An Investigation into a Sustainable AMS Food Delivery System

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Abstract

The new SUB at UBC will be completed December 2014 and is attempting to achieve LEED Platinum certification, a title given to the most sustainable buildings in the world. Not only should this certification refer to the materials used to construct the building and the construction process itself, but it should also influence the operations of the building and its businesses. The current delivery system used by AMS Food and Beverage to transport food throughout the campus is a gasoline powered vehicle. The primary stakeholder for this project, Collyn Chan, the sustainability coordinator of the new SUB, is concerned with the carbon emission of this vehicle and is requesting a recommendation for a more environmentally friendly vehicle to replace the current food delivery vehicle. This task is being investigated by a group of students currently enrolled in APSC 262, whom will determine an environmentally friendly vehicle option that can suitably serve as a food delivery vehicle for AMS Food and Beverage.

This report describes a TBL analysis to evaluate which environmentally friendly vehicle would be the most suitable option as a delivery vehicle for AMS Food and Beverage. The three vehicle options compared in this report are a manual bicycle, a fully electric scooter and a fully electric car. Through the TBL analysis, the environmental, economic and social impacts associated with each vehicle's capability to deliver food were compared. Additionally, the stakeholder also required that the vehicle recommendation be able to travel across campus in a timely manner, protect the deliverer and the food cargo from Vancouver's weather throughout the entire calendar year and be able to carry at least 100 boxes of pizza in one trip. Only vehicles which were deemed to be relatively environmentally friendly and that met the constraints listed by the project stakeholder were considered in the TBL analysis; any other options were ruled out in a primary stage of the investigation.

The result of the TBL analysis of the vehicle options considered determined that a fully electric car, such as the Smart Fortwo Electric Drive, or the Nissan Leaf 2014 SV, would be ideal for delivering food items throughout campus. The recommendation given by this report is that AMS Food and Beverage should replace their current gasoline powered food delivery vehicle with more environmentally friendly fully electric vehicles.

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Glossary

Salvage value	The estimated value that an asset will realize upon its sale at the end of its useful life.
City car	A city car (also known as urban car or mini) is a small car intended for use primarily in an urban area.

List of Abbreviations

AMS	Alma Mater Society
APSC	Applied Science
BEV	Battery-Powered Car
ICEV	Internal Combustion Engine Car
LEED	Leadership in Energy and Environmental Design
LFP	Iron Phosphate Lithium-ion
NCM	Nickel Cobalt Manganese Lithium-ion
NiMH	Nickel Metal Hydride
SUB	Student Union Building
TBL	Triple Bottom Line
UBC	University of British Columbia

1.0 Introduction

Our project is to investigate a new, sustainable delivery system for AMS Food and Beverage. The primary stakeholder for this project is Collyn Chan, the sustainability coordinator of the new SUB. One of the objectives of the new SUB is to earn and maintain a certification of LEED Platinum ("Naming Our SUB", 2014), the highest rating given for sustainable design, construction, operation, and maintenance of sustainable buildings ("LEED", 2014). The sustainability of the new SUB building is not limited to its design and construction, but also includes the operations of the building and the businesses contained therein, and their respective impacts and interactions with the surrounding campus community. The focus of our project is to investigate and recommend a sustainable method of food delivery for the AMS Food and Beverage business within the new SUB. The recommended method of delivery should be economically viable and be more environmentally friendly that the current delivery system, meeting the standards of the new SUB for sustainable operations.

Our goal is to find a sustainable method of delivering food from the new SUB building to various buildings on the UBC Vancouver campus during breakfast, lunch and dinner times, and both during and after regular working hours. To accomplish this goal, we must evaluate various vehicle options utilising a TBL analysis and determine which option is the best option for AMS Food and Beverage to acquire for its deliveries across campus. The factors that should be considered for each vehicle include the environmental impact of the construction and operation of the vehicle, as well as how to provide a convenient, affordable service to UBC students and staff that order food to be delivered. Additionally, the stakeholder requires that the vehicle to be recommended be able to access the roads on UBC campus, and the vehicle should protect both the delivery person and the cargo from the weather, and should be able to operate for the entire calendar year. Furthermore, the stakeholder requires that the vehicle be capable of transporting up to 100 pizzas in one trip, having a cargo hold with dimensions of four feet by four feet by five feet.

