THE FEASIBILITY OF BIOFUEL IMPLEMENTATION IN DALHOUSIE UNIVERSITY OPERATIONS

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ABSTRACT

Vehicle fleet statistics, surveys, interviews, and a review of current research were used to assess the feasibility of using biofuels (particularly biodiesel) in Dalhousie University's current vehicle fleet. Economic and environmental considerations were examined by calculating Dalhousie vehicles' current fuel consumption and associated emissions production and comparing these to predicted figures using diesel and a 20% biodiesel mixture. Social considerations were examined by surveying Dalhousie students to assess their understanding and attitudes to biofuel use at Dalhousie, while interviews and associated research contribute to understanding the technical considerations of biofuel use. While Dalhousie is poorly positioned to implement biofuels due to its total reliance on gasoline powered vehicles, the potential economic, social, and environment benefits shown here are compelling and could be gradual incorporated into Dalhousie operations.

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1.0 – INTRODUCTION

1.1 - Background Information

The world currently faces very serious problems surrounding the supply and use of energy resources. Whether it is for producing electricity, powering a vehicle or heating a home, the wide use of non-renewable fossil fuels has had a negative impact on the environment and has created political and social unease. Canada is both a large producer and consumer of fossil fuels, producing 2.4 million bbl/day of oil and consuming 2.3 million bbl/day in 2004 (World Factbook, 2006). Although this level of consumption appears to match production, Canada imports about 1 million bbl/day of oil and exports about 1.6 million bbl/day, due in part to the transportation challenges of being the world's second largest nation (World Factbook, 2006). Because Canada imports about 45% of its oil, there is a strong dependence on production in other countries and a vulnerability to international price fluctuations.

Although this issue of dependence on foreign oil is important, it is not the only problem. Fossil fuels resources can only be renewed over a long geological time scale, meaning that if and when the oil reserves on earth have been completely depleted, there will not be any more for millions of years. While total depletion of these resources is not expected in the near future the continuing rise in demand, particularly among rapidly developing nations such as China and India, is beginning to stretch existing supplies and raise oil prices worldwide.

These problems of dependence associated with fossil fuels tend to only relate to human interests. However, the past and current use of fossil fuels has impacted the natural environment in many significant ways. Air pollution and the mass transfer of

carbon from the ground into the atmosphere are among the largest concerns. Any problem with the environment can also be seen as a problem for humans, who depend on the natural world for everything. Worldwide attention is beginning to be paid to these problems, and initiatives like the Kyoto Protocol, which sets targets for international carbon emissions, are among the responses developed to address these issues.

The use of fossil fuels has caused many problems, and use by different sectors has had various levels of impact. Transportation accounts for a large portion of all fossil fuels used in the world. As people drive around more and more in cars and trucks, they are consuming a non-renewable resource and contributing to the air pollution locally as well as globally. However, transportation has become an essential aspect of our lives and our work and is in most cases unavoidable. Even an institute like Dalhousie University must have a fleet of vehicles running every day to maintain university operations. This is a fairly small scale of activity compared to a city or a country, but the cumulative effects of many small-scale uses of fossil fuels have contributed enormously to problems outlined above.

1.2 - Research Problem

Reducing dependence on a non-renewable energy source that is often imported and subject to price changes is an important step in gaining energy security and independence. Such objectives are pertinent to all sectors of energy use, and in terms of transportation would ensure that the flow of goods and people around the world is uninterrupted. This is an important goal for Canada, but it can also be applied on a smaller scale. If Dalhousie University were to gain energy independence and security,

then its operational vehicle fleet would be able to run problem-free well into the future. The environmental impact of energy use in transportation must also be addressed. In combination with shifting from non-renewable resources, decreasing the effects of energy use on the environment is essential to becoming sustainable energy consumers. On a national scale, Canada would like to reduce carbon emissions to meet their Kyoto responsibilities. On a small scale, Dalhousie University could reduce its impact on the atmosphere in the Halifax area and hopefully become a more sustainable institution.

