

# Electric Vehicle Charging Infrastructure for Private Company Adoption

EEDS Capstone Course, Spring 2018



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## **I. Executive Summary**

After the City of Columbus was awarded the Smart Cities Grant, accomplishing sustainability goals have been a top priority within the Columbus community. The Ohio State University (OSU) has partnered with Smart Columbus to connect graduating students with various projects that focus on accomplishing these sustainability goals. This report will focus on the implementation of electric vehicle (EV) charging stations within private companies for employee and customer use.

Our project group focuses on four main objectives to create a comparative cost and benefit analysis. Our group first looked into institutions that have already installed workplace charging stations to gain background knowledge on EV chargers. Initial benchmarking research was conducted to determine accurate costs for two different types of charging stations, Level 2 and DC Fast Chargers. Level 2 chargers are lower powered chargers that take about 8 hours to produce a full charge (most likely to be used for employees) and DC Fast Chargers are high powered chargers that produce a full charge in 30 min - 1 hour (most likely to be used for customers). A cost analysis was conducted to show the purchasing and operational costs over a ten-year time period. We identify several monetized and non-monetized benefits that include increased employee recruitment and retention and corporate marketing benefits. Our group also analyzed how many tons of carbon dioxide were reduced per year and carbon dioxide savings per year with different levels of charger utilization.

We found that over a ten-year time period, Level Two chargers would have a discounted (3%) cost of \$94,844.85 and DC Fast chargers would have a discounted cost of \$99,804.01. Although these costs are relatively expensive, the overall benefits of workplace charging stations can outweigh these costs. The average cost-per-hire for companies is approximately \$4,129 per

year[MRE1], (Society for Human Resource Management, 2016), and the appeal of workplace charging to employees or new employees could reduce this cost. Our group analyzed potential changes in annual employee turnover and new employee acquisition to demonstrate possible business cost savings associated with the appeal of workplace chargers to current and potential employees. Although not easily monetized, corporate branding can also be a significant benefit for companies considering the growing importance of sustainability initiatives within businesses in the modern workplace.

We recommend that private companies install both Level 2 and DC Fast chargers, with each quantity dependent on the time utilized at each charging station. Level 2 chargers are ideal for employees that will spend extended amounts of time on site, and DC Fast chargers are more fitting for customers that spend 30 minutes to 1 hour on site. Although initial costs are high, companies who adopt these amenities early will benefit from corporate environmental leadership, acquiring and retaining an innovative workforce, and select financial incentives provided by the U.S. government and other companies.

## **II. Introduction**

The City of Columbus has developed many initiatives to help transition Columbus into a Smart City, one of which is to install a minimum of 250 charging ports at work places during the grant period and develop an electric vehicle charging infrastructure within the City of Columbus. As electric vehicles become more commonplace in Columbus, more companies are realizing that creating a charging infrastructure may be an important employee and customer recruiting tool, and contribute to creating a modern and innovative workplace. Our goal through this capstone course is to create an extensive cost benefit analysis for private companies considering installing

electric vehicle (EV) charging stations on their property for employees and possible customers. We hope that our research will provide guidance to private companies that are considering the installation of electric vehicle charging stations in their workplaces. Our report will highlight the economic, environmental, and social benefits that charging stations bring to the workplace, as well as the benefits, specifically for employers. Our team focused on four main objectives:

- ***Objective I: Conducting benchmarking analysis***, which includes two components of research; gaining insight from case studies of cities and workplaces who have installed EV charging infrastructure, and gathering data on current costs and benefits for electric vehicle charging station options in Ohio and the United States.
- ***Objective II: Conducting cost analysis*** associated with electric vehicle charging infrastructure, which includes installation, equipment, electricity and maintenance & repair costs.
- ***Objective III: Analyzing benefits*** that can be derived from the charging infrastructure, both monetizable and non-monetizable.
- ***Objective IV: Providing actionable insight for stakeholders***

### **III. Objectives**

This analysis consists of many different research methods in order to collect vital information and data. This includes benchmarking, gathering data from academic articles, the cost and benefit analysis, and conclusion of research. To conduct this analysis, we relied mainly on internet research and communications with collaborators from the City of Columbus, Smart Columbus, the Columbus Partnership, and State Auto.

