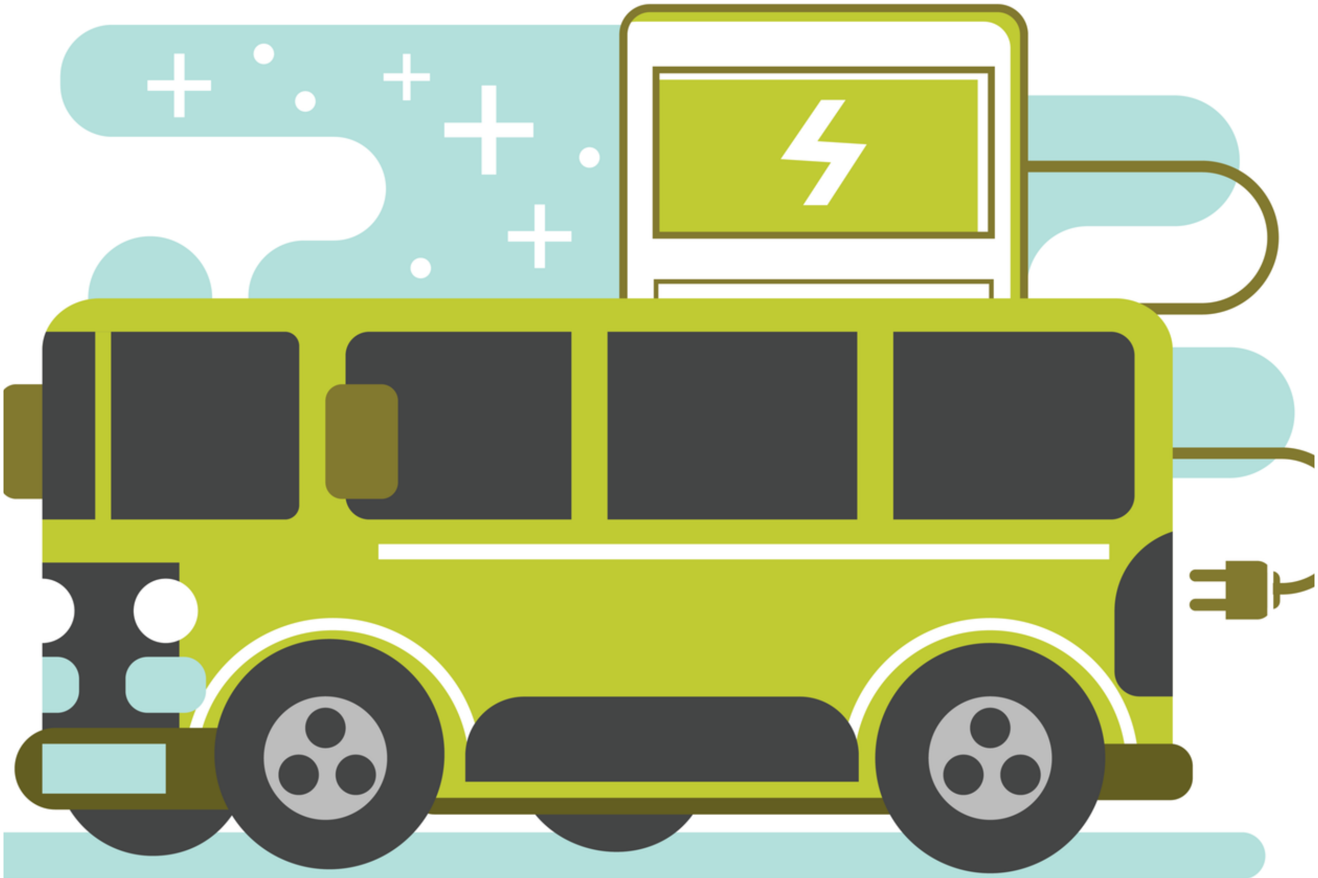

Campus Bus Electrification

Final Report

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EXECUTIVE SUMMARY

Ultimately, for the duration of the winter term of 2020, our group within ENV 332 (Practicum of Environmental Management), was assigned to investigate the feasibility and possibility of converting the existing shuttle bus system between the University of Toronto Mississauga (UTM) and the University of Toronto St. George's (UTSG) campus from a diesel based fuel consumption system, to an electric based fuel consumption system, otherwise known as 'electrifying' the shuttle bus system. This was ultimately proposed as a viable project of interest by the Environmental Management/Sustainability Coordinator of the University of Toronto Mississauga Campus, Chelsea Dalton, in which she ultimately expressed interest in attempting the conversion because of the vast amounts of Carbon Dioxide and other emissions produced by the existing model of consumption by the diesel buses. Hence, electrification would vastly reduce the campus's carbon footprint, and potentially be much less expensive than diesel based buses in long term cost analyses. The feasibility of electrification was meant to be accomplished through any means possible; purchasing newer electric buses, converting diesel buses to electric dependant hybrids, and even exploring the possibility of engineering our own electric buses. However, after several months of research, we have fundamentally decided that the most effective course of implementation would be to purchase one or two electric shuttle buses initially, and then slowly discontinue the existing fleet of diesel shuttle buses, after a brief beta testing period consisting of a year. This is primarily due to a combination of factors and methods we have employed to obtain accurate information as to which option of implementation would best suit the needs of our client. For instance, after performing a cost-benefit analysis, we fundamentally concluded that our project would be far too expensive in simply just replacing the existing fleet of diesel buses in their entirety, as the buses performed roughly 44 trips back and forth between the U of T Mississauga campus and the St. George campus. Hence, due to the average recharge time for an electric bus being too long (roughly 3 hours for the average models

surveyed) we ultimately suggest that it would be far too expensive and ineffective to replace the entire existing fleet of diesel buses any time soon, as electric bus models would not be able to meet the consumer demands that the previous diesel fleet was able to consistently provide, and therefore prove itself to be cost ineffective. These findings were also further substantiated through an additional survey, conducted by our group and another group assigned to assess the overall comfort of the current fleet of buses to see if additional modifications could be made to increase consumer satisfaction, and possibly increase the likeliness of attracting new customers. Thus further validating our ultimate recommendations that an electric bus system is possible, however it must be a phased implementation with multiple steps to avoid incurring a significant enough charges to ultimately make the project unattractive to investors.

INTRODUCTION