Alternative fuel sources, such a biodiesel, present the best opportunity to address the problems outlined above. Biodiesel is a renewable resource that can be produced locally and can be used to power diesel engines in motor vehicles (Biodiesel, 2006). Emissions reductions can also be achieved when using biodiesel, making it a more environmentally sustainable fuel source (Biodiesel, 2006). Although biodiesel presents an opportunity to solve problems, there is also the problem that many people are not aware of its existence and its potential benefits. Awareness of alternative fuels must be established before it they can be put into wide use and begin have a positive impact.

1.3 - Biodiesel

Biodiesel is a fully renewable energy resource that is made from natural oils found in plants or animals, containing no petroleum products (Biodiesel, 2006). It can be added to regular diesel fuel at various mixture ratios and then used in a regular diesel engine (Biodiesel, 2006). The production of biodiesel is depicted in figure 1.1 that follows.

Figure 1.1 – Biodiesel Production

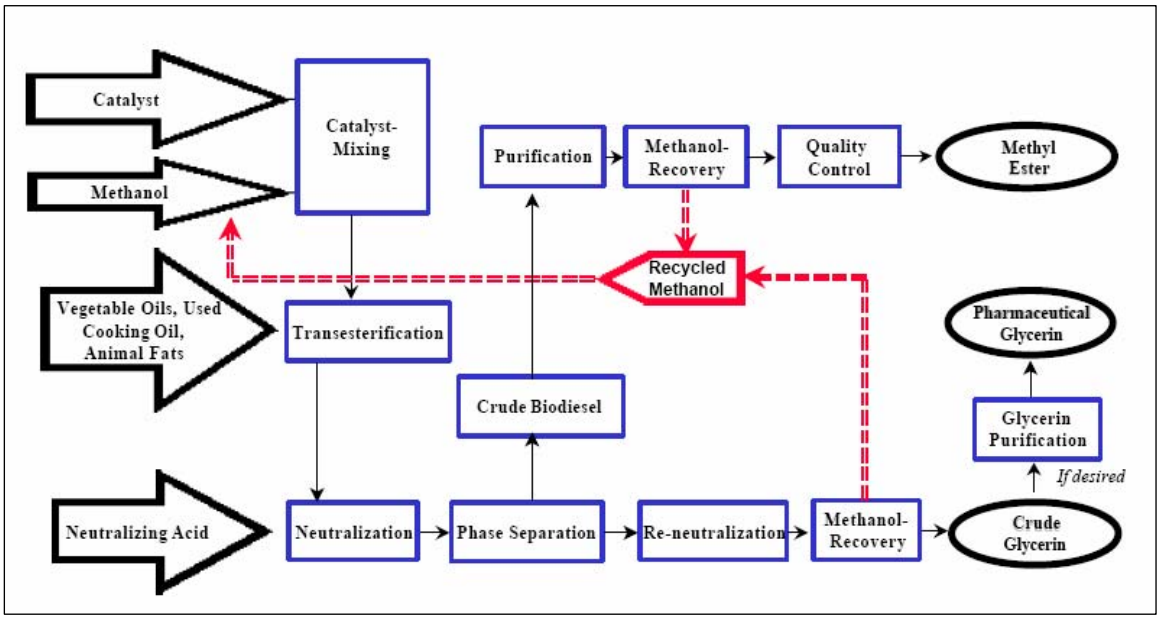

Figure 1.1 – The biodiesel production process is outlined as a flow chart. From Biodiesel, 2006.

Biodiesel is produced by mixing a fat or oil with an alcohol in the presence of a catalyst, which creates glycerin and methyl esters. The methyl esters are what are known as biodiesel (Biodiesel, 2006). When biodiesel is used in a mixture with regular diesel fuel there is almost no difference in power, there is increased lubricity and there are usually significant reductions in different types of emissions (Biodiesel, 2006). There can be some problems with clouding in colder temperatures, which can clog the fuel lines (Biodiesel, 2006).