## *Objective I: Conducting a Benchmarking Analysis*

The purpose of objective 1 was to conduct a benchmarking analysis on EV charging stations. The research task included gaining insight from early adopters who have installed EV charging infrastructure, and gathering data on current costs and benefits for electric vehicle charging station options in Ohio and the United States. By analyzing the data found, we created a baseline of cost and benefits with which we were able to conduct our analysis' and create recommendations. The data collected for each of the research tasks represent a holistic view of the state of current EV charging stations and their data.

In our initial research, we found that Level 1 chargers put an amount of energy that is too little to be efficient at workplaces, so our team focused on two types of chargers, the Level 2 Charger and the DC Fast Charger. Our research compared various costs for electric vehicle charging stations such as installation, physical unit costs, and maintenance. We collected data on costs and benefits from leading distributors and informants like Chargepoint, EV Solutions, and the U.S. Department of Energy. Comparing the different electricity utilizations of the two chargers and speaking with key informants, which will be discussed in the cost section, we were able to determine an average usage of kwh per day, per charger and the expected cost of electricity based on usage. Through our benchmarking, it was found that workplace charging stations can have great influence over the adoption of electric vehicles, making employees 20 times more likely to drive an electric vehicle if workplace charging stations are available (Energy.gov, 2014). Data from other states and cities that have implemented electric vehicle workplace charging programs have been extremely helpful in our research to identify employer/company benefits, which will be discussed in the benefits section of this report. We explored various programs in California, such as the California Plug-In Electric Vehicle

Collaborative and the Calstart Employer EV Initiative. Few companies in Ohio have implemented workplace charging, but we looked into the AEP Headquarters, Abercrombie, and the public charging stations at Easton Place.

*Objective II: Conducting a Cost Analysis*

For our second objective, we conducted a cost analysis of expenses associated with implementing electric vehicle chargers. Due to our key informants not yet having a budget or goal for charger implementation, we created a mock scenario for our analysis that consists of installing ten Level 2 chargers and two DC Fast Chargers. To simulate a common analysis a private organization may conduct when considering implementing an investment of this size, we chose to show the analysis over a 10 year period. Costs are made up of four components; installation fees, maintenance and repair, increase in electricity bill, and charger equipment costs.

Element	Year										
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
Installation	\$ (5,000.00)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Maintenance & Repair	\$ -	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)
Electricity Bill Increase	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)	\$ (6,550.00)
Charger Equipment	\$ (30,000.00)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Total Costs Per Year</b>	<b>\$ (41,550.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>	<b>\$ (6,850.00)</b>
Discounted Costs (3%)	\$ (41,550.00)	\$ (6,650.49)	\$ (6,456.78)	\$ (6,268.72)	\$ (6,086.14)	\$ (5,908.87)	\$ (5,736.77)	\$ (5,569.68)	\$ (5,407.45)	\$ (5,249.95)	
<b>Project Total Costs</b>	<b>\$ (103,200.00)</b>										
<b>Discounted Total Costs</b>	<b>\$ (94,884.85)</b>										

Element	Year										
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
Installation	\$ (20,000.00)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Maintenance & Repair	\$ -	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)	\$ (300.00)
Electricity Increase	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)	\$ (6,540.80)
Charger Equipment	\$ (20,000.00)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Total Costs Per Year</b>	<b>\$ (46,540.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>	<b>\$ (6,840.80)</b>
Discounted Costs (3%)	\$ (46,540.80)	\$ (6,641.55)	\$ (6,448.11)	\$ (6,260.30)	\$ (6,077.96)	\$ (5,900.93)	\$ (5,729.06)	\$ (5,562.20)	\$ (5,400.19)	\$ (5,242.90)	
<b>Project Total Costs</b>	<b>\$ (108,108.00)</b>										
<b>Discounted Total Costs</b>	<b>\$ (99,804.01)</b>										

The first step in our analysis was to calculate the initial fee; this consisted of installation and charger equipment costs. We found that it cost approximately \$35,000 for installation and equipment fees for ten level 2 chargers and \$40,000 for two DC fast chargers. This number was calculated by averaging the costs that top distributors are charging their consumers for installation and equipment fees. We gathered our information and data from leading distributors and informants in the industry like Chargepoint, EV Solutions, and the U.S. Department of Energy.

