# APSC 261 Sustainability Project: An Investigation into Triple bottom Line Assessment of Sustainable Transport Options

**Alimzhan Adilbayev, Arwinder Jaspal, Robert Halas, Sittinon Sukhaya**

**University of British Columbia**

**APSC 261**

**November 22, 2012**

# APSC 261 Sustainability Project:

## An Investigation into Triple bottom Line Assessment of Sustainable Transport Options

Alimzhan Adilbayev
Arwinder Jaspal
Robert Halas
Sittinon Sukhaya

Course instructor: Dr. Carla Paterson
Tutorial instructor: Mr. Faizal Karim
Date of submission: November 22, 2012

## Abstract

The UBC farm is in need of buying a pickup truck to continue its daily operations, since the current one is quite old. UBC farm representative Véronik Campbell asked the APSC 261 students to carry out research on the best potential type truck that is currently on the market.

This report presents a triple-bottom line assessment on some of the types of trucks that can be used. During the research 3 types of trucks have been of a particular interest: combustion engine with a biodiesel option, hybrid and electric. This report also considers using a truck from a car co-op. Taking into account the economical, environmental and social impacts, it was suggested that the best choice would be buying an electric truck (Might-E Truck) for UBC Farm.  The economical impact analyses the price of a vehicle, fuel and maintenance costs. The environmental impact analysis highlights factors such as GHG emissions and air pollutions. The social impact mainly addresses the health issues due to the air pollution produced by the trucks.

# Contents

# List of Figures

## Glossary

| | |
|---|---|
| Carbon Monoxide | A product from the incomplete combustion |
| Differential Pricing | Method in which a product/service has different prices based on the type of customer, quantity ordered, delivery time, payment terms, etc. Also known as discriminatory pricing, multiple pricing or tiered pricing. |
| Electric Vehicle | Automobile that is propelled by one or more electric motors, using electrical energy stored in batteries or another energy storage device |
| Energy Density | An amount of energy stored in a given system or region of space per unit volume. |
| Greenhouse Gases | Gases in an atmosphere that absorbs and emits radiation within the thermal infrared range |
| Nitrogen Oxides | A binary compound of oxygen and nitrogen |
| Tailpipe Emissions | Emissions resulting from engine operations that exit through a vehicle's tailpipe system |

# List of Abbreviations

| | |
|---|---|
| B100 | 100% Biodiesel |
| B20 | 20% Biodiesel and 80% Diesel |
| CEV | Clean Energy Vehicle |
| CH4 | Methane |
| CO | Carbon Monoxide |
| CO2 | Carbon Dioxide |
| Co-op | Cooperative |
| EV | Electric Vehicle |
| GHG | Greenhouse Gas Emissions |
| GMC | General Motors Company |
| HEV | Hybrid Electric Vehicle |
| ICEV | Internal Combustion Engine Vehicle |
| kWh | Kilowatt-Power |
| UBC | University of British Columbia |
| UCS | Union of Concerned Scientists |

# 1.0 Introduction

The UBC Farm needs a truck, which will be used about 3 times a week to carry vegetables and fruits that are produced on the farm. The current truck is old and needs to be replaced by a truck that will have a better performance and will be in line with the triple bottom line assessment. Extensive research through journals, books and car dealership websites has been done to find out what the best solution would be. When choosing a truck the economical component was a prime factor. A wide range of specifications were compared to find the best price, quality, service and innovation. A comparison on 3 types of vehicles was carried out which were: combustion engine with biodiesel option, hybrid and electric. Véronik Campbell, a stakeholder of the UBC Farm, set the specifications of the truck, which our team strived to exceed. Environmental impact was taken heavily into account, since the University of British Columbia strives to be a pioneer in green technology.

## 2.0 Combustion Engine Vehicle

Biodiesel is a clean burning alternative fuel, which is produced from assorted lipids such as vegetable oil. Pure Biodiesel contains no petroleum (B100, 100% biodiesel), however it can be blended with petroleum-derived diesel. These blended biodiesel are commonly blended at the ratio of 20:80 (20% biodiesel and 80% diesel) and are usually called B20. Biodiesel can be used in common diesel combustion engines with no modifications. Almost all vehicles manufactured after 1978 are compatible with biodiesel, however, biodiesel that has higher concentrations than B20 will require seals and hoses with a material that is biodiesel resistant (such as Teflon or Viton) when used for an extended period of time. A low temperature, biodiesel can become gel like any diesel fuel, however, the gel point for 100% biodiesel is higher than petrol diesel. B100 is not recommend to be used below 5 degrees. B20 is a better alternative when used in cold weather since it behaves almost identical to petroleum diesel. Biodiesel is simple to use, biodegradable, nontoxic, and a renewable energy source. It emits fewer pollutants into the atmosphere which makes it a more eco-friendly alternative to diesel.