The UTM Shuttle Bus service enables U of T students (and non U of T students) to travel between the UTM shuttle stop (located at the Instructional Centre building) and the U of T St. George (UTSG)'s shuttle stop (located at the Hart House activity centre) via a diesel school bus. Each trip normally follows the Ontario 401 highway, and each trip usually lasts a duration of 40-120 minutes depending on the severity of traffic. For many individuals attending UTM, this is an extremely affordable and convenient mode of transportation back and forth between Toronto and Mississauga, which spares many commuter students time, money, and additional expenses finding a means of reaching UTM without the aid of a personal vehicle. However, because of the frequency of travel and fuel expenditure needed to reach regular consumer demand for trips (roughly 44 trips back and forth between Hart House and the Instructional Centre) this has easily led to the service becoming one of the most carbon emissions producing aspects within the university's operation. Hence, the Environmental Management/Sustainability Coordinator at the University Of Toronto Mississauga, Chelsea Dalton, ultimately suggested investigating viable alternative methods of fuel. Hence our group's ultimate task of investigating the possibility of electrifying the existing shuttle bus system as a viable mode of fuel was investigated by our group for the duration of the semester.

GOAL

As previously stated before, our project goals were to investigate the possibility and feasibility of transitioning UTM's current diesel fleet into a fleet of electric buses, via a variety of different means; we could look into the possibility of purchasing an electric fleet, the process and the overall time it would take to convert the existing diesel buses into hybrids relying on both electric power and diesel, or even a cohesive report stating the need to keep the existing diesel buses because they do not produce much in terms of emissions or the cost and logistics would be far too expensive. This evidence was meant to be accomplished through virtually any cohesive means possible, whether this was developing a cost-benefit analysis to assess the overall expense that purchasing electric shuttles would produce or another method that would help us reach a conclusion.

OBJECTIVE

Our team will provide a detailed plan, supplementary data and a questionnaire report, outlining whether the UTM shuttle bus may be replaced by a new energy vehicle. This research helps UTM achieve "zero emission" project goals as well as fall in compliance with green environmental protection strategies. These reports are intended to determine whether current shuttle bus operations and exhaust emissions are seriously affecting the environment, and which is the basis for the successful implementation of electric vehicle replacement. To simulate a similar environment, this solution will be supplemented by examples from other university campuses in the world. From these reports, we will incorporate additional suggestions on how to implement the electric shuttle buses that have been proposed.

RECOMMENDATIONS

- Adopt the project budget conducted by Chelsea Dalton, the Environmental Sustainability leader of the UTM system, a shuttle bus collaborative project management system, and implement this shuttle bus system in accordance with project goals and objectives. In addition we will make further adjustments based on data from questionnaire surveys with students, institutions and external customers.
- Follow the environmental protection and economic guidelines through the "zero-emission" or "low emission" framework, and gradually phase out the fossil energy shuttle bus to be replaced, and then gradually upgrade the UTM shuttle bus.