Our next step in the cost analysis was to predict the increase in the electricity bill after installing electrical charging stations. For this analysis, we assumed a standard 8 hour workday and that level 2 chargers will be used primarily by employees while DC Fast chargers are reserved for customers and the public. We estimated that there will be a 400 kilowatt hour increase in output per day for both level 2 and DC fast chargers. We determined this by speculating that level 2 charging stations would be operating for a full 8 hour work day. We multiplied this by the 5 kilowatts per hour output per station (EV Solutions, 2018). Results show an increase of 400 kilowatt hours per day for ten level 2 chargers. Secondly, we determined a 400 kilowatt increase a day for DC fast chargers by estimating the number of full charges the ports will generate a day. We concluded that one DC charger will provide the equivalent of 4 full charges in a day. This will generate a total of 8 full charges in a day for two DC fast chargers.



With an average full charge at 50 kilowatts per hour (Van der Put, 2017), there will be a 400 kilowatt hour increase per day for two DC fast chargers. With this newly calculated information we were able to predict that the increase in the electricity bill for both level 2 and DC fast chargers will be around \$6,550. This number was computed by multiplying the 400 kilowatt increase a day by the rate in which our key informants are paying for their electricity and accounting for the number of days in a year.

The final variable we observed was the maintenance and repair costs. Based from key informants from AEP, we determined this costs to be a yearly expenditure of \$300. This was approximated by averaging AEP's yearly maintenance and repair fees for their private electric vehicle charging stations.

Lastly, after examining the total cost over a ten year period we concluded that the total project cost with a 3% discount rate is roughly \$95,000 for ten level 2 chargers and \$100,000 for two DC fast chargers. After the total costs were obtained, we used this scenario to calculate the monetized and non-monetized benefits of carbon savings, employee acquisition and overall turnover rates.

### *Objective III: Analyzing Benefits*

The benefits associated with workplace EV charging stations fall under two main categories; environmental benefits and economic benefits. Both types of benefits can also be broken down into monetized and non-monetized benefits. We include the monetized benefits in the cost benefit analysis, and discuss the benefits that are difficult to monetize through this report. Electric vehicle initiatives in California provided us with important information in terms of benefit evaluation, because they have implemented programs centered around workplace

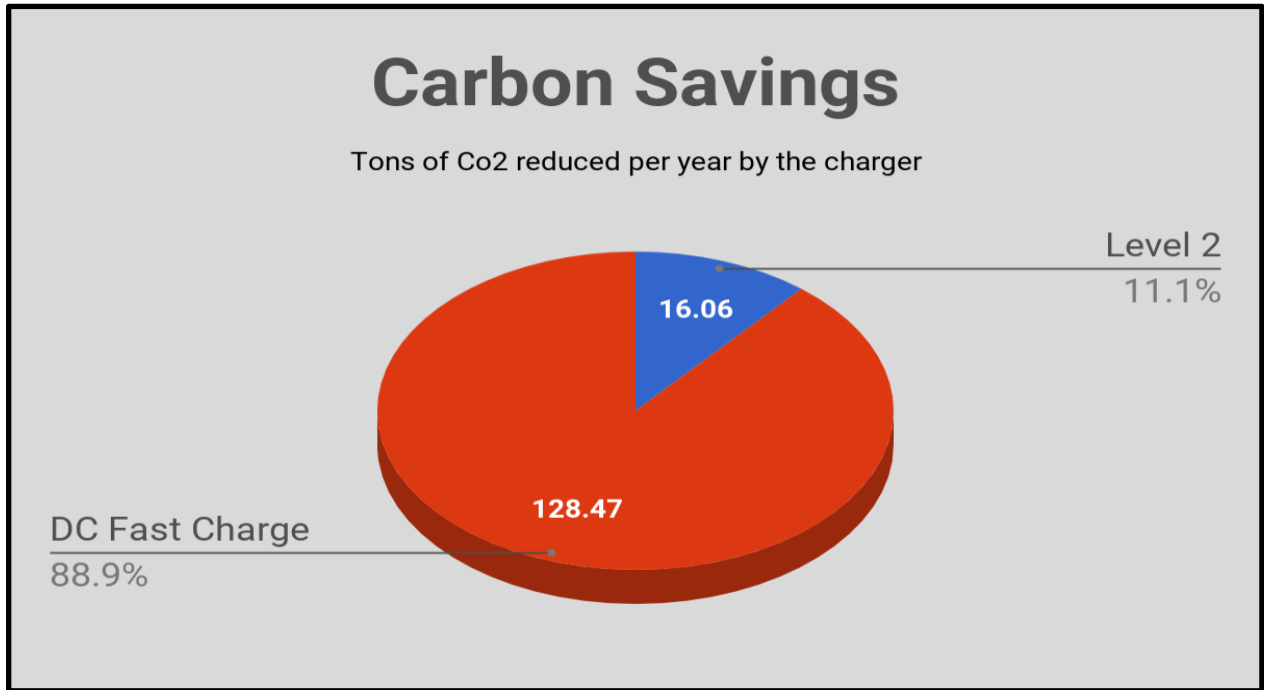
charging stations since 2013 (California, 2013). Companies in Columbus who are trying to implement workplace charging may also find these articles and presentations, located in the appendices, helpful in their efforts to implement workplace charging. The United States Department of Energy has also identified various benefits for workplace charging through their Workplace Charging Challenge.

