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Alternative fuel vehicles today and their impacts in the Transportation industry

By Abdul M. Miraz
Student No. 019025766

Bachelor of Science in Civil Engineering, West Virginia University Institute of Technology, Montgomery, West Virginia, U.S.A. 1995

Submitted to the Civil Engineering Department for course work CV 8001: Civil Engineering Project in Partial Fulfillment of the Requirements for the Degree of

Master of Engineering in Civil Engineering

at

Ryerson University, Toronto, ON, Canada

April 2004

Signature of student.....
Abdul M. Miraz
Dept. of Civil Eng., M. Eng. Student

Accepted by.....
Dr. Said M. Easa, Chairman & Professor
Department of Civil Engineering
Project Advisor

Accepted by.....
Dr. Ziad Saghir, Professor
Dept. of Mechanical and Industrial Eng.

Accepted by.....
Dr. Mohamed Lachemi, Canada Research Chair in Sustainable Construction, Associate Professor & Graduate Program Director

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Abstract

Canadians are concerned about their environment around them, global warming and also related issues regarding this aspect. But on the other hand many don't realize that the cars and trucks that they drive are a major source of these problems, and that there are alternative choices of transportation that they can make out there.

Majority of us drive or ride in vehicles that are powered by petroleum based fossil fuels i.e. gasoline or diesel. But some people, however, are choosing to drive vehicles that run on smaller amounts of fuel, and/or partially or completely on fuels other than diesel or gasoline. These types of advanced and alternative fuel vehicles (AFVs) help reduce our dependence on foreign oil imports, save us money on fuel costs, and improve our air quality.

Alternative fuels nowadays have received some attention as a potential option to curtail the carbon dioxide emissions from vehicles. My project report discusses the feasibility and desirability of the use of alternative fuels as a strategy to mitigate automotive carbon dioxide emissions. For example what types of impact are we to expect in the transportation industry due to alternative fuel vehicles and are they economically feasible to consumers? And what type of long-term benefits do they offer? And if a person is willing to know more about these alternative fuel vehicles that are out in the market, where should they go for more information? It is a type of a summary of all the aspects about alternative fuel vehicles and their pros and cons.

Project Advisor: *Dr. Said M. Easa, Chairman & Professor of Civil Engineering*

Acknowledgements

This project is the final step in my protracted and meandering journey through the Graduate program. It has been a tremendous experience for me, educationally and otherwise, and I have a number of people to thank for that.

I would lo like to thank my father Dr. Md. Mirazuddin Mondal, who is a professor of Mathematics at East-West University in Dhaka, Bangladesh who encouraged me for this Graduate degree and always gave me encouragement to keep on going and to never give up. My Master's program would have never been accomplished without his encouragement.

My graduate program would have never been completed without the supportive and understanding attitude of my program supervisor, Dr. Said M. Easa, Dr. Ziad Saghir and not to mention Dr. Mohamed Lachemi, for which I am very grateful. I appreciate their understanding for realizing the difficulty for a part-time student while having a full-time job.

I feel particularly fortunate in having completed a significant portion of my graduate program with the first batch here at Ryerson University Class of '2001 – the times spent with them were marvelously stimulating for me, intellectually and socially. I also have to mention Ms. Leah Stanwyck, for always responding to my requests promptly in a very professional fashion.

The process of completing this program has also given me the opportunity to get a first-hand and eye-opening glimpse into the nightmarish and surrealistic fashion in which a project is completed in the real world.

I would also like to express my appreciation and gratitude to my wife for her constant love, encouragement, and support. And in the end I would like to thank my General Manager at work for always being cooperative in letting me leave work early, due to my classes or reasons related to my graduate studies.

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1. Introduction

Here in Canada air pollution continues to be one of its priority environmental and health challenges. The federal, provincial and local governments, in cooperation with the industry, have taken measures in the past few decades to reduce pollution and improve air quality. But on the other hand at the same time, improvements in technology have permitted reductions in the emissions of air pollutants entering the environment. Therefore, as a result, emissions of some particular air pollutants in Canada have gone down over the past few decades. However, there are still some problem areas that remain, with some regions not meeting Canada's air quality objectives for all pollutants. For the benefit of all Canadians not only we should take action to correct these areas of problem, we should also make sure that the improvements that have been achieved are maintained.

Major impacts to the environment and to human health, including the effects of fine particulates (PM_{10}), ground-level ozone, and toxic substances are due to the use of vehicles. The use of vehicles significantly contribute to the emissions of carbon dioxide, and thus to climate change. In addition, the Canadian population is growing and the number of vehicle-kilometres driven is also increasing.

My project report will focus on the impacts of vehicle emissions on the air quality here in Canada, and it proposes recommendations that will result in near and long term improved air quality.

For Canadians the greatest concerns are for air pollutants from vehicles use, which are nitrogen oxides, volatile organic compounds (VOCs), air toxins such as benzene, and fine particulates. Just as an example, nitrogen oxides and VOCs released from vehicles are the principle agents causing smog (ground-level ozone), and they also form secondary fine particulate aerosols. These pollutants are recognized as contributors to human health impairments such as respiratory disease. Benzene, which is a substance that is present in gasoline, is a proven carcinogen; fine particulates, which are extremely fine particles of solid matter, can be inhaled and have been shown to contribute to premature death. On top of that pollutants present in the atmosphere can lead to damage to agricultural crops, degradation of forests, soil and water ecosystems, and can also reduce eye-sight. In certain regions of Canada a higher levels of some of these pollutants are present. For example, ground level ozone tends to be in higher concentrations in the Lower Fraser Valley, the Windsor-Quebec City corridor and the Saint John area. However, from time to time, almost all the regions in Canada do experience higher levels of ozone.

Under certain climatic conditions almost more than half of the ground-level ozone and its precursors flow from the United States of America into South-Western Ontario and the Atlantic Canada. The majority of this trans-boundary pollution originates from vehicles from the United States of America. Thus, there are

opportunities for Canada to demonstrate leadership and to encourage actions by the U.S. with respect to emissions from these vehicles.

Other pollutants such as toxic substances, particulates, and greenhouse gases are of concern in all regions of Canada. In order to reduce these pollutants, and for it to be most effective, it requires the coordinated efforts of both the federal and provincial/territorial governments.

Therefore the need is evident that Alternative fuel vehicle seems to be the only solution to our problem. In this project report I will also discuss what types of impact are we to expect in the transportation industry due to AFVs and are they economically feasible to consumers? And what type of long-term benefits do they offer? And if a person is willing to know more about these alternative fuel vehicles that are out in the market, where should they go for more information? It will be a type of a summary of all the aspects about Alternative fuel vehicles and their pros and cons.

We all know that this is a limited world with limited resources. So for researchers and scientists it is their duty to come up with ideas and technologies that will utilize the natural resources that we have in their maximum potential. We all know that in conventional vehicles we use petroleum and diesel in the majority of our vehicles in the roads today. But aren't there other types of fuels out there? I personally wasn't very much aware about this whole area of subject (Alternative fuels) that is so important for us to know as consumers. Completing my project I am amazed to know the environmental benefits that it has on our overly polluted cities.

Me being a supporter of alternative fuel vehicles I will tell consumers **why one should consider AFVs**. The reason being most alternative fuel vehicles produce less pollution than petroleum vehicles, tax credits and financial incentives help lower the cost of alternative fuel vehicles, the prices of alternative fuels are more stable and they are often lower than petroleum fuels. And the thing that is most important is that the use of alternative fuels reduces our dependence on imported foreign oil.

1.1 Project Summary

In my project I will be going in detail about the following subjects: The various types of emissions; various alternatives to the solution of the problem; alternative fueled vehicles and the new technologies; and alternative fuels and issues regarding their - availability, environmental performance, safety, vehicle performance, refueling sites, conversion, and also the technology development.

An average vehicle (car or light truck) on the road today emits more than 600 lbs of air pollution each year.[17] These pollutants (such as CO, SOx, NOx, and particulate matter) contribute to smog and to many health problems. For example, smog can cause eye and respiratory tract irritation, and CO can inhibit the ability of a person's blood to carry oxygen to vital organs. An average vehicle, through its combustion of fossil fuels, also emits greenhouse gases. Greenhouse gases—such as CO_2, CH_4, Nitrous Oxide, hydrocarbons, and chlorofluorocarbons—surround the Earth's atmosphere like a clear thermal blanket, allowing the sun's warming rays in and trapping the heat close to the Earth's surface. This natural greenhouse effect keeps the average surface temperature at around 33°C.[17] Canadian GHG emissions are also relatively high on a per-capita basis, among industrialized countries; Canada was ranked fourth in GHG emissions per capita after Luxembourg, Australia and the United States in 1996, and transportation has played a large role in this increase.[14]

Therefore the need is evident and alternative fuel vehicle seems to be a big part of the solution to our problem. In my project report I will discuss what types of impact are we to expect in the transportation industry due to AFVs and are they economically feasible to consumers? And what type of long-term benefits do they offer? And if a person is willing to know more about these alternative fuel vehicles that are out in the market, where should they go for more information? It will be a type of a summary of all the aspects about alternative fuel vehicles and their pros and cons.

Therefore the basic goal of my project is to analyze the problem stated above and reaching at a natural conclusion that by reducing vehicle emissions, AFVs and advanced vehicle technologies help combat both air pollution and global climate change. My project report will also conclude with a survey done among the general public here in Toronto, Ontario. The survey was done using the telephone and also in person handing out the questionnaire in the appendix from my work place. Some of the candidates were also my neighbors. The purpose of my survey was to gauge Torontonian public awareness of the state of alternative fuel vehicles development and also to find out about their environmental consciousness.

2. What is the Need for an Alternative Source of Power?

Internal combustion engine has powered vehicles for over 100 years. As an example in the United States, internal combustion engines power 98% of all new vehicles sold.[17] Moreover, most consumers are quite satisfied with the both the cost and performance characteristics of the internal combustion engine. So, the first question that needs to be addressed is why should an alternative power source be developed?

The ***first*** reason an alternative power source is the inefficiency of the current power source. The internal combustion engine, though it continues to improve its fuel economy, is only 19% efficient.[17]

The ***second*** reason for an alternative power source is the impact on the environment. Energy use is the largest source of greenhouse gas emissions, accounting for approximately 86% of total emissions.[17] With only 5% of the global population, the United States emitted 25% of the global CO_2 emissions. In 1999, global emissions of CO_2 from fossil fuels were 6.1 billion metric tons.[11] Globally, and in the United States, about 1/3 of the total CO_2 emissions came from the combustion of coal, while nearly 45% comes from petroleum. CO_2 emissions in the United States are expected to increase by approximately 2% per year through 2010.[11] These emissions have a significant impact on the health of the world's population. There are over 113 million in the United States and over one billion people worldwide that suffer from severe air pollution. According to the World Bank, over 700,000 deaths result annually. [11] Many of the emissions are thought or known to cause cancer in humans. The Environmental Protection Agency estimates that vehicle emissions pose *"the greatest potential threat to public health in the largest number of urban areas"*. [6]

The ***third*** reason for development of an alternative power source is the reliance on foreign oil. Though fuel economy has significantly improved, the United States total demand for foreign oil has increased and its share of imported oil is up from 36% in 1975 to more than 50% today.[6] America's reliance on foreign oil could be cut in half if the U.S. Department of Energy reaches its goal of hydrogen energy providing 10% of total energy consumption by 2025.[6] Given the tragic events of September 11, 2001, the availability of domestic energy sources are even more important today.

The ***fourth*** reason for the development of an alternative power source is the limit on our planet's resources. Over 380 Quads (equivalent of approximately 10 barrels of oil for every person on the planet) of energy are used everyday. Thus, with no change in usage, the current supply of oil is estimated to last approximately 100 years.[6] However, it is reasonable to expect an exponential increase in the demand for energy as the total population grows and as developing countries increase their per capita energy demands. Energy use is dominated by the United States, Canada and the other developed world countries. The United States uses 97 Quads per year, which is roughly equal to China, Russia, Japan and Germany combined.[6] Thus, it is reasonable to expect that the demand for energy in the developing countries will grow in step with the growth in their economies.

2.1 Emissions in the Transportation Sector

A significant contributor of greenhouse gas (GHG) emissions in Canada continues to be the transportation sector. It is estimated that in the year 1997 transportation related emissions accounted for twenty-seven percent of all GHG emissions in Canada.[4] Importantly, passenger car approx. twenty-seven percent and passenger light truck approx. seventeen percent emissions combined represent over forty-four percent of transportation sector GHG emissions. The most recent information in Alberta available (1996) indicates that the transportation sector accounted for fourteen percent of the total GHG emissions in the province, and that thirty-five percent of transportation sector emissions resulted from passenger cars and light trucks.[4]

Canadian GHG emissions are also relatively high on a per-capita basis. As Figure-2 shows, among industrialized countries, Canada was ranked fourth in GHG emissions per capita after Luxembourg, Australia and the United States in 1996.[14]

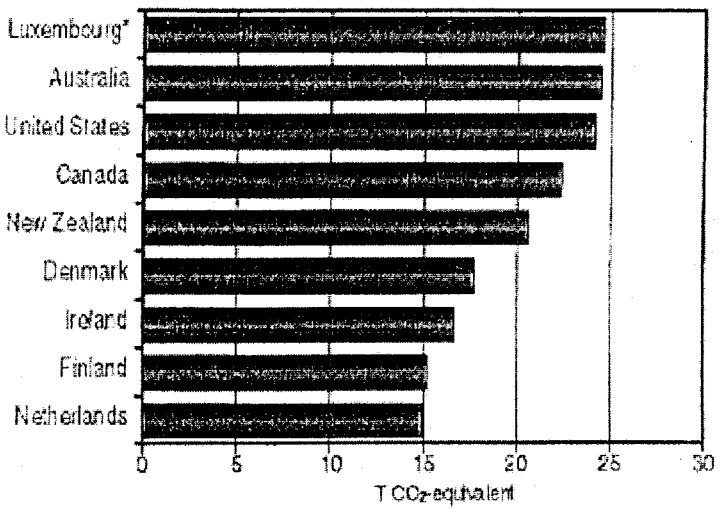

Figure 2: *Highest Per Capita GHG Emissions Among Industrialized Countries (1996 – Canada 4th); * 1995 data*
Source: Key World Energy Statistics 99. International Energy Agency

It is quite scary to know that today the global car park – or total number of vehicles in the world- exceeds 750 million vehicles: however this represents only 12% of the people in the world. With no change in vehicle penetration, there would be over one billion vehicles on the road by 2050.[6] In either case, if we continue to rely on the internal combustion engine, the world's dependence on oil will increase dramatically and therefore contribute to the emissions in the transportation sector.