BACKGROUND INFORMATION

WHY REPLACE NEW ENERGY VEHICLES?

Global attention is paid to climate change, air pollution, and carbon emissions, as they are interwoven with the global depletion of resources that result from the combustion of fossil fuels. Hence, the greater push for alternative eco-friendly sources of transportation has been surmounting for quite some time, primarily through the form of electric or solar powered vehicles. Many governments also see this as a fantastic way to reduce carbon emissions which greatly approximate several countries' carbon footprints. For example, in the UK, 23% of total carbon emissions come from transportation. Therefore, the local government has formulated support policies to encourage people to buy electric vehicles, and gradually phase out and eliminate "dirty" (or fossil fuel dependent) vehicles. However, new energy vehicles are expensive, and the supporting facilities have not formed a system, so it takes time and patience to replace the old and the new and change the method of operation predated by several centuries.

POLITICAL CONTEXT

The Canadian federal government has shown a strong interest in the "new energy" program in recent years, especially focusing on the development of electric vehicles. According to data released by the government in 2019, only 136,000 of the 25 million vehicles driving on Canadian roads are electric vehicles. The survey shows that 54% of Canadians say that the next car they want to buy will be an electric car, and 10% of Canadians say that the next car they buy will definitely be an electric car. In the same year, energy ministers and business leaders from all over the world gathered in Vancouver to participate in the tenth meeting of clean energy ministers to discuss all issues related to clean energy. At the same time, the International Energy Agency released a new "Global Electric Vehicle Outlook". According to the previous forecast, there will be 130 million electric vehicles on global roads by 2030.

Canada 's goal is to sell 100% zero-emission vehicles by 2040, and its medium-term goal is to reach 10% by 2025 and 30% by 2030. To help achieve these goals, the federal government will invest $ 5 million (CAD) to induce automakers to set voluntary zero-emission vehicle sales targets. The federal government has also introduced purchase incentives to make electric cars cheaper. Starting from May

1 this year, consumers can enjoy discounts of up to $5,000 (USD) for electric batteries or hydrogen fuel cell vehicles. All-electric vehicles priced below $45,000 (USD) are eligible for a full discount, while plug-in hybrid vehicles can receive discounts of up to $2500 (USD). However, we cannot know whether these policies will tilt toward the UTM shuttle bus. Unlike the situation where personal vehicles park their cars at work or at home for most of the day, the use of commercial vehicles such as taxis and school buses is almost constant, Driving several kilometres day after day. Public vehicles are usually more polluting, which means that if they switch to the zero-emission version, they have a higher potential for emission reduction. For every 1,000 traditional electric buses replaced, it is estimated that 500 barrels of diesel can be saved every day. As part of the electric vehicle policy package, the federal government has also introduced tax incentives for companies that want to use electric vehicles. Companies that purchase electric vehicles can offset the cost of passenger cars up to $55,000 (USD) in the year of purchase, plus business tax. They can also deduct the full cost of electric medium and heavy vehicles (such as vans, buses and trucks) in the first year without a maximum amount. This accelerated tax write-off makes a big difference. So if schools can get government support, then replacing electric cars will no longer be a distant dream.

CHALLENGES ENCOUNTERED BY UNIVERSITY ELECTRIC VEHICLES

Before the new energy vehicles became popular, the consideration of replacing electric school buses has been considered by several post-secondary schools and the entire education industry in the world. However, after investigation, it has been found that there have been no particularly successful cases in Canadian colleges and universities. Through research, it has been found that the development of electric vehicles seems to be unstoppable. Conversely, after additional analysis, universities worldwide have not generally electrified (or sustainably fueled) their school buses. This is ultimately because the new policy regarding the use of new energy vehicles does not encourage the promotion of new energy school buses through public transport, public service, sanitation, postal or logistical fields. In other words, new energy school buses cannot enjoy the same subsidy policies as ordinary new energy buses. Without subsidies, the typical school bus is quite likely to remain diesel powered, as there are a series of problems that plague it's operation, known as "management diseases" such as remote management (and accident protection of buses), weight and safety issues, and difficulties in cost-sharing, making them an enormous challenge. In this way, in the context of the development of new energy buses, it is not difficult to understand that the new energy school bus is still silent. So what are the challenges encountered in the development of electric vehicles? Firstly, there is the issue of security. Some experts in the bus industry said: "The school bus service has a special student group and a high degree of social attention. At this stage, there are still problems and controversies about the battery safety and system safety of new energy buses." Therefore, until the new energy bus technology, especially the safety protection technology is fully mature, the possibility of the policy bottleneck of the new energy school bus being released is not high. However, some experts pointed out that since new energy buses have been widely used in the bus industry, safety issues should not become a bottleneck restricting the development of new energy school buses. Secondly, it is too difficult to operate. The new energy bus is still in the stage of demonstration operation, and thus it remains untested and unverified. Although it can be said that the school shuttle bus faces more problems, it is challenging to implement the purchase cost and operating cost allocation, let alone the purchase and operation of new energy school buses.