### *Monetized Benefits*

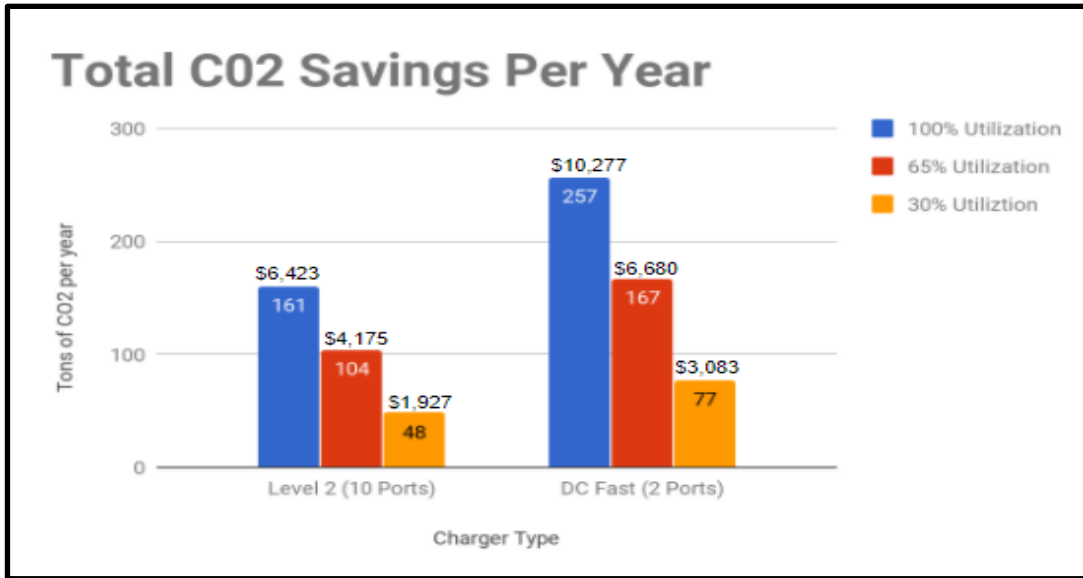
As the majority of private companies are for-profit, our group realizes that return on investment is an important factor in any type of company changes and implementations. Although the monetized benefits depend on company specific values, we are able to generalize certain costs to find an average value for benefits in our analysis.

When people think of electric vehicles, two factors generally come to mind immediately; clean energy and reduced or zero emissions. The first benefit our analysis focuses on is how EV charging stations play into the reduction of greenhouse gas emissions. In collaboration with our capstone Decarbonization research group we found that 0.01807 tons of carbon dioxide is emitted per a full charge of an electric vehicle while 0.1422 tons of carbon dioxide is emitted per full trip of a standard gas powered vehicle. Currently, electric vehicles have an average range of ~100 miles per charge, while the average standard vehicle gets about 300 miles. To make up for this difference, we multiplied the emissions of electric vehicles by a factor of 3, resulting in 0.05421 tons of carbon dioxide emitted from electric vehicles at the standard vehicle range equivalent. Even with the adjusted numbers, there is a reduction of 0.08799 tons of carbon dioxide when individuals use electric vehicles rather than standard gas powered vehicles.

Using the reduction in carbon found per full trip and the average amount of charges expected per day, we were able to calculate the expected reduction in carbon dioxide per year per charger. (see below graph)



However, it is not yet reasonable to assume that these chargers will be used 100% of the time, so using the same scenario we used in our cost analysis (the installation of 10 level 2 charges and 2 DC Fast chargers) we took the combined carbon reduction and showed carbon savings with the chargers being used only 65% of the time and 30% of the time. (see chart below) Even without full utilization, there is significant savings in carbon emissions per year. Taking the carbon savings per year and using the current social cost of carbon, \$36/ton, (EPA, 2017) we were able to find the cost of the carbon reduced, a benefit companies can show in their sustainability reports.



