1 above) stimulated interest in CNG as a motor fuel, government and industry officials agreed that CNG's price, lower than gasoline, was its main selling point. The government announced that CNG should be sold at not more than 50 percent of the price of gasoline. Though it did not control CNG's price, the government could influence its price indirectly through its involvement in natural gas production and distribution, its contract to purchase natural gas, and its regulatory authority. Between 1979 and 1985, CNG prices ranged from 42 to 65 percent of gasoline prices. The government also offered grants, loans, and tax write-offs to defray some costs of vehicle conversion that ranged from about $670 to $1,230, depending on the type of vehicle.

Government incentives to business and industry were intended to stimulate rapid growth of a CNG fueling network, but there were obstacles to building this network. CNG fueling equipment and installation costs were a major obstacle for the small station owner, especially when the market for CNG was limited. The cost of installing CNG compressors, storage tanks, dispensers, and related equipment ranged from about $140,000 to $220,000. The government initially provided grants to cover 25 percent of station equipment costs and in 1981 expanded the grants to also cover installation costs. Major oil companies did little initially to develop CNG fuel stations. Despite government incentives that helped defray CNG fueling station costs and lower CNG prices, and which offered the station owners higher profit opportunities, the CNG refueling network grew slowly. Only 49 CNG stations were opened by 1981, and most were owned by independent fuel retailers.

A breakthrough in fueling infrastructure development occurred in 1981—after the incentives for fueling stations were increased—when a major oil company entered the CNG market and began to install CNG facilities at stations. Oil company officials said they decided that CNG would help maintain their market share against the other large oil companies. The company anticipated that CNG would increase its gasoline sales because many of the converted CNG vehicles were dual-fueled, and it expected motorists to fill both their gasoline and CNG tanks.

The oil company that entered the CNG market also helped solve another fuel infrastructure problem. Some fuel stations were not close to natural gas pipelines, and could not obtain CNG. The company developed a

"mother-daughter" CNG distribution system for stations not served by natural gas pipelines. At the "mother" station, natural gas from the utility gas main was compressed and dispensed into storage tubes on truck beds that were transported to outlying "daughter" stations. The CNG in the storage tubes was then pumped to the station's dispensers. Later, other oil companies entered the market. By 1986, there were about 400 public and private CNG stations located throughout the North Island.

Getting consumers to convert their vehicles to CNG also was slow—only about 32,000 conversion kits were sold between 1979 and 1982.[2] Although consumers were shown their initial conversion costs could be recovered from their savings on lower CNG prices, consumers were not convinced. By 1983, concern about the slow growth in CNG use prompted the government to (1) introduce a loan program that reduced consumers' initial costs and (2) revise its conversion goal to have 200,000 CNG vehicles on the road by 1990. The loan program enabled consumers to finance their vehicle conversion costs with no down-payment, low-interest loans. Sales of vehicle conversion kits increased to more than 20,000 in 1983 after these loans were introduced. Market research indicated that these loans were an important factor for about 75 percent of the consumers who converted their vehicles. These actions, with rising gasoline prices, helped further increase vehicle conversions to 29,500 in 1984.

Slow growth in CNG use was also related to many consumers' negative perceptions of CNG after experiences with poorly-performed vehicle conversions, according to government and industry officials. Some consumers experienced cold starting problems, excessive power loss, and repeated tune-ups with their converted vehicles. According to these officials, the government incentives attracted many unskilled, under-trained CNG equipment installers. Installations were often done on a trial-and-error basis because there were a wide range of vehicle makes, models, and ages presented for conversion. Some consumers repeatedly returned to their CNG installer seeking correction of the problems; some switched back to gasoline. Officials said the post office converted its vehicles to CNG, but later converted some of them back to gasoline. However, according to industry officials, some problems occurred because vehicles were too old or were in poor mechanical condition, and should not have been converted. They also indicated that some performance problems resulted when vehicles were not tuned to operate on the variations in gas from different natural gas fields.

[2]CNG vehicle conversions were counted by the number of conversion kit sales.