2.2 Emissions by Passenger Vehicles

All over the country in majority of the cities, the personal automobile is the single greatest polluter, as emissions from millions of vehicles on the road add up. Driving a private car is probably a typical citizen's most "polluting" daily activity. The average distance traveled in Canada annually per vehicle has been increasing. It had risen to 18,000 km in 1996 from 17,000 km in 1990.[1] This trend, of increased mobility, is projected to continue. In Canada the passenger vehicle population continues to grow. Over the period 1990-1996 the number of passenger vehicles (gasoline and diesel automobiles and light trucks) in Canada increased from 14.7 million to 15.5 million.[1] In the 1990s, North American sales of light-duty gasoline trucks, vans, and four-wheel drive vehicles have been increasing at a much faster rate than automobile sales. In Canada over the period 1990-1996 the population of passenger light trucks increased by twenty-four percent, while the number of cars being driven declined.[1] The net effect has been an increase in total fuel consumption.

Although some degree of regional variability does occur in regard to passenger vehicle emissions, particular trends continue to manifest across Canada. But the net result of these trends is continuing growth in passenger vehicle GHG emissions.

Sources of Auto Emissions: The power to move a car comes from burning fuel in an engine. Pollution from cars comes from by-products of this combustion process (exhaust) and from evaporation of the fuel itself, shown in the figure below (Figure 2.2).

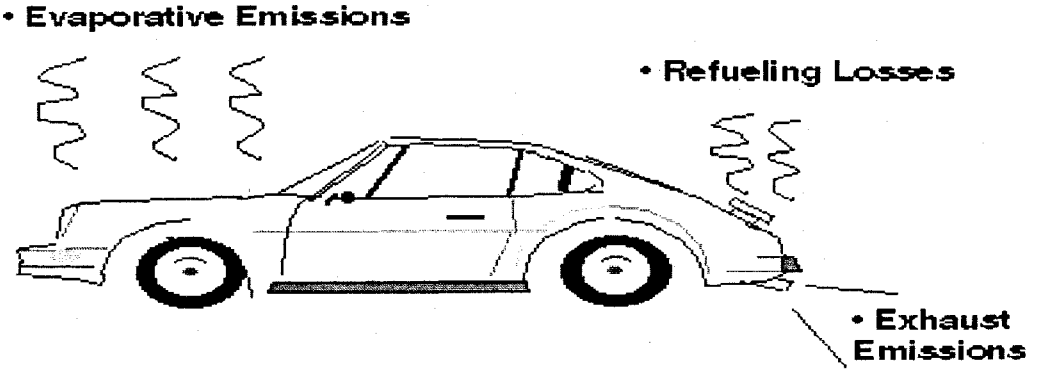

Figure 2.2: Vehicle showing source of emissions

Emissions from passenger vehicles could be reduced in two different ways: *First,* the way in which we engage in transportation activities, and *second,* to change the very nature of transportation. The first strategy involves behavior modification, whereby individuals alter their transportation habits and partake in less GHG intensive transportation choices and practices and the second strategy involves both incremental and extensive changes to vehicles and transportation infrastructure, and the development of new technology to be implemented over the short, medium, and longer-terms.

3. Current Vehicle Engineering and Design Changes

Internal combustion engines in passenger vehicles convert the heat released by the combustion of fuel into mechanical energy to drive the wheels. Because there is limitations in the engine design, friction and heat loss reduce the overall efficiency. Due to this, several strategies are under development to improve the efficiency of internal combustion engines. And it is done by using design features that minimize engine size, by incorporating design features that minimize throttling losses and friction, improving engine efficiency, by reducing the heat loss to the coolant, by running the engine at the lowest speed at which the required power can be generated, by reducing engine friction and parasitic losses (efficiency losses to accessories such as air conditioning), by increasing combustion speed, to improve the combustion process and increase efficiency, by recapturing and using exhaust heat energy, and also by increasing the compression and/or expansion ratios of the engine to improve efficiency

3.1 Vehicle Weight Reduction and Drag Reduction

Fuel economy can also be increased through vehicle weight reduction and drag reduction. Weight reduction measures generally involve the use of alternative materials in the design of the vehicle and its components, which includes minimizing engine size. And measures to reduce drag include designing more aerodynamic vehicles and minimizing friction between vehicles and the road surface. One can achieve reducing weight and drag by doing the following: by using lightweight engine components, by using lower rolling-resistance tires, by using aluminum bodies, by the improvement of the aerodynamics of passenger vehicle design, by reducing the brake drag, by using high-strength steel bodies, by incorporating vehicle design changes and by substituting other materials.

3.2 Progressive Vehicle Technologies

The U.S. Government formed a partnership, in Sept' 93, The Partnership for a New Generation of Vehicles (PNGV), with Chrysler Corporation, Ford Motor Company, and General Motors Corporation, to initiate development of vehicles that would achieve three times the fuel efficiency of conventional ones. By January 1998 the technology selection process was completed, identifying four key areas for further research that would enable the goal of the partnership to be achieved: (1) Hybrid-electric vehicle, (2) Direct-injection engines, (3) Fuel cell technology; and (4) Lightweight materials.

3.2.1 Hybrid-Electric Vehicle

The Hybrid propulsion systems have two power sources onboard a vehicle. The *first* power source may be a combustion engine, fuel cell, or gas turbine, which convert fuel into usable energy. The *second* power source is an electric motor that lowers the demand placed on the first power source. Depending on the situation, either or both of the power sources may be in operation. For example, under city driving conditions the electric motor may be sufficient to propel the vehicle, while the combustion engine would operate on the highway, and if a steep incline was encountered both power sources may operate in tandem. And the end result is superior fuel economy. The hybrid technology has another very important advantage, which is the energy normally lost during braking can be captured and used to regenerate the electric motor onboard.

Therefore, Hybrid electric vehicles (HEVs) combine the internal combustion engine of a conventional vehicle with the battery and electric motor of an electric vehicle, resulting in twice the fuel economy of conventional vehicles. This combination offers the extended range and rapid refueling that consumers expect from a conventional vehicle, with a significant portion of the energy and environmental benefits of an electric vehicle. The practical benefits of HEVs include improved fuel economy and lower emissions compared to conventional vehicles.

The Hybrid power systems were conceived as a way to compensate for the shortfall in battery technology. Because batteries could supply only enough energy for short trips, an onboard generator, powered by an internal combustion engine, could be installed and used for longer trips. We thought in the old days that by biasing the system toward battery-electric power and operating on wall-plug electricity as much as possible, efficiency and emissions would then be about as optimal as we could hope for until better batteries came along. Therefore the natural conclusion of this concept was that, with better batteries, we probably would not need hybrids at all. But after 20 years of study, it seems that hybrids are taking center stage and electric vehicles are only being used in niche market applications where fewer miles are traveled. Hybrids will never be true zero-emission vehicles, but the first hybrids on the market will cut emissions of global-warming pollutants by a third to a half, and later models may cut emissions by even more.[9]

Hybrid-Electric Advantages: Hybrid vehicles have a lot more advantages than regular gasoline powered vehicles. Just as an example, its regenerating braking capability helps minimize the loss of energy and it recovers the energy used to slow down or stop a vehicle. Its engines can be sized to accommodate average load, not peak load, which reduces the engine's weight, its fuel efficiency is greatly increased, and its emissions are greatly decreased. Hybrid Electric Vehicles can reduce dependency on fossil fuels because they can run on alternative fuels. Special lightweight materials are also used in order to reduce the overall vehicle weight of Hybrid Electric Vehicles and now they are at the forefront of transportation technology development.

3.2.2 Direct-Injection Engines

On the other hand Direct-injection engines exhibit an efficiency advantage over conventional combustion engines by injecting fuel directly into each engine cylinder. Already researchers are optimistic about integrating already efficient direct-injection engines into hybrid vehicle applications to achieve further fuel economy improvements. This technology is widely used in heavy-duty diesel vehicle and equipment applications for increased efficiency over traditional diesel engines. Volkswagen offers a direct injection engine on its Beetle, Golf, and Jetta platforms,[17] that are rated as the most fuel-efficient subcompact and compact vehicles offered in North America (excluding the Honda Insight and Toyota Prius hybrid vehicles).

3.2.3 Fuel Cell Technology

Regarding Fuel cell technology, over the long term it could result in zero or near-zero emission vehicles with equivalent range, performance, and refueling of conventional vehicles. Electricity is generated from fuel cells via a chemical reaction between hydrogen and oxygen, which is used to power a traction motor that drives the wheels of the vehicle. Here the hydrogen can be carried onboard as a compressed gas or it may be derived from any hydrocarbon fuel, including gasoline, natural gas, methanol, ethanol, or propane. There is ongoing research, which is focused on reducing fuel cell size, lowering production costs, and developing efficient, compact onboard fuel reformers to provide hydrogen. Market presence of fuel cell vehicles is estimated as early as within the next five years to over a decade for production-ready designs. It all depends on the rate of technological advancement and choices, refueling considerations, fuel choice, production costs, and market acceptance.

3.2.4 Light Weight Materials

In addition to changes in vehicle propulsion systems, advanced materials that combine weight savings with increased strength will be integrated into vehicle design and engineering. The likely material to be utilized could be aluminum, steel, plastics, magnesium, and composites (carbon fiber, metal matrices etc.). In order to ensure that advanced materials are incorporated into production vehicles they must be durable and cost-effective, therefore current research focuses on vehicle manufacturing methods, design, structural engineering, and increasing the recyclability of new materials. Therefore materials research has been and continues to be a critical component of vehicle engineering.

4. The Alternative Fuels Act

"Alternative fuels are substantially non-petroleum and yield energy security and environmental benefits."[17] (DOE) U.S. Department of Energy currently recognizes the following as alternative fuels: methanol and denatured ethanol as alcohol fuels (mixtures that contain no less than 85% of the alcohol fuel), natural gas (compressed or liquefied), liquefied petroleum gas (propane), hydrogen, coal derived liquid fuels, fuels derived from biological materials, 100% Biodiesel (B100), and electricity (including solar energy).[17]

The Alternative Fuels Act: On June 22, 1995 the Alternative Fuels Act[3] became law here in Canada. The Act applies to all government departments, agencies and Crown Corporations here in Canada. It is required by the Act that the federal fleet use alternative fuels whenever it is cost effective and operationally feasible and also the government departments adhere to a schedule for procuring vehicles that operate on alternative fuels.[3]

An effective alternative fuel must offer as a minimum, equivalent or lower emissions than gasoline engines under this Act. The Act also prescribes a schedule for procurement of vehicles that will be capable of operating on alternative fuel. The Acts purpose is to accelerate the use of alternative fuels in vehicles here in Canada.

4.1 Characteristics of Alternative Fuels

Table: 4.1 Characteristics of Alternative Fuels

	Compressed Natural Gas (CNG)	Ethanol (E85)	Liquefied Natural Gas (LNG)	Liquefied Petroleum Gas (LPG)	Methanol (M85)
Chemical Structure	CH_4	CH_3CH_2OH	CH_4	C_3H_8	CH_3OH
Primary Components	Methane	Denatured ethanol and gasoline	Methane that is cooled cryogenically	Propane	Methanol and gasoline
Main Source	Under-ground reserves	Corn, grains or agricultural waste	Underground reserves	A by-product of petroleum refining or natural gas processing	Natural gas, coal, or woody biomass
Energy Content per Gallon	29,000 Btu	80,460 Btu	73,500 Btu	84,000 Btu	65,350 Btu
Energy Ratio Compared to Gasoline	3.94 to 1 or 25% at 3000 psi	1.42 to 1 or 70%	1.55 to 1 or 66%	1.36 to 1 or 74%	1.75 to 1 or 57%
Physical State	Gas	Liquid	Liquid	Liquid	Liquid

Source: www.afdc.doe.gov [17]

4.2 Emissions from Alternative Fuels

All the alternative fuels do reduce ozone-forming tailpipe emissions. By looking at the figure below we can see the percentage of combined carbon monoxide (CO) and nitrogen oxide (NO_x) emissions for each alternative fuel as compared to reformulated gasoline (RFG). Here we can see that the emissions from CNG vehicles are estimated to be 20%, compared to 100% emissions from vehicles using RFG. Which shows that vehicles powered by CNG shows an eighty percent reduction in ozone-forming emissions.

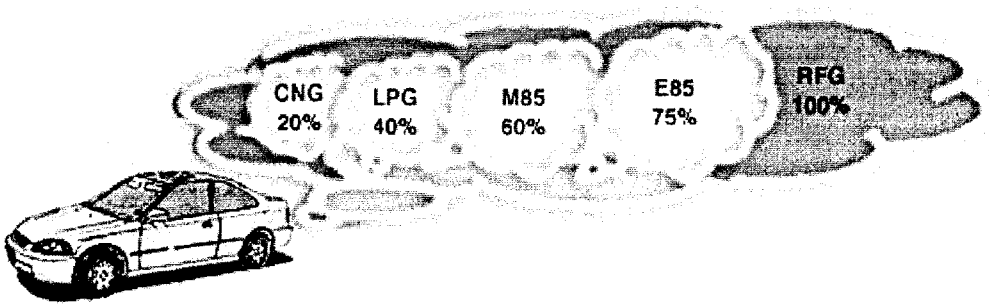

Figure 4.2: Percentage of CO and NO_x emissions for each alternative fuel as compared to reformulated gasoline (RFG). Alternative Fuels Data Center; afdc.doe.gov

Similarly the emissions from LPG, M85 and E85 are estimated to be 40%, 60% and 75% consecutively compared to 100% emissions from vehicles using RFG (reformulated gasoline).

4.3 Alternative Fuel Prices Compared to Gasoline

The price of alternative fuels changes in accordance with outside factors. Obviously, it changes because of international economic changes and also because of the change of supply and demand, just as it fluctuates for diesel and gasoline. In order to have access for alternative fuels, it varies from region to region and also the geographic location can greatly affect the price at the pump. Just as an example, considering the easy accessibility for propane due to the Dixie pipeline, it is generally less expensive in southern states; similarly natural gas is much more economical in the urban areas; and ethanol producers tend to sell their fuel in the Midwest to cut down on fuel transportation cost.

Gasoline	CNG	E85	LNG	LPG	M85
$1.00	less	more	more	less	less

Fig. 4.3 Average price compared to gasoline, Source: Alternative Fuels Data Center. afdc.doe.gov

5. Alternative Transportation Fuel in Canada

Around the world Canada is recognized as a leader in the development and use of alternative transportation fuels (ATFs). Today, there are more than 170,000 alternative fuel vehicles (AFVs) in use from British Columbia to Newfoundland. Propane, the first ATF to be widely used in Canada, accounts for approximately 150,000 of the AFV total.[4] While propane vehicles are located from coast to coast, the vast majority is in Ontario and the western provinces. Propane fuel is available through an extensive network of some 5,000 public refueling stations throughout the country. There are an additional 20,000 vehicles operating on natural gas (NG), supported by approximately 120 public natural gas refueling stations. Natural gas vehicles (NGVs) are presently concentrated in the lower mainland of British Columbia, the Edmonton–Calgary corridor, southern Ontario and the Montréal–Québec City corridor. In addition, a demonstration of more than 500 methanol vehicles is underway in British Columbia, Alberta and Ontario. Ethanol and electric vehicles are not yet commercially available in Canada[4]

History of Alternative Transportation Fuel in Canada: The Canadian federal government had begun to support the use of some alternative gaseous fuels in the early 1980s, and it continues to support it at the present time. The federal government came up with some programs to assist the natural gas and propane industry to overcome early barriers in the marketplace and also to establish these type of fuels as viable alternative fuels here in Canada. As the federal government started to show support, some of the provincial governments also started to show support in some of the initiatives. And because of these two governments along with the industry working together the programs became a success.