## 2.1 Economical Impacts

The main factor that is used to determine the most economical type of fuel is it price. The price per unit energy of the various fuels are analyzed and compared as shown in Figure 1 below:

**Figure 1:** Price per unit energy of Diesel, B20 and B100

| Fuel Type | Unit Price ($/L) | Energy density (kWh/L) | Price per unit energy ($/kWh) |
|---|---|---|---|
| Diesel | 3.45 | 10.118 | 0.341 |
| B 20 | 3.50 | 10.055 | 0.348 |
| B100 | 4.05 | 9.771 | 0.414 |

Source: Unit Price obtained from http://www.afdc.energy.gov/afdc/pdfs/afpr_jan_11.pdf
Energy density obtained from table

As shown in the table above, the price per unit energy of B100 is the highest followed by B20 and finally, diesel. It is important to consider that the price of the biodiesel is largely associated with the price of feedstock, which contributes up to 80% of the total cost. As a result, if the price of feedstock goes down, the price of biodiesel will go down as well.

## 2.1.1 Biodiesel Production at UBC

The UBC Sustainability Club started the production of biodiesel on campus in 2002. This has reduced the amount of discarded waste vegetable oil as well as Plant Operations vehicle emissions to varying degrees. However, biodiesel production has been limited to 500L per year due to lack of funding, and most of this is used by UBC Plant Operations. As a result, it is unlikely for UBC farm to have biodiesel that is produced at UBC in the near future.

## 2.2 Environmental Impacts

GHGs (Green House Gases) are gases in the atmosphere that absorb and emit radiation within the thermal infrared range. In other words, GHGs allow the radiation from the sun to pass through the atmosphere, but prevent it from exiting. This results in the world slowing heating up causing the phenomenon known as “ Global warming”. Global warming is predicted to trigger increasing heat waves, flooding, and frequent and violent storms. Carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) are the primary greenhouse gases in the Earth's atmosphere. Emissions resulting from diesel, B20 and B100 are examined over the entire life cycle, which includes the downstream and upstream emissions by Natural Resources Canada (NrCan). The findings of this study are shown in Figure 2 below.

**Figure 2:** Lifecycle of GHG and non-GHG emissions

| | Diesel Fuel (grams/mile) | B20 (grams/mile) | B100 (grams/mile) |
|---|---|---|---|
| **GHGs** | | | |
| $CO_2$ | 2180.2 | 1870.4 | 588.3 |
| $CH_4$ | 4.906 | 4.418 | 2.408 |
| $N_2O$ | 0.094 | -0.202 | -1.443 |
| Total $CO_2$ Equiv. | 2312.4 | 1900.5 | 191.4 |
| **Non-GHGs** | | | |
| CFCs+HFCs | 0.003 | 0.003 | 0.003 |
| CO | 20.448 | 17.738 | 5.232 |
| $NO_x$ | 25.292 | 27.833 | 25.976 |
| VOC ozone weighted | 2.206 | 2.023 | 1.595 |
| $SO_x$ | 1.305 | 1.240 | 0.746 |
| PM | 1.278 | 1.232 | 0.777 |

Source: (Levelton Engineering, 2002)

As shown in the table, there is a consistent reduction trend showing that a higher content of biodiesel emits less GHG and non-GHG over their carbon lifecycle (with the exception of NOx gases).

## 2.3 Social Impacts

Emissions from combustion engine contain hazardous air pollutants and toxic air contaminants such as carbon monoxide (CO), Sulphur (SOx), Particulate matter (PM), and Polycyclic aromatic hydrocarbon(PAH) / NPAH. These pollutants and contaminants are significant threats to human health and wellness. For example, carbon monoxide (CO) inhibits the blood's capacity to carry oxygen. This may lead to the termination of oxygen supply to vital organs such as the heart and brain, which in turn causes chest pain. Particulate matter (PM) can cause irritation of airways, coughing and difficulty in breathing, it also decreases lung function and causes bronchitis. Biodiesel exhaust emissions have significantly lower amount of hazardous air pollutants and toxic air contaminants when compared to diesel exhaust emissions. Figure 3 below shows the reduction of hazardous air pollutants in percentage of B20 and B100 relative to diesel fuel.