Our report will compare three different types of vehicles and recommend to our stakeholder the one that is most suited to deliver food from the new SUB to various locations about the UBC campus. The three vehicles compared in this report are a fully electric car, a fully electric scooter and a manual bicycle, with the last two options requiring some form of wagon to tow the cargo. These three vehicles were selected for the final investigation due to all having zero direct carbon emission; this was a large factor in selecting the top candidates, as this standard is in keeping with the new SUB's goal for LEED Platinum.

The TBL analysis will be used as a measure of sustainability and viability for each vehicle. In the following sections of the report, the environmental impacts, economic impacts, and social impacts of each vehicle will be compared to determine our recommendation. Section 2.0 will compare the environmental factors of each vehicle, Section 3.0 will consider the economic factors of each vehicle, and Section 4.0 will examine the social factors of each vehicle. Finally, the report will compare each vehicle to the requirements and constraints set forth by the stakeholder and review the environmental, economic and social analyses of the previous sections to determine the ideal vehicle to recommend to our stakeholder.

2.0 Environmental Factors

The environmental assessment of the vehicle options for a new delivery system for AMS Food and Beverage is a very important consideration to determine a final recommendation; if a vehicle option will not be sustainable enough to conform to the policies of the new SUB and its LEED certification, then it should not be recommended. This section investigates the prominent environmental aspects of the vehicle options being considered for recommendation; the aspects considered are emissions, energy consumption life cycle and disposal of the vehicle.

2.1 Emissions and Energy Consumption

Air emission is a prominent index defining the sustainability of the vehicle fuel and design types. As the UBC new SUB project is projected to be LEED Platinum for sustainable design ("Naming Our SUB", 2014), all operations within the new SUB and AMS services are expected to be sustainable as well, including the delivery of food on campus. Many design variables and frameworks affect vehicle air emission and energy consumption including fuel types, motor engine technologies, aerodynamics and vehicle weight.

The solution to the current conventional method of vehicle design should be a combination of light-weight design and a fuel efficient engine; this class of vehicle would reduce air emission significantly (McAuley, 2003). The preferred materials used in the production of these lightweight vehicles are plastics and composites instead of heavy, metal based structures. In addition, contrary to expectations, lightweight metals such as aluminum, magnesium, new ultra strength steels, and hybrid composites could be used for manufacturing of the lightweight vehicles to improve the development and architecture design of the vehicles.

The main pollutants created by the usage phase of the automobile life cycle include carbon monoxide (CO), Nitrogen oxides, Sulfur dioxide and volatile organic compounds (VOC) (McAuley,2003). One third of the energy consumption and emission in the United States is from vehicle use, which is a reflection of the problem posed in this project. Fully electric vehicles have zero fluid emission and do not produce greenhouse gases; it is for this reason that only electric vehicles and manual bicycles were selected as options for the TBL analysis of this report.

2.2 Life Cycle Assessment and Disposal

A life cycle assessment is an analysis tool to assess the environmental impacts associated with all stages of a products life from production to disposal. When a product is evaluated for its environmental sustainability, the production and disposal of the product must also be considered, as those processes also have byproducts that may be as harmful to the environment, if not more so.

To determine if an electric vehicle is appropriate to replace the current AMS food delivery vehicle, the materials and components of the vehicle must be examined for their environmental impacts, specifically the battery and electronics. Below, Figure 1 shows a comparison of LFP, NCM, and NiMH batteries; the figure shows that NiMH batteries have largest impact, followed by NCM and LFP, respectively (Majeau-Bettez , Hawkins, and Strømman , 2011). Examining the figure below shows that the Lithium ion batteries have less of a harmful impact on the environment, with LFP batteries have the lesser impact of the two; this is due to a greater lifetime expectancy and less harmful material choices. In conclusion, any electric vehicles to be recommended should utilise LFP battery technologies instead of NCM or NiMH.