5.1 Propane

Propane is the type of gas maintained as liquid under pressure. It is non-toxic, has high octane and there is large surplus. There is a potential market for propane in the sector of transportation. Fifty percent of production is currently exported. There are about 5,000 public and 2,000 private stations across Canada. The average price for propane is about sixty five percent to seventy five percent of gasoline.[7] Certification is required to refuel propane vehicles. The original equipment manufacturer (OEM) production presently is limited but it is expanding

Numerous independent shops provide conversions of gasoline vehicles in all provinces across Canada. Six and eight cylinder engines are normally converted. Vehicles can be converted for mono-fuel (propane only) or bi-fuel (propane/gasoline) operations. Conversion cost: $2,400 to $2,800, higher for increased range/multiple storage tanks.

The performance of propane vehicle range to eighty percent of gasoline vehicle.[1] They can add storage capacity to match or exceed gasoline range and there is no significant degradation of performance relative to gasoline or diesel. Regarding their environmental performance, propane-powered vehicles have greenhouse gas advantage over gasoline. Their reactive hydrocarbon emissions are lower than gasoline and it has no evaporative emissions. Their particulate emissions are much lower than diesel and also lower than gasoline. It also has low carbon monoxide relative to gasoline. It has no emissions of benzene, butadiene and aldehydes are lower than gasoline A good safety record is maintained by national standards, staff training. And certification of equipment installers and refueling sites are mandatory due to safety. Engine parts last much longer in propane vehicles. The engine, including the exhaust system has much longer life than gasoline vehicles. Converting into propane vehicles make a lot of sense for high usage fleet vehicles for example taxis, police cars RCMP fleet etc.

5.2 Natural Gas

If a person wants to own one of the cleanest running vehicles on the road it can now be a reality. In order to meet the growing demand for environment-friendly vehicles, the O.E.M.s have added natural gas-dedicated vehicles to their line up of cars and trucks. They are built right at the factory and strictly operate on natural gas and provide economic and environmental savings.

Natural Gas is recognized worldwide as the preferred low emission fuel alternative to gasoline, diesel and propane. Since natural gas is already delivered through existing gas lines to most businesses, it's very easy to use. Natural Gas is the safest, cleanest and most cost-effective fuel for ones refueling needs. It offers substantial cost savings, reduced emissions and is always available. Used as a vehicle fuel for decades, natural gas is the cleanest and safest fuel available today. One can only be in a winning situation by using Natural Gas as an Alternative Fuel. You as a consumer are not only saving money but are also saving the environment by using a much safer fuel. There could be a substantial savings by using Natural Gas because of the price being much lower than gasoline. Another advantage that one has by using natural gas, as an Alternative Fuel is that it keeps the engine much cleaner which in return needs less frequent maintenance.

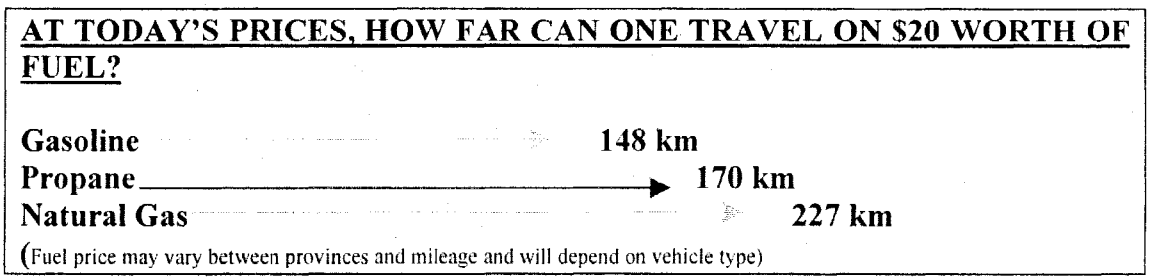

Figure 5.2: Travel distance for using gasoline, propane and natural gas. Source: The Natural Gas Vehicle Alliance. www.ngvcanada.org

This figure (*figure 5.2*) shows us that at todays price: for example $20 worth of fuel we can travel approximately 148 km with gasoline, 170 km with propane and 227 km with natural gas. It gives us a comparison between the three types of fuel - natural gas, propane and gasoline.[8]

Choosing a natural gas vehicle is a very wise environmental decision. Natural gas burns cleaner than gasoline and other alternative fuels, and drastically reduces harmful tailpipe emissions, including: carbon monoxide (CO); nitrogen oxide (NOx); volatile organic compounds (VOC) and particulate matter. And because it is contained in a pressurized fuel system, it completely eliminates evaporative emissions (gasoline vapours containing the cancer causing substance, benzene). As well, natural gas reduces greenhouse gas, which contributes to climate change.

There are about 130 public and 80 private stations; the public stations are concentrated in lower mainland of British Columbia, Calgary-Edmonton corridor and

southern Ontario. Two thousand of them are small refueling appliances. Thirty-five percent of federal fleet can access natural gas for vehicles (NGV). The average price is about sixty percent of gasoline and there is no certification required for refueling. [1]

For Natural Gas original equipment manufacturer (OEM) vehicle production is expanding to include mono-fuel (NGV only) and bi-fuel (NGV/gasoline) options. Vehicle manufacturers offer widest selection of all ATF vehicles. In after-market conversions to natural gas the majority of light-duty vehicles are bi-fuel conversions. The average conversion cost is $3,500 to $4,000.[4] There are approximately 90 NGV conversion shops in operation at the present time.

Particulate and air toxic emissions are very low relative to gasoline and diesel and it has low carbon monoxide relative to gasoline. Regarding safety, natural gas is the fuel that is used to heat our homes and offices. It is also a proven vehicle fuel used around the world for the last 50 years.[8] If Natural Gas spills it rapidly disperses into the air also because it is lighter than air, natural gas does not settle in low-lying areas, as does heavier propane or gasoline vapors. It is considered a safer vehicle fuel than either gasoline or propane.

City of Hamilton converting to NGVs: Hamilton, Ontario a city located in the south-west corner of Lake Ontario in the past have often been painted as a "steel-town" whose history is often built on industry at the environments expense. The problem with that image and reputation is now being wiped away as the new City's green initiatives are taking place. When the City was amalgamated with the four other municipalities on January 2000, it created a task force on environmental excellence. Natural gas vehicles were to be introduced in all its public fleets' wherever possible. As a result, all of its transit buses are now being switched to natural gas by replacing the ever-aging diesel buses. Therefore the city at present now operates over 100 Natural Gas Vehicles and estimates the lifetime cost of a dedicated natural gas-powered bus at $157,500, compared with $172,300 for a dedicated diesel bus[12].

5.3 Methanol

History of Methanol: Methanol has been seen as a possible large volume motor fuel substitute at various times during gasoline shortages and it was often used in the early part of the century to power automobiles before inexpensive gasoline was widely introduced. In the early 1920s, some viewed it as a source of fuel before new techniques were developed to discover and extract oil. The World War II era saw wide use of synthetically produced methanol as a motor fuel in Germany. During the wartime fuel shortages throughout Europe prompted the use of the fumes produced by wood-burners as a source of fuel to power vehicles.

The use of methanol as a motor fuel received attention during the oil crises of the 1970s due to its availability and low cost. Problems occurred early in the development of gasoline-methanol blends. As a result of its low price some gasoline marketers over blended. Others used improper blending and handling techniques. This led to consumer and media problems and the eventual phase out of methanol blends. However, there is still a great deal of interest in using methanol as a neat fuel. Many tests have shown promising results using 85-100 percent by volume methanol as a transportation fuel in automobiles, trucks and buses. The flexible-fuel vehicles currently being manufactured by General Motors, Ford and Chrysler can run on any combination of ethanol, methanol and/or gasoline.

Methanol in Canada: Canada is a major producer of methanol. About 75% of production is exported. It is stored, transferred and dispensed like gasoline. There are approximately 12 stations in Alberta and British Columbia. Also portable refueling stations are available. The price is about equal to regular gasoline on energy-equivalent basis. Regarding its performance the acceleration is higher than for gasoline vehicles. The range approaches that of comparable gasoline vehicles through use of a larger fuel tank. Methanol vehicles have no improvement in greenhouse gas emissions relative to gasoline vehicles but VOC emissions are lower than for gasoline vehicles. It also has lower carbon monoxide emissions relative to gasoline. It has low benzene and formaldehyde emissions are similar to those from gasoline. Gasoline must be added to produce M85 to improve cold starting and it has flame luminosity. But fire risk is lower than that for gasoline.

It's Pros and Cons: Methanol use in current-technology vehicles has some distinct advantages and disadvantages. On the plus side, methanol has a higher octane rating than gasoline. This reduces "knock" in today's engines and can result in greater fuel efficiency with proper adjustment of the engine's compression ratio. Methanol's high heat of vaporization results in lower peak flame temperatures than gasoline and lower nitrogen oxide emissions. Its greater tolerance to lean combustion higher air-to-fuel equivalence ratio results in generally lower overall emissions and higher energy efficiency. Dedicated-methanol-fuel vehicles would increase this advantage even further.

However, several disadvantages must be studied and overcome before neat methanol is considered a viable alternative to gasoline. Methanol's energy density is about half that of gasoline, reducing the range a vehicle can travel on an equivalent tank of fuel. Current-technology vehicles using neat methanol at temperatures below 45 deg. Fahrenheit are difficult to start because of methanol's lower vapor pressure and single boiling point. However, engineering solutions to these problems have been identified and are under development.

Methanol Regions: Table 5.3 below shows the major Methanol producing regions in the world, Canada being the number fourth in the list. Therefore it is available in abundance and to utilize it is the responsibility of the people.

Table 5.3: Leading Methanol Producing Regions

Leading Methanol Producing Regions	
	Billions of Gallons per Year
Europe	2,616
USA	1,805
Australia/Asia	900
Canada/Mexico	837
Far East/Asia	733
South America	713
Middle East	628
Africa	266
Total World	8,498

Source: Information Resources, Inc. and Clean Fuels Development Coalition [13]

5.4 Ethanol

History of Ethanol: Since the 1900s ethanol has been used as a motor fuel. Henry Ford in the year 1908 designed his Model T car to run on ethanol. At that time he had thought that ethanol made from renewable biological materials would be the principle automobile fuel. But in the early 20th century a new dominant fuel, the gasoline had emerged. Because of it had a low rating of octane it was suitable for the material then available for engine construction. As time went by there was also a growing, seemingly unlimited supply of low cost petroleum from all the discoveries of oil fields. But today, ethanol has become widely used around the globe as an environmentally friendly fuel. Ethanol production in Canada is expected to triple by 2005 to 1 billion litres per year.[7]

Ethanol in Canada: Ethanol is playing an increasing role in meeting the country's needs for renewable fuels as the Canadian ethanol industry continues to grow. Ethanol, which is first blended with gas and sold in Manitoba twenty years ago, today ethanol is offered at approximately 1,000 locations in six provinces (the four Western provinces, Ontario and Quebec). The annual ethanol production is approximately 238 million litres per year, here in Canada of which some is exported to the United States. The federal government has committed itself to increase ethanol production in Canada by 750 million litres per year[7] for supporting the industry. At present there are lots of initiatives underway which will boost the production significantly in the next coming years.

Ethanol is one of the best tools we have to fight air pollution from vehicles. It contains 35% oxygen; is non-toxic, soluble in water and it is quickly biodegradable. By adding oxygen to fuel it results in the type of fuel combustion which is more complete, thus reducing harmful tailpipe emissions. By increasing the ethanol production, it will provide a much- needed economic boost to the rural part of Canada. Ethanol provides a vital values-added market for corn, wheat and other commodities. In the U.S. it has been found by research that the use of grain for ethanol production adds up to 45 cents to every bushel of corn.[7] Therefore by increasing the production of ethanol here in Canada, it is just a matter of time before similar increases to Canadian corn prices are realized. It is now widely accepted that the ethanol industry has had and will continue to have a very positive impact on out economy particularly at the local level. Ethanol is a liquid fuel. When it is used as five percent to ten percent low-level blends in gasoline it is referred to as E5 to E10. Low-level blends can be used in any gasoline vehicle. It is also used as blend of 85% ethanol and 15% gasoline E85 in light-duty vehicles. E85 requires special equipment and is stored, transferred and dispensed like gasoline. E85 has high octane. Precautions are required at E85 sites to avoid water contamination. Currently there are several hundred stations that offer ethanol blends and numbers are expanding. High-level ethanol blends E85 are not yet available in Canada. Low-level ethanol blends are priced comparable to gasoline. There is very limited selection of E85 vehicles offered by original equipment manufacturers.

5.5 Electric Power

The most available out there is electricity and also there is low-cost electricity available out there. For electric vehicles the off-peak capacity can be utilized. And for refueling slow recharge is possible at fleet sites or at home. In Canada, so far public sites are not yet available. At the present moment there are a limited selection of electric vehicles available from manufacturers out there. If anybody wants to purchase an electric vehicle it is by special arrangement only by the Original Equipment Manufacturer. In Canada, in the field of battery technology there are some on going research projects. Regarding vehicle performance, the range with the conventional lead acid batteries is from 50 to 100 km. And for advanced batteries their range is around 200 km. For Electric vehicles, they can have low or medium or high power depending on the application and the way they are configured. Because there is a high price to replace batteries it reduces the advantage of the low cost off peak electricity. Electric vehicles have near zero emissions. Electric vehicles are just as safe as electric appliances. Even after considering emissions from electricity generation plants, Electric Vehicles would have a beneficial impact on air quality in major Canadian urban centers. Therefore the overall mix of electricity generating sources in Canada means low greenhouse gas emissions for electric vehicles.

5.6 Hydrogen

Hydrogen is stored as compressed gas (3,000 psi), cryogenic (very low temperature) liquid, metal hydride (a hydrogen compound) or in a hydrogen carrier such as methanol. It is non-toxic. There is inexhaustible supply through the electrolysis of water, using renewable energy sources. Currently there are limited refueling sites to those used for fuelling prototype vehicles.

Fuel cell powered transit buses are currently being demonstrated for hydrogen vehicles. Commercial fuel-cell buses are in operation today. Experimental buses in Montréal are fuelled by hythane (a mixture of natural gas and hydrogen). There are various prototype automobiles and trucks powered by hydrogen-fuelled, internal combustion engines are now in operation. Fuel cell powered automobiles are expected to be on the market by 2005. Fuel-cell bus meets or exceeds diesel bus in performance. They also have a quieter operation and they have more power at low speeds. Hydrogen fuel-cell vehicle is 2 to 3 times more energy-efficient over a driving cycle compared to an internal combustion engine running on gasoline or diesel.

Hydrogen is the cleanest fuel, it has zero emissions from hydrogen-powered fuel-cell vehicles, also it has no greenhouse gases, no particulates or hydrocarbons, no carbon monoxide, nitrogen oxides or ozone and no toxic components. It is as safe or safer than gasoline. Any fuel leak rapidly disperses, and there will be no pooling of fuel. Hydrogen detectors are used at refueling stations and on-board. A major obstacle to

the use of hydrogen as a fuel is the high cost of electrolysis with current technology. But research is currently ongoing to reduce production costs.