**Figure 3:** Comparison of hazardous chemical substances

| Chemical substances | B100 | B20 |
|---|---|---|
| Carbon monoxide(CO) | 48% reduction | 10% reduction |
| Polycyclic aromatic hydrocarbons(PAH) | 80% reduction | 13% reduction |
| Nitrated PAH(NPAH) | 90% reduction | 50% reduction |
| Particulate matter(PM) | 47% reduction | 10% reduction |
| Sulphur($SO_x$) | 100% reduction | 20% reduction |

Source: Boyd, Murray-Hill & Schaddelee, 2004, p.31

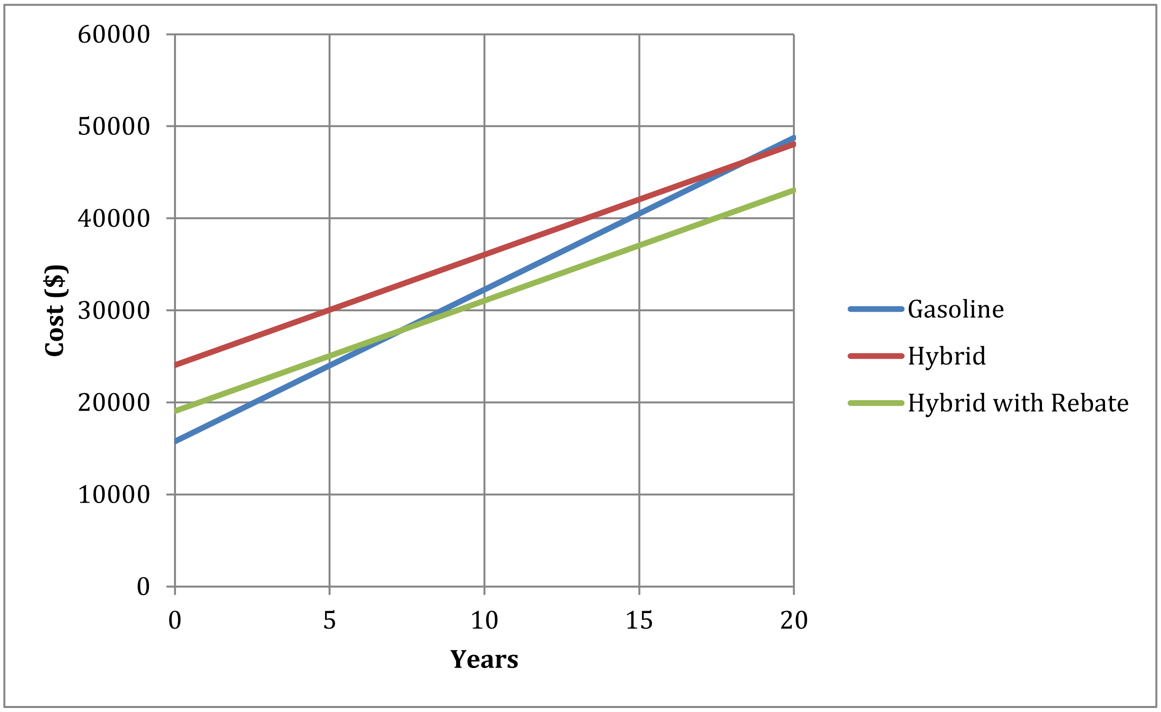
# 3.0 Hybrid Electric Vehicle

A hybrid vehicle is any vehicle that uses a combination of two power sources to move the vehicle. The most common type, and the type that we will be assessing in this report is the Hybrid Electric Vehicle (herein referred to as HEV). A hybrid electric vehicle uses a combustion engine along with an electric motor to more efficiently power the vehicle. The first mass produced HEV was the Toyota Prius, which was introduced in Japan in 1997. Since this over 5.8 million HEVs have been sold worldwide. The significantly increased fuel economy of HEVs is the main reason why they have become so popular in recent years. The low fuel consumption of HEVs is attributed to technology such as regenerative braking (which changes the cars energy from kinetic to electric) and start-stop technology (which turns off the vehicle’s combustion engine while it is idling).