The industry initially regarded CNG promotion as a government responsibility. However, a 1984 government review of the program concluded that the private sector should become more involved in marketing CNG. The review found that public confidence in the program was weak, and that consumers and industry perceived CNG as a government program and fuel. Government and industry officials explained that the government had taken the lead in introducing CNG with incentives and strong promotional efforts. As a result of aggressive government support, consumers developed the perception of CNG as "belonging to the government." Based on the review, the government concluded it should concentrate on the problems of poor quality vehicle conversions and an uneven fueling distribution system, and offered funds to help industry produce a CNG marketing plan. The government then (in 1984) announced that all of its CNG financial incentives would end by December 31, 1987, with the expectation that industry would continue CNG marketing.

To address conversion problems, industry and government initiated a program requiring that conversion equipment installers be registered and receive more training. Government loans were restricted to consumers using registered installers. Strict quality control measures were installed, which included conversion warranties by registered installers.

A new administration with a more market-oriented economic philosophy and commitment to reduce the national deficit was elected in 1984, according to government officials. After considering the increase in CNG vehicle conversions in 1983 and 1984, the new government decided that the need for continued government financial aid should be reviewed. In June 1985, the government limited the number of conversion loans to 1,600 per month, required cash deposits, and increased the loan interest rates. Government and industry officials pointed out that the sudden changes caused consumer apprehensions about the program because the government appeared to be abandoning the fuel that it had vigorously promoted and given respectability to as a motor fuel. The impact of these changes was dramatic; monthly CNG conversion kit sales fell sharply from 5,500 in May to 240 in December 1985, according to a government document. The situation was complicated by falling oil/gasoline prices that reduced CNG's price advantage in 1986. Annual conversion kit sales fell from about 24,000 in 1985 to about 4,000 in 1986. The government also sold its interest in the synthetic gasoline plant to a major oil company.

To stem the decline in CNG fuel sales and vehicle conversions, the government gave the natural gas industry a grant of $2 million to help revive the program. According to government sources, industry used some of this grant for vehicle conversion loans and warranties. However, according to one source, high administrative costs limited the program's effectiveness. Instead of loans, the industry then offered vehicle conversion grants using matching funds from some local utilities.

Throughout most of the CNG program, the natural gas industry and utilities allowed the government to promote CNG, according to industry and government officials. Industry was slow to become involved after the government reduced its support in 1985, and falling oil prices made gasoline more attractive to consumers. The number of CNG vehicles in New Zealand peaked at about 110,000 in 1986, then dropped to about 45,000 in 1989. The CNG fueling network grew to about 400 stations in 1986, but has decreased to about 350 stations since then.[3] Although the pump price of CNG is about 60 percent of the price of gasoline, consumers have difficulty distinguishing its price advantage. According to industry and government sources, when consumers compare the prices of gasoline and CNG displayed on pumps and station advertisements, gasoline generally appears to be only marginally higher priced. This problem occurs because gasoline pumps measure price per liter while the government requires that CNG pumps measure price per kilogram.

A 1989 gas industry study concluded that if CNG use continued to decline in New Zealand, CNG would disappear as a motor fuel by 1993. Officials of a major oil company said they were likely to stop selling CNG at some stations in the near future;[4] another company was already phasing out its CNG facilities. The gas industry, however, recently initiated plans to recapture lost sales. A February 1991 market research report prepared for the industry pointed to some potential for CNG vehicles from both private and business users. The study found that when consumers converted their vehicles to CNG, they used CNG most of the time, were attracted by its price advantage, and were likely to install CNG in their next vehicle. In 1991, the gas industry began a major promotional campaign to win back consumer confidence in CNG. CNG is being marketed to fleets as a high-performing, low-priced fuel that helps the environment because of its lower emissions.

[3]Industry sources noted that some less profitable CNG stations were closed, but this has not had a serious impact on consumers refueling convenience.

[4]The company plans to continue selling propane.

The Propane Program

Government planning for the introduction of propane as a vehicle fuel began in 1979. The government was interested in developing increased propane production and a fueling infrastructure. In 1980, the government became firmly committed to propane as a vehicle fuel, particularly for the South Island. The government provided industry with a loan and a fuel price subsidy to develop elements of a large-scale distribution system. To help local fueling stations defray the approximately $28,000 to $56,000 cost of installing propane, the government provided loans and grants for 25 percent of equipment and other costs.

