AEDECON 4567 Capstone Final Report

Identifying Electric Vehicle (EV) Charging Infrastructure Characteristics and Incentives for EV adoption by Yellow Cab Columbus

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1.0 - Executive Summary

Our research identified the willingness of Yellow Cab Columbus (YCC) drivers to switch to Electric Vehicles (EVs) and elicited their opinions and concerns when it comes to EV charging infrastructure and the use of these vehicles in Yellow Cab's fleet.

Morgan Kauffman, CEO and Owner of YCC does not currently have any EV's incorporated into his fleet. YCChad previously tested a Tesla model, but the trial was unsuccessful as the amount of charging needed was not satisfactory. Morgan Kauffman's plans for YCC in the future consist of a fully electric and decentralized fleet. To give further emphasis on the benefits of this transition, a cost analysis was conducted to compare the cost of a 2018 Toyota Camry and a 2018 Chevrolet Bolt for typical use patterns and usual life. The costs included in the analysis were purchasing cost, maintenance costs, and fuel costs. After 2.5 years the financial burden of the more expensive Bolt is recuperated through lower annual operation and maintenance costs.

We researched other cities that have implemented EV's into their transportation services to gain background information on how they went about transitioning, as well as to identify any potential advantages and/or disadvantages of EV's. This baseline research was consulted in the curation of survey questions. The survey was distributed to all YCC drivers with 40 responses received. 50% of respondents said they would seriously consider switching to an EV. Two main advantages that were identified by the drivers were the lessened environmental impact and reduced noise. Two main disadvantages that were identified by the drivers were the lack of charging infrastructure and limited range. YCC will be able to consult our findings when making the transition to EVs. Smart Columbus will be able to consult our findings to inform adoption by other transportation service providers in the City of Columbus.

Survey respondents also identified optimal locations for charging infrastructure within Columbus. This information along with a heat map of trip destination frequency from YCC was used to identify charging locations that would aid YCC and other transportation service providers in EV adoption. We recommend that DC fast chargers be put in these locations so that drivers do not lose fare income while charging their vehicles for long durations of time.

2.0 - Introduction

This semester long research project was done to support the Smart Columbus sustainability goals on behalf of The School of Environment and Natural Resources' Senior Capstone Course at The Ohio State University. The focus of this report is on the Vulcan Priority 2 which outlines the electrification of Transportation Service Providers. The basis for this priority was to conduct a survey for Transportation Service Providers to identify incentives to convert to electric vehicles (EVs). Yellow Cab Columbus (YCC) was chosen as the Transportation Service Provider to receive these surveys in conjunction with Morgan Kauffman, the owner and CEO, to provide the data for this priority and feedback for Smart Columbus.

Objective 1 one was to identify YCC's current state and their wants and needs moving forward. Kauffman has announced that YCC is transitioning to EVs in the next few years to stay at the forefront of innovation and limit consumption of fossil fuels. YCC has no EVs in their fleet. This survey will provide insights about cab driver opinions and perceptions that will ease YCC's transition to EVs.

Objective 2 was to create and distribute the survey to YCC drivers to collect feedback their willingness to adopt EVs. 13 questions were asked and analyzed. Some questions elicited a general overview of benefits and barriers of EVs while other questions asked about personal needs of the drivers to switch to these vehicles. Analysis of these survey results provided an in-depth look for what drivers would like and the locations needed for charging EVs. From the survey results, the adoption of EVs would rely heavily upon the availability of charging stations in the area where the drivers meet customers.

Objective 3 involved locating the critical charging locations for cab drivers if they were to drive an EV. A large difference between fossil fuel powered vehicles and an EV is the availability of fueling or charging spots. The City of Columbus is beginning to place charging stations throughout the city but seeks input on further locations. This Yellow Cab survey creates a realistic foundation for another data point Smart Columbus can consider for their locations.

Kauffman distributed the survey through his communication portal with cab drivers on March 23rd, 2018. We found that most respondents would be willing to switch to EVs if given a choice. The environmental aspect of EVs was a topic that was deemed important by the cab drivers. An anxiety of the cab drivers, if they were to convert to EVs, was the amount of

charging stations that would be available for use during driving hours. We recommend that Kauffman move forward with the adoption of EVs.