## 3.1 Economical Impacts

Based on data from the U.S. Department of Energy and the U.S. Environmental Protection Agency we are able to compare some economic values between a 2012 Honda Civic and a 2012 Honda Civic Hybrid. Depending on selectable options, the hybrid will be as much as $8,295 more expensive than the combustion engine vehicle (United States, Department of Energy). However, the hybrid saves $450 per year on fuel, this means that it would take a maximum of over 18 years to pay off the additional price of owning the hybrid. Although it seems like owning the hybrid will cost substantially more than the combustion engine vehicle, there is a rebate by the BC Government known as the Clean Energy Vehicle (CEV) Program, which has incentives up to $5000 for each eligible clean energy vehicle (Transport Canada). Figure 4 shows the cost of owning a Hybrid without the rebate, the cost of owning a hybrid with the maximum rebate as well as the cost of owning the gasoline model. Please note that this illustration only takes into account the initial cost of purchasing the vehicle as well average cost of fuel per year.

**Figure 4:** Cost of owning a 2012 Honda Civic




Source: http://www.fueleconomy.gov/

From this table we can see that although it takes much less time for the additional costs of the hybrid to pay off, it still takes over 7 years. It is also important to note that fuel and cost of the car are not the only expenses that must be taken into consideration. Another significant factor is maintenance, however, there is no substantial difference between the maintenance costs of a HEV and a similar combustion engine vehicle. There is however the cost of replacing the batteries in HEVs, which can cost as much as $4900 not including installation or replacement fees.

## 3.2 Environmental Impacts

HEVs are groundbreaking in their use of regenerative braking and start-stop technology to increase fuel economy and lower carbon emissions. Using the example of a 2012 Honda Civic Hybrid and a regular 2012 Honda Civic introduced in the previous section we can compare the tailpipe emissions (grams per mile CO2) to gain a clear understanding of the environmental impacts of HEVs. An average Honda Civic emits around 278 grams per mile of CO2 (4.2 metric tonnes per year) whereas the hybrid version emits a mere 202 grams per mile (3.0 metric tonnes per year). Therefore every year the hybrid version emits 1.2 metric tonnes less of dangerous CO2 into the atmosphere, which is very substantial in the long run.

Although HEVs are much better environmentally when it comes to carbon emissions, they have their own environmental flaws with the batteries as well as raw materials needed. Although most of the batteries used in HEVs these days are lithium batteries, there are still many that use nickel metal hydride batteries. The main issues with the nickel batteries are that they are known carcinogens and cannot fully be recycled (Hybrid Battery Toxicity, 2006). The advanced electric motors in HEVs also require rare earth elements and it is believed that there will be a major shortage of the elements in the near future (Equity Research, 2006).

## 3.3 Social Impacts

Although the social impacts of owning a hybrid may not be as significant as the economic or environmental impacts, they are still very important and must be considered in this report. One of the main social impacts of HEVs is the noise pollution, or lack thereof. Due to the fact that much of the power of an HEV comes from the electric motor, there is only a small amount of noise produced. This is an important factor around UBC as it means that the vehicle will not disrupt classes as much as combustion engine vehicles.

## 4.0 Car Co-op

Unlike owning a vehicle, car rental and car sharing have fewer types of vehicles to choose from. Car sharing starts by first booking a certain vehicle. Once the vehicle is booked, it must be picked up from its designated parking spot. When the vehicle is no longer needed it is simply returned to the same parking spot. While using a car rental or car co-op program still has the cost of fuel, other costs (such as maintenance or insurance) are significantly lower. There is, however, an additional cost, known as a renting or sharing fee, which is calculated on an hourly or daily basis. This will be further explained in section 4.1 Economical Impacts.

## 4.1 Economical Impacts

As mentioned, car sharing is very similar to car renting in terms of how they operate, however, the costs of their services are very different. To start with, car rental has a higher fixed insurance cost that is billed separately. Furthermore car rental companies prefer for their client to rent on a daily basis (as opposed to hourly). In addition, fuel and hourly rates are significantly higher in rental than car sharing. This makes car rental overall more expensive than car sharing and therefore less popular. Due to this fact (that renting is very similar to car sharing, but with a higher price) it will not be further investigated in this report.