THE UNIVERSITY OF TORONTO'S ELECTRIC CAR PLAN

The University of Toronto Mississauga campus has always advocated green energy. And every year a lot of capital is invested in the field of environmental protection. For example, the new teaching building completely abandons the air-conditioning system and uses reasonable design to minimize energy consumption such as the teaching building. However, after data collection, we found that the University of Toronto's St. George's College has also been working on breakthroughs in electric vehicle batteries. The University of Toronto Electric Vehicle (UTEV) Research Center and founding partner Havelaar Canada have a partnership that is committed to developing cutting edge electric vehicle (EV) technology. Nevertheless, the University of Toronto still has no conclusive plans to replace the electric school bus directly, as previously mentioned in this analysis.

This means that the University of Toronto has realized the bright prospects of electric cars, but it is still not optimistic that electric cars can be replaced today. However, our team believes that the environmental advantages of electric buses depend on greenhouse gas emissions in power generation. The net emissions of electric buses driven by renewable/clean electricity are zero. For example, relevant experts found that, despite the high investment costs, electric buses are still feasible in the long run. A research report shows that by 2030, the upfront cost of electric buses will be about the same as that of fossil energy vehicles. Currently, the cost of an electric bus is about two to four times that of its cost. However, if the entire life of the bus is considered, the cost will be significantly reduced. Relevant experts said that by 2023, life cycle costs (including fuel and maintenance costs) would be roughly the same, and if the health costs of diesel are taken into account, the current price will be close to this level. At the same time, the University of Toronto researchers found that compared with diesel buses, electric vehicle maintenance costs are more than 40% cheaper.

PROBLEM STATEMENT

The UTM Shuttle Bus Service is one of the campus's biggest contributors to its carbon footprint. However, this service is widely used and extremely beneficial to a multitude of UTM students that need it in order to attend class from downtown Toronto, as it's final destination is at the Hart House student centre of UTSG. Fundamentally, our group proposes to understand the feasibility of implementing electricity as a viable alternative to the regular diesel-powered bus fleet we currently have at our disposal. Hence, to aid in our discussion and final conclusions, we have incorporated numerous survey results, statistical calculation, and research to assert our final decisions and recommendations. Thus, we expect that this will further aid our ultimate recommendation on which method of implementation is ecologically the least impactful to our carbon footprint.

METHODS

Our project involved various different methods of gathering information and receiving feedback. This section will discuss how we went about applying these methods:

The first method was client interviews. This involved frequent consultation with our client, the Environmental/Sustainability Co-ordinator at UTM, Chelsea Dalton. Chelsea provided us with basic information on the project and ideas of where to find data that she didn't have access to. She directed us to the UTM Office of Parking and Transportation where we conducted additional interviews to find information on the budget and fuel efficiency statistics related to the current diesel bus fleet.

Our second method was a jurisdictional scan. This method looked at the electric vehicle programs that have been implemented in American universities. We contacted these universities through email and asked similar questions so that we could compare their answers (see Appendix C for the questions asked).

Our third method was information gathering. To decide which electric and hybrid buses would be our final recommendations, we searched the internet for different bus models. We picked multiple models at various prices, ranges, etc. then as a group picked 2 electric and 2 hybrid buses that best met the needs of our client.

Our fourth method was an emissions comparison. We used journal articles to find the fuel efficiency and emissions released from our bus models. We found a stark comparison of carbon monoxide released between a typical diesel bus within UTM's existing fleet and the Orion VII hybrid bus we chose. Electric buses obviously have extremely low to virtually no emissions so there was no need to find those numbers.

Our final method was the conduction of a survey. This was done in collaboration with a group doing a project based on bus comfort. Since both projects would involve the surveying of people who take the shuttle bus, it was decided that a collaboration would benefit both groups. Both groups collaborating meant that there were twice as many people which allowed us to get more survey responses for a higher confidence interval. Each group was tasked with getting 150 responses, 25 per person, for a total of 300. After combining our surveys, our group got our surveys from the bus stop at the UTM Instructional Centre, and the other group got their surveys from people in different locations on campus in order to get more non-shuttle bus riders. In the end, due to the unexpected Covid-19 virus outbreak, we were only able to obtain 277 responses. Fortunately, this number was still above the required 261 responses to have a confidence level of 99% (see Appendix A for calculation of sample size). We asked various questions in order to determine how much people care about the greenhouse gases from the shuttle buses and how much they would be willing to pay to switch to a cleaner alternative (see Appendix B for our group's survey questions). Additionally, we used some of the bus comfort group's questions in order to determine whether students find the shuttle buses uncomfortable and if it's a large enough problem to warrant more comfortable options on a new bus.