3.0 - Objective 1: Identify current state of Yellow Cab's fleet and determine its wants, needs, and interests in switching to EVs.

3.1 Methods and Means of Data Collection

The purpose of objective 1 was to gather baseline data of the composition of YCC's current operating vehicle fleet. In order to further analyze the company and its capabilities of EV adoption we first needed to gather more information about the governing entities within in the company and what their attitudes are towards the adoption of EVs. Developing knowledge of the structure of YCC's business model was essential for the group to the further analyze how the adoption of EVs would play out within this company. Objective 1 required communication with Morgan Kauffman the Owner and CEO of YCC. We connected with Morgan through phone conference calls, email and a tour of the YCC facility.

To further support Yellow Cabs Columbus's decision to incorporate the Chevy Bolt EV 2018 into their fleet, we did a price analysis of two scenarios. The first scenarios is that Yellow Cab buys the Chevrolet Bolt 2018 and operates it for eight years. For the second scenario, we look at their current fleet and found that the latest gasoline powered car they incorporated into their operations was a Toyota Camry, so the second scenario represents Yellow Cab abandoning their idea of an electric fleet and buying a Toyota Camry 2018 and operating it for eight years. For this analysis, Microsoft Excel was used to generate tables and graphs. Information was found through online research regarding the initial buying costs of both cars, price of electricity, price on maintenance, federal tax credit against EV purchases, and the range of both vehicles at full fuel capacity. Morgan Kauffman provided information for this analysis on the miles driven on average per year at YCC for one vehicle.

3.2 Data Collected

Data collected on the wants, needs, and interest of YCC's administration on adopting EVs into their car fleet was collected through phone conference calls and emails with Morgan Kaufman the CEO/Owner of YCC, as well as a tour of the YCC facility in Columbus OH. Through multiple conversations with him we learned that YCC's fleet currently consists of 151 vehicles. Their oldest model is a 2008 Toyota Crown Victoria and their newest model that they

have incorporated into their fleet is a 2017 Toyota Prius V. They currently have no full EVs in their fleet. Morgan also explained to us that he **wants** the YCC fleet to consist of only EVs in the future. For this transition to happen for YCC, they **need** EVs to be less infrastructure restrained in Columbus. YCC had an unsuccessful attempt to incorporate an EV in the past due to the lack of availability of charging stations in areas of the city in which the drivers operate. Morgan is working closely with Smart Columbus to aid in the strategic implementation of EV charging infrastructure in Columbus. Morgan expressed great **interest** in EV adoption, and he has decided on the Chevrolet Bolt 2018 for the model of car he will begin to incorporate into the YCC fleet. He also expressed interest in having a fully electric and fully decentralized fleet in the future. Morgan feels that it is inefficient for his drivers to be driving to the YCC headquarters to then drive out among Columbus for their work hours. He has worked on developing a car distribution system that can be located in multiple spots around Columbus. Drivers would then be able to travel to the nearest car distributor to pick up a vehicle.

For the cost analysis, we used a timeline of eight years. Kaufman said vehicles in YCC's fleet have a lifespan of up to 400 thousand miles. With the yearly mileage of 55,000, that means that the lifespan in years of their vehicles exceeds seven years, which motivated our choice of an eight-year analysis. We also collected information on make, model, and year of the EV that Yellow Cab intends on incorporating into their fleet. Kaufman provided us with a copy of fleet listings in the form of an excel document. This document listed the make, model, year and type of all 151 vehicles in their fleet currently. This document was used to identify the latest all-gasoline vehicle that had been introduced to their fleet which was a Toyota Camry. Online research revealed the suggested retail price of both vehicles. The price for a 2018 Chevrolet Bolt is $37,495 (2) and the current federal credit for purchasing an EV is $7,500 (8); these two numbers were used to estimate an initial buying cost of $29,995. The starting price for a 2018 Toyota Camry is $23,495 (3). The range (miles on full tank) of the Toyota Camry was calculated by averaging the estimated 420.5-mile range in city and the 594.5 miles on the highway, which yields an average 507.5 miles of range on a full tank (4). The Chevrolet Bolt's range is estimated at 238 miles on a full charge (2). The Toyota Camry has 14.5-gallon tank. With an average price of fuel of $2.50/gal, this car will cost $36.25 to fuel each full tank (4). The Chevrolet Bolt has a 60-kwh battery (5). With a cost estimate in the City of Columbus of $11.33/kwh for commercial electricity, this car will cost $6.80 to refuel each full charge (6). The estimated miles traveled a