To encourage consumers to convert their vehicles to propane, the government offered loans and a conversion kit grant of $84 to offset the conversion cost. Although a propane conversion costs less than a CNG conversion, its pump price did not offer the incentive of CNG since propane's price was closer to gasoline.

The propane fueling infrastructure grew slowly because the supply of propane was constrained and the industry initially was not well organized to develop a national distribution system, according to government and industry officials. In addition, some communities' concerns about the safety and environmental implications of propane storage facilities slowed development. At the beginning of the program, the propane industry consisted primarily of small businesses selling propane for cooking and recreational use and small industrial purposes. Later, major oil companies with an interest in propane provided additional funding and leadership in organizing industry efforts. By 1985, however, most of the propane distribution infrastructure was in operation. The network of fuel stations selling propane also grew to approximately 600 stations.

Supported by government incentives, consumer interest in propane vehicle conversions also grew slowly as a result of the limited fueling stations and the early problems with poorly-performed conversions. According to an industry official, the poor quality of initial conversions created a negative impression of propane among consumers. Although only 3,500 conversions had been performed by July 1982, government incentives helped to increase conversions, so that 36,000 were performed between 1983 and 1985. At that time, the government reduced its incentives, and conversion kit sales plummeted from 3,800 to 525 in seven months.

After government support was reduced in 1985, the propane industry received a $2 million government grant and took an aggressive role in

marketing conversions. It started a propane marketing program and provided free conversion kits and loans to consumers expected to travel more than 15,500 miles per year. By 1991, propane sales had surpassed CNG sales.

Results

New Zealand's alternative fuels program has had mixed results, with both accomplishments and disappointments. Public acceptance of CNG and propane fuels and converted vehicles has fluctuated. The government's goal of 50,000 propane vehicles was met, but the goal of having 200,000 CNG vehicles on the road by 1990 was not attained. The program's initial achievement was to get more than 110,000 CNG vehicles on the road by 1986. However, according to government and industry officials, consumers' interest in CNG vehicles declined because of concerns about (1) quality of the early vehicle conversions, (2) government commitment to the program following its phaseout of financial incentives, and (3) less significant fuel price advantage because of decreasing gasoline prices. The number of CNG vehicles declined to about 45,000 vehicles and the number of CNG fueling stations fell to 350 (from 400) in 1991. By contrast, development of the propane fueling infrastructure and market was late in starting. As industry involvement and leadership developed, the number of propane vehicles increased to about 55,000 by 1991. Government and industry officials also indicated that the number of propane fueling stations increased to 600 and has remained relatively stable in recent years. While the CNG conversions fell far short of program goals, government evaluations pointed out that, at the peak of the program in 1986, about 10 percent of New Zealand's vehicles were converted to use CNG or propane; representing more CNG and propane vehicles per capita than any other country.

The government's goal of 50 percent self-sufficiency using domestically-produced CNG, propane, and synthetic gasoline was met, according to government and industry officials. About 35 percent of the displaced imported oil was attributed to the use of synthetic gasoline. Government and industry officials called synthetic gasoline a technological success, but considering its high production costs, they questioned whether this was the most efficient way to use natural gas as a motor fuel. CNG and propane fuels accounted for almost 15 percent of the imported oil displaced.

Government and industry officials also indicated that the program showed the success of government-industry collaboration. In this collaboration,

government provided the initial leadership and financial incentives; industry, with government assistance, provided the fuel network and vehicle conversions, and later assumed marketing responsibilities. The program also helped create new business expertise in alternative fuels—which, according to industry officials, is being marketed in other countries. It also helped stimulate the extension of the natural gas pipeline network on the North Island. Although environmental protection was not initially a program objective, government and industry officials told us that concerns about vehicle emissions and their impact on air quality have led to CNG being marketed as a clean fuel. Despite these accomplishments and recent industry marketing initiatives, there has been no indication of a significant long-term upswing in consumers' acceptance of CNG and propane vehicles.