FINDINGS

SURVEY RESULTS

In the end, we managed to collect 277 responses between this group and the bus comfort group. 88.8% of respondents were students at UTM, so there was a sizable pool of respondents that would be able to speak to voice student opinions regarding electficiation. There was a considerable amount of data regarding various aspects of bus comfort, the ones we took into consideration when considering bus upgradability were; bus safety, seat availability, comfort, and smoothness (data for all categories can be found in Appendix D). From these 3 categories, we found that only 12.2% of respondents were unsatisfied with bus safety. Seat availability was a demonstrably bigger issue with 39.8% of respondents unsatisfied. Comfort and smoothness was the largest issue with 74.5% of respondents unsatisfied. We took this data into consideration when picking our bus recommendation. Since comfort and smoothness were such a large issue, buses with additional comfort options such as air conditioning systems, wheelchair lifts, and extra space were weighed more heavily. Seat availability is not something that could be addressed with bus upgrades, but could possibly be alleviated with an increase in shuttle bus rides during peak hours which means buses with a greater range would be more useful as they could finish more trips before being switched or refuelled.

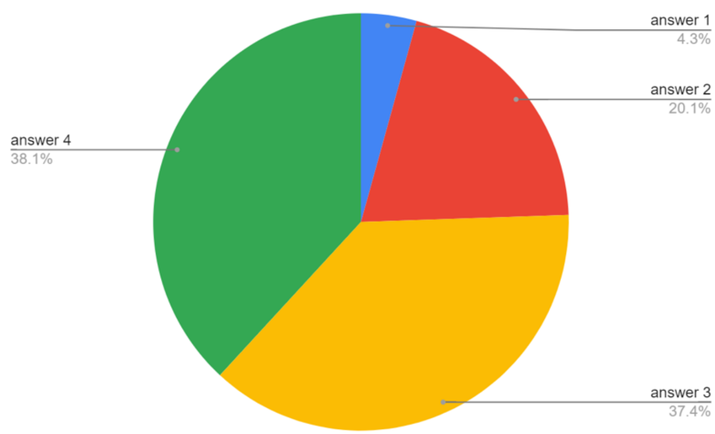

Figure 1: Pie chart of survey responses showing importance to respondents of switching to electric buses

This question asked from 1-4, how important was minimizing campus greenhouse gases produced by the shuttle bus. If we aggregate 1/2 and 3/4 into unimportant and important, we find that 75.5% of all respondents consider reducing shuttle bus greenhouse gases important. This shows the overwhelming support that UTM students, both rider and non-rider, are showing towards the idea of an electric shuttle bus.

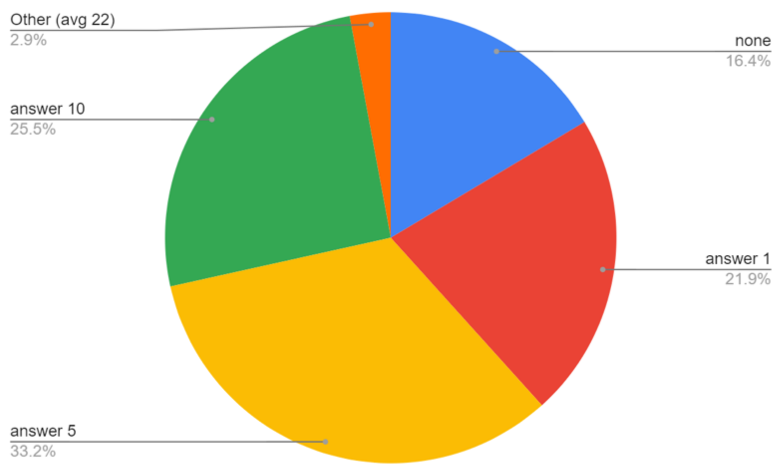

Figure 2: Pie chart illustrating donation responses by percentage

This question asked respondents how much they would be willing to contribute if UTM was to switch to an electric or hybrid bus, answers included $0, $1, $5, $10, and other.We can see respondents were very willing to donate, the average came out to $5.1 per person. If this average were applied to all students, 14,741 according to the 2016 census, an extra $75,000 a year could be raised to put towards the switch to electric buses.