year on a single vehicle of 55,000 miles, divided by the ranges on both vehicles, gives us the number of refuels need per year of operation (Toyota Camry: 55,000/507.5 = 108.37 refuels a year; Chevrolet Bolt: 55,000/238 = 231.09 recharges a year). The number of refuels/year was then multiplied by the cost to refuel each vehicle to give us the Refuel Cost per year in USD. Toyota Camry: 108.37*36.35 = $3,939.41. Chevrolet Bolt: 231.09*6.80 = $1,570.97. The maintenance cost of both vehicles was estimated by Edmund.com, which listed maintenance costs over a five-year period while driving 15K miles a year in a Toyota Camry. The price for the first 4 years or first 60k miles was used to estimate a price of maintenance per mile for the car while its mileage is under 60k: $.035/miles. The price of the fifth year was used to estimate the price per mile of the car with over 60k miles: $.11/mile. Since YCC cars drive 55K miles a year on average, the maintenance cost of $1895.67 was used for year one and then the price of $6101.33 was used for the remaining 7 years. Since the maintenance costs of a Chevy Bolt have not been quantified yet due to the model being so new to the market, the maintenance cost of Nissan Leaf 2018 was used. The price for the first 4 years or first 60k miles was used to estimate a price of maintenance per mile for the car while its mileage is under 60k: $.033/miles. Since YCC cars drive 55K miles a year on average the maintenance cost of $1809.05 was used for year one and then the price of $5529.33 was used for the remaining 7 years. The price of the 5th year was used to estimate the price per mile of the car with over 60k miles: $.10/mile.

3.3 Findings

Kauffman is very interested in having a fully electrical fleet sometime in the near future. He is already working towards this by evaluating EVs in the market currently and working with Smart Columbus to ensure the vehicles will not be infrastructure restrained in Columbus. Morgan has decided to incorporate the Chevrolet Bolt 2018 into his fleet in the near future. He is shaping this vision with his idea of decentralized vehicle holding locations where drivers can travel to the nearest location and retrieve a vehicle as opposed to having all drivers travel to the YCC facility.

The cost analysis was used to determine which vehicle would be the cheapest to own and operate over the lifetime of the vehicle. We found that although the initial buying cost of the Chevrolet Bolt 2018 is higher than that of the Toyota Camry 2018, beginning in the 3rd year of operation, the Chevrolet Bolt becomes the cheaper car to purchase. Because of lower

maintenance and fuel costs, the Chevrolet Bolt ends up being $12,895.56 cheaper at the end of eight years. Below is a graph of accumulated costs over the eight-year projected lifespan.
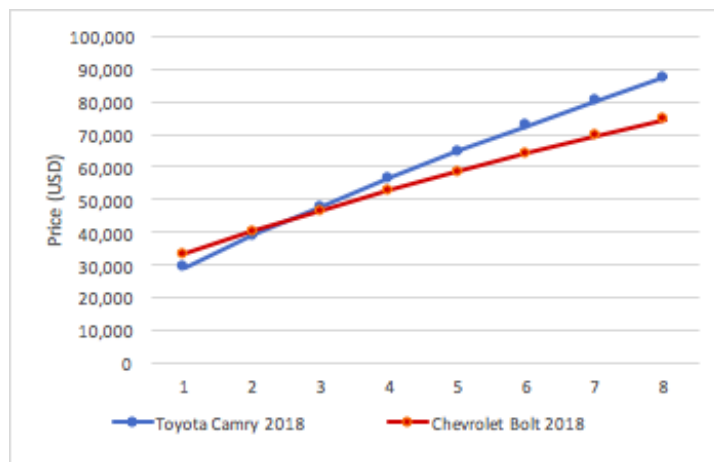
(Dataset #1)

3.4 Limitations and Challenges

YCC tried introducing a Tesla vehicle to their fleet in the past and the test failed. They found that the charging infrastructure would not support their business operations that requires drivers to travel up to 200 miles a day around Columbus. Our group was worried when we learned this because we felt YCC might be more reluctant to introduce an EV once again. Fortunately, Kaufman is still very interested in the adoption of EVs and even with a failed attempt to incorporate an EV into YCC business operations he remains persistent on the transition to an all-electric fleet.