One should also know that the environmental performance of regular petroleum vehicles are also improving parallel to all of these alternative fuels, in order to regulate the emissions of CO, HC, and NOx. Not only are gasoline and diesel getting cleaner, now a days the vehicles are equipped with sophisticated diagnostic systems in order to ensure that they operate at optimal emissions level. It is wrong to assume that in future all the alternative fuels only will give us a substantial environmental benefit over gasoline unless the modern engines and its technology also continuously improve along with it.

5.7 Performance Comparison of Alternative Fuels

Below is a summary of the environmental performance and vehicle performance of some alternative fuels:

Table 5.7: Performance Comparison of Alternative Fuels

Fuel	*Environmental Performance*	*Vehicle Performance*
Ethanol	- Ethanol blended gasoline's use fuel ethanol made from Ontario grown corn which benefits farmers and the economy - When using E10 or E85 its emissions from Carbon Monoxide are less from gasoline - When compared to diesel it generates low levels of particulates - When the Ozone production from E-10 fuelled vehicles is compared to gasoline it is the same - If the ethanol from biomass is used the greenhouse gas emissions are less	- When E10 blends are used the vehicle performance and fuel consumption are the same as gasoline - Cleans the vehicle fuel tank and fuel lines - Reduces unburned hydrocarbons (especially in older vehicles) - Ethanol blended gasoline's meet the BMW North American standard of intake valve cleanliness for unlimited mileage
Hybrid Gasoline/ Electric	- The recycling of the toxic components from batteries are critical when vehicles are disposed - When operating in the electric mode it has lesser emissions - When gasoline engine is working it therefore effects the air quality	- Hybrid gasoline engines are (Ultra Low Emissions Rated) ULEV rated - Depending on the mode of operations its range is greater than gasoline - It has zero emissions when it operates in the electric mode - One can get maximum benefit during stop and go and low speed city driving conditions

Propane	- It has no evaporative emissions, and its reactive hydrocarbon emissions are lower than gasoline - It also has lower carbon monoxide compared to gasoline - Compared to gasoline it also has advantage over greenhouse gases - Its particulate emissions are lower than gasoline and a lot lower than diesel	- It can add storage capacity to match the range of gasoline - Its range is about 80% of gasoline run vehicle - Compared to diesel or gasoline it has very little degradation of performance
Electric	- There isn't ant emissions in these type of vehicles - Low greenhouse gas emissions in Canada due to the electric mix that exists - When the vehicles are disposed the recycling of the toxic material in the batteries are critical - One needs to consider the emissions for air quality that are generated from the electricity plants	- Their range isn't much - They are special purpose clean vehicles - Because the batteries weigh a fair amount it reduces the vehicles performance
Natural Gas	- It also has no evaporative emissions, and its reactive hydrocarbon emissions are lower than gasoline - Similarly compared to gasoline it also has low carbon monoxide - Also compared to gasoline it has advantage over greenhouse gases - One of the major advantages over emissions that a natural gas vehicle emissions has is very low reactivity of ozone	- There might be a slight loss of power when these type of vehicles are converted - Compared to gasoline vehicles it has a range almost 50%, range could be increased if

6. Alternative Fuel Incentives/Tax Advantages

Various financial incentives exist for purchasers of alternative fuel vehicles, which directly lowers its cost. Financial incentives are available from the federal government and also the provincial government. In addition, incentives may be available from local natural gas utility companies for fleet applications. There are also tax advantages associated with alternative fuel vehicles. These tax advantages serve to lower both the cost of purchasing and the cost of operating alternative fuel vehicles.

6.1 Federal Government Programs

The Canadian federal government offers financial incentives to purchasers of natural gas vehicles through two methods: (1) The Natural Gas for Vehicle Program, and (2) Exemption from Excise Tax on Natural Gas as a Transportation Fuel.

(1) The Natural Gas for Vehicles Program (NGVP): The federal government in 1983 started the Natural Gas for Vehicles Program. The NGVP program provides financial contributions towards the purchase of natural gas vehicles. Contributions are $3,000 for a medium duty natural gas vehicle, $2,000 for a light duty natural gas vehicle and $500 for a vehicle converted to natural gas operation. The program also provides a $500 contribution to the dealer selling the vehicle.[4] Under the NGVP program it provided a grant of $500 for the conversion of a vehicle to natural gas operation. To be eligible for the contribution, the vehicle must be registered in a region that is serviced by natural gas supplied from Alberta and be in good mechanical condition. Local natural gas companies are administering this program.[4]

(2) Exemption from Excise Tax on Natural Gas as a Transportation Fuel: Natural gas for vehicles is exempt from federal excise tax. Gasoline is subject to federal excise tax of 10 cents per litre, and federal excise tax on diesel fuel is 4 cents per litre. The only federal tax on natural gas is the Good and Services Tax (GST) of seven percent, which applies to all other transportation, fuels as well. Natural gas's exemption from the federal excise tax provides the fuel with the first of several tax advantages.

The *Ethanol Fuel Initiative* is another federal program that is designed to increase the use of ethanol as a transportation fuel. The strategy that the federal government has currently is to encourage using ethanol blended gasoline both in the low level (E-10) and high level (E-85) blends. Currently most of the vehicles can use low level blends and flexible fuel vehicles can use the high level blends.[4]

Software for AFVs: QTOOL SE is a software package developed by Natural Resources Canada (NRCan), the Canadian Natural Gas Vehicle Alliance (CNGVA) the Propane Gas Association of Canada (PGAC), and the vehicle manufacturers. It is very user-friendly software for consumers to find out the cost effectiveness of vehicles capable of operating on alternative fuels.[4]

6.2 Provincial Government Programs

The government of Ontario provides incentives to purchasers of alternative fuel vehicles in the form of tax refunds and reduced taxes. Just like Ontario many other provinces also are following the lead of the federal government by providing tax relief for alternative fuels.

Sales Tax Refunds: The Ontario Ministry of Finance provides rebates of the 8% provincial sales tax (PST) paid on the purchase price of a factory-equipped alternative fuel vehicle, or on the cost of an aftermarket conversion. The PST is refundable up to a limit of $750 on propane-powered vehicles, and up to a limit of $1000 on vehicles powered by alternative fuels other than propane. (These limits do not apply to buses, in which case the tax is refundable in full) Qualifying vehicles are those that: operate exclusively on natural gas, propane, electrical energy, ethanol, methanol, or operate as dual-powered vehicles (that use one of the alternative fuels noted above and that can also be powered by gasoline or diesel fuel). A refund is not available on vehicles using a mixture of an alternative fuel and gasoline or diesel fuel.

Time Limits for Conversions - For refunds of the retail sales tax on vehicles converted after purchase, conversions must be completed within 180 days from the date the vehicle is purchased. If the conversion is not completed within the 180 days, a buyer may still be entitled to a refund of the eight percent retail sales tax paid on the cost of conversion kit and the labour to install the kit. Vehicles leased on long-term leases are also eligible for refunds of the retail sales tax, subject to the refund limits above. Leases must be for twelve months or more, and vehicles must meet all of the above requirements.

Fuel Conservation Tax - In addition to the 8% retail sales tax, the fuel conservation tax paid on new passenger cars or sport utility vehicles (bought or leased) may be refunded if the vehicles operate, or are converted to operate, exclusively on an alternative fuel. A refund of this tax is not available if a vehicle can operate as a dual-powered vehicle.

In addition the government of Ontario does not tax automotive natural gas, methanol, or ethanol. The provincial tax on gasoline is 14.7cents per litre, and the tax on automotive diesel fuel is 14.3 cents per litre. Propane used for automotive is taxed in Ontario at a rate of 4.3 cents per litre. Here propane is taxed at a lower rate than gasoline relative to its energy content; it is taxed at forty percent of its energy equivalent level. If like gasoline, propane were taxed on an energy content basis, the tax on propane would be 10.8 cents per litre.

6.3 Utility Company Incentives

Enbridge Consumers Gas - For qualifying vehicles or applications, Enbridge Consumers Gas offers incentives valued at $1000 for factory equipped dedicated natural gas vehicles, and incentives valued at $500 for factory equipped bi-fuel natural gas vehicles. Incentives available from Enbridge Consumers Gas for NGV conversions are based on vehicle use and the level of fuel consumption. For further information, one should call 1-888-NGV-4SAV (1-888-648-4728).

Union Gas - Incentives are available from Union Gas for some commercial applications. Incentives are based on fuel consumption levels and are evaluated on a case-by-case basis. For information one should call: 1 (800) 265-5277.

7. Alternative Fuel Vehicle Models Available in the Market

Following is a list of different alternative fuel vehicles that are available in the market or are nearing completion:

Table 7: Model Year 2003, Alternative Fuel Vehicles Available in the Market or Nearing Completion

Fuel Type	Model	Vehicle Type	Emission Class	Power-train	[1]Fuel Capacity	[2]Range
American Honda Motor Corporation 888-CCHONDA http://www.honda.com						
CNG Dedicated	Civic GX	Compact Sedan	ILEV, SULEV (Tier II Bin II)	1.7L, 4-cylinder	8 GGE	200 mi
DaimlerChrysler 1-800-999-FLEET http://www.fleet.chrysler.com						
CNG Dedicated	Dodge Ram Van, Dodge Ram Maxi Van	Van	ILEV, ULEV (CA-SULEV)	5.2L V8	18.7 GGE	200-300 mi
E85 FFV	[3]Chrysler Town and Country, [3]Dodge Caravan, [3]Dodge Grand Caravan	Minivan	LEV	3.3L V6	20 Gal	320-420 mi
E85 FFV	[3]Chrysler Sebring Sedan, [3]Chrysler Sebring Convertible, [3]Dodge Stratus Sedan	Sedan, Convertible	LEV	2.7L V6	16 Gal	300-400 mi
E85 FFV	[3]Chrysler Voyager	Van	LEV	3.3L V6	20 Gal	300-400 mi
Ford Motor Company 1-877-ALTFUEL http://www.fleet.ford.com						
CNG Bi-Fuel	F-150	Light-Duty Pickup	ULEV	5.4L V8	12.3 GGE	175 mi
CNG Dedicated	E-Series Van (E250 and E350) E-Series Wagon (E350)	Van Wagon	SULEV, (CA-SULEV)	5.4L V8	Standard 19.2 GGE/ Extended Range 28.9 GGE	Standard 280 mi/ Extended Range 420 mi
CNG Dedicated	F-150	Light-Duty Pickup	ILEV, SULEV, (CA-SULEV)	5.4L V8	21.7 GGE	350 mi
CNG Dedicated	Crown Victoria	Sedan	ULEV	4.6L V8	Standard 12.3 GGE/ Extended Range 16.2 GGE	Standard 200 mi/ Extended Range 350 mi
E85 FFV	[3]Taurus [3]Mercury Sable & Mountaineer	Sedan Wagon	ULEV	3.0L V6	18 Gal	250-350 mi
E85 FFV	[3]Explorer [3]Mercury Mountaineer [3]Explorer Sport	SUV	LEV	4.0L SOHC V6	22.5 Gal 17.5 Gal 23 Gal	TBD
E85 FFV	[3]Ranger FFV	Light-Duty Pickup	LEV	3.0L V6	19.5 Gal	TBD
LPG Bi-Fuel	F-150	Light-Duty Pickup	ULEV	5.4L V8	26.2 GGE	400 mi

Fuel Type	Model	Vehicle Type	Emission Class	Power-train	[1]Fuel Capacity	[2]Range
General Motors Corporation 1-888-GM-AFT-4U http://www.gmaltfuel.com						
CNG Bi-Fuel	Chevy Silverado GMC Sierra	Light-Duty Pickup	LEV	6.0L V8	20 GGE	220-280 mi
CNG Bi-Fuel/ CNG Dedicated	Bi-Fuel & Dedicated versions of: Chevy Express GMC Savana	Cargo or Passenger Van	ULEV (Dedicated CA-SULEV)	6.0L V8	11.2 GGE (bi-fuel)/20.3 GGE (dedicated)	120-160 mi (bi-fuel)/220-280 mi (dedicated)
CNG Bi-Fuel	Chevy Cavalier	Sedan	LEV	2.2L V4	6.2 GGE	110-160 mi
E85 FFV	[3]Chevy Tahoe [3]GMC Yukon	SUV	Tier 1	5.3L V8	26 Gal	260-338 mi
E85 FFV	[3]Chevy Suburban [3]GMC Yukon XL	SUV	Tier 1	5.3L V8	32.5 Gal	309-402 mi
E85 FFV	[3]Chevrolet Silverado [3]GMC Sierra	Light-Duty Pickup	Tier 1	5.3L V8	34 Gal (long box) 26 Gal (short box)	327-392 mi (long)/255-305 mi (short)
Mazda USA 800-222-5500 http://www.mazdausa.com						
E85 FFV	B3000	Light-Duty Pickup	LEV	3.0L V6	19.5 Gal	230 - 300 mi
Mercedes-Benz USA 800-367-3672 http://www.mbusa.com/brand/index.jsp						
E85 FFV	C320 Sports Sedan	Sedan	LEV	90 degree V6, 195 cu in.	16.4 Gal	300-400 mi
Nissan North America 800-NISSAN1 http://www.nissandriven.com/menu_nf.html						
Electric (Lithium-Ion)	[4]Altra-EV (select fleets in CA)	Mid-Size Wagon	ZEV	62 kW AC Induction	NA	80 mi
Electric (Lithium-Ion)	[4]Hypermini (select fleets in CA)	Two Seater	ZEV	24kW AC Induction	NA	40 mi
Solectria Corporation 781-932-9009 http://www.solectria.com						
Electric (Lead Acid)	Citivan	Service Van	ZEV	125kW AC Induction	52 modules (Sealed PbA)	40 mi

[1] CNG and LPG vehicles fuel capacity based on slow fill @ 3600 psi.

[2] Estimated range on alternative fuel and based on fuel capacity. For EVs, range depends on battery type.

[3] All E85 vehicles are flexible fuel vehicles (FFVs).

[4] Available for lease to selected fleets.

Glossary of Abbreviations

AC = Alternate Current
CA = California
CNG = Compressed Natural Gas
E85 = 85% Ethanol 15% Gasoline
EV = Electric Vehicle
FFV = Flexible Fuel Vehicle
Gal = U.S. Gallon
GGE = Gasoline Gallon Equivalent
LEV = Inherently Low Emission Vehicle
kW = Kilowatts
kWh = Kilowatt Hours
L = Liter
LEV = Low Emission Vehicle
LPG = Liquefied Petroleum Gas (propane)
MI = Miles
NiCd = Nickel Cadmium
NiMH = Nickel Metal Hydride
PbA = Lead Acid
SULEV = Super Ultra Low Emission Vehicle
SUV = Sport Utility Vehicle
TBD = To Be Determined
ULEV = Ultra Low Emission Vehicle
ZEV = Zero Emission Vehicle

Other Websites

Alternative Fuel Vehicle Buyers Guide
www.fleets.doe.gov/vbg

Alternative Fuels Data Center
www.afdc.doe.gov

U.S. DOE Clean Cities Program
www.ccities.doe.gov

Gas Electric Hybrids in the Market: More people here in North America, especially women are ready to give gas-electric vehicles a try, according to a study on hybrid vehicles. In the overall, the survey concluded that more women were interested in hybrid vehicles than men. Agoura Hills, California-based Power after doing the survey found 30% of new-vehicle buyers would consider a hybrid "definitely", and also another 30% said that they would consider it "strongly". The survey concluded that the majority of the people who were going to purchase a car said that they would want a vehicle that they are already driving in a hybrid. A person already driving a sport utility vehicle preferred to have a hybrid sport utility vehicle, similarly people who were driving minivans preferred to have a hybrid minivan.