Over the past few years, car co-op has become very popular due to its cost and flexibility that suits city lifestyle. However, the question is whether or not it would be an appropriate option for the UBC farm. Figure 5 illustrates the cost of using a popular car co-op service called “Modo”.

**Figure 5:** Membership and service costs

| | co-op membership |
|---|---|
| to start | $500 refundable shares purchase*<br>$20 registration fee |
| per hour | $3 (max of $36 per 24-hours)<br>no hourly charge between 11pm and 7am |
| per km | 40¢ per km for the first 35 km;<br>25¢ per km for each additional km up to 150 km;<br>15¢ per km after that |
| recurring | $2 + HST admin fee for each of the first three bookings per month ($6 max per month)<br>$1 + HST annual membership fee |

Source: http://www.modo.coop

According to UBC farm, the desired vehicle would be used approximately three times a week. Assuming that the vehicle would be used all day, the cost per hour that will be billed would be 108 CAD per week. In addition, UBC farm would have to pay for every kilometre that the vehicle is used for. This is where the extra and unnecessary cost is applied. The nearest approachable truck that the car co-op (Modo) can provide is at West 8th & Bayswater which is approximately 7 kilometres away from UBC Farm. This means that personnel from UBC Farm would have to travel to this location and drive the vehicle back to the farm to use it. Furthermore, the vehicle would have to be returned when the farm no longer requires it. This means that every time the vehicle is used it must make two unnecessary trips. As a result, the flat price that the UBC Farm would have to pay is $114 (note that this value does not include the additional costs of using the vehicle when it is at the farm).

## 4.2 Environmental Impacts

Car co-ops help in the reduction of harmful emissions by taking cars off the road. Furthermore it encourages the use of multi-mode transportation including walking, cycling, and busing. A single share vehicle can easily and effectively replaces 5 to 20 vehicles on the road. Once people join a car co-op, they drive approximately 72% less than they did when they had their own car. In addition, greater support of car co-ops would cause a decrease in demand for new cars, which may be effective in reducing the number of new cars that are manufactured.

## 4.3 Social Impacts

As mentioned before, a single share vehicle can easily and effectively replaces 5 to 20 vehicles on the road. This reduction in amount of cars not only leads fewer emissions, but it also improves the wellbeing of society as a whole. Fewer cars mean fewer parking requirements for municipalities and private developments. Furthermore it will reduce the accidents that might occur. In conclusion, car co-ops can lead to safer and healthier communities.