4.0 - Objective 2: Create and administer a survey to Yellow Cab drivers to determine their opinions and concerns regarding the adoption of EVs to their fleet.

4.1 Methods and means of data collection

To complete objective 2, we needed to gain background information on EVs and cab companies that have already incorporated them into their fleets. We identified several known disadvantages from review of similar research. From a feasibility study of EV adoption into taxi services, conducted by students of the Graduate School of Innovation and Technology, KAIST (Korea Advanced Institute of Science and Technology) we gathered possible disadvantages that may concern drivers. These disadvantages include "long charging time, small vehicle size, and anxiety about the vehicle's range" (Baek, Kim, & Chang, 2016, p. 1). We took these into consideration and presented them in our survey to YCC drivers. We asked them to rank each

perceived disadvantage on a scale of 0-4, 0 being "No Disadvantage" and 4 being "Big Disadvantage". We used this same method for perceived advantages of EVs as well. The advantages presented to the drivers in this question included: cheaper to run, cheaper to maintain, better for the environment, increased safety, and reduced noise. We also posed the question of "If Yellow Cab allowed its drivers an option to convert to an EV in the next 2 years, how seriously would you consider switching to an EV?". We decided to pose this question to be able to summarize our survey's intent and the response that we received from the drivers.

4.2 Data Collected

The data that was collected from the survey was found using Qualtrics. Qualtrics was utilized to create the structure and foundation of the base survey elements. This program was also used as the portal for the data analysis information to make informed choices for the recommendations. Qualtrics was also used to provide an anonymous link so that there were no identifying indicators in the data. This research was conducted with approval of OSU's Institutional Review Board.
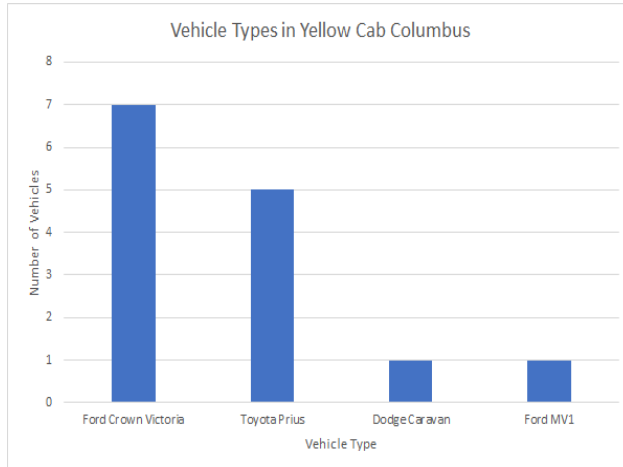

4.3 Findings

Out of the approximately 235 YCC drivers, 40 responded. Out of these 40 responses there were 21 responses that were complete enough for data analysis. Some survey questions have more than 21 validated responses. Data was still collected and counted for the survey questions that the drivers chose to answer even if they did not fill out the whole survey.

The first question asked was the amount of years that the Yellow Cab driver has been driving with Yellow Cab. There were 29 respondents of this question and of these respondents there were 8 drivers that had been with Yellow Cab for 10 years or more. Based off the 30% of respondents being with Yellow Cab for 10 years or more, their thoughts could be much different compared to younger drivers within the company. These older drivers may have stronger ties to the company and in turn care more about what is happening to company such as the adoption of EVs.

The second survey question was a general question of whether the driver was leasing or buying the vehicle which is the structure that Yellow Cab operates under. Of the 28 respondents 17 leased the vehicles and 11 owned the vehicles that they drive. Question three of the survey involved the make and model of the current vehicles that are in use by the drivers. Question four
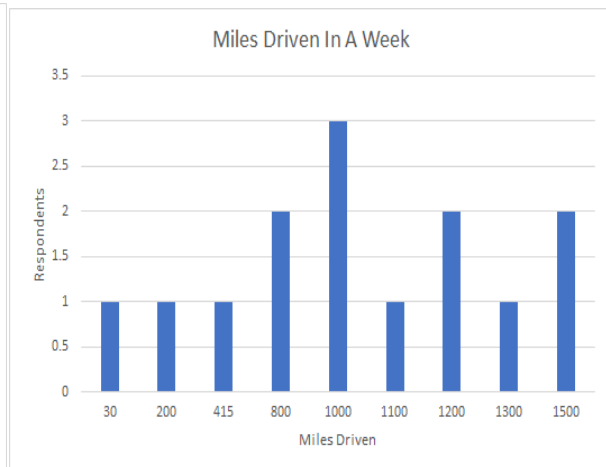
involved the total mileage driven in an average week. Question five and six provided information on how many hours and at what time of day drivers will typically drive. The distributions for questions three and four are recorded below.