ELECTRIC OPTION 1: LION-C

The first electric bus option that was researched was the Lion-C. The prices range from $250,000 - 350,000 and have a distance of 100-250 km per charge. Standard charging time is 4-6 hours, much shorter than option 2, and also allows for an upgraded fast charging battery if purchased. It can seat 72 passengers, which matches the capacity of the current UTM diesel shuttle bus. Additional comfort options are available, such as wider spacing, wheelchair lifts and air conditioning options, which can ultimately allow UTM to tackle lowering greenhouse gas emissions and increase the comfort and satisfaction of the shuttle bus. Currently, based on our survey results, 75.5% of respondents reported being unsatisfied with the shuttle bus and the Lion- C is one possible way to move towards better results.

ELECTRIC OPTION 2: BLUE BIRD

The second electric bus option that was considered is the Blue Bird. The prices range from $300,000- $400,000 (USD) and has a charging distance of 200km per charge. With a standard battery, charging time is 8 hours, and with upgraded fast charging technology, charge time is 3 hours. Price variation for standard versus upgraded technology is uncertain. It seats 84 passengers, the greatest of all 4 buses we compared. The Blue Bird would allow UTM to have a zero emission shuttle bus but is much more costly than the Lion- C. With customization being uncertain, the Blue Bird does not seem to be the better option for the electric busses.

HYBRID OPTION 1: IC BUS - CE DIESEL HYBRID SERIES

The first hybrid option that was found during our research is from the bus manufacturer IC Bus, specifically their CE Diesel model hybrid series. The price range of this bus is $210,000 for each bus, and have a range of around 800 km. These buses are hybridized versions of the normal CE diesel school buses, and since UTM is currently using school buses for the shuttle service, these buses will be similar in size, seating capacity and range. The seating capacity is comparable to a normal school bus, with a capacity of 72 passengers. The fuel economy is where the hybridization is useful, as it increases fuel economy from 47l/100 km for a regular school bus, to 27l/100km. The benefit of this bus is that it is a diesel hybrid, meaning that there is no need to charge it, or do anything extra that wouldn't already be done for a normal school bus. This means that no extra infrastructure, like charging stations, will have to be built for UTM to implement this bus. On the downside however, is that compared to the electric buses this hybrid bus will not completely erase emissions. Also, there is likely extra maintenance that comes with diesel buses, even if they are hybrid, which is something that could be avoided as well by going electric (Schoolbusfleet.com, 2011).

HYBRID OPTION 2: ORION VII DIESEL-HYBRID BUSES

The Orion VII diesel-hybrid bus option is the second comparable hybrid option we found through our research. The Orion VII diesel-hybrid bus is a city bus that has been converted into a hybrid option. Comparatively however, it has a lower seating capacity of 44, compared to the 72 of the IC Bus CE series hybrid, it is far more expensive at a price range of $734,000, and it has a poorer fuel economy of 47 l/100km in comparison to 27 l/100km. One factor that it does have going for it is the fuel range, which is 1000 km compared to the 800 km of the IC Bus CE hybrid series.

Nonetheless, the Orion VII diesel-hybrid bus is also not a school bus, but is rather a city bus, and thus has a different seating capacity (as mentioned before) and is something that the UTM students may not be accustomed to (Bow & Lubinski, 2019).

EMISSIONS COMPARISON

In terms of reducing greenhouse gas emissions, the option of going electric has the most appeal, because it eliminates emissions altogether. Electric buses also offer a ride that has less vibration and less noise compared to all the other options. On the other hand, the lengthy charging times, and the relatively shorter range of maximum 250 km even with the larger battery pack (which is still more than 500 km smaller than the range of the traditional buses) are all factors that need to be taken into account. Battery-electric vehicles' still have a major flaw which is range.

As for the recommended hybrid option, it eliminates issues like range anxiety and charging times, but isn't very fuel efficient in comparison to electric options which don't require fuel nor rids of emissions completely. Hybrid-electric buses consume less energy and produce considerably fewer emissions by combining an internal combustion engine with an electric motor. Hybrid-electric buses use Ultra low Sulfur diesel which releases lower emissions compared to gasoline that regular busses use. Hybrid buses that are prepared with particulate matter filters are approximately 90 percent lower than a conventional diesel bus without a particulate filter in terms of greenhouse gas emissions. According to a research guided by the Northeast Advanced Vehicle Coalition (NAVC), Nitrogen Oxides (NOx) emissions were lower by 30 to 40 percent in diesel hybrids compared to conventional diesel vehicles. Diesel hybrid buses are also proven to exhibit low carbon monoxide (CO) emissions compared to a conventional diesel bus. Figure 3 below shows a comparison of emissions in hybrid buses and conventional buses, based on New York City Transit reports.