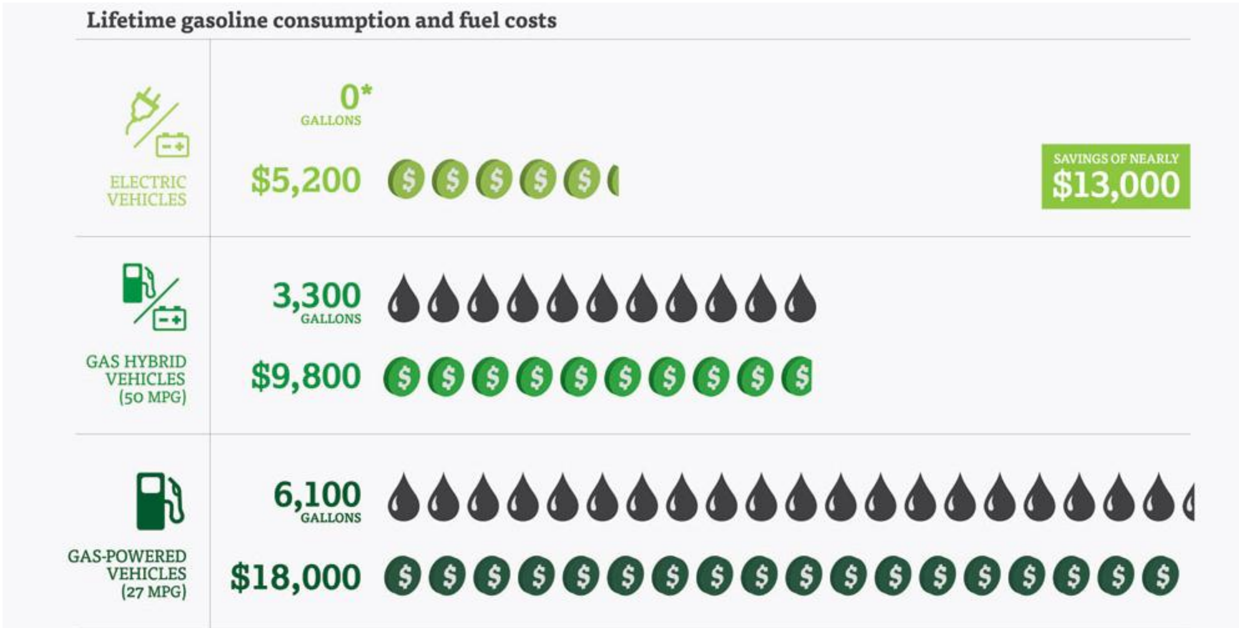
## 5.0 Electric Vehicle

General Motors Company (GMC) first introduced electric Vehicles (EVs) in the 1990s. However large oil companies realised the technology was an economical threat to the oil and gas industry, hence they managed to halt further advancement of EV technology (Paine, 2006). Today, transportation plays a dominant role on environmental degradation. Unregulated greenhouse gas emissions and oil supply deficiencies have given EVs an edge in the automobile industry. EVs are propelled by one or more motor (or electric motors) powered by packs of batteries. EVs are well known for their energy efficiency. EVs convert roughly 59% to 62% of the supplied electricity to its wheels compared to an internal combustion engine vehicle, which converts only 17% to 21% of energy stored in the fuel to propulsion power (Milner et al., 2011).

## 5.1 Economical Impacts

Based on the statistics by the Union of Concerned Scientists (UCS), EV owners save nearly $1,200 per year. EVs slash oil consumption and cost thousands of dollars less to fuel compared with combustion engine vehicles (Union of Concerned Scientists, 2012). Figure 6 shows the lifetime gasoline consumption and fuel costs of three different types of vehicles, namely electric vehicles (EVs), gasoline hybrid vehicles and gasoline powered vehicles (combustion engine vehicles):

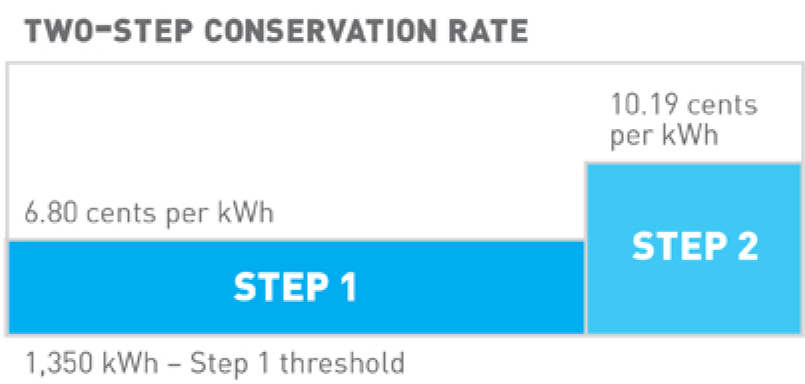
**Figure 6:** Lifetime gasoline consumption and fuel costs




Source: http://www.ucsusa.org/clean_vehicles/smart-transportation-solutions/advanced-vehicle-technologies/electric-cars/emissions-and-charging-costs-electric-cars.html

Operating costs of an EV depend significantly on the world region in which the EV is operated. For an example, BC Hydro utilizes differential pricing of electricity known as Two-Step Conservative Rate. Figure 7 shows the BC Hydro's policy for electricity price.

**Figure 7:** BC Hydro electricity price




*Source: https://www.bchydro.com/accounts-billing/customer-service-residential/residential-rates.html*

When one of the stakeholders of UBC Farm (Véronik Campbell) was consulted, she mentioned that the truck would be used three days a week at most (personal communication, October 10, 2012). UBC Farm will only have to charge the EV the night before it is used since the frequency of usage is just three days a week and electricity consumption is not very high. The maintenance costs for an EV is cheaper than a commercial gasoline vehicle because of fewer moving parts. Electric cars, for instance, do not require multiple gears to match power curves.