Survey Question Three   Survey Question Four
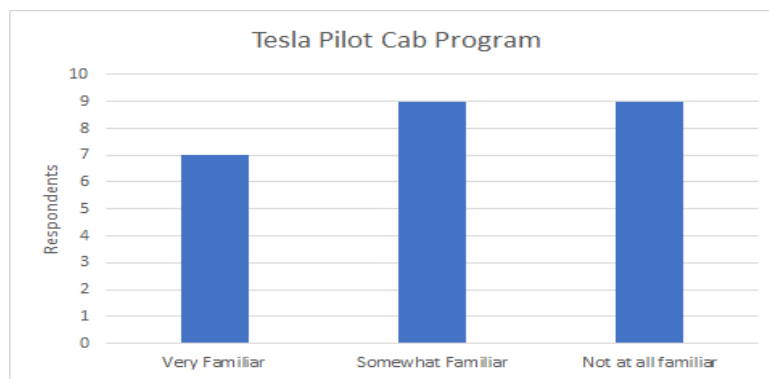

(Dataset #4)   (Dataset #4)

The next nine survey questions were based around EVs. The seventh survey question asked drivers if they have heard of Yellow Cab testing out a Tesla vehicle in their fleet. The eighth asked drivers if they have ever driven an EV before. The ninth and tenth survey question asked the driver what they believe to be both advantages and disadvantages of EVs. The eleventh survey question asked what the biggest barrier was thought to be.

Survey Question Seven

(Dataset #4)

The twelfth survey question was an open-ended call to suggest locations important in placing charging stations for Yellow Cab drivers (analyzed in objective 3). The thirteenth survey question involved asking if the driver would consider switching to an EV. These two survey questions involved the largest weight in consideration of whether the cab drivers would be willing to convert to EVs and if so where charging for these vehicles will be available. In objective 3 on page twelve, you can view the twelfth survey question results and below is the distribution of the thirteenth question.
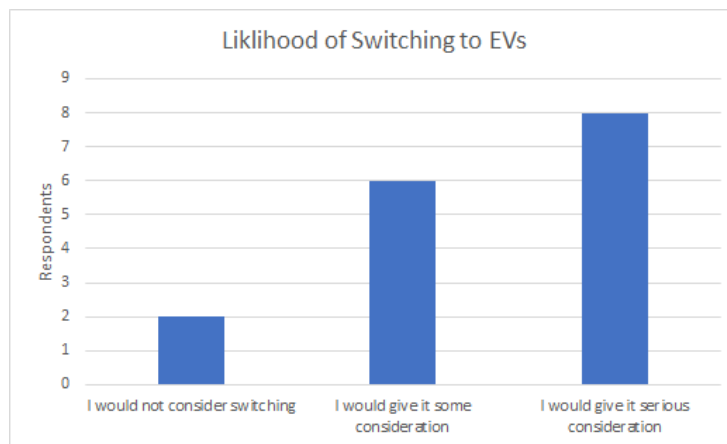
(Dataset #4)

The survey provides locations for where charging stations will need to be. The consensus of Yellow Cab drivers is that in general they are more than likely to switch to EVs if given the chance. The biggest benefits and concerns were logged to provide an overview of what cab drivers are contemplating when thinking about switching to EVs as their daily mode of transportation. For a Transportation Service Provider like YCC there is a drive from both management and drivers for the adoption of EVs.