1.4 - Literature Review

There has been a significant body of research surrounding the production and use of alternative fuels, and many projects specifically studying biodiesel. Some of the largest organizations that research and support biodiesel are Biodiesel Canada, Canada

Renewable Fuels Association, the National Biodiesel Board on the United States, the U.S. Department of Energy, Pacific Biodiesel in Hawaii and many other research and corporate institutions. These sources provide a wealth of information on the technical and environmental costs and benefits of producing and using biodiesel, while performing the valuable service of expanding awareness of alternative fuels.

There have also been projects that assess the use of biodiesel for transportation needs. The University of British Columbia has an ongoing project to create a sustainable supply of biodiesel that can be used locally for transportation needs (The Biodiesel Project, 2006). The Halifax Regional Municipality has also adopted a biodiesel project where the fuel is used as a 20% mixture with regular diesel to power all of the public transit buses in the municipality; a project hat has enjoyed much success (Buses and Ferries, 2006). There was also a similar project with public buses in the city of Montreal.

Though many of these projects provide useful information, the fact that biodiesel is a relatively new fuel source means that there are no long run observations of the costs and benefits of using biodiesel. This may be an unavoidable problem when dealing with new technologies, but it does pose a problem when attempting to measure the long term effects of biodiesel.

1.5 - Research Questions and Objectives

The main question in this study is: What is feasibility of using biodiesel as a fuel source for the Dalhousie University vehicle fleet? In order to answer this central question, there are many smaller questions that address the different aspects of the research problem. This study first examines if using biodiesel is technically possible for Dalhousie

vehicles. Then, the economic costs and benefits of using biodiesel in the vehicle fleet are computed and compared to current cost. Environmental benefits and costs will be measured in terms of using biodiesel compared to regular fuel. The effects on the university community and the Halifax community of using biodiesel will also be examined. A mixture of quantitative and qualitative analysis will be used to answer these questions and reach conclusions.

1.6 - Importance of the study

This study is significant for several reasons. First, it is an attempt to find a way to reduce the environmental impact of Dalhousie University through its use of energy for transportation. Second, it adds to the body of research in the area of alternative fuels, and for biodiesel in particular. Third, conclusions from this study can be applied to other universities and similar institutions that wish to become more sustainable. Finally, it can provide more information for the community and will hopefully contribute to the growth of alternative fuel use in Halifax.

1.7 - Purpose Statement

The purpose of this study is to assess the feasibility of using biodiesel for all transportation vehicles that are owned and operated by Dalhousie University. Overall feasibility will be assessed through examining the technical, economic, environmental and social costs and benefits of using biodiesel at Dalhousie.

2.0 – METHODS

2.1 – Vehicle Fleet

Various Dalhousie University Departments were contacted requesting information on their vehicle operations, eventually providing us with a listing of the vehicles owned and operated by Dalhousie University, their age, engine type, and kilometers traveled. Table 2.1 shows the vehicle information obtained. This formed the basis for subsequent fuel consumption and greenhouse gas (GHG) production vital to assessing the feasibility of implementing biodiesel at Dalhousie from an environmental, economic, and technical standpoint.

Based on these collected data vehicle annual mileage was estimated assuming that all vehicles were purchased the year prior to their model year (a 2004 would be purchased in 2003, as vehicle model years generally precede calendar years) and that all kilometers were traveled equally during its time of service. Using the mileage data annual fuel consumption and annual carbon dioxide (CO2), carbon monoxide (CO), Nitrous oxide (NOx) hydrocarbons/volatile organic compounds (HC/VOCs) and sulphur dioxide (SO2) were calculated. While the individual characteristics of each type of emission will not be discusses here these compounds are strongly believed to degrade local air quality and contribute to acid rain production the greenhouse effect, making them climate change threats as well as threats to human health and the environment in some cases.