The Future

The future success or survival of CNG and propane in New Zealand is uncertain. A surge in vehicle conversions and fuel sales during the Persian Gulf War was not sustained when the crisis disappeared. The outcome of recent natural gas industry marketing efforts is unknown, and some oil companies' continued involvement in CNG markets remains a further question. Although propane sales have been sustained by an organized propane industry, an industry official expressed concern that maintaining fuel sales and vehicle conversions may be difficult, since many of the vehicles converted in earlier years will be retired.

Survey of Consumers Using CNG Vehicles in Vancouver, British Columbia, Canada

We wanted to obtain first-hand information about consumers' experiences using alternative fuels to learn why consumers decided to convert their vehicle, what their experiences were when they drove the converted vehicle, and how satisfied they were with the conversion. The local gas utility in Vancouver, British Columbia had begun a CNG vehicle conversion program several years ago, and provided us with a list of consumers who had converted their vehicles.

Vancouver consumers who convert their vehicles to use CNG through the utility's program receive government and utility financial assistance. The utility also offers low-interest financing to reduce up-front vehicle conversion costs. Consumers pay $1,245 for a conversion through the utility, although the cost of a CNG conversion without financial assistance averages about $2,200 in Vancouver. Most consumers also lease one or more CNG storage cylinders from the utility. The cylinders can be installed in various locations such as in a car trunk or underneath a truck, depending on the vehicle type and size.

After a vehicle has been converted, consumers can use either natural gas or gasoline by flipping a switch that allows them to change from one fuel to the other. Consumers can refuel at CNG stations throughout the Vancouver metropolitan area and some locations elsewhere in the province of British Columbia.

Scope and Methodology

The survey was conducted by telephone during April and May 1991. GAO attempted to contact the 620 consumers who converted their vehicles during a 14-month period ending on September 30, 1990 (see app. V for a copy of the questionnaire used and a tabulation of the responses received). Interviews with 475 of the consumers were completed, a response rate of 77 percent. Talking with consumers who had converted vehicles during this time period allowed GAO to learn about recent experiences with CNG, and assured that consumers had at least six months' experience with their converted vehicle.

GAO developed and pretested the telephone survey questionnaire. A survey research organization performed additional pretests and conducted consumer interviews using the computer-assisted telephone interviewing technique (CATI). GAO attended interviewer training and monitored early interviews for accuracy and objectivity. The respondent for each interview was the person determined by the interviewer to be the main driver of the

converted vehicle. Interview time averaged about twenty minutes per respondent.

Profile of Consumers and Their Vehicles

Survey results indicate that Vancouver consumers who converted their vehicles to CNG were most often male and between the ages of 31 and 45. Their households generally had two or more vehicles, and two or more drivers. Almost all (96 percent) of the respondents still owned the vehicle for which GAO requested information and about 13 percent have another CNG vehicle in their household. They use their CNG vehicles mostly for driving to work or for business.

The survey respondents indicated that they use CNG much more often than gasoline in their vehicles and would be most likely to use gasoline when the vehicle was running low on CNG and when they were driving outside Vancouver—and away from most fuel stations.

About half of the survey respondents said that advertisements or government information were an important source of information in attracting them to CNG for their vehicles. Friends or family, newspaper or magazine articles, or demonstrations or exhibits were also mentioned as important information sources by at least 36 percent of the respondents.

Why Consumers Converted Their Vehicles

Almost all (92 percent) of the consumers surveyed indicated that economic considerations were a major reason for converting their vehicles. About 58 percent of the respondents also said that concern about the environment was a major reason for converting to CNG, and Canada's dependence on imported oil was mentioned by 26 percent of the respondents as a major reason for their conversion decisions. However, over half the respondents said it was not very likely that they would have converted their vehicles if the price of CNG and gasoline were about the same.

Experience Using CNG Vehicles

Almost all respondents (96 percent) said they were satisfied with their CNG vehicle, including 63 percent who said they were very satisfied. The major factors contributing to their satisfaction were saving on fuel costs, safety of the CNG vehicle, and the level of maintenance needed. In their comments, some respondents mentioned that their CNG needed less maintenance and less frequent oil changes. Four out of five respondents said they would be very likely to convert their next vehicle.