Question fourteen of the survey asked drivers, "If Yellow Cab allowed its drivers an option to convert to an EV in the next 2 years, how seriously would you consider switching to an EV if it **increased** the cost of operating your cab by 2%, 5%, 10%, 20%" and drivers were to answer to each percentage with their likelihood of considering to switch. We also asked drivers in question fifteen, "If Yellow Cab allowed its drivers an option to convert to an EV in the next 2 years, how seriously would you consider switching to an EV if it **decreased** the cost of operating your cab by 2%, 5%, 10%, 20%". Both questions were created as key questions of our survey. However, due to the low response rate, and response inconsistency, these results to be unusable. We recommend that future researchers pose this question as we believe it will bring about

valuable information. However we recommend rephrasing it so that more useful results can be collected.

4.4 Limitations and Challenges

A major challenge was getting enough responses to provide a solid foundation for the data analysis. Even though we were able to get 40 responses from Yellow Cab drivers some were incomplete. Out of the 21 responses made the distribution of 21 cab drivers compared to the 235 drivers working with yellow cab is quite low. This survey was not incentivized and possibly could have received a higher response rate if incentives were offered.

5.0 - Objective 3: Determine locations for EV charging infrastructure in Columbus that would aid cab drivers in using their EVs during service hours.

5.1 Methods and means of data collection

A key question posed in our survey read, "If Yellow Cab were to introduce EVs into its fleet, where do you think charging stations should be located to ensure that cab drivers will be successful? Please type in the names of any locations you think would be a good location for a charging station." We made this question open-ended, allowing drivers to enter their personal preferences for charger locations. After reviewing the survey responses, we then made edits to a heat map that was provided to Yellow Cab from the National Renewable Energy Laboratory (NREL) of the trip destination frequency of 124 drivers using 12 vehicles found in Section 6. Recommendations. This map gave us insight into where the drivers are going most often and what routes they're using to get there. We combined this analysis with the survey results to create a recommendation that would be most helpful in Yellow Cab's future electrification plans. We felt that since the biggest barrier to adopting EVs, identified by the drivers in a separate question, was lack of charging stations, it would be best to directly address this concern with these possible locations for chargers throughout the city, pointed out on the heat map pictured in section 6. Recommendations.

5.2 Data Collected

We were able to obtain several suggestions from fifteen out of forty respondents. Although our response rate was lower than anticipated, we still believe that the suggestions from these drivers should be taken seriously as many of their responses were similar and we assume their fellow drivers would agree on these areas. It should also be noted that the remaining drivers

who did not respond to the survey, or completed the survey without filling out this question, should be given the chance to voice their opinions and concerns with the EV switch, including thoughts on areas for charging stations as they may bring new insight for areas that would be beneficial for all drivers.

5.3 Findings

From this key survey question, the downtown area was identified as the number one most popular suggestion for charging stations, with seven out of fifteen respondents listing it in their answers. Other popular locations identified include the Yellow Cab terminal, locations off East Broad street, the Grandview Yard, areas near the John Glenn Columbus International Airport, and at their own homes.

To make the most accurate recommendations for charging characteristics, we focused on the EV that Yellow Cab intends to integrate into their fleet, which is the Chevy Bolt EV. The Bolt EV "accepts the universal connector on every standard Level 2 charging port", as noted by ChargePoint (EV Life, 2017). Level 2 chargers add about 25 miles of range to the Bolt EV for every hour of charge. An option for faster charging is the DC Fast charger which adds roughly 90 miles of range in half an hour. Cost wise, the Chevy Bolt EV has lower costs of "refueling" to regular gas vehicles when charged on both a Level 2 charger and a DC Fast. The average cost to add 50 miles of range on a gas-powered vehicle is $4.76, while adding 50 miles of range on a Level 2 and DC fast costs about $1.18 and $2.66, respectively (EV Life, 2017).

5.4 Limitations and Challenges

One of the main limitations to our analysis, as noted before was the low response received from the survey. The response rate did not reach the 25% we had hoped for. This created a challenge in identifying how most Yellow Cab drivers felt about adopting EVs into the fleet. We believe our recommendations for placement and characteristics of charging are still valid as we have incorporated the useful responses we received in our final report.

6.0 - Recommendations

The research and analyses leads us to recommend that YCC continues its plan to have drivers adopt EVs for their business operations. As shown in the cost analysis, after just 3 years of operation the Chevrolet Bolt 2018 becomes the cheaper car to own and operate. After eight years of operation, which is the approximate average lifetime of vehicles in YCC's fleet vehicles,

the owner will have saved $12,895.56 with the purchase of the Chevrolet Bolt 2018 compared to the Toyota Camry 2018.