Table 2.1 – Vehicle Fleet Specifications

Make/Model	Model Yr.	Fuel Type	Odometer Kms.	Division
Chev. 2500 3/4 ton Van	2004	gas	17,154	Mail Services
Chev. 2500 3/4 ton Van	2004	gas	20,213	Library Truck
Chev. 2500 3/4 ton Van	2004	gas	12,022	Custodial Serv.
GMC Savanna Van	2004	gas	40,851	Security
Chev. Impala	2005	gas	41,315	Security
Chev. 1500 1/2 ton Pick-up	1995	gas	39,050	Trades/Custod.
Chev. Silverado 1500 1/2 t P/U	2005	gas	13,128	Grounds Serv.
Dodge Ram 1500 1/2 t P/U	1999	gas	80,059	Grounds Serv.
Dodge Ram 1500 1/2 t P/U	2003	gas	30,891	Grounds Serv.
Dodge Ram 2500 3/4 t P/U	2003	gas	57,485	Trades Group
Ford 150 1/2 ton P/U	1994	gas	171,718	Trades Group
Ford F700 3 ton	1995	gas	80,959	Recycling
Ford F150 1/2 t P/U w box *	1996	gas	165,514	Trades Group
Ford F350 Cube Van	1999	gas	115,183	Grounds Serv.
Ford F450 Cube Van	2004	gas	64,933	Trucking Moves

Table 2.1 – Dalhousie University's vehicle fleet, including age, engine type, kilometers traveled to date and the division who operates the vehicle.

Fuel consumption for each vehicle was calculated from the U.S. EPA fuel consumption database (US EPA, 2006) or estimated based on the closest available vehicle of similar class. Annual emissions production was estimated from annual fuel consumption using figures (normally per km emissions various types) from the U.S. EPA and several EU nations. SO2 was calculated based on the sulphur content in fuel

produced in Halifax by Imperial Oil (Imperial Oil, 2006), with complete conversion of sulphur into SO2 assumed. For each vehicle these calculations were repeated for the same mileage on an equivalent diesel engine, and repeated again assuming a 20% biodiesel fuel mixture. Annual fuel cost was also calculated each fuel type based on consumption and cost of that fuel type. Costs are based on typical fuel costs in Halifax for the week of March 21st 2006 (N.S. Department of Energy, 2006). Comparison of some emissions (notably VOC/HC) may be less accurate due to the variety of emissions production figures available and the need to use European sources for many diesel emission calculations and North American sources for gasoline emissions. Others (CO2, SO2, and CO) are believed to be more accurate, assuming complete combustion of the fuel being burned.

2.2 – Dalhousie Survey

Surveying was used to gauge the social impact of using biodiesel at Dalhousie. We attempted to gain a better understanding of the current knowledge about biofuels within the Dalhousie population and whether their use would be looked on favorably. It was determined that the ideal sample size for the survey would have been 540 people to have produced confidence level of 95% and a margin of error of five percent. Due to time constraints our sample size of the survey was limited to 100 respondents. “Simple Random” collection was used, where each and every person in the population has equal probability of being chosen for the sample. The surveys were conducted for one week (excluding weekends) two times a day, (8-9 am, 12-1 pm) in front of the Student Union Building.

Surveys were self administered and collected in the winter days of March. The temperature on most days was below 0 degrees Celsius or very close to it. The surveyors approached the students, introduced themselves, and asked the students to participate on a voluntary basis in the biofuels survey. After all of the survey data was collected, it was then tallied and put into tables and charts. A copy of the survey is included in Appendix 1.

2.3 - Interview

An Interview with Dave Ronn from the *Maritime Biodiesel Co-op* was required to supplement some of the data collected from the surveys. This was necessary to gain a deeper understanding of the problem at hand and possible benefits of implementation. The interview was of an informal nature and was approximately 20 minutes. The date, time and place for the interview was established at the convenience of Mr. Ronn. See Appendix 2 for a copy of interview questions.

3.0 – RESULTS

3.1 – Vehicle Fleet Statistics

Initial calculations revealed that diesel is particularly attractive with regards to fuel consumption. As a somewhat higher energy fuel, savings of up to 30% are sometimes possible as compared to an equivalent gasoline engine (Louisiana DNR, 2006). As diesel fuel in N.S. is generally equivalent or slightly lower in price than regular gasoline (N.S. Department of Energy, 2006) significant cost savings can be achieved by using diesel or biodiesel powered vehicles, as shown in table 3.1.