## 5.2 Environmental Impacts

Transportation produces 24% of the total $CO_2$ emitted which makes transportation the second largest source of $CO_2$ emissions. EVs produce zero tailpipe emissions and are estimated to reduce carbon emission by 70-85% by 2030 (Tran, 2012, p. 328). EVs are successful at reducing tailpipe GHG emissions, but on the other hand, the process of generating electricity continues to produce pollution and waste. However, low carbon electricity sources such as nuclear and renewable energy are likely to displace fossil fuel electricity in order to minimize GHG production (Sandy, 2012, p. 6060). Another factor that makes EVs so clean is that they don't need half of the parts that a gasoline powered vehicle does (including gasoline and oil). This means that they are not at risk of shedding any worn out radiator hoses or fuel filters to be dumped into overcrowded landfills, and leaking contaminated oil into our water supply, killing plant and animal life.

## 5.3 Social Impacts

EVs produce zero carbon and GHG emissions and therefore do not have the health issues related with tailpipe emissions of combustion engine vehicles. A common feature in all EVs is regenerative braking system. Regenerative breaking system helps to reduce braking dust. Braking dust is a potential hazard in cities because of its foul smell and it can cause breathing difficulty. Regenerative braking in EVs helps to reduce the impact caused by braking dust. Moreover, EVs produce less noise than combustion engine vehicles because the electric motors do not involve combustion. Quieter EVs bring serenity to the community around UBC campus.

# 6.0 Comparisons

After performing a triple bottom line assessment on our four types of vehicles, we can see that each have their own advantages and disadvantages relative to one another. This section will give a brief comparison so that we can determine the best choice for the UBC Farm.

From an economical standpoint, a combustion engine vehicle or car co-op seem like better choices than EVs and HEVs due to the lower initial costs. However, the CEV rebate from the BC government as well as the fuel economies of EVs and HEVs means that this difference will balance out in only a few years.

Even considering the environmental risks that are associated with HEV and EV batteries, EVs still seem like the best environmental choice. The car co-op is also a good option as it reduces the number of vehicles on the road. The combustion engine vehicle does not do as well environmentally (whether it is using diesel or biodiesel) as it has the lowest fuel economy and emits the most GHGs.

The social aspect was very much taken into consideration as UBC and the City of Vancouver strive to be seen as a green campus and city respectively. EVs and Hevs are superior to the ICEVs in this aspect as they have very low noise pollution and do not have the negative health issues related to excess tailpipe emissions. Car co-ops are also seen as a greener alternative than buying a combustion engine vehicle as they promote alternate methods of transport such as walking and public transport.

From this comparison we can see that car co-ops and EVs/HEVs seem to be the better choices. However, due to the limited availability of car co-ops as well as the large distances required to retrieve the vehicle car-coops seem to be inefficient for UBC Farm.

The further comparison of EVs and HEVs revealed that EVs are better both financially and environmentally. The EVs that has been found is manufactured in BC and called Might-E Truck.

## 7.0 Conclusion and Recommendations

After completing our research and comparing our four types of vehicles, we have come to the conclusion that the best choice for the UBC Farm would be an Electric Vehicle (EV). As discussed in the previous section, the zero tailpipe emissions and reduced noise pollution mean EVs are significantly better than the other options in both the environmental and social aspects. The only issue with selecting an EV is the price, however, we have found a truck known as the Might-E Truck (manufactured by Canadian Electric Vehicles Ltd. on Vancouver Island) that costs only around $22,000 new (Ecarco). This may seem too expensive, however, with the CEV rebate from the BC government we believe that this is the best option for the UBC Farm in the long term. To conclude, the impressive benefits associated with the Might-E Truck (and EVs in general) as well as the fact that the truck meets all of the specifications and requirements set by Véronik Campbell make it the obvious choice as the new vehicle for the UBC Farm.

**Figure 8:** The Might-E Truck

## References

Alemzadeh, A., Graebel, D., & Lau, B. (2012). *An Investigation into Biodiesel Production on UBC Campus* (Rep.). Retrieved October 29, 2012, from http://www.sustain.ubc.ca/sites/sustain.ubc.ca/files/seedslibrary/APSC262_4_CARLA_Assessment%20of%20Biodiesel_Team01_FINAL.pdf

Biodiesel Questions & Answers - Fusion Renewables. (n.d.). *Biodiesel Questions & Answers - Fusion Renewables*. Retrieved October 30, 2012, from http://www.fusionrenewables.com/products-services/biodiesfel/biodiesel-questions-answers/

Boyd, M., Murray-Hill, A., & Schaddelee, K. (2004). Biodiesel in british columbia – feasibility study report. Retrieved from http://www.saaep.ca/Biodiesel.pdf