After analyzing the survey results received by the cab drivers, there is a willingness to consider adoption of EVs. The use of the Vulcan grant money could assist this Transportation Service Provider with moving forward in changing all of the cab fleet to EVs. The responding cab drivers appear malleable enough to begin the process of EV adoption. The biggest barriers expressed by the cab drivers are the lack of charging stations, which is explored below.

We believe it's in the best interest of YCC to offer a variety of Level 2 and DC Fast chargers depending on location and charge time required. Having Level 2 chargers at the homes of drivers who are interested, as well as at the Yellow Cab lot would be most cost effective and

(Dataset #5)

efficient for drivers use since these are locations that the cabs are expected to sit for longer periods of time. Placing DC Fast chargers in the downtown Columbus area, Grandview Yard,

and areas relatively close to major highways will be most successful for the drivers as these are areas where breaks during shifts can be taken and the faster charger provided by the DC Fast port will be a convenience and an advantage for Yellow Cab.

The heat map included above reflects these recommendations. The blue dots are recommended areas for charging stations, with the larger blue dots representing areas that require either multiple types of chargers (Level 2 and DC Fast), or a larger number of chargers since these were identified as popular areas for charging.

We believe Smart Columbus and Yellow Cab should continue to hold Priority 2 in which this research study was based on at a high standard. The partnership already has great plans in motion to create a more decentralized cab service and we have found that the implementation of the Chevy Bolt EV into their fleet would be welcomed by their drivers. Despite our small survey response, we believe that the drivers will be pleased with the integration of EVs based largely on their environmental benefits and cost savings. We recommend that as Yellow Cab moves forward with the building of their new network structure and electrification that they keep in mind the majority of drivers who did not respond to the survey and be open to their ideas and concerns. It was made clear to us that Morgan Kauffman wanted to help Columbus pioneer the movement toward EV transportation service because it's the right thing to do and will help the city reach their sustainability goals, despite the costs Yellow Cab may incur at the start.

We recommend for future research to gain a larger response from the drivers of transportation service providers like YCC, so that there is a more holistic understanding of what these drivers expect when making a large switch such as the implementation of EVs. As stated before, our research findings and recommendations are limited to the amount of responses received from our survey and there may be other YCC drivers who have alternative ideas for where chargers should be placed, or varying opinions of the implementation of EVs into the fleet in general. It may also be beneficial for future research to conduct a cost benefit analysis of the Chevy Bolt EV model that includes societal as well as private costs and benefits and to compare this model against other standard and hybrid models that come to market, so that YCC can remain well informed.

7. 0 – Conclusion

From our survey results, we found that 50% of respondents would seriously consider adopting EVs. However, perceived barriers such as lack of charging locations, limited range, and charging time must be addressed during implementation. We also located several possible locations for charging stations that Yellow Cab drivers feel would remedy their concern with charger locations. We found from the survey responses that nearly 35% of respondents felt that this lack was the biggest barrier to adopting EVs, followed by perceived disadvantages of the limited range and time to recharge. We also asked the drivers about perceived advantages of EVs and 35% answered that the benefits to the environment is the biggest advantage for them, followed by reduced noise, and the cost savings to run and refuel an EV.

Our recommendations are for YCC and Smart Columbus to move forward with their implementation of EV's in their future plans for a decentralized cab service. We believe the drivers will welcome this change from Yellow Cab and that Columbus will become a greener city, helping Smart Columbus reach its sustainability goals. We agree with Morgan Kauffman that making this switch is the right thing to do, despite any large costs incurred at the beginning of implementation, the social and economic benefits in the long run will make it worthwhile. Smart Columbus should continue to invest time in their partnership with Yellow Cab as we foresee this switch to be one that will put Columbus on the map for innovation in sustainability and other cities like ours will be inspired to implement EVs into their transportation service providers as well.