FU: charge-discharge 50 MJ		**NiMH**	**NCM**	**LFP**
GWP_{100}	*kg CO_2-eq*	3.5	1.9	1.4
FDP	*kg oil-eq*	0.99	0.45	0.37
$FETP_{inf}$	*kg 1,4-DCB-eq*	0.13	5.1×10^{-2}	3.4×10^{-2}
FEP	*kg P-eq*	4.5×10^{-3}	2.7×10^{-3}	2.0×10^{-3}
HTP_{inf}	*kg 1,4-DCB-eq*	5.6	4.1	2.7
$METP_{inf}$	*kg 1,4-DCB-eq*	0.13	5.6×10^{-2}	3.7×10^{-2}
MEP	*kg N-eq*	4.0×10^{-3}	2.5×10^{-3}	1.9×10^{-3}
MDP	*kg Fe-eq*	1.1	0.85	0.30
ODP_{inf}	*kg CFC-11-eq*	1.0×10^{-5}	1.1×10^{-5}	7.5×10^{-6}
PMFP	*kg PM10-eq*	2.3×10^{-2}	3.6×10^{-3}	2.1×10^{-3}
POFP	*kg NMVOC*	1.7×10^{-2}	4.5×10^{-3}	3.0×10^{-3}
TAP_{100}	*kg SO_2-eq*	9.8×10^{-2}	1.2×10^{-2}	6.5×10^{-3}
$TETP_{inf}$	*kg 1,4-DCB-eq*	1.2×10^{-3}	3.1×10^{-4}	1.7×10^{-4}

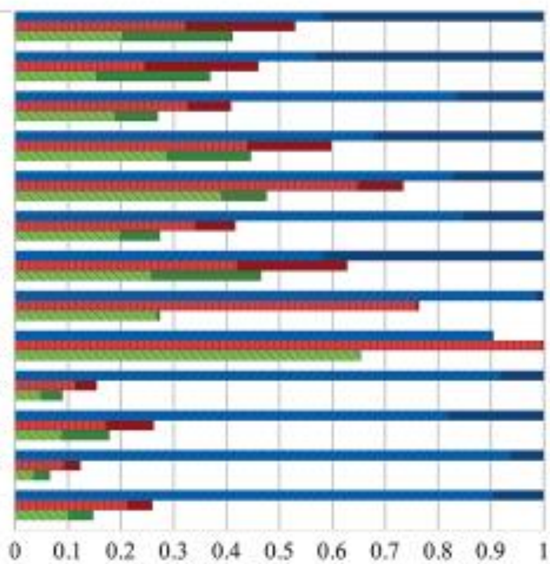

Figure 1: Life cycle environmental impacts of NiMH, NCM and LFP batteries

3.0 Economic Factors

The economic factors to be considered should be those that deal with the monetary bottom line and cash flow of the delivery service; these factors could be income or expenditures, taxes, business, employment, and business diversity factors *(Slaper & Halls, 2011)*. The economic factors examined in this report are the factors that concern financial feasibility and financial sustainability. Although the project requirements do not include a specific budget for the new food delivery vehicle, this report examines the financial concerns when making a capital investment. This report considers the purchase cost, regular repair, maintenance and fuel costs, and a long term forecast for each vehicle option.

3.1 Purchase Cost

The purchase cost is one of the largest costs associated with the vehicles and also affects the salvage value, which will be examined in section 3.3. In this context, the purchase cost of a vehicle refers to the purchasing price of the delivery vehicle; the unit price of each vehicle option is based on public information released by its dealer or provider. Since each type of vehicle may have a variety of models, and consequently prices, this analysis will be based on the most suitable model chosen from each type of vehicle.