The second monetized benefit that we examined is employee recruitment costs. This tends to be a surprisingly expensive cost to companies. According to the Society for Human Resource Management, the average cost-per-hire for companies is \$4,129 (Society for Human Resource Management, 2016). A breakdown of different recruitment costs can be found below:

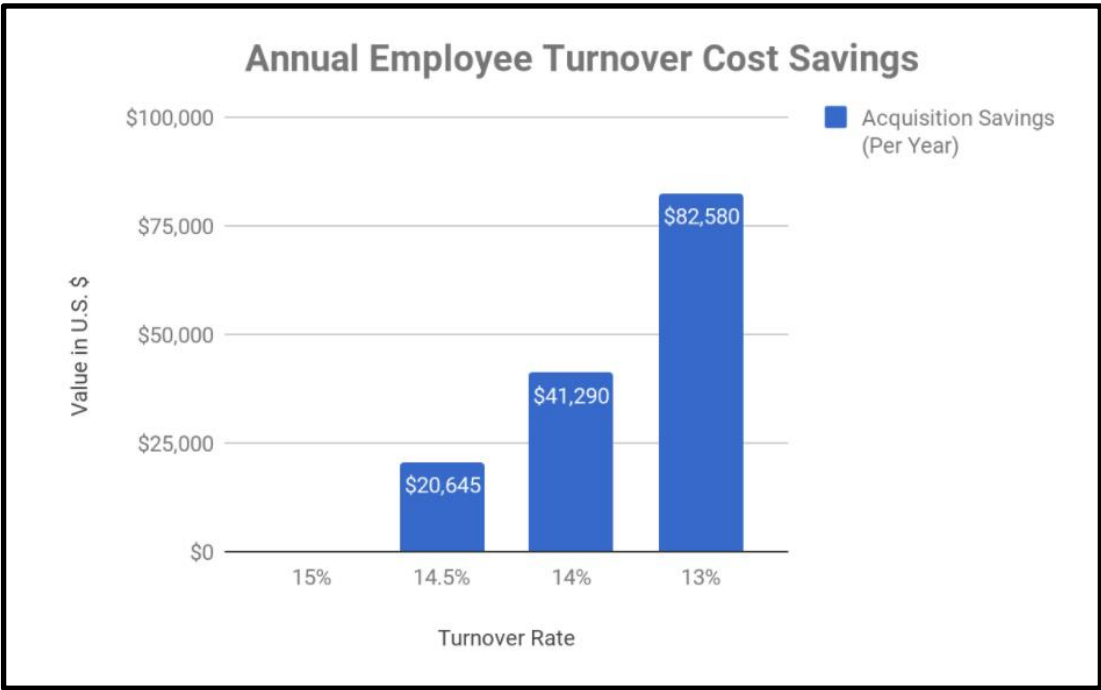
- Cost open positions job boards and other advertisements
- External recruiting by third party
- Employer branding events
- Partnerships with other companies or institutions
- Salary cost of hiring team

On average, it takes about forty-two days to fill an open position (Society for Human Resource Management, 2016). Workplace EV chargers are a rare commodity in Columbus and make a difference in employee recruitment and retention. According to the Melink Corporation, 80% of employers offer EV charging as a benefit to retain and attract a talented, modern workforce (PR Newswire, 2015). Due to the current and predicted future trends in electric

vehicle adoption in Columbus, workplace chargers will likely become a necessary asset for companies to attract an innovative and forward-thinking workforce.