Hybrid SUV:

Fig 7a: Ford Escape Hybrid

Ford Escape Hybrid (*Figure 7a*) was the first sport utility vehicle (SUV) in the U.S. that came out in 2003.

Hybrid Cars:

"Honda Insight"

Fig 7b: Honda Insight

The first hybrid vehicle in the U.S. market introduced in 1999. It has a tiny racy look and seats two people.

"Toyota Prius"

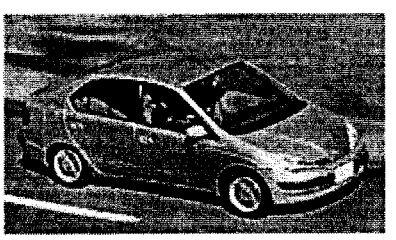

Fig 7c: Toyota Prius

The second hybrid in the U.S. market had an increase in sales of 180% in the year 2001. Toyota has a target sale of 14,000 sales of Prius annually. It has the distinction of being the leader in hybrid vehicle sales.

"Honda Civic Hybrid"

Fig 7d: Honda Civic Hybrid

Honda's second hybrid, the 2003 Civic started to sell in April 2002. It looks very similar to the regular Civic sedan. Also it is produced in the same assembly line as to the other Civics. The most tempting thing that this hybrid Civic has to offer from the regular Civic sedan is it offers 50 miles/gal. in combined city/highway fuel mileage. It has all the looks very similar to the typical Civic sedan. This Honda Hybrid sedan is a high-tech alternative to the conventional economy cars, i.e. the Toyota Echo and the Volkswagen's turbo-charged diesel cars.

Honda which is almost every year the top selling small car in North America was very smart to base the front drive Civic Hybrid on its regular Civic, which has set the pace for subcompact car refinement. The reason was because Honda didn't want potential car buyers to be scared of the gasoline-electric setup of its new model. The Civic Hybrid does not require any more maintenance than the regular gasoline Civic. Honda has projections of selling two thousand of its Civic Hybrid models every month in the U.S., which is a fairly large number for hybrids.

There is an immediate savings in gas with the Honda Civic Hybrid. The savings is so great that it almost makes owners pretty much strangers to gas filling stations. The Civic Hybrid delivers approximately 46 miles/gallon in city driving and approximately 51 miles/gallon on highway driving with its 5-speed manual transmission, and approximately 48 miles/gallon and 47 miles/gallon with its automatic continuously variable transmission. It only requires the regular grade gasoline and one can get more than six hundred miles from its 13.2-gallon fuel tank. On the other hand the Civic with the next highest fuel economy is its 117 HP gasoline-engine. It delivers approximately 36 miles/gallon in city driving and 44 miles/gallon in highway driving with the five-speed manual transmission and 35 miles/gallon and 40 miles/gallon with the continuously variable transmission. Therefore there is no doubt that the Honda Civic Hybrid offers an impressive fuel economy compared to other vehicles even compared to it's very own gasoline-powered Civic. The one thing that's different from the regular Civic sedan is that the Civic Hybrid model has a more aerodynamic front end and a small rear spoiler.

7.1 Ford a Major Player in AFVs

Ford Motor Company quotes themselves as the major player in AFVs and their motto is "Driving Environmental Solutions". They claim that they provide more alternatives in Alternative Fuel Vehicles for any business, than any other Original Equipment Manufacturer (O.E.M.), which is true because of all the different options that are available out there. Ford Motor Company's role is to help develop innovative transportation solutions as well as to educate visitors about a balance between transportation and nature. Ford also claims that their vehicles do not compromise the beauty of the parks.

Currently one can choose from three different fuels, and a total of eleven different models. Below are some of the Alternative Fuel Vehicles that are available out there.

Ford Taurus: **A flexible Fuel Vehicle** – Vehicles that run on Ethanol are called Flexible Fuel Vehicles (FFVs) because they can run on ethanol, gasoline or any combination of the two fuels in one tank. It's available on the LX, SE and SES sedans and also on the SE wagons. It is LEV (Low Emission Vehicle) certified and has a 3.0L 2V V6 engine, and has on-board fuel mixture sensors.[15]

Crown Victoria: **A Natural Gas Dedicated Vehicle (NGV)** – It's available on the LX and heavy-duty commercial use models. It is ULEV (Ultra Low Emission Vehicle) certified, has a 4.6L V8 engine w/automatic transmission. There is an optional extended range package available for police and heavy duty commercial use applications.[15]

E-Series Cutaway Dedicated NGV - It was introduced in 2001 and there cannot be any other vehicle more perfect for school bus, hotel, and airport shuttle companies than this vehicle. It is available on the E-450 Cutaway. It is ULEV (Ultra Low Emission Vehicle) certified, has a 5.4L V8 engine w/automatic transmission. It has 225 horsepower with 325 ft/lbs torque.[15]

Electric Ranger - The Electric Ranger is the type of vehicle that reduces the usage of valuable resources and with rechargeable batteries it is considered a very ecologically friendly vehicle. It is a considered a ZEV (Zero Emissions vehicle) which makes it a perfect indoor vehicle. It has a driving range of 120 kms and it can accelerate from 0-80 km/hr in 12.5 seconds. The Electric Ranger has 90 horsepower and 140 ft/lbs of torque. It can reach up to a top speed of 120km/h.[15]

Think City – In order to provide another innovative and environmentally friendly transportation solutions this Think City vehicle was introduced. It is a stand alone type of vehicle that's perfect for warehouses, military bases, closed gate communities, zoos, campuses or any indoor place because it has zero emissions and also are quiet to operate. It seats two people, can only reach up to a top speed of 90 km/h, and its range is 80 kms.[15]

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F-Series Light Duty Bi-Fuel LPG – The only Original Equipment Manufacturer (O.E.M.) that offers a factory built Bi-Fuel Propane pickup is Ford Motor Company. Production is beginning in February of 2004. It has a 5.4L V8 B-fuel CNG engine w/automatic transmission, 230 horsepower and 325 lbs/ft torque.[15]

8. Life Cycle Emissions

One will get an incorrect assessment of an alternative fuel by only controlling vehicle emissions, without considering the upstream emissions. The total emission, which includes the overall life cycle of a particular fuel, is life cycle emissions. It consists of the emission that is created while the fuel is produced, it consists of the emission while the fuel is being delivered in the market while transporting it, and it also consists of the emissions while it is being used at the vehicle in its operation.

Therefore life cycle is a methodology for the assessment of environmental impacts of production systems on a cradle-to-grave basis. Life Cycle Analysis approach is an end from the conventional assessments which tend to focus either on product manufacturing or end of life disposal. Several studies have been done on the life cycle of different alternative fuels. And their results all vary a lot because of the type of assumptions made in estimating emissions. In my report I will quote from the data of a study that is of importance here in Canada. It will be from the study "Alternative transportation fuels in Canada: Prospects and Policies" produced by the Canadian Energy Research Institute in 1996.[21]

The life cycle emissions for alternative fuels was calculated in the Canadian Energy Research Institute study by estimating and incorporating upstream emissions, downstream emissions and vehicle emissions.

Table 8 Life Cycle Emissions Comparison (Light Duty Vehicles) (g/km)

Pollutants	Gasoline	Natural Gas	Propane
CO_2	291.04	221.554	256.93
N_2O	0.002	0.007	0.013
CH_4	0.676	1.11	0.625
CO_2	3.13	1.633	0.457
NOx	0.27	0.717	1.373
VOCs	1.607	0.69	0.862
SO_2	0.189	0.252	0.268
CO_2 Equivalent	305.952	247.062	274.255
Ozone	2.189	1.282	1.613

Source: Environmental Assessment of Propane as a Motor Vehicle Fuel, November 2001 [21]

For CH_4 the potential for global warming that is used to find emissions on a CO_2 equivalent basis is "21" and "310" for N_2O. Here the pollutants for Ozone are calculated as the total for the emissions for CO/7, NOx/2 and Volatile Organic Compounds. Here the reason for CO/7 and NOx/2 is because they are estimated to contribute 7 and 2 times less to the formation of ozone than Volatile Organic Compounds. If one wants to do an overall evaluation of emissions for the different vehicle technologies, all the things starting from the fuel cycle from wells to wheels and cycle of vehicle through the recovery of material and the disposal they are all to be put into consideration.

8.1 The Development of the Greet Model

The Center for Transportation Research at Argonne National Laboratory had been conducting fuel-cycle analysis for different transportation fuels and vehicle technologies for the past 20 years. And then in the year 1995 Argonne started developing a spreadsheet–based fuel cycle model. It was funded by the U.S. Department of Energy. GREET (Greenhouses gases, Regulated Emissions, and Energy use in Transportation) was introduced with its first version, a fuel cycle model. This model was released in 1996 and it is free to the public. [19]

After it was introduced it evolved significantly. It's updated version GREET 1.5a which was released in January of 2000 was used in this analysis. It can be downloaded free of charge. For a given transportation fuel/technology combination the GREET 1.5a separately calculates : (a) the fuel-cycle consumption of, total energy, fossil fuels (petroleum, natural gas, and coal), and petroleum, (b) fuel-cycle emissions for Green House Gases, primarily carbon dioxide (CO_2) , methane (CH_4), and nitrous oxide (N_2O), and (c) fuel-cycle emissions of five criteria pollutants i.e. VOCs, CO, NOx (nitrogen oxides), PM_{10} (particulate matter with a diameter < 10micrometers), and SOx (sulfur oxides)[21]

Table 8.1 in the next page shows the fuel-cycle energy and emission changes of the technologies that are near-term (Options that are already available or will be available within the next few years) using dedicated Compressed Natural Gas (CNG) and Liquefied Propane Gas (LPG) vehicles relative to baseline gasoline's vehicles that are fueled with conventional gasoline's.

By looking at the results we can clearly see that compared to gasoline vehicles, Liquefied Propane Gas and Compressed Natural Gas vehicles gives us a lot of energy and emissions benefits. We also can see that Liquefied Propane Gas vehicles gives us better energy and emissions benefits than Compressed Natural Gas vehicles. These results say that alternative fuel vehicles must be optimized in order to take the advantage of specific fuel properties.

Table 8.1 GREET MODEL (Fuel –Cycle Energy and Emission Changes)

	Percent Change Compared to Gasoline Vehicles	
	Dedicated CNG Vehicles	**Dedicated LPG Vehicles**
Total energy	1.1%	-11.3%
Fossil fuels	-0.5%	-11.3%
Petroleum	-99.4%	-98.2%
VOC: Total	-70.5%	-62.5%
VOC: Urban	-74.1%	-58.7%
CO: Total	-34.8%	-39.6%
CO: Urban	-35.5%	-39.7%
Nox: Total	26.6%	-17.2%
NOx: Urban	22.4%	-4.8%
PM10: Total	-36.0%	-42.5%
PM10: Urban	-32.0%	-31.4%
Sox: Total	-33.6%	-87.4%
SOX: Urban	-96.2%	-98.1%
CH_4	201.1%	2.5%
N_2O	-23.7%	-1.2%
CO_2	-16.1%	-13.4%
GHGs	-10.2%	-12.7%

Here the "minus" means decrease compared to gasoline and "plus" means an increase[21]

Here when compared to gasoline propane and natural gas both offered lower emissions of carbon monoxide, toxic hydrocarbons and ozone precursors. On the bass of life –cycle they both produce less greenhouse has emissions than gasoline. Also when comparing all the aspects, for example emissions, vehicle performance, fueling infrastructure and cost, it shows than propane is better than Compressed Natural Gas. Therefore propane should offer substantial benefits in the economic and environmental aspect especially significantly in police cars, taxicabs, and other high usage vehicles.

Regarding batteries which is one of the main power sources for AFVs, and likely to increase in the future, there is on going research which is primarily aimed at the performance of a battery that can deliver at a certain cost. And by studying only the use phase in life cycle of batteries for alternative fuel vehicles only gives a limited picture of the total environmental impact of these batteries. Therefore if only the use phase is considered then battery-powered vehicle should be the cleaner alternative fuel vehicle when compared to gasoline vehicles because they have no tail pipe emissions. But batteries use large amount of hazardous and toxic material that must be taken into consideration when calculation the environmental attributes for AFVs. Therefore the entire life-cycle for batteries must be considered, that should involve the accounting for the material required to manufacture the batteries, the process used for manufacturing the battery, the battery phase of use, disposal and also recycling. Therefore when considering environmental issues for alternative fuel vehicles one should always include the tailpipe emissions and the emissions from processes at other stages in the life of the alternative fuel.

9. Survey in Alternative Fuel Vehicle

I conducted a survey here in Toronto, using the telephone and also in person handing out the questionnaire in the appendix from my work place, some in my neighborhood and also in some of my friend's neighborhoods. Each survey required approximately five minutes of the respondent's time. It gives us a somewhat knowledge of Torontonian public's awareness and views regarding alternative fuel vehicles in Toronto, Ontario. In my survey, I had responses from thirty people.

The questions that I had selected to ask my respondents would give us an idea of the public's awareness on the environment around them and also to the extent of how much they know about alternative fuel vehicles. There are questions that will be asked concerning attitudes about the pollution and the environment. It will therefore gauge the public's awareness to how much they know about the alternative fuels that are out there and is the government doing enough about it in order to promote it.

9.1 Objective of My Survey

One of the major aims of my project was to summarize and analyze the results of my survey that was done using the telephone and also in person handing out the questionnaire from my work place, some in my neighborhood, and also some in my friend's neighborhoods, of consumer vehicle preferences and attitudes toward the alternative fuel vehicles. It basically will gauge the awareness of the state of alternative fuel vehicles among the public. It will also give us an idea of the interest of Torontonian's in respect to the advanced technology and environmentally friendly vehicles that are out there. Basically it will show us the knowledge that Torontonian's have or are interested in knowing in this area of transportation. Therefore the questions that I have selected to ask will garner opinions about a Torontonians attitude towards the environment related to the means of transportation that they use and their knowledge in the alternative fuels that are available out there. Overall as a summary I could say that the questionnaire will measure the respondents awareness of alternative fuel vehicles and attitudes about air pollution and environmentalism. It will somewhat ascertain whether and to what extent respondents have heard about alternative fuel vehicles, also it will show us of how concerned they are about the air pollution in their area, also it will show us the Torontonians perception of the relative safety of alternative fuels to gasoline, and finally it will also show us to what extent does the Torontonian's consider themselves environmentalists.