Table 3.1 - Fuel Consumption and cost

	Fuel Consumption (L/year)	Fuel Cost (March 21st 2006 prices in Halifax)
Gasoline	29600	$ 31,624
Diesel	22199	$ 22,998
Biodiesel (20% mix)	22100	$ 22,321

Table 3.1 – Total fuel consumption and associated cost (based on Halifax gas prices for the week of March 21st, 2006 from the Nova Scotia Department of Energy, 2006). Gasoline consumption is based on individual vehicle mileage figures provided by Dalhousie University, while diesel figures are based on an average 25% fuel saving for equivalent diesel engines (Louisiana Department of Natural Resources, 2005, Bankrate.org, 2006). Lower fuel consumption for a 20% biodiesel mixture reflects the lack of lower-energy constituents in biodiesel (Biodiesel, 2006).

While diesel fuel may create more emissions than gasoline on a litre to litre basis the reduction in fuel required for the same mileage using a diesel engine can greatly improve GHG emissions. A 20% biodiesel mixture also reduces emissions of HC/VOC and CO as compared to regular diesel, though it may increase NOx slightly and produces the same amount of CO2, as shown in table 3.2. Uncertainty is greatest in calculations of sulphur emissions, which depend on the sulphur content of the fuel being burned.

Biodiesel may be advantageous if it comes from a sulphur-free source. As mentioned in section 2.1 the HC/VOC calculations may be exaggerated owing to discrepancies between emissions figures gathered from around the world, potentially inflating the improvement seen between diesel/biodiesel and gasoline. The improvement from diesel to biodiesel, however, should be accurate.

Table 3.2 - Total Emissions (Kg/year)

	CO2	NOx	SO2	HC/VOC	CO
Gasoline	65,089	207	1.78	241	367
Diesel	58,384	190	11.10	43	129
Biodiesel	Diesel Equivalent	194	Source Dependant	34	115

Table 3.2 – Various emission types (in Kg/year) for the three fuel types. Diesel shows reduced emissions in every category except for sulphur emissions, which depend on the quality of the fuel. Biodiesel is equivalent or superior to diesel with the exception of slightly increased NOx. Sulphur content of biodiesel depends on fuel source, and may be superior to diesel if made from plant material or may have increased sulphur content from other sources (such as used cooking oil).

An breakdown of the percentage change in fuel consumption, fuel cost, and emissions production is provided in table 3.3. This clearly indicates that a vehicle fleet operating on biodiesel would provide considerable cost savings and would provide positive environmental benefits, with the possible exception of sulphur dioxide production.

Table 3.3 - Effects of conversion from gasoline to biodiesel (% change)

CO2	-10
NOx	- 6.3
SO2	~+500
HC	-86
CO	-67
Fuel Consumption	-25
Fuel Cost	-30

Table 3.3 – Percentage changes in fuel consumption, fuel cost, and emissions between gasoline and biodiesel are compared here. Sulphur production may increase substantially (reflecting the sulphur content guidelines for Canadian gasoline and diesel fuel, not engine performance) while overall fuel consumption and other emissions are reduced, in some cases quite substantially.

3.2 – Survey Results

Survey results indicate that 66% of the total population interviewed claim some awareness of biofuels. The survey revealed that university esteem would rise in the eyes of 61% of the student surveyed after the implementation of biofuels; however, only 50% said it would marginally affect their choice of universities, if given. Moreover, 46% revealed that they would consider using biofuels in their personal vehicle, following Dalhousie's successful implementation. Figure 3.1 charts the responses to the survey questions found in appendix 1. These results suggest that biofuel on use would be socially favorable, but response was somewhat mixed.