Survey respondents were least satisfied with the convenience of fuel stations—33 percent were generally or very dissatisfied. The distance they could drive without having to refuel, the space required for the CNG tanks, engine performance when extra power was needed, and the time it takes to refuel also caused some dissatisfaction among the respondents.

Some comments from the survey respondents help to illustrate their experiences.

- It's saving us lots of money. Wish everybody was on it for the environment's sake. [I'm] more pleased than I thought I would be. Initially I thought the payback [for the cost of conversion] would be a year, but it's about six months.
- It's not often you run into a product that is this cheap and so good for the environment. I find that very satisfying. [It] increase[s] the life of the engine; the oil stays cleaner.
- The only downfall is traveling to "The States" and having to use regular gasoline. Generally, it has saved probably thousands of dollars on fuel costs. Would do it to other vehicles if it were more convenient.
- I feel the life of the engine is doubled and [it's] easy on the environment. The savings of driving a big car is equal to operating a small [one].

GAO Survey of British Columbia Natural Gas Consumers

U.S. General Accounting Office

GAO Survey of British Columbia Natural Gas Consumers

March 1, 1991

Before interview begins, fill out the following information:

1. When did consumer convert vehicle?

Month: _____

Year: _____

2. What kind of vehicle did consumer convert?

_____ 1950-1991
Make of vehicle Year

Median model year was 1986

INTRODUCTION

Hello, my name is _____ from the General Accounting Office in the United States. I'm calling about a study we are conducting on natural gas vehicles for the U.S. Congress. May I speak to _____ ?

I'm calling to ask you about participating in a telephone survey. British Columbia (BC) Gas gave us your name on a list of consumers who had vehicles converted for natural gas fuel. We will be issuing a report to the U.S. Congress on alternative fuels and vehicles to help them decide what direction the U.S. should be taking in this area. We would especially like to talk to you because you are one of the many people in Vancouver who have experience using natural gas for your vehicle.

Before I ask you about participating in our survey, I need to check our information on your vehicle. The BC Gas records show that you had your [YEAR] [MAKE] converted in [MONTH AND YEAR OF CONVERSION]. Is that correct?

1. [ ] Yes

2. [ ] No --> a. ***Enter proper information:***

Year of conversion: _____

Year of vehicle/make: _____ _____
(year) (model)

3. Are you the main driver of the vehicle?

1. [ ] Yes

2. [ ] No --> a. Is someone else the main driver of the car, or do you share it with other people in your household?

1. [ ] Someone else--> I'd like to talk to ***[Main driver]*** about our telephone survey. Is [she/he] at home?
[Go to beginning of interview and start over with main driver]

2. [ ] Share

3. [ ] Other

4. I would like to interview you for our survey, and it will take about 20 minutes. Is now a good time to talk?

[If not a good time, make appointment with R for later]

TELEPHONE SURVEY RESULTS

We entered the percent of consumers who responded to the telephone survey questions. If less than 95 percent of the 475 consumers who completed interviews responded to a specific question, we also entered the number of consumers who responded. For example, if 300 responded to a specific question, we entered n=300.

[Start here for call backs:]

I'm calling from the U.S. General Accounting Office in the United States about our survey on your vehicle that uses natural gas. Our interview will take about 20 minutes. Are you ready?]

I'd like to start by saying that this interview is voluntary. If there's any question that you don't want to answer, just tell me and we'll go on to the next question. OK?

5. I'd like for you to think back to the time you first found out about natural gas as an alternative fuel. I'm interested in what first attracted your attention to natural gas as an option for your vehicle. As I read a list of ways that people first hear about natural gas, please tell me whether or not each source of information was important for you.

The first way is ... [READ FIRST ITEM] Was that an important source of information for you when you first found out about natural gas as a vehicle fuel?

The next way is ... [READ NEXT ITEM] Was that an important source of information for you when you first found out about natural gas as a vehicle fuel?