The unit price for a bicycle ranges from as low as $150 up to $10,000 or even higher. The most common 21.5" frame size bicycles with hydraulic disc brakes, proper suspension lockout and 8 speed shifter cost from $650 to $750. These features are deemed to be either safety related or necessary in terms of workload. It is also worth noting that each bicycle will need to be upgraded in order to transport the delivery cargo; after upgrading, its maximum load capacity, in the measure of number of pizzas, is five 12" pizzas or one cubic foot *(Coup-on-a-box, 2014)*.

The unit price for an electric scooter is approximately $1400 to $1700 with minimum features. Some of the electric scooters are sold with built-on rack, which may save the cost for upgrading, However, its load capacity is similar to that of a bicycle, as their mechanical structures are not fundamentally different.

For an electric vehicle, the unit price has a very large fluctuation; an electric Smart car starts from $27,000, whereas a Tesla S model costs at least $70,000 *(Mercedes-Benz Canada Inc.,2014)*. A city car would be sufficient for the purposes of this project, and are much more financially viable. Therefore, the price of a Smart car will be used in calculation. The Smart Fortwo Electric Drive is designed for a capacity of two people with a passenger volume of 46 cubic feet in addition to its 8 cubic feet of trunk volume *(The Car Connection, 2014)*.

Based on the cargo volumes listed above, to fulfill the cargo requirements of the project, AMS Food and Beverage would require 80 to 100 bicycles or electric scooters, or 2 electric city cars. The total purchase cost of bicycles is $56,000 to $70,000; for electric scooters the minimum total cost is $112,000; and for electric city cars the total cost is $54,000. In conclusion, in terms of purchase cost, it would be optimal to recommend electric city cars as the new food delivery vehicle.

3.2 Regular Repair, Maintenance and Fuel Cost

The purchase cost of the vehicles is not the only major factor when examining the financial impacts of a vehicle; one must also consider the costs incurred from daily operations, such as repair, maintenance, and fuel costs.

The fuel cost of each vehicle option will be minimal, due to the nature of the options selected for analysis. The electricity cost for electric cars and electric scooters is much less than that of gasoline, and the distance to be traveled for a single delivery is relatively small compared to the maximum range of the electric vehicles.

The repair cost of electric vehicles is estimated to be greater than the repair cost for scooters or bicycles due to the increased complexity of the system. Further, while it is possible for regular staff to repair bicycles or electric scooters, it requires a professional technician or mechanic to repair an electric car given the complexity of the car system.

3.3 Long Term Forecast

The salvage value of an asset is the remaining value of the specific model of vehicle examined in Section 3.1. The lifetime of each vehicle is arbitrarily chosen as 3 years and the salvage value of each type of vehicle will be its market value 3 years after purchase.

According to various used car market offerings, the market price for a 2010 or 2011 Smart Fortwo ranges from $10,000 to $14,000. Conversely, a uniform price for a 3-year-old bicycle or scooter is difficult to obtain, as not many are listed; it is doubtful that there is any noteable salvage value left in these vehicles. In terms of the salvage value of each vehicle option, electric cars are recommended.

4.0 Social Factors

Since the AMS is an organization run for students by students, the key social factors that impact the decision of a new delivery vehicle are those that pertain to student interests. Examples of these factors include timeliness of delivery, cost for delivery, and student job opportunities. With these factors in mind, students should be able to quickly and easily place and receive their order for minimal cost, if any. Furthermore, the delivery person operating the vehicle should be a student, if possible, and the position should be available to any person, regardless of age, race, gender, etc.

4.1 Labour Requirements

When choosing an appropriate vehicle to transport potentially large amounts of cargo, the operator should not need to physically exert themselves more than a reasonable amount, as this will restrict the possible applicants and could potentially lead to injury. Although a manual bicycle with a wagon might easily pull a wagon with some cargo, if the wagon is fully loaded, this will put extra strain on the delivery person, whom then may need to carry the heavy load inside a building, possibly up many flights of stairs.

In this case, one of the electric vehicles would be a better solution for transporting large amounts of cargo across campus. The electric scooter has a slight advantage is this respect, as the smaller profile may allow it to park closer to the entrance of the destination building.