Figure 3.1 – Survey Results

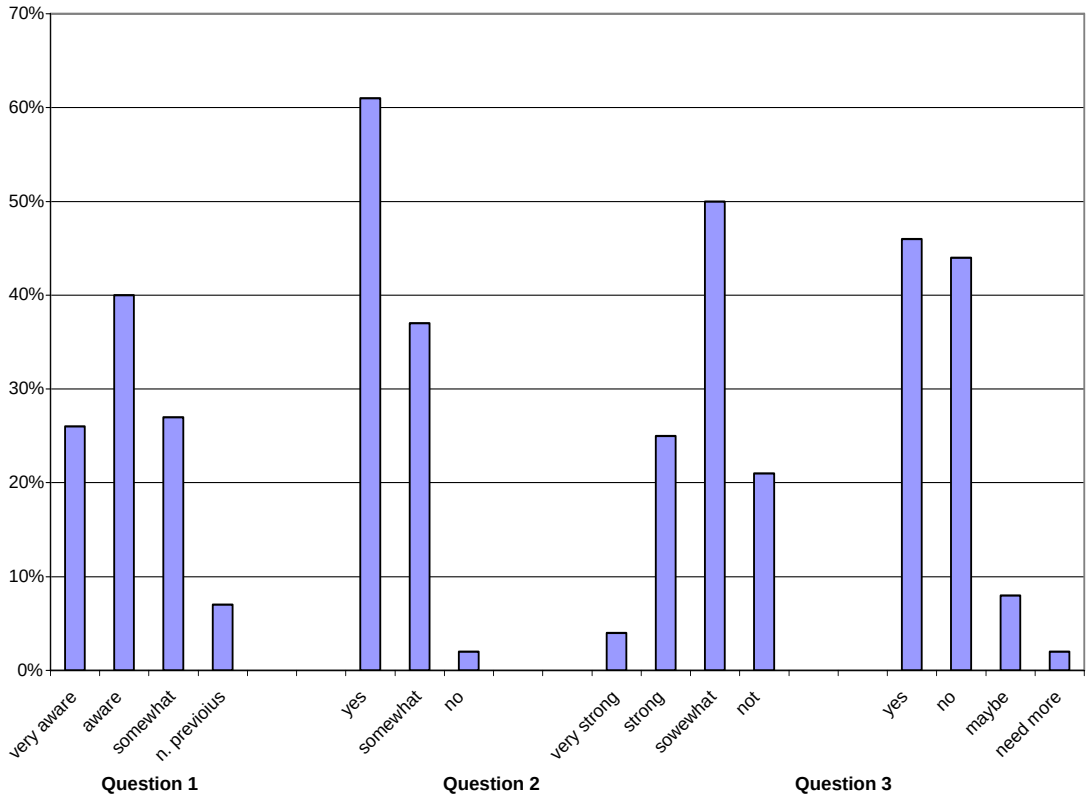

Figure 3.1 – Responses for each survey question. Question 1 asked if respondents were aware of any benefits of using biofuels. Question 2 asked if respondents would look more favorably on Dalhousie if it implemented biofuels, while question 3 asked if this would affect there choice of a university. Question 4 inquired if respondents would be more likely to use biofuels in there person vehicle if Dalhousie successfully implemented their use on campus.

In doing surveys, the time it took some participants to reply to some questions varied from person to person. The costs associated with producing surveys may also be an obstacle, especially if more participants are interviewed. Sometimes it was difficult to get people to participate in the survey. In the morning many people were either on their way to write midterms or were late for class and therefore did not have time to answer

questions. For our purposes, surveys were advantageous in that they reach a large percentage of the population within a short period of time. They also provide opportunity for additional thoughts and explanations which otherwise may not have been considered. The one-week time restriction allocated for data collection purposes was sufficient for our purposes but not for an intensive study.

3.3 - Interview

Dave Ronn, co-founder of the *Maritime Biodiesel Co-op*, was interviewed in his NSPIRG office on Monday March 20, 2006. The primary topic discussed was technical feasibility as we were interested to see if this project could be implemented if many of the cars on campus ran on gasoline. Moreover, for the diesel engines, we were interested in the compatibility of biodiesel in a conventional diesel engine and any existing repercussions. Mr. Ronn claimed that using biodiesel in a diesel engine was highly feasible; however, the correct proportion of biodiesel to diesel must be determined to prevent clogs. Mr. Ronn did mention the gelling property of biodiesel in that it freezes at a much higher temperature than conventional diesel, which is a discouraging property of the fuel since Halifax experiences such long winters.