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8. Voelcker, J. (2017, June 9). How much is a replacement Chevy Bolt EV electric-car battery? Retrieved April 12, 2018, from https://www.greencarreports.com/news/1110881_how-much-is-a-replacement-chevy-bolt-ev-electric-car-battery

9.0 - Appendix

9.1 - Data Sets

Dataset #1: Price Analysis of Chevy Bolt EV 2018 vs Toyota Camry

Sources:

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7. Voelcker, J. (2017, June 9). How much is a replacement Chevy Bolt EV electric-car battery? Retrieved April 12, 2018, from https://www.greencarreports.com/news/1110881_how-much-is-a-replacement-chevy-bolt-ev-electric-car-battery

Description: The above sources were used to create a price analysis comparing the 2018 Chevrolet Bolt and the 2018 Toyota Camry. Data was collected from the above sources on

initial cost of the vehicles, price of electricity, price on maintenance, federal tax credit for electric vehicle and range of both vehicles at full fuel capacity.

Dataset #2: Conference Call and On-site Yellow Cab Visit Notes

Sources: Key findings from recorded conference calls. Recordings uploaded to Data Files.

AEDECON 4567. (2018). *First Conference Call with Bud Braughton*[MP3]. 18th Avenue Library: Giovanna Busco. (2018)

AEDECON 4567. (2018). *Conference Call with Braughton. McSweeney, and Kauffman*[MP3]. 18th Avenue Library: Giovanna Busco. (2018)

Description: On February 1st, 2018 Giovanna Busco, Casey Scott and Jordan Hampshire had a conference call with Kevin McSweeney and Norman (Bud) Braughton. In this conference call, we reviewed the overall scope of the project and consulted our collaborators on which transportation service provider to focus on for our research project. From this call, we decided to focus of Yellow Cab Columbus. On February 6th, 2018 Giovanna Busco, Casey Scott and Jordan Hampshire had a conference phone call with Morgan Kaufman and Kevin Mcsweeney. In this conference call, we were introduced to Morgan Kaufman the owner and CEO of YCC, we discussed more in detail about YCC and their business operations. We asked key questions about the number of drivers they employee, the number of vehicles they operate, how many miles they drive on each vehicle each year, etc. Morgan Kaufman also told us more about the Tesla failed test drive in this conference call. In conclusion of this conference call Morgan invited us to visit the Yellow Cab Columbus Headquarters in Columbus. During our visit, we toured the facility and were able to better visualize their business operations. During the visit, Morgan expressed to us in detail his wants, needs and interests in converting to electric vehicles and his vision for the future of YCC.

Dataset #3: EV Feasibility Research Data

Source: Baek, S., Kim, H., & Chang, H. (2016). A Feasibility Test on Adopting Electric Vehicles to Serve as Taxis in Daejeon Metropolitan City of South Korea. *Sustainability,8*(9), 964. doi:10.3390/su8090964

Description: This feasibility test report was used to identify perceived advantages and disadvantages of EV fleet adoption. It was also used to gain background information on the responses of other drivers who have adopted EVs as taxis.

Dataset #4: Yellow Cab Driver Survey Data
Source: Survey and its results created by team members, with help from instructor Brian Roe, and critiques from Andrew Duvall. Found in Data Files uploaded to Carmen.
OSU AEDECON 4567: Fleet Adoption Survey (Yellow Cab Columbus), [PDF file].
Description: This survey which was distributed to Yellow Cab drivers was used to gain insight into their opinions and concerns concerning the adoption of EVs into the YCC fleet. This survey includes 18 questions total with a voluntary agreement statement at the beginning. Not all questions were able to be used for this research report due to inconsistencies with survey responses.

Dataset #5: Heat Map with Recommendations for Charging Locations
Source: NREL. Figure 8. Heat map of Columbus trip destination frequency derived from INRIX data set, [heat map]. Denver, CO: NREL, 2017.
OSU AEDECON 4567: Fleet Adoption Survey (Yellow Cab Columbus), [EXCEL file].
Description: The heat map first introduced to us at our Yellow Cab Columbus visit was given to us by Kevin McSweeney of Smart Columbus. The National Renewable Energy Laboratory conducted this survey in INRIX tracking to produce a heat map of trip destination frequency from 12 cars in Yellow Cab's fleet. We used this heat map to enhance our recommendations for charging stations along with locations identified by drivers in the survey results excel file which can be found in the Data Files section uploaded to Carmen.

9.2 - List of Primary Contacts
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