	Yes (1)	No (2)	*[If volunteered:]* Can't remember (3)
a. Advertisements	47	53	
b. Newspaper or magazine articles	36	64	
c. A friend or family member	41	59	
d. Government information	55	45	
e. A demonstration or exhibit	36	64	

6. Now I'd like to ask about the reasons you decided to convert your [YEAR] [MAKE] to natural gas. I'm going to read a list of reasons and ask you how important each one was in making your decision. As I read each reason, please tell me whether it was a major reason, a minor reason, or not a reason for converting your vehicle to natural gas fuel.

The first one is ... [READ FIRST REASON]. Would you say that was a major reason, a minor reason, or not a reason for converting your vehicle?

The next one is ... [READ NEXT REASON]. [AS NECESSARY:] Would you say that was a major reason, a minor reason, or not a reason for converting your vehicle?

	Major reason (1)	Minor reason (2)	Not a reason (3)
a. I wanted to save money on fuel	92	7	*
b. I was concerned about gasoline's affect on the environment	58	34	8
c. I wanted to help decrease Canada's dependence on foreign oil	26	42	31
d. The cost of converting the car was attractive	42	35	23
e. I planned to drive this vehicle a lot	89	7	3

* = Less than one percent

7. I realize this next question may be difficult to answer because it asks you to second guess your decision on converting to natural gas. Assume for a minute that the price of natural gas and gasoline were about the same. Then think about whether you still would have converted your vehicle to natural gas. How likely is it that you still would decide to convert if the price of natural gas and gasoline were the same? Would you say... very likely, somewhat likely, not very likely, or can't you say?

Percent

1. [26] Very likely

2. [21] Somewhat likely

3. [53] Not very likely

4. [ ] Can't say

8. Besides your [YEAR] [MAKE] are there any other natural gas vehicles in your household?

1. [ ] Yes --> a. How many are there altogether?

13 percent had more than one vehicle
_____ natural gas vehicles

2. [ ] No ---> *[Write in "1" for question 8A]*

9. *[If more than one natural gas vehicle in household:]* Please answer these next questions about first vehicle I talked about, your [YEAR] [MAKE].)

Which of the following best describes your [YEAR] [MAKE]? Is it a car, van, truck, or something else?

	Percent
1. [33] Car	
2. [36] Truck	
3. [29] Van	
4. [2] Other--> (Specify)	

10. Can you tell me if the engine is four, six, or eight cylinders?

	Percent
1. [13] Four	
2. [26] Six	
3. [60] Eight	
4. [*] Other --> (Specify)	
5. [ ] Don't know/Can't say	

* = Less than one percent

11. Do you still own this vehicle? [AS NECESSARY: That is, is your household still using it?]

	Percent
1. [96] Yes --> *Skip to 12*	
2. [4] No --> a. In what month and year did you sell it?	

_____ _____
Month Year

12. How many tanks for natural gas fuel does your vehicle have?

_____ tanks

Number	Percent
1	21
2	65
3-5	14

13. Now I'd like to ask some questions about your patterns of using your vehicle, regardless of whether you are using natural gas or gasoline. Please think for a minute about different reasons that you use your vehicle. I'd like to read a list and ask you for each one whether it is a major reason, a minor reason, or not a reason for the driving you do with your natural gas vehicle. The first one is ...[READ FIRST ITEM]. Would you say that is a major reason, a minor reason, or not a reason for driving this vehicle?

The next one is ...[READ NEXT ITEM]. Would you say that is a major reason, a minor reason, or not a reason for driving this vehicle?

	Major reason (1)	Minor reason (2)	Not a reason (3)
a. Driving to work	78	8	14
b. Running household errands such as shopping or taking children to school	37	41	22
c. Driving outside the city of Vancouver	47	35	18
d. Using the vehicle for commercial purposes for a business you own or work for	53	8	39

[If R says "Major" or "Minor" to part (d), ask:] What percent of the time do you use the car for commercial use?

_____ percent

Percent of time vehicle used commercially	Percent (n=285)
50 percent or less	25
51-75 percent	11
76-90 percent	29
91-100 percent	35

We understand that your vehicle can use both gasoline and natural gas. [PAUSE TO LET RESPONDENT AFFIRM.] Please think for a minute about how often you use natural gas versus gasoline for your vehicle. Generally speaking, about what percent of the time would you say you use the natural gas fuel for this vehicle?