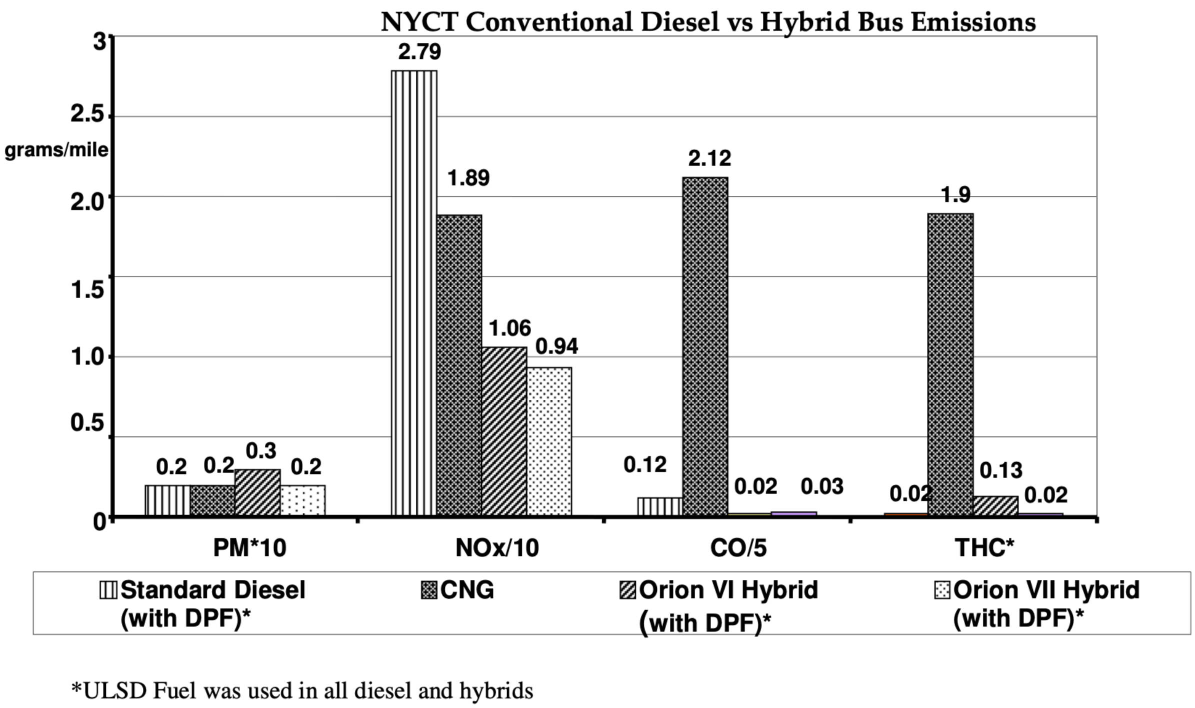

Figure 3: A comparison of emissions in hybrid bus and Conventional buses, based on New York City Transit reports.

Hybrid versions use about half the amount of fuel /diesel as a traditional bus, with their fuel consumption coming in at 27 l/100km in comparison to around 53 l/100km for a regular school bus (Hallmark et al., 2011). Though these results are significantly less than a UTM bus's emissions, it is pertinent to note that it is still quite high (more than double) in comparison to the average vehicle. Also, due to the heavy use that the shuttle buses go through, a fuel economy of 27 l/100km still means hundreds of litres of fuel a day being put into the atmosphere. Hence, in an emissions and environmental sense the only option that is valid is to go with the fully electric bus.

RECOMMENDATIONS

IMPLEMENTATION

Ultimately, after concluding our research as a group, we have decided that proceeding with purchasing a minimal amount of shuttle buses (one or two to start) would be the most efficient method of implementing the electric shuttle buses on campus. Our reasoning came down to 2 main points; the cost efficiency and buying electric buses that have the lowest upfront amount of costs. Thus, a full fleet could be obtained overtime without incurring large costs or possibly going into deficits. Secondly, it is easier to beta test. It is easier to assess the integration and overall performance of a minimal amount of electric buses over a period of time as opposed to buying an entire electric fleet. Finally, electric buses are the most environmentally friendly option. Based on the survey, UTM students are very much in favour of cutting down greenhouse gases from the shuttle buses and this is the best way to do so.

BUS CHOICE

We ultimately decided that recommending the Lion-C electric school bus was the correct decision. The Lion-C is able to match the seats of the current shuttle buses, while offering the greater range at a lower cost compared to the other electric option. The Lion-C also offered additional comfort options that met our standards based on the survey, such as wider spacing and air conditioning options. The Lion-C beats out the hybrid buses on account of it being electric and is therefore emission-free. This means less pollution for the world and the students waiting for the bus.