When asked about the economic feasibility of implementation, Mr. Ronn explained that the reason biodiesel (from Wilson's Fuel) was more expensive than conventional fuel was because the government presently offers no subsidies for production. In fact, Wilson's Fuels makes almost zero profit from biodiesel, which may cause them to stop all production of the fuel in the future. When asked about the overall feasibility of biodiesel Mr. Ronn explained that it was by no means a final solution. He

explained that a successful initiative would have to be coupled with a decrease in consumption of fuel; specifically a decrease in the amount driving. Mr. Ronn expressed environmental concern with large-scale production, in that cultivation would not be carbon neutral. He recommended that a biofuel-based economy should be medium scale, in that the fuel would be locally produced using waste oil from fryers in city restaurants. Interview questions and responses are found in appendix 2.

3.4 – Additional Technical Considerations

While there are several technical implications in switching to biodiesel the most significant consideration is that no Dalhousie University Vehicles are currently diesel powered. Addressing issues such as an appropriate fuel source, the effect on vehicle warranties and cold weather operation of biodiesel are relevant to an eventual implementations but the current lack of even a single diesel vehicle to use as a test-bed poses a major hurdle in any attempt implement biofuels in Dalhousie operations.

4.0 - DISCUSSION AND CONCLUSIONS

4.1 – Discussion

In light of recent attention regarding the increased use and demand for energy, our research becomes important in finding new and alternative ways of living in a more sustainable way. Using biofuel is one way to decrease emissions down and to raise awareness of energy issues. Having examined the costs and benefits of using biofuels on campus in any machinery that was compatible with this type of fuel.

Significant findings include the fact that Dalhousie does not operate any diesel vehicles. Two rented two Tiger Patrol vans are the only diesel engines used on campus, and no current rental agreement allows for biodiesel to be used. Despite this significant limitation we also found that purchasing and implementing biofuel would cost considerably less than regular gasoline. Diesel engines also generally have longer useful lives (Bankrate.org, 2006) making the use of diesel vehicles on campus a very cost-effective option for Dalhousie decision makers to consider.

Environmentally, it was found that using biofuel instead of regular gasoline decreased the rates of virtually all emissions. It is most noticeable for the HC/VOC and CO emission numbers, but is also true for CO2 emissions and NOx emissions. These emissions reductions would allow Dalhousie to present a positive example to the community of Halifax and show a commitment to working toward a more sustainable campus. This would also aid in Canada's effort to meet Kyoto targets while improving local air quality.

Survey results indicated that a general awareness of biofuels exists within the Dalhousie community, though continued education and experience with biofuels may encourage individuals to consider more sustainable transportation options, such as biofuels. Dalhousie departments may be far more inclined to implement biofuels if awareness and support within the student and faculty increases.

4.2 – Additional Steps

While a lack of diesel vehicles is a major hurdle, there are a variety of other steps that can be taken to reduce emissions and lower fuel costs on campus. These include setting up a no idling policy on campus, switching to hybrid vehicles, and decreasing fleet size. Another feasibility assessment would be required to fully explore these, but many options are available to individuals and institutions that wish to take steps to reduce transportation emissions. Efforts like these are relatively simple and can make a significant impact when considering a multi-vehicle fleet as used by Dalhousie.

Implementation of biofuels on campus remains a possibility, but would require a long-term plan. Gradually replacing existing vehicles (when they would naturally be phased out) with equivalent diesel vehicles would begin reducing fuel costs and emissions. Oils used in cooking food on campus could actually be used and recycled to produce biofuel, this would keep all production local and eliminate the need for purchasing it commercially. This would require a small chemistry lab and individuals willing to work to produce biodiesel to mix for campus uses, as is operation at the University of British Columbia (The Biodiesel Project, 2006).

4.2 – Conclusions

Further research is needed if Dalhousie were to implement the use of biofuels on campus. This is important because the desire and education about alternate sources of energy needs to be increased. Also, due to the lack of diesel engines on campus and other reasons discussed throughout the study, the implementation of biofuels is not currently feasible. But the economical, social, and environmental aspects are favorable enough to consider adopting some policies that might make this possible in the future. Feasibility in this case rests with individuals willing to take an interest and push for implementation of a biofuels program. All of the obstacles noted here can be overcome with enough interest and support, but these ideas must be championed by someone in a decision-making capacity before they are likely to see any level of implementation.