____ percent

Percent of time CNG used	Percent
Less than 50 percent	2
50-74 percent	3
75-94 percent	39
95-100 percent	56

IF 100 percent, skip next question.

14. I'd like to ask you about several conditions under which you might use gasoline rather than natural gas when driving your vehicle. I'll read a list of conditions to you. As I read each condition, please tell me whether it would be a major reason, a minor reason, or not a reason for the times that you would switch to gasoline in driving this vehicle. The first condition is [READ FIRST ITEM]. Would you say that is a major reason, a minor reason, or not a reason for the gasoline driving that you do?

The next condition is [READ NEXT ITEM]. Would you say that is a major reason, a minor reason, or not a reason for the gasoline driving that you do?

	Major reason (1)	Minor reason (2)	Not a reason (3)
a. Starting the vehicle in cold weather (n=434)	23	26	51
b. Driving up a long, steep hill (n=442)	18	32	50
c. Driving outside Vancouver (n=435)	39	31	30
d. Running low or running out of natural gas fuel (n=442)	78	15	8
e. Running gasoline though the fuel system every now and then (n=440)	39	40	21

15. Next we'd like to ask about your satisfaction with several aspects of your natural gas vehicle. As I read each item concerning your vehicle, I'll ask you how satisfied or dissatisfied you are.

The first item is [READ FIRST ITEM]. Would you say you are... very satisfied, generally satisfied, generally dissatisfied, very dissatisfied, or would you say you are uncertain?

The next item is [READ NEXT ITEM]. [AS NECESSARY:] Would you say you are very satisfied, generally satisfied, generally dissatisfied, very dissatisfied, or would you say you are uncertain?

	Very satisfied (1)	Generally satisfied (2)	Generally dissatified (3)	Very dissatisfied (4)	Uncertain (5)
a. Maintenance needed for your vehicle	62	30	3	2	3
b. The performance of your engine on natural gas when you need extra power	25	58	12	4	2
c. Convenience of fuel stations when you need natural gas in Vancouver	24	40	22	11	2
d. The time it takes to fill up on natural gas	34	53	10	2	1
e. The amount you save on fuel costs	91	8	*	*	*
f. The distance you can drive without having to refuel with natural gas	22	50	23	4	2
g. Space required in your vehicle for the natural gas tanks	32	49	14	4	2
h. The safety of your vehicle	71	27	*	*	2

* = Less than one percent

16. Overall, how satisfied or dissatisfied are you with your natural gas vehicle. Are you very satisfied, generally satisfied, generally dissatisfied, very dissatisfied, or would you say you are uncertain?

	Percent
1. [63] Very satisfied	
2. [33] Generally satisfied	
3. [*] Uncertain	
4. [2] Generally dissatisfied	
5. [2] Very dissatisfied	
6. [ ] *[If volunteered:]* Don't know/Can't say	

--> a. Could you tell me more about that?

* = Less than one percent

17. We want to ask you how likely you'd be to convert the next vehicle you buy to natural gas. Would you say ... very likely, somewhat likely, not very likely, or can't you say?

	Percent (n=418)
1. [80] Very likely	
2. [12] Somewhat likely	
3. [8] Not very likely	
4. [*] Can't say	

* = Less than one percent

18. I just have a few more questions about you and your household. First, we need information about the age and gender of the BC customers. What is the date of your birth? [AS NECESSARY: I need the month, day, and year.]

____/____/____
Month Day Year

Age of customer	Percent
Less than 30	12
30-45	49
46-60	27
Over 60	11

19. And, are you male or female?

	Percent
1. [89] Male	
2. [11] Female	
3. [ ] Refused to say	

20. What is the total number of vehicles in your household presently, including your natural gas vehicle?

____ vehicles

Number of vehicles	Percent
1	17
2	50
More than 2	33

21. Finally, including yourself, how many drivers are there in your household?

_____ drivers

Number of drivers	Percent
1	17
2	62
3-6	21

22. That's all the questions I have for this interview. Thank you very much for your help with our survey. Do you have any additional comments that you'd like to make?