9.2 Summary of Survey Results

The following is the findings of my survey: In *Question No. 1*, thirty (100%) out of thirty people said that they had heard about alternative fuel vehicles. This number is quite encouraging because that's everyone that knows or somehow heard that there are alternative choices out there. Canada being a country of immigrants, where there are lots of people coming from the third world country each year, to me this is a very encouraging figure that people are actually aware that there are other types of options other than gasoline out there. Because people are already aware that there are options out there it is our duty to let them know of the various options and their benefits us being transportation professionals.

Compared to the Electrical Vehicle (EV) Consumer Survey in 1999 there was a very similar question, " *Have you ever heard of electric vehicles*". The response was that 87% had and the remainder 13% never heard about electric vehicles.[20] (*Figure A.1a*) From the comparison chart we can see that the number of people that have heard about AFVs has increased from 87% to 100%. In my survey the results are more promising because it shows that people now in the year 2004 are more aware about vehicle fuel choices and its availability out there. My question was more general therefore the response is more positive than the more specific question of people hearing about electric vehicles only. Like I said earlier they have heard about alternative fuel vehicles, therefore it is the duty of the people in this industry to try to tell them about the different choices and the most benefits that it has to offer.

In *question No. 2* out of the thirty people that were asked this question 5 (17%) people said "yes" and the other 25 (83%) people said that "no" that they have never seen an alternative fuel vehicle out there. Here these numbers are very alarming because people know that they are out there but they just haven't seen one. This is very damaging to the public because they will forget about it and will also not be able to know of how it looks and be able to compare the looks from a conventional gasoline-powered vehicle. It will always remain a mystery for the public unless they are able to actually see it. It is therefore very important to have these types of vehicles out on the road as many as possible and also to come up with ways to make them noticeable. By having more and more alternative vehicles out there public's confidence will grow when they actually see the vehicle running on the road.

A similar question *"Have you ever seen an electric vehicle"* was asked in the survey in the Electric Vehicle (EV) Consumer Survey of 1999" and the response was that 75% of the people had not seen electric vehicles.[20] Compared to my survey there is an increase of people that haven't seen AFVs. Also in my survey the question was in general about any AFVs and in the EV Survey about Electric Vehicles. Therefore the answer for being "*no*" which has increased is also because the question is more specific in the EV Survey. It seems like the automakers are not doing a very good job in promoting alternative fuel vehicles, especially in commercials, auto shows etc. where they could promote these types of vehicles.

In *Question No. 3*, 22(73%) out of 30 people here said that they were concerned about the environmental pollution created due to vehicles out there. This figure (73%) is a very encouraging number. *(Figure A.3)* It tells us that almost three-quarter of the population are aware that the environment out there is polluted by the emissions that are coming out from these transportation fuels of vehicles. The other 27% people that are not aware about the outdoor air pollution due to vehicles tells us that there is more for transportation professionals to do out there. To make these people aware of the dangerous consequences and pollution that are caused due to the emissions from gasoline fuel vehicles. The almost three quarter of the people who are concerned about the environmental pollution is a positive sign for automakers to market the environmentally friendly vehicles because it tells us that the public are already aware of the environment that is suffering. Now, if these autos are economical in gas, there should be no doubt to market these alternative fuel vehicles to consumers easily.

In *Question No. 4*, it confirms that the knowledge of people in alternative fuel vehicles is very low. Here we see that only 7% people think that they are knowledgeable in this type of vehicles, which is a very low number of people. And the number of people that do not almost know anything about it is 40%. *(Figure A.4)* People who think they know just a little bit about the alternative fuel vehicles selected the next category "4" which was 20%. And even a little bit less than that chose the category"3" which was again another 20% of them. Here these results only confirm that people knowledge in this area of field is very limited and there is a lot of room for advancement. In the Electric Vehicle Consumer survey of 1999 a similar question was asked regarding people's knowledge in Electric vehicles. The response was almost very similar because it showed that 60% people almost had no knowledge about Electric Vehicles and a very low 5% people only had some knowledge about the Electric Vehicles out there.[20]

In *Question No. 5*, here 40% people responded by saying that electricity is the most economical fuel. Also another 40% responded by saying that natural gas is the most fuel-efficient alternative fuel out there other than gasoline. *(Figure A.5)* Here it shows that people even with basic knowledge can come to a conclusion that electric vehicles are the most economical vehicles. I could only think of one reason why 40% people think that natural gas is an economical fuel among the others because they see all these natural gas and propane powered taxicabs all over Toronto out there. It has to be economical otherwise the taxicab drivers would not be driving these types of alternative fuel vehicles.

In *Question No. 6*, here also 40% people responded by saying that electricity is the most environmentally friendly alternative fuel out there compared to others. The next one that my respondents think is the most environmentally friendly is Natural gas, 27% people think that. *(Figure A.6)* Therefore it again shows that people even with basic knowledge can come to a conclusion that electric vehicles are the most environmentally friendly vehicles along with natural gas compared to the conventional gasoline powered vehicles. The other thing that is most interesting in

this response is that only 3% people think that gasoline is still the most environmentally friendly fuel out there. *(Figure A.6)* That is a very low number. I am sure that people only because of their lack of knowledge in this field can make that comment.

In *Question No. 7*, the thirty people that were surveyed 21 (70%) of them responded by saying that they would pay more for a vehicle that had the same benefits that a conventional vehicle had to offer and if that vehicle was more environmentally friendly. It's a positive sign because it shows that people care about their environment that they live in and are willing to sacrifice some money to achieve that. It is also to note that 9 (30%) people said that they are not going to pay more to purchase a most expensive vehicle even though it offered all the benefits that a regular conventional vehicle had to offer. Probably the question should be more specific that how much more do they have to pay for this type of vehicle. Probably that's why the 30% people were not willing to pay more. Only if the question were more specific by saying how much more then probably more people would have said yes to this answer.

In the Electric Vehicle Consumer Survey of 1999 a much similar question was asked if people were willing to pay more for an Electric Vehicle, and 52% responded by saying that they would pay $1,000 or more extra, another 18% said that they would pay $2,000 or more and 7% responded by saying that they would not pay anything extra.[20] When compared to my survey, it shows less people are willing to pay more for the extra cost. Here the number increases probably because in my survey it doesn't say how much the extra cost might be. So people without knowing what the additional cost might be are skeptical on making a commitment.[20]

In *Question No. 8*, the thirty people that were surveyed 27 (90%) of them responded by saying that they would pay more for a vehicle that had the same benefits that a conventional vehicle had to offer and if that vehicle gave better gas mileage they would purchase that vehicle. *(Figure A.8)* Here it seems that people are willing to pay more because they see savings of gasoline, which will in return pay off for the extra cost for the alternative fuel vehicle. People are very concerned with the amount of money that they have to spend on gasoline. Here in this question the response confirms that because they see a savings from the gas mileage they are willing to pay more for the type of vehicle at front.

In *Question No. 9* the thirty people that were asked this question 11 said that they had at one point in time seen an ad in the newspaper, which is almost 37% of them. The only thing that is very positive in my survey is that all thirty of them at some point in time have seen a commercial, which was promoting alternative fuel vehicle. It seems like the media is so far doing a good job in promoting them Also 43% said that they have seen an ad in the TV. If the media continues to play a role in promoting these types of vehicles it will not only persuade consumers to purchase these vehicles and save the environment, in return they can also benefit from better mileage, etc. Even though the media is playing a role in promoting these vehicles there need to be more coverage in the future.

In the 1999 Electric Vehicle Consumer Survey a similar question was asked regarding Electric Vehicle Survey. And the Question was" Have you seen media covering Electric Vehicles in the past 12 months", and the response was 44% said "No" and 56% had said "Yes".[20] Therefore there is always room for improvement for the media to promote alternative fuel vehicles.

In *Question No. 10*, here 70% people out of the thirty that were surveyed responded by saying that the government is not doing a good job in offering incentives to consumers of alternative fuel vehicles. *(Figure A.10)* Consumers are clearly concerned about their environment as we saw in the previous answers and they feel that government should take financial steps to encourage the growth of clean alternative fuel vehicles. It shows that a large number of people wants to do something about our environment if there is government support by tax incentives, rebate checks, etc. Almost three quarter of the people are saying that there is not enough government support. Therefore our government needs to come forward and take a positive stand in promoting these vehicles.

In *Question No. 11*, here 93% people are willing to sacrifice a little bit of money for the research and development of cleaner vehicles. *(Figure A.11)* This shows that consumers do support the environment to be cleaner in which they live in by paying a little from their pocket.

Comparing with the 1999 Electric Vehicle Consumer survey it shows that people are still eager to pay more for saving the environment Also in that survey the people supported in majority in saving the environment by responding to a similar question in 84% in favor of it. Here there is an increase in the results in my survey in people willingness to pay a little extra for the alternative fuel to save the environment. It went from 84% to 93% [20]

In *Question No. 12*, it is very encouraging to know that even if people had to refuel their vehicles twice as much, they are still willing to go that extra hassle to save the environment by lower emissions. 63% people are willing to do that and 37% are not. *(Figure A.12)* Therefore there are a big number of people it shows that are environmentally conscious.

Conclusion

Canada is facing an unprecedented environmental challenge today with climate change and the ever-increasing release of green house gases. Ethanol blended gasoline's are high performance gasoline's that are good for your car, competitively priced and they offer additional benefit of being environmentally friendlier than conventional gasoline's. Ethanol is widely accepted as the most environmentally friendly fuel available today. It reduces GHGs and other harmful pollutants while providing important value-added markets for grain at a time when commodity prices are at an all time low. Ethanol blended gasoline's help reduce emissions of carbon monoxide by up to 30%. Ethanol blended gasoline's are certified to meet Canadian General Standards Board (CGSB) specifications – a requirement of the Province of Ontario. Also as the ethanol industry continues to grow, its impact on the economy will be felt in variety of areas, such as at the local level, farmers will see new markets for grain while the government will benefit from the increased tax revenue. As the government has committed itself to increase production by 750 million litres per year, its estimated impact on the economy will be significant.

Vehicles powered by such fuels as electricity, natural gas/propane, and alcohol etc. will also reduce petroleum usage and could improve urban air quality. Alternative fuel vehicles (AFVs) differ from gasoline vehicles in terms of cost (purchase price and fuel cost) and, in terms of such attributes as vehicle range between refueling, fuel availability and convenience of refueling, operating performance, reliability, and interior space.

The natural gas industry has an enormous impact on the Canadian economy, by employing over 55,000 people directly and providing about $13 billion in economic benefits. Because there is an abundance of natural gas here in Canada, its price and assured supply are not threatened by offshore events that are very unpredictable. On top of that by purchasing natural gas, one's dollar stays in Canada where it belongs and help support our country's economy and secure jobs for Canadians. Nowadays lots of our school buses are using natural gas all across the country. Also Canada Post's natural gas vehicles reflect the government's commitment to incorporating alternative fuels into its fleet. Other types of vehicles, such as ice resurfacing equipment, forklifts, heavy duty trucks and transit buses are also all becoming more popular in Canada.

The anticipated growth in world energy demand will greatly influence transportation fuel prices and alternative fuel options in the coming century. Alternative fuels can provide real economic savings to consumers and business and at the same time deliver significant environmental benefits. Fuel savings of 30% to 45% over gasoline are possible with natural gas and propane fuels. With these levels of savings, the incremental cost to acquire a natural gas or propane vehicle can often be repaid in two years or less. Methanol fuel is marketed at a price approximately equal to gasoline on an energy-equivalent basis. All of the alternative fuels offer air quality benefits and

some have the additional advantage of producing less greenhouse gas emissions compared to conventional fuel vehicles.

Although alternative fuels are being serious consideration for tackling the global warming and other environmental issues related to passenger transportation, it seems clear that currently available options are applicable mainly for a few selected scenarios rather than on a global scale, and even then primarily for local air pollution issues only.

Beyond alternative fuels, a number of additional options (such as increasing the efficiency within a given mode of transportation, and switching to more efficient modes) are presently available to policy-makers that could serve as tools to effectively tackle the greenhouse emissions problem from automobiles. Most of these options do not suffer from any major technological constraints, and very importantly, also offer the possibility of ameliorating other problems (such as local air pollution, traffic congestion, high-cost per passenger mile, and inefficient resource utilization) related to personal automobile use. It is this potential to simultaneously deal with the many facets of transportation–related issues that makes these choices particularly interesting and useful.

Automakers and researchers will continue to develop and improve on the transportation technologies I have discussed. They're exploring better ways to use fuel cells, alternative fuels, and EV and HEV systems. They are also working on new ways to store energy, and creating lightweight advanced materials to make vehicles that run cleaner and use less fuel.

In addition to the technologies available now, researchers across the United States and Canada are developing new advanced technologies for use in cars, minivans, pickup trucks, sport utility vehicles, buses, and heavy-duty trucks-that will steer us toward an even cleaner future with more available, domestic fuel resources.

Recommendations

After working on my project following are my recommendations: Giving more incentives/subsidies to people using alternative fuel vehicles. Because the more incentives that are available out there, the more people are going to be encouraged to use it. By making the refueling sites more abundant in number is going to be more convenient. It is very important to have numbers of refueling stations in order for it to be successful. Also by giving tax rebate to the fuelling stations having alternate fuels is an idea that will have a very positive outcome. Media should play an adequate role in brain storming the people to use alternative fuel vehicles, because that is also their responsibility in doing so. Information about refueling sites locations should be assisted by the Government. It should be made mandatory for taxicabs to be operated on alternate fuels (specially abundant in our country). Recently TTC has ordered for 127 hybrid electric vehicles, which is a very positive thing towards the right direction for our City. Similarly more money should be put into bring more vehicles in other parts of the country too. Additionally more money is also needed for the research in this field for sustainable transportation and a better future.

The future might look pretty scary if nothing drastic isn't done at the present time. Throughout the report I not only stop by talking about the problems that might occur if the pollution rate is not decreased, I also talk about the solutions that are available out there and what we all can contribute by working together, the public along with the government to save our world from the disaster that is eminent if nothing is done about it. This is a problem that just wouldn't go away by avoiding it or by forgetting about it. Therefore, it is in the best interest for people to learn to the best of their knowledge regarding the ways of how we can get around this eminent disaster in future and come up with solutions. One being, reducing pollution in the transportation sector by introducing more and more alternative fuel vehicles out there.

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Appendix

Survey in Alternative Fuel Vehicle Awareness

1. Do you know or have you ever heard about alternative fuel vehicles?

   a) Yes
   b) No

2. If you have, have you ever seen one?

   a) Yes
   b) No

3. Are you concerned about the outdoor air pollution due to vehicles?

   a) Yes
   b) No

4. If you have heard or seen an alternative fuel vehicle, how much do you think your knowledge is on a scale from 1 to 5?
   1 – being an expert and 5 – not knowing very much about it.