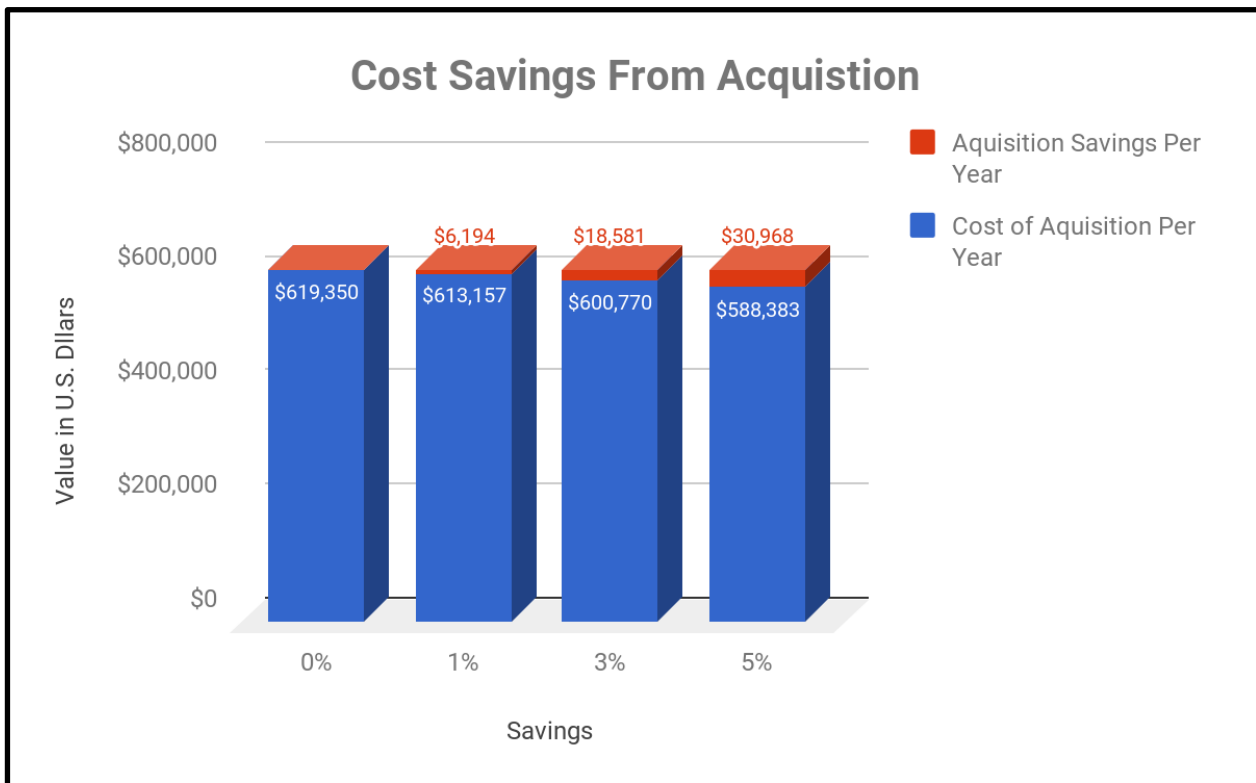
One of the major benefits of installing workplace EV chargers is a reduction in these recruitment costs. This is due to some potential hires seeking out businesses with EV chargers, as well as the more general desire to work for a company that is viewed as being more sustainable and environmentally conscious. Recruitment costs can also decrease due to less employees turnovers, because the installation of EV chargers can also improve existing employee retention.

Employee acquisition and retention savings are among the most noticeable economic benefits of installing workplace chargers. In order to calculate these potential savings, the data mentioned above from the Society for Human Resource Management was used to find the savings that is possible with a 1,000 employee firm. It is also important to note that this analysis was produced with a baseline turnover rate of 15% to represent the insurance sector. Below is a graph to illustrate the savings that occur if a firm is able to reduce its turnover rate and the subsequent acquisition costs.



The cost savings associated with a decrease in turnover that EV chargers can create is a substantial monetary benefit for any firm that installs them, rising to savings as great as \$82,000 per year if turnover decreased by 2%. This should be considered as a significant return on investment for any firm considering EV charger installation.

Another way that acquisition savings can be viewed is from a percent savings per hire, instead of a decrease in turnover. Under a 15% turnover rate, a 1000 employee firm will spend about \$620,000 per year on employee replacement costs, which can be seen as the baseline in the graph below. The installation of these chargers can be used as a marketing tool and decision



factor in new hires, reducing the cost the company spends on acquisition.