Canada, Transport. (n.d.). *Transportation Rebates and Incentives*. Retrieved November 2, 2012, from http://www.livesmartbc.ca/incentives/transportation/index.htm

Car Search. (n.d.). *Considering Buying A Used Car?* Retrieved November 2, 2012, from http://www.carsearch.com/buy-used.html

Department of Health, Government of South Australia. (2009). *Polycyclics aromatic hydrocarbons(PAHs): health effects*. Retrieved from Scientific Services Public Health website: http://www.health.sa.gov.au/pehs/PDF-files/ph-factsheet-PAHs-health.pdf

*Equity Research* (Rep.). (2006, October 6). Retrieved November 2, 2012, from Insinger de Beaufort website: http://www.gwmg.ca/images/file/Insinger_Report.pdf

Home :: Modo the car co-op :: Carsharing in metro vancouver. (n.d.). *Home :: Modo the Car Co-op :: Carsharing in Metro Vancouver*. Retrieved November 2, 2012, from http://www.modo.coop/

Hybrid Battery Toxicity. (2006, April 8). *New Hybrid Reviews, News & Hybrid Mileage (MPG) Info*. Retrieved November 2, 2012, from http://www.hybridcars.com/battery-toxicity.html

Levelton Engineering Ltd. And (S&T) Consultants Inc. (September 2002). Assessment of biodiesel and ethanol diesel blends, greenhouse gas emissions, exhaust emissions end policy Issues. Retrieved from http://www.levelton.com/

Lu, M., Gill, J., & McEwan, W. (2012). *An Investigation into Biodiesel as Fuel for UBC Plant Operations Vehicle Fleet* (Rep.). Retrieved October 29, 2012, from http://www.sustain.ubc.ca/sites/sustain.ubc.ca/files/seedslibrary/APSC262_4_Dawn_BioDiesel%20at%20UBC_Team02_FINAL.pdf

Miller, M., Holmes, A., Conlon, B., and Savagian, P., "The GM "Voltec" 4ET50 Multi-Mode Electric Transaxle," SAE Int. J. Engines 4(1):1102-1114, 2011, doi:10.4271/2011-01-0887.

MIGHT-E TRUCK JR. (n.d.). *Ecarco*. Retrieved November 2, 2012, from http://www.ecarco.com/Canadian%20EV/might-e.htm

Paine, C. (Director) (2006). Who killed the electric car? [DVD].

Rental trucks and trailers. (n.d.). *U-Haul: Your Moving and Storage Resource*. Retrieved November 2, 2012, from http://www.uhaul.com/

Sandy Thomas, C.E. (2012). How green are electric vehicles? *International journal of hydrogen energy.* 37, 6053-6062. Retrieved November 7, 2012 from http://www.sciencedirect.com/science/journal/03603199

Tran, Martino (2012). Realizing the electric-vehicle revolution. *Nature Climate Change.* 2, 328-333. Retrieved November 7, 2012 from http://www.nature.com/nclimate/archive/issue.html

Union of Concerned Scientists. (2012).State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings Across the United States. Retrieved November 8, 2012 from http://www.ucsusa.org/clean_vehicles/smart-transportation-solutions/advanced-vehicle-technologies/electric-cars/emissions-and-charging-costs-electric-cars.html

United States, Department of Energy. (n.d.). *Find and Compare Cars*. Retrieved November 2, 2012, from http://www.fueleconomy.gov/feg/Find.do?action=sbs

Wright, P. (2010, March 23). What are the Risks involved in Buying a Used Car? *Goarticles.com*. Retrieved November 2, 2012, from http://goarticles.com/article/What-are-the-risks-involved-in-buying-a-used-car/2710327/

Yew, K. S., Koo, T. J., & Tham, W. H. (2012). *An Investigation into the Comparative Performance of Biodiesel against Petroleum-derived diesel by Analyzing their Environmental, Economic and Social Impacts* (Rep.). Retrieved October 29, 2012, from http://www.sustain.ubc.ca/sites/sustain.ubc.ca/files/seedslibrary/APSC262_4_CARLA_Assessment%20of%20Biodiesel_Team01_FINAL.pdf

Union of Concerned Scientists. (2012).State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings Across the United States. Retrieved November 8, 2012 from http://www.ucsusa.org/clean_vehicles/smart-transportation-solutions/advanced-vehicle-technologies/electric-cars/emissions-and-charging-costs-electric-cars.html