   (a) 1 (b) 2 (c) 3 (d) 4 (e) 5

5. If you were given the choices below which do you think is the best alternative fuel out there regarding its fuel economy?

   a) Gasoline
   b) Ethanol
   c) Natural Gas
   d) Methanol
   e) Electricity
   f) Hydrogen

6. If you were given the choices below which do you think is the best alternative fuel out there regarding its environmental benefits?

   a) Gasoline
   b) Ethanol
   c) Natural Gas
   d) Methanol
   e) Electricity
   f) Hydrogen

7. Are you willing to pay more for a vehicle that is environmentally friendly and has almost or very close to all the benefits of a current gasoline powered vehicle?

   a) Yes
   b) No

8. Are you willing to pay more for a vehicle that is better in gas mileage and has almost or very close to all the benefits of a current gasoline powered vehicle?

   a) Yes
   b) No

9. Have you seen any of the following media advertising alternative fuel vehicles in order to promote it?

   a) Newspapers
   b) Magazines
   c) TV
   d) Radio

10. Do you think our Government is doing a good job to promote alternative fuel vehicles out there, by offering enough incentives to individuals who are purchasing it?

    a) Yes
    b) No

11. Are you willing to pay a little more for your gasoline if the extra money was to be used to achieve cleaner vehicles in Canada?

    a) Yes
    b) No

12. If you had to refuel your vehicle twice as often in order to reduce vehicle emissions are you willing to do so?

    a) Yes
    b) No

Question 1.

Do you know or have you ever heard about alternative fuel vehicles?
a) Yes b) No

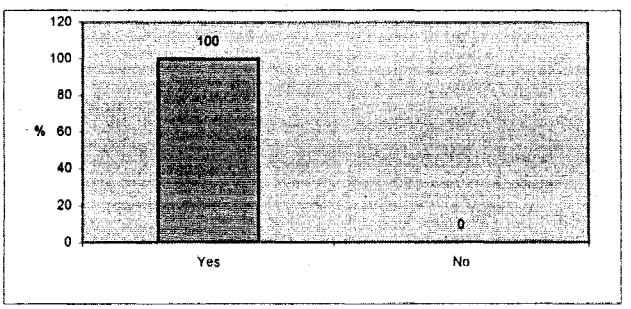

Figure A.1 Results for Survey Question No. 1

	Count	Percent
Yes	30	100
No	0	0
Total	30	100

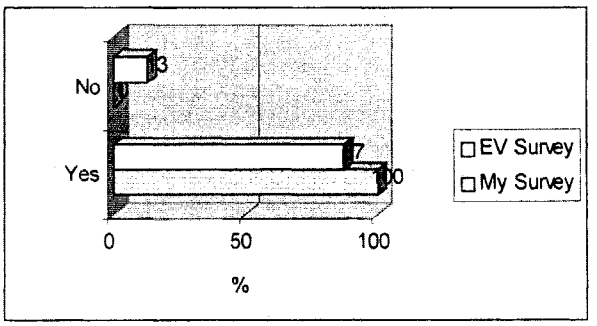

Figure A.1a Comparison Chart between My Survey and EV Survey

Conclusion: Thirty (100%) out of thirty people said that they had heard about alternative fuel vehicles. This number is quite encouraging because that's everyone that knows or somehow heard that there are alternative choices out there. Canada being a country of immigrants, where there are lots of people coming from the third world country each year, to me this is a very encouraging figure that people are actually aware that there are other types of options other than gasoline out there. Because people are already aware that there are options out there it is our duty to let them know of the various options and their benefits us being transportation professionals.

Compared to the Electrical Vehicle (EV) Consumer Survey in 1999 there was a very similar question, " *Have you ever heard of electric vehicles*". The response was that 87% had and the remainder 13% never heard about electric vehicles.[20] (*Figure A.1a*) From the comparison chart we can see that the number of people that have heard about AFVs has increased from 87% to 100%. In my survey the results are more promising because it shows that people now in the year 2004 are more aware about vehicle fuel choices and its availability out there. My question was more general therefore the response is more positive than the more specific question of people hearing about electric vehicles only. Like I said earlier they have heard about alternative fuel vehicles, therefore it is the duty of the people in this industry to try to tell them about the different choices and the most benefits that it has to offer.

Question 2.

If you have, have you ever seen one?
a) Yes b) No

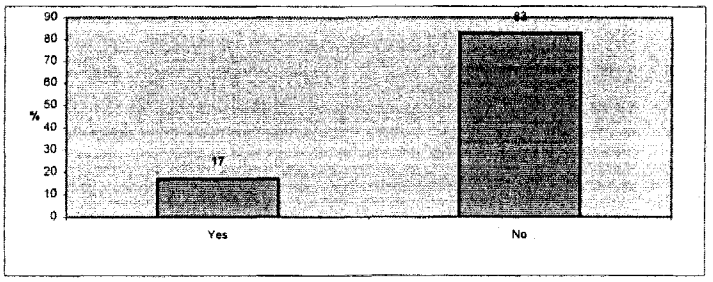

Figure A.2 Results for Survey Question No. 2

	Count	Percent
Yes	5	17
No	25	83
Total	30	100

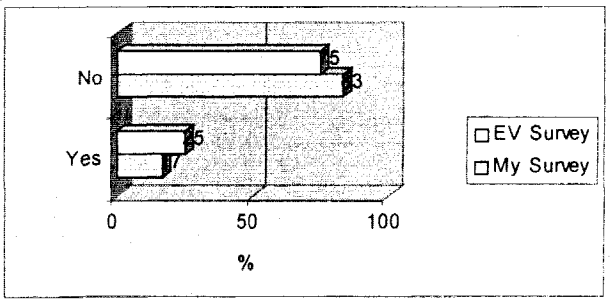

Fig A.2 a Comparison Chart between My Survey and EV Survey

Conclusion: Out of the thirty people that were asked this question 5 (17%) people said "yes" and the other 25 (83%) people said that "no" that they have never seen an alternative fuel vehicle out there. Here these numbers are very alarming because people know that they are out there but they just haven't seen one. This is very damaging to the public because they will forget about it and will also not be able to know of how it looks and be able to compare the looks from a conventional gasoline-powered vehicle. It will always remain a mystery for the public unless they are able to actually see it. It is therefore very important to have these types of vehicles out on the road as many as possible and also to come up with ways to make them noticeable. By having more and more alternative vehicles out there public's confidence will grow when they actually see the vehicle running on the road.

A similar question *"Have you ever seen an electric vehicle"* was asked in the survey in the Electric Vehicle (EV) Consumer Survey of 1999". The response was that 75% of the people had not seen electric vehicles.[20] Compared to my survey there is an increase of people that haven't seen AFVs. Also in my survey the question was in general about any AFVs and in the EV Survey about Electric Vehicles. Therefore the answer for being "*no*" which has increased is also because the question is more specific in the EV Survey. It seems like the automakers are not doing a very good job in promoting alternative fuel vehicles, especially in commercials, auto shows etc. where they could promote these types of vehicles.

Question 3.

Are you concerned about the outdoor air pollution due to vehicles?
a) Yes b) No

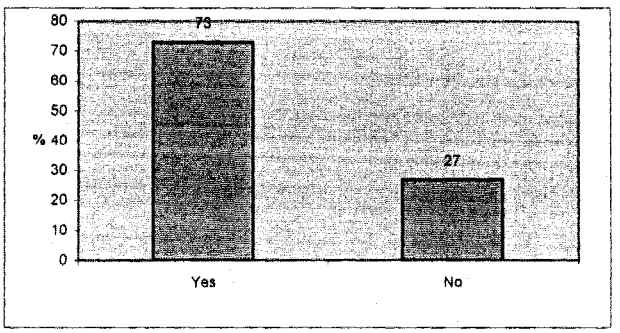

Figure A.3 Results for Survey Question No. 3

	Count	Percent
Yes	22	73
No	8	27
Total	30	100

Conclusion: 22(73%) out of 30 people here said that they were concerned about the environmental pollution created due to vehicles out there. This figure (73%) is a very encouraging number. It tells us that almost three quarter of the population are aware that the environment out there is polluted my the emissions that are coming out from these transportation fuels of vehicles.

The other 27% people that are not aware about the outdoor air pollution due to vehicles tells us that there is more for transportation professionals to do out there. To make these people aware of the dangerous consequences and pollution that are caused due to the emissions from gasoline fuel vehicles.

The almost three quarter of the people who are concerned about the environmental pollution is a positive sign for automakers to market the environmentally friendly vehicles because it tells us that the public are already aware of the environment that is suffering. Now, if these autos are economical in gas, there should be no doubt to market these alternative fuel vehicles to consumers easily.

Question 4.

If you have heard or seen an alternative fuel vehicle, how much do you think your knowledge is on a scale from 1 to 5?

1 – being an expert and 5 – not knowing very much about it.

(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

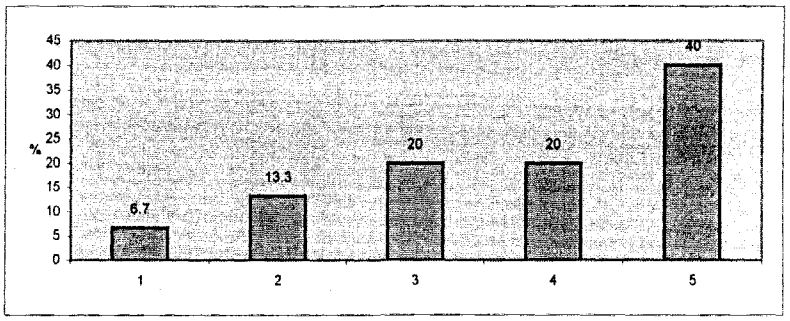

Figure A.4 Results for Survey Question No. 4

	Count	Percent
1	2	6.7
2	4	13.3
3	6	20
4	6	20
5	12	40
Total	30	100

Conclusion: This question confirms that the knowledge of people in alternative fuel vehicles is very low. Here we see that only 7% people think that they are knowledgeable in this type of vehicles, which is a very low number of people. And the number of people that do not almost know anything about it is 40%. People who think they know just a little bit about the alternative fuel vehicles selected the next category "4" which was 20%. And even a little bit less than that chose the category"3" which was again another 20% of them. Here these results only confirm that people knowledge in this area of field is very limited and there is a lot of room for advancement.

In the Electric Vehicle Consumer survey of 1999 a similar question was asked regarding people's knowledge in Electric vehicles. The response was almost very similar because it showed that 60% people almost had no knowledge about Electric Vehicles and a very low 5% people only had some knowledge about the Electric Vehicles out there.[20]

Question 5.

If you were given the choices below which do you think is the best alternative fuel out there regarding its fuel economy?

a) Gasoline; b) Ethanol; c) Natural Gas; d) Methanol ; e) Electricity; f) Hydrogen

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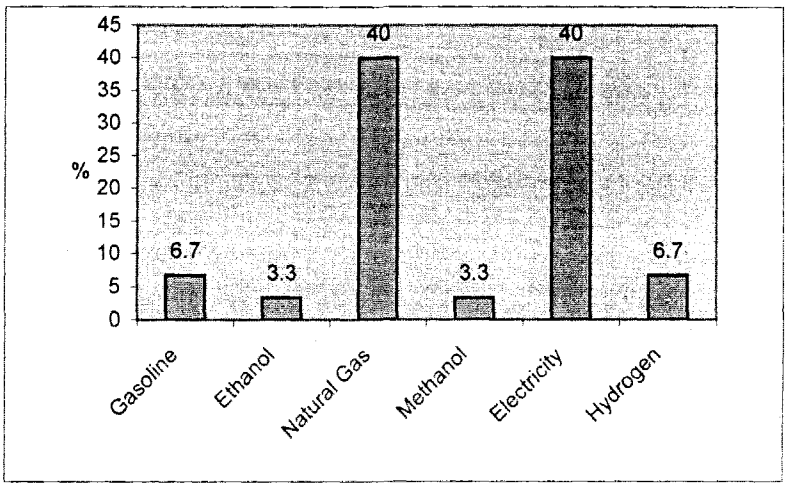

Figure A.5 Results for Survey Question No. 5

	Count	Percent
Gasoline	2	6.7
Ethanol	1	3.3
Natural Gas	12	40
Methanol	1	3.3
Electricity	12	40
Hydrogen	2	6.7
Total	30	100

Conclusion: Here 40% people responded by saying that electricity is the most economical fuel. Also another 40% responded by saying that natural gas is the most fuel-efficient alternative fuel out there other than gasoline. Here it shows that people even with basic knowledge can come to a conclusion that electric vehicles are the most economical vehicles. I could only think of one reason why 40% people think that natural gas is an economical fuel among the others because they see all these natural gas and propane powered taxicabs all over Toronto out there. It has to be economical otherwise the taxicab drivers would not be driving these types of alternative fuel vehicles.

Question 6.

If you were given the choices below, which do you think is the best alternative fuel out there regarding its environmental benefits?

a) Gasoline; b) Ethanol; c) Natural Gas; d) Methanol; e) Electricity; f) Hydrogen

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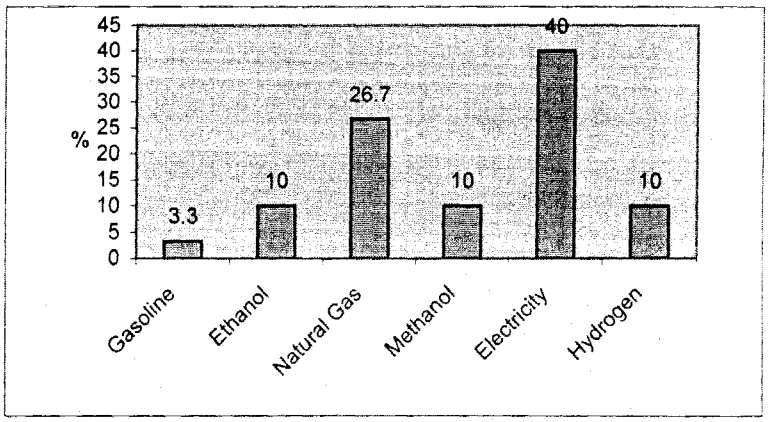

Figure A.6 Results for Survey Question No. 6

	Count	Percent
Gasoline	1	3.3
Ethanol	3	10
Natural Gas	8	26.7
Methanol	3	10
Electricity	12	40
Hydrogen	3	10
Total	30	100

Conclusion: Here also 40% people responded by saying that electricity is the most environmentally friendly alternative fuel out there compared to others. The next one that my respondents think is the most environmentally friendly is Natural gas, 27% people think that. Therefore it again shows that people even with basic knowledge can come to a conclusion that electric vehicles are the most environmentally friendly vehicles along with natural gas compared to the conventional gasoline powered vehicles. The other thing that is most interesting in this response is that only 3% people think that gasoline is still the most environmentally friendly fuel out there. That is a very low number. I am sure that people only because of their lack of knowledge in this field can make that comment.

Question 7.