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APPENDIX 1

SURVEY

Dalhousie University Biofuel Assessment Project

This questionnaire is being issued as part of a project to test the feasibility of using biofuels and other hybrid technology for Dalhousie University campus vehicles and maintenance equipment. Specifically, the questions below attempt to measure any possible impacts such an initiative would have on the community and the community's views about both the University and alternative fuel sources.

Please answer the questions below to the best of your ability. Your name is required, and the answers to these questions will be kept confidential. If you have any additional comments, please use the section at the bottom of the sheet. Thank you for your participation.

Please circle your answer to each question.

1. Are you aware of the environmental benefits including emissions reduction that can be achieved by using fully renewable biofuels as an additive to the fuel used in motor vehicles?

Very aware Aware Somewhat No previous knowledge

2. As a member of the Halifax community, would you have a more favourable opinion of Dalhousie University if it used biofuels or other alternatives energy schemes in campus vehicles and maintenance equipment?

YES Somewhat NO

3. If you had to choose between attending one of two seemingly identical universities, to what degree would the knowledge that one of the universities used biofuels as a part of a "greening the campus" initiative influence you final decision?

Very strongly Strongly Somewhat Not at all

4. Thinking hypothetically, if you owned a motor vehicle and knew that Dalhousie had successfully implemented an alternative fuels system for campus vehicles and equipment, would that encourage you to try alternative fuels for your own vehicle?

YES NO Maybe Need more information

APPENDIX 2

INTERVIEW

1. The long term compatibility of biofuels in diesel engines is still unknown. While many advocates suggest that biofuels are compatible with these engines, the long term effects are still unclear and could potentially hamper the engine.

Considering this uncertainty, do you feel that the use of biofuels would be **technically** feasible for campus engines?

2. Currently, only diesel engines are compatible with biofuels. While it is possible to change current gas engines to diesel ones, this can be a very labourious and costly process for the university. According to local mechanics, a new engine plus labour cost is quite expensive. Presently all the vehicles (except one rented can) on campus run on gas, all of which would have to be switched.

Considering these factors, do you think that switching campus vehicles that currently run on gas to ones that run on diesel is **economically** feasible?

3.While it may not be directly economically advantageous to implement biofuels on campus there may be many secondary benefits that would be created. Please evaluate the feasibility of each.

a. If Dalhousie implemented biofuels, university image may be affected increasing its esteem in the eyes of other Canadian universities as well as Canadian high school graduates: an economic benefit that may far surpass the initial costs.

b. Since Dalhousie is such a well respected institute in the HRM, if they implemented biofuels in their fleet, many individuals may follow suit for their own automobile, broadening the environmental benefits of the broader Halifax community.

c. Due to an increase in demand for biofuels, a window of new business opportunity may arise, strengthening the Halifax and broader Nova Scotian economy.

4. The cost of biodiesel is approximately _____/litre compared to _____/litre of gas. Economically speaking, given this high cost of biodiesel, do you think that secondary benefits of implementing biofuels would outweigh these costs?

5. While our project is specifically evaluating biofuels, there are many **alternatives** that may have similar environmental benefits at a lesser cost to the university.
From the list below, can you explore the practical and economic feasibility of each?

- Decreasing fleet size
- route length
- stop idling of tiger patrol vans
- encourage the purchase of electric cars to replace conventional automobiles
- vehicles with better fuel efficiency,

6.Many pieces of literature have expressed environmental concerns with biofuels. Some agree that producing biofuels is not carbon neutral, in that during harvesting procedures, more carbon is released into the atmosphere than is absorbed by the crop. A second criticism is that producing biofuels is not environmentally sustainable. Since one crop is harvested constantly, the land will soon be exhausted and left barren. Moreover, excess amounts of land would be used to cultivate mass amount of biofuels- land which could be better used to cultivate crops that people could eat.

Given your knowledge of biofuels cultivations, do you have any environmental concerns regarding the use and/or harvesting of biofuels?