4.2 Training Requirements

Another limiting factor on the eligibility of potential applicants is the need for special training not offered by the employer. In this case, the eligibility of student applicants for the delivery person role is restricted by the requirement of a driver's license to operate the electric vehicles. To be legally allowed to operate the electric car or electric scooter, the delivery person is required to hold, at minimum, a valid class 7 license.

4.3 Community Reception

Finally, possibly one of the strongest social factors affecting the recommendation for AMS Food and Beverage is the community reception. If the community is unhappy with the service being offered, they will not continue to use it.

One very important requirement of a delivery service is that the delivery must be made very quickly. Food is a very volatile good; as time goes by, the order item will start to lose value very quickly, and the longer any customer is required to wait, the less pleased they will be with the service, and they will become more likely to stop using the service. Depending on the routes available, any of the vehicles could have an advantage over the other options, but if special permissions are allowed for the electric car to drive on restricted roads across campus, then the advantage of the scooter and bicycle decrease drastically.

Another requirement of a delivery service is that if there is a cost to the customer, that cost should be minimal. This is especially true when one considers the size of UBC campus; if the cost of delivery is above a certain price point, the customer will travel the relatively short distance to pick up their order.

5.0 Conclusion and Recommendations

A new, sustainable delivery system for AMS Food and Beverage is required to ensure that the operations of the new SUB are as sustainable as the design and construction of the building itself, which is projected to attain LEED Platinum certification ("Naming Our SUB", 2014), the highest rating given for sustainable design, construction, operation, and maintenance of sustainable buildings ("LEED", 2014). This report will recommend a new vehicle option to conduct deliveries of food items to various locations throughout the UBC Campus. The recommended method of delivery should be economically viable and be more environmentally friendly that the current delivery system.

The project stakeholder requires that the vehicle to be recommended be able to access the roads on UBC campus, should be able to operate for the entire calendar year, and should protect both the delivery person and the cargo from weather conditions. The vehicle options selected for the TBL analysis all meet these requirements, with the bicycle and scooter options being more susceptible to weather conditions and offering less protection to the rider. The vehicle should also be capable of transporting up to 100 pizzas in one trip, having a cargo hold with dimensions of four feet by four feet by five feet. The electric car option may not have sufficient space for an order of this magnitude in one trip, but the stakeholder can investigate more spacious options for a larger delivery, or operating in multiple trips; the bicycle and scooter options will require some form of trailer to transport this much cargo, which will be an additional cost to AMS Food and Beverage.

In addition to ensuring that the vehicle options conform to the requirements set forth by the project stakeholder, the vehicle options were compared using a TBL analysis, investigation the environmental, economic and social impacts of each option. The vehicles chosen for analysis are all very similar in their environmental impacts; all of them have zero greenhouse gas emissions and do not rely on a fuel source other than electricity or manual power.

Aside from the requirement that the vehicle recommendation be environmentally sustainable, the recommended vehicle must also be financially viable. Although the electric car option has a higher unit price point, and a fuel cost associated with it, it also has a salvage cost and has no need for an additional trailer to carry the cargo for deliveries. Furthermore, the electric car can travel a further distance on a single charge and recharges more quickly than an electric scooter.

Through the social analysis, it is clear that all options have similar benefits and drawbacks; they all must be able to deliver the food items quickly and for a minimal cost to the customer. The main social drawback of the bicycle is the physical exertion required by the delivery person, whereas the other vehicle options require a valid driver's license. The reduction in labour requirements is a more influential factor, as it acts as a variable cost to the employee, whereas the license is a one time investment, which many students may already possess before enrolling at UBC.

Based on the results of the TBL analysis of the vehicle options considered, we have determined that a fully electric car, such as the Smart Fortwo Electric Drive, or the Nissan Leaf 2014 SV, would be ideal for delivering food items throughout campus. This is due to the range and charging times of the electric vehicles, as well as the social factors discussed above. We recommend that AMS Food and Beverage investigate specific models of electric vehicles to replace the current food delivery vehicle, as this report focuses primarily on categories of delivery vehicle options.

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