Are you willing to pay more for a vehicle that is environmentally friendly and has almost or very close to all the benefits of a current gasoline powered vehicle?

a) Yes b) No

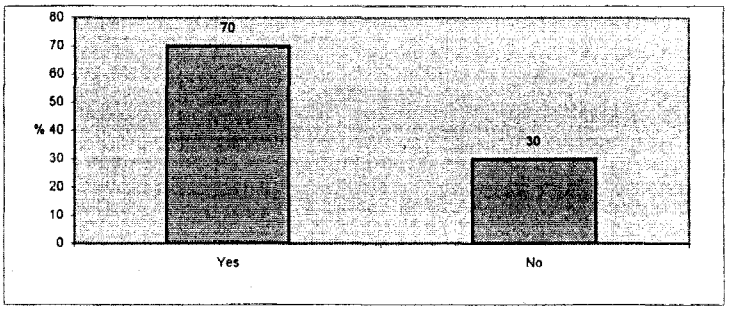

Figure A.7 Results for Survey Question No. 7

	Count	Percent
Yes	21	70
No	9	30
Total	30	100

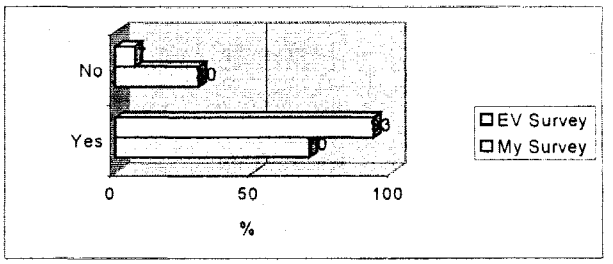

Figure A.7a Comparison Chart between My Survey and EV Survey

Conclusion: The thirty people that were surveyed 21 (70%) of them responded by saying that they would pay more for a vehicle that had the same benefits that a conventional vehicle had to offer and if that vehicle was more environmentally friendly. It's a positive sign because it shows that people care about their environment that they live in and are willing to sacrifice some money to achieve that. It is also to note that 9 (30%) people said that they are not going to pay more to purchase a most expensive vehicle even though it offered all the benefits that a regular conventional vehicle had to offer. Probably the question should be more specific that how much more do they have to pay for this type of vehicle. Probably that's why the 30% people were not willing to pay more. Only if the question were more specific by saying how much more then probably more people would have said yes to this answer.

In the Electric Vehicle Consumer Survey of 1999 a much similar question was asked if people were willing to pay more for an Electric Vehicle? 52% responded by saying that they would pay $1,000 or more extra, another 18% said that they would pay $2,000 or more and 7% responded by saying that they would not pay anything extra.[20] Comparing it with my survey, here we see that less people are willing to pay more for the extra cost. Here the number increases probably because in my survey it doesn't say how much the extra cost might be. So people without knowing what the additional cost will be, are skeptical on making a commitment.

Question 8.

Are you willing to pay more for a vehicle that is better in gas mileage and has almost or very close to all the benefits of a current gasoline powered vehicle?

a) Yes
b) No

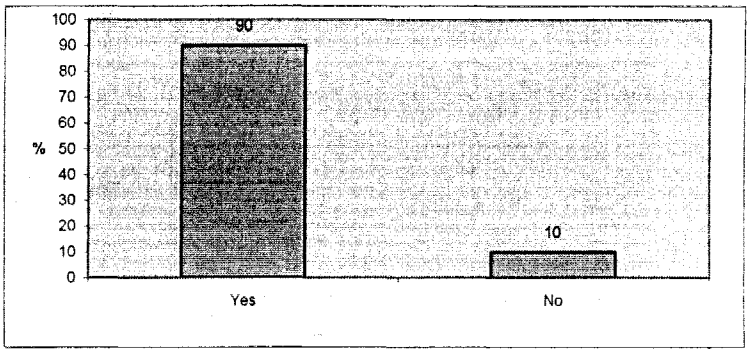

Figure A.8 Results for Survey Question 8

	Count	Percent
Yes	27	90
No	3	10
Total	30	100

Conclusion: The thirty people that were surveyed 27 (90%) of them responded by saying that they would pay more for a vehicle that had the same benefits that a conventional vehicle had to offer and if that vehicle gave better gas mileage they would purchase that vehicle. Here it seems that people are willing to pay more because they see a savings of gasoline which will in return pay off for the extra cost for the alternative fuel vehicle. People are very concerned with the amount of money that they have to spend on gasoline. Here in this question the response confirms that because they see a savings from the gas mileage they are willing to pay more for the type of vehicle at front.

Question 9.

Have you seen any of the following media advertising alternative fuel vehicles in order to promote it?

a) Newspapers
b) Magazines
c) TV
d) Radio

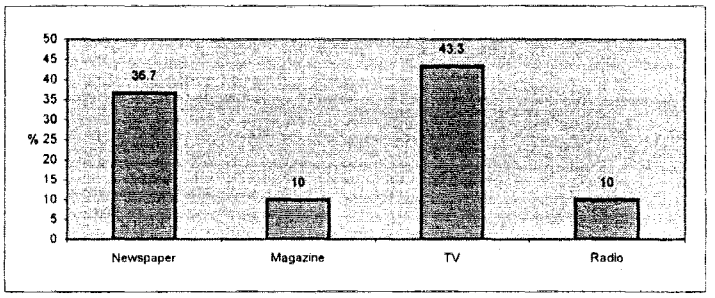

Figure A.9 Results for Survey Question No. 9

	Count	Percent
Newspaper	11	36.7
Magazine	3	10
TV	13	43.3
Radio	3	10
Total	30	100

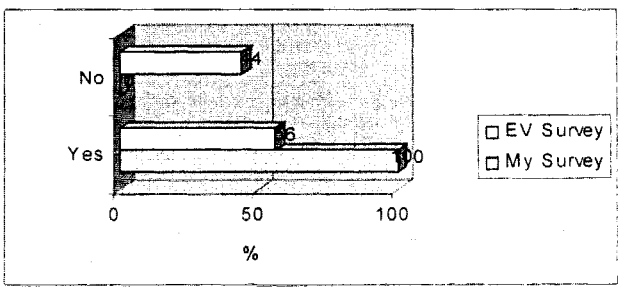

Figure A.9a Comparison Chart between My Survey and EV Survey

Conclusion: In this question the thirty people that were asked this question 11 said that they had at one point in time seen an ad in the newspaper, which is almost 37% of them. The only thing that is very positive in my survey is that all thirty of them at some point in time have seen a commercial, which was promoting alternative fuel vehicle. It seems like the media is so far doing a good job in promoting them Also 43% said that they have seen an ad in the TV. If the media continues to play a role in promoting these type of vehicles it will not only persuade consumers to purchase these vehicle and save the environment, in return they can also benefit from better mileage, etc. Even though the media is playing a role in promoting these vehicles there need to be more coverage in the future.

In the 1999 Electric Vehicle Consumer Survey a similar question was asked regarding Electric Vehicle Survey. The Question was" Have you seen media covering Electric Vehicles in the past 12 months?" The response was 44% said "No" and 56% had said "Yes".[20] Therefore there is always room for improvement for the media to promote alternative fuel vehicles.

Question 10.

Do you think our Government is doing a good job to promote alternative fuel vehicles out there, by offering enough incentives to individuals who are purchasing it?

a) Yes
b) No

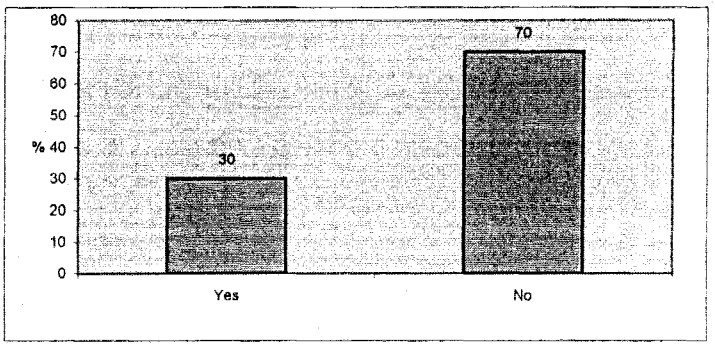

Figure A.10 Results for Survey Question No. 10

	Count	Percent
Yes	9	30
No	21	70
Total	30	100

Conclusion: Here 70% people out of the thirty that were surveyed responded by saying that the government is not doing a good job in offering incentives to consumers of alternative fuel vehicles. Consumers are clearly concerned about their environment as we saw in the previous answers and they feel that government should take financial steps to encourage the growth of clean alternative fuel vehicles. It shows that a large number of people wants to do something about our environment if there is government support by tax incentives, rebate checks, etc. Almost three quarter of the people are saying that there is not enough government support. Therefore our government needs to come forward and take a positive stand in promoting these vehicles.

Question 11.

Are you willing to pay a little more for your gasoline if the extra money was to be used to achieve cleaner vehicles in Canada?

a) Yes
b) No

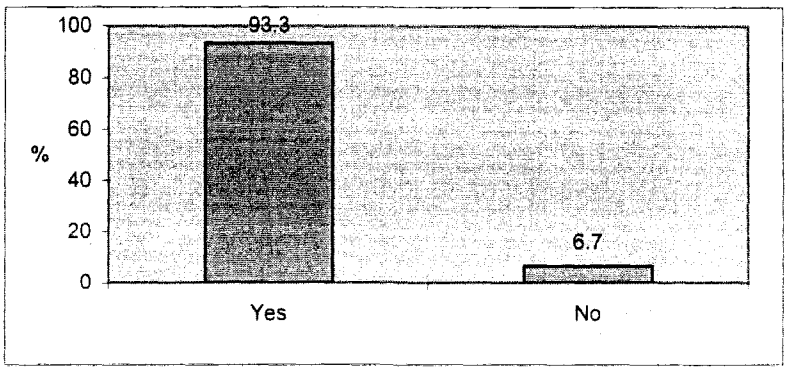

Figure A.11Results for Survey Question No. 11

	Count	Percent
Yes	28	93.3
No	2	6.7
Total	30	100

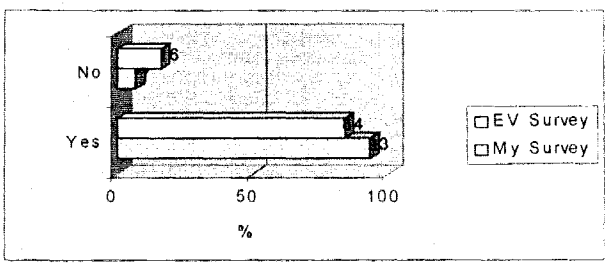

Figure A.11a Comparison Chart between My Survey and EV Survey

Conclusion: Here 93% people are willing to sacrifice a little bit of money for the research and development of cleaner vehicles. This shows that consumers do support the environment to be cleaner in which they live in by paying a little from their pocket.

Comparing with the 1999 Electric Vehicle Consumer survey it shows that people are still eager to pay more for saving the environment Also in that survey the people supported in majority in saving the environment by responding to a similar question in 84% in favor of it. Here there is an increase in the results in my survey in people willingness to pay a little extra for the alternative fuel to save the environment. It went from 84% to 93% [20]

Question 12.

If you had to refuel your vehicle twice as often in order to reduce vehicle emissions are you willing to do so?

a) Yes b) No

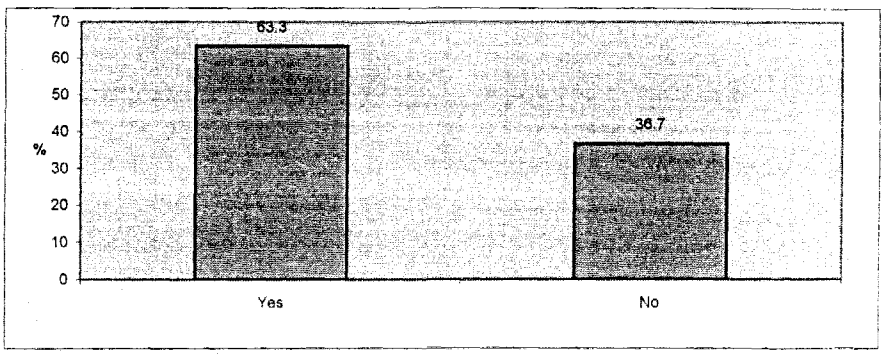

Figure A.12 Results for Survey Question No. 12

	Count	Percent
Yes	19	63.3
No	11	36.7
Total	30	100

Conclusion: It is very encouraging to know that even if people had to refuel their vehicles twice as much, they are still willing to go that extra hassle to save the environment by lower emissions. 63% people are willing to do that and 37% are not. Therefore there are a big number of people it shows that are environmentally conscious.

For more information one can go to the following links:

A few websites regarding Alternative Fuel Vehicles:

American Coalition for Ethanol	www.ethanol.org
American Methanol Institute	www.methanol.org
American Gas Association	www.aga.org
Canadian Natural Gas Vehicle Alliance	www.ngvcanada.org
Canadian Renewable Fuels Association	www.greenfuels.org
California Energy Commission	www.energy.ca.gov
Clean Cities Hotline	www.ccities.doe.gov
Electric Vehicle Society of Canada (EVS)	www.evsociety.com
Electric Drive Transportation Association	www.evaa.org
Environmental Defense Canada	www.edcanada.org
Energy Information Administration	www.eia.doe.gov
FuelMaker Corporation	www.fuelmaker.com
Ford Motor Company	www.fleet.ford.com
Ford Motor Company Canada	www.fleet.ford.ca
LNG Express	www.lngexpress.com
National Alternative Fuels Hotline	www.afdc.doe.gov
Natural Resources Canada	www.oee.nrcan.gc.ca
National Ethanol Vehicle Coalition	www.e85fuel.com
National Gas Vehicle Coalition	www.nvvc.org
National Propane Gas Association	www.propanegas.com
National Alternative Fuels Training	www.naftp.nrcce.wvu.edu
Propane Vehicle Council	www.propanegas.com/vehicle
Renewable Fuels Association	www.ethanolRFA.org
U.S. Clean Car Campaign	www.cleancarcampaign.org

A National (U.S.) Alternative Fuels Hotline:

In the U.S. one can call toll free in between the hours of 9 am and 6 pm to get information regarding Alternative Fuels at 1(800) 423-1363 if calling from the U.S. and also if one is an international caller they can call 1(703) 934-3069. The Hotline can also be contacted by e-mail at hotline@afdc.nrel.gov.

Newsletters & Magazines Regarding Alternative Fuel Vehicles:

If a person is willing to know more about AFVs they can go to some of the following newsletters and magazines. There are lots of them that are absolutely free of cost.

AltFuels Advisor
Alternative Fuel Price Report
Alternative Fuel News
Biodiesel Bulletin
Biofuels News
Biobased Products and Bioenergy Newsletter
Clean Fuels Forum
Clean Fuels Report
Conservation Update
DOE Pulse
Electric Vehicle Progress
eNEWS
ECO
e-FFICIENCY NEWS
Electrifying Times
E85 FYI
EREN Network News
Ethanol Report
Fleets & Fuels
Fuel Cell Technology Update
FuelSense
Fuel Cells Today
Green Car Journal
Hybrid Vehicles
Inside the Greenhouse
LNG Express
Natural Gas Fuels
NGV Worldwide
New Fuels & Vehicles Report
Propane Vehicle
Trans Forum and Future Drive
Transportation Times
World Natural Gas Vehicles