Organizations and Companies Contacted by GAO

The companies, associations, government agencies, consultants, and other organizations that GAO contacted for information in performing this study are shown below.

Academic and Research Organizations

Canada	Canada Energy Research Institute
New Zealand	University of Auckland Department of Scientific and Industrial Research
United States	Johns Hopkins University, School of Advanced International Studies World Resources Institute

Auto/Truck Industry

Brazil	Associacao Nacional dos Fabricantes de Veiculos Automotores (National Association of Automobile Manufacturers) Itacolomy de Automoveis, Ltda. (Auto Dealership) General Motors do Brasil, Ltda.
United States	Ford Motor Company Detroit Diesel Corporation General Motors Corporation Volkswagen of America, Inc.

Consumer Organizations

Canada	British Columbia Automobile Association
New Zealand	Automobile Association (Auckland)
United States	Automobile Club of Southern California

Energy Experts

Canada	Patrick Brown, British Columbia Research
New Zealand	John Stephenson, University of Auckland
United States	E. Eugene Ecklund, Executive Director, Alternative Transportation Fuels Foundation Daniel Sperling - Director, Institute of Transportation Studies, University of California, Davis Harry Kopp, L.A. Motley and Company (former Deputy Chief of U.S. Mission to Brazil) Dr. Carlos Alberto Primo Braga, Center of Brazilian Studies, Johns Hopkins University, School of Advanced International Studies Sergio C. Trindade, President, SET International, Ltd.

Fleet Operators

Brazil	Cooperativa Mista de Motoristas Autonomos de Taxis Especiais de Sao Paulo

Canada	British Columbia Automobile Association British Columbia Hydro British Columbia Telephone Ministry of Defense Province of British Columbia, Fleet Management
New Zealand	Auckland Cooperative Taxi Society Auckland Regional Council, Bus Transport

Government Agencies

Brazil	Companhia de Technologia de Saneamento Ambiental, Sao Paulo Ministry of Infrastructure, Energy Secretariat Secretariat of Regional Development, Sugar and Alcohol Project Office of the President, Secretariat of Science and Technology
Canada	Ministry of Agriculture Ministry of Energy, Mines, and Resources Ministry of Environment Ministry of Environment, Province of British Columbia
New Zealand	Ministry of Commerce
United States	California Air Resources Board California Energy Commission South Coast Air Quality Management District (California) U.S. Department of Energy U.S. Department of State U.S. Embassy, Brasilia, Brazil U.S. Consulates, Rio de Janeiro and Sao Paulo, Brazil U.S. Embassy, Ottawa, Canada U.S. Consulate, Vancouver, British Columbia, Canada U.S. Embassy, Wellington, New Zealand U.S. Consulate, Auckland, New Zealand

Industry Consultants

New Zealand	Liquid Fuels Management Group
United States	Acurex Corporation (California)

Fuel Industry

Brazil	Esso Brasilera de Petroleo, S.A. Petrobras, Petroleo Brasileiro, S.A. Shell Brasil, S.A.
Canada	British Columbia Gas Consumers Gas Premier Pacific Natural Gas, Inc. Shell Canada Products, Ltd.
New Zealand	Auckland Gas Company (Utility) Gas Development Center Liqui-Gas Natural Gas Corporation BP Oil New Zealand Limited (British Petroleum) Caltex Shell Oil
United States	Amoco ARCO Products Company

Trade Associations

Brazil	Cooperativa de Produtores de Cana, Acucar e Alcool Sociedade dos Produtores de Acucar e de Alcool

Canada	Canadian Gas Association Canadian Oxygenated Fuels Association Propane Gas Association
New Zealand	Liquefied Petroleum Gas Association
United States	American Gas Association American Methanol Institute Electric Vehicle Development Corporation LP Gas-Clean Fuels Coalition Motor Vehicle Manufactures Association National Association of Fleet Administrators National Automobile Dealers Association National Propane Gas Association Natural Gas Vehicle Coalition Petroleum Marketers Association of America Renewable Fuels Association Service Station Dealers of America

Vehicle Converters

Canada	Alternate Fuels Conversions Cap Tex Service Centre
New Zealand	Morrison Alternative Fuel Systems Transport Fuel Systems

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