CONCLUSION

Overall, our group has worked diligently to gather data and conduct an analysis, considering many factors to produce a recommendation that meets the needs of our client, Chelsea Dalton, the goals of the University of Toronto Mississauga campus and ultimately, the goals of UTM students. We began this process unsure of what our outcome would be, but were hopeful that we could effectively determine the feasibility of electrifying the UTM shuttle bus. Both Chelsea and UTM made it clear that reducing emissions was extremely important but needed to occur within the current bus operations. Meaning, reducing the number of shuttle trips or passengers was not a viable possibility. Equally important, we began the task of collecting data to produce a cost-benefit analysis. Within this data collection, we began to observe that it would be very expensive to purchase a whole new fleet of busses. We initially determined three possible outcomes, of which one was cost-effective but environmentally degrading, the second was expensive but zero emission or lastly, a middle ground for cost and emissions.

With the various constraints in mind, we narrowed down to 4 potential busses (2 electric and 2 hybrid). To assist our decision making, a survey was conducted and produced some powerful results. 75.5% of the UTM population found greenhouse gas emissions to be important and an average of $5.1 (CAD) willing to be donated per person. Consequently, these results determined that UTM and its students take pride in trying to be environmentally friendly and one day, a carbon emissions free school and therefore, the shuttle bus should reflect that. This led us to our final recommendation: phased implementation. By implementing one or two electric Lion- C busses initially, and over time, converting the whole fleet, UTM will be able to stay within budget and reduce emissions. In conclusion, based on our data and research, we believe this is the most effective and feasible way to electrify the UTM shuttle bus, as well as reduce carbon emissions for the university campus overall.

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APPENDIX

APPENDIX A

Calculation of Sample Size

The determination of sample size is of critical importance in sample surveys. If the sample size is too large, it will cause a great waste of human, material and financial resources; if the sample size is too small, the sampling error will be too large, the survey data will be skewed, and thus the results will be affected. Back to the UTM shuttle bus, the available seats range from 36 - 48 passengers depending on the bus and if mobility aids are present (calculated at 2 persons per seat). According to our recent calculations, we found that roughly 800 people take the school bus to and from both campuses per day. There are 4 months in one semester and after simple calculation we found that in our rough estimate, our target population is around 12,000 people. For the sake of this calculation, if we assume that our survey respondents have a confidence level of 99% (which is to be expressed as a percentage) and represents how often the true percentage of the population who would answer the survey, and the confidence interval we have chosen is to be 6 (as this has been consistently proven and cross-referenced with other relevant universities and organizations). In addition, if the formula to calculate sample size is: Sample Size = (Distribution of 50%) / ((Margin of Error% / Confidence Level Score)Squared), then we can ultimately obtain a sample size of 261 people.

APPENDIX B

Survey Questions

Group 7 Survey Questions

Name:

Email (if you want to be included in contest for…):

Are you currently a UTM student?

□ Yes □ No

How important to you is lowering campus greenhouse gases related to the shuttle buses, on a scale from 1 to 5? (1 being unimportant, 5 being very important)

□ 1 □ 2 □ 3 □ 4 □ 5

Would you be willing to pay a small fee for a more comfortable bus?

□ Yes □ No

How much would you be willing to contribute if UTM switched to an electric bus?

□ $0 □ $1 □$5 □ $10 □ Other ____

If you are not a UTM student, would you be willing to pay a $1-2 price increase for shuttle tickets?

□ Yes □ No

APPENDIX C

Questions we asked in the jurisdictional survey

- Did you face any challenges (especially cost) in electrifyin (or hybridizing) the buses?
- How were you able to afford the upfront costs (increased tuition or budgeted)?
- Any benefits that have occurred?
- How many trips are you able to make in one charge?
- What bus models did you end up selecting?
- Any other information you're willing to share?

APPENDIX D

Bus Comfort Category Data

	Satisfaction Chart			
	4 (Very Satisfied)	3 (Somewhat Satisfied)	2 (Somewhat Unsatisfied)	1 (Very Unsatisfied)
Timeliness	61	94	31	9
Frequency	47	82	50	16
Feeling Safe	112	60	21	3
Bus Driving	93	62	30	10
Wifi Presence	30	43	58	61
Wifi Connection	25	37	65	66
Waiting	36	64	66	30
Seats Availability	31	87	56	22
Seat Comfort	8	42	79	67
Heating & Cooling	28	76	58	33
Smoothness	12	55	70	58
Overall Satisfaction	22	105	60	9