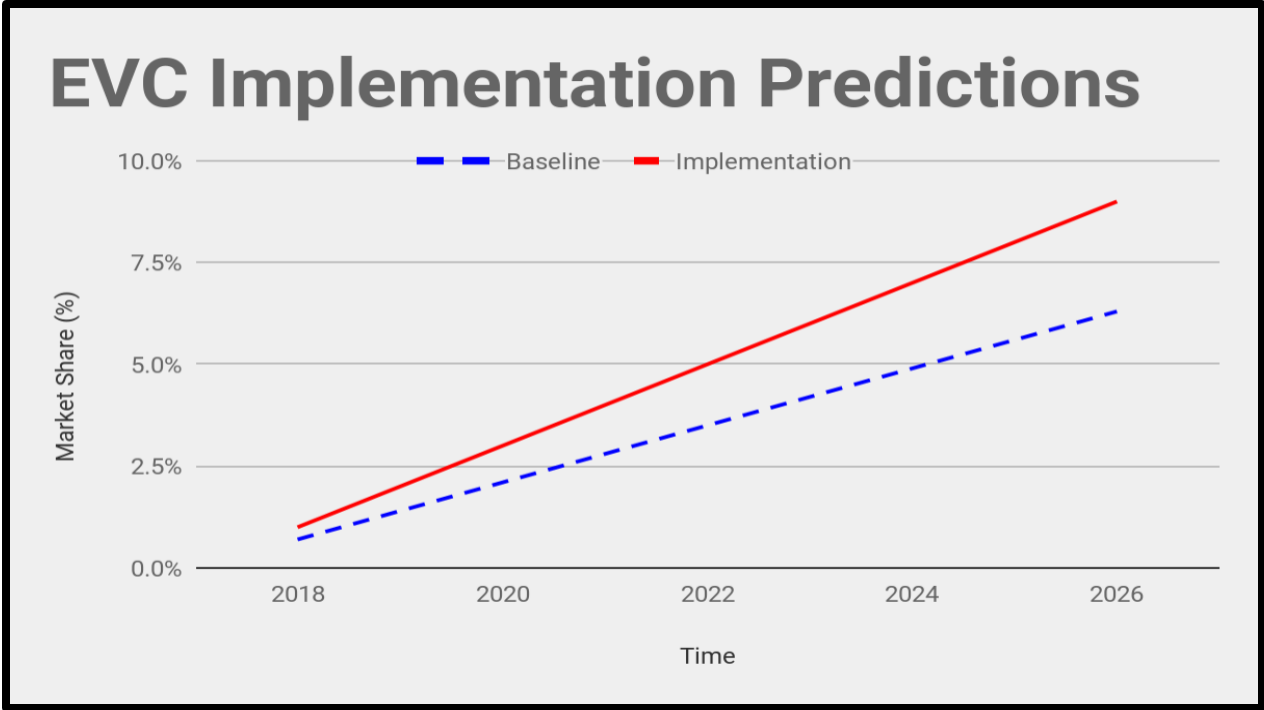
This analysis examined the total savings that can be acquired with a reduction in cost per acquisition. The firm would save \$41 per hire under a 1% savings, \$124 per hire under a 3%

savings, and \$206 under a 5% savings. The graph above illustrates the total costs of acquisition with these per hire savings, and its associated savings, under a constant 15% turnover rate.

### *Non-Monetized Benefits*

Non-monetized benefits were of interest for this study to interpret other social, environmental, and economical savings that EV charging stations can offer. There are several benefits within these indicators. The main benefits of focus are branding the company to environmental compliance standards, carbon sequestration from the city of Columbus, and the possibility to make profit for not only the company, but the public as well, due to electricity costs becoming more affordable in the future. All of these benefits are conducted in lieu of promoting a smarter Columbus from the leaders of our city to eventually the public body.

First, branding a company to comply with environmental stewardship shows that the company is not only responsible but also appealing to stakeholders. By targeting an environmental challenge through innovative solutions like EV infrastructure, research has shown employees are 20 times more likely to drive an electric vehicle (Energy.gov, 2014) if EV infrastructure was implemented. In addition, the market share in Ohio for new EVs is forecasted to increase by 0.03% per year after EV infrastructure is adopted. (Bloomberg, 2018). Based on this forecast data, a general prediction for the state of Ohio's market share of EV sales has been conducted by comparing the baseline EV sales and predicted EV sales after implementation of EV chargers.



While EV’s baseline says EV sales are growing by .3% each year, with the implementation of EV infrastructure, people would be more inclined to purchase EV’s, increasing annual growth in market share to .7%. This increases Ohio’s market share from 6.3% to 9% (2.7% more growth with EVCS implementations) over a nine year time period. The implementation of workplace chargers also demonstrates corporate leadership, can further a company’s progress towards achieving its sustainability goals, and could enable certain types of certifications such as Leadership in Energy and Environmental Design (LEED) Certification, Green Globes Certification, B-Corp Certification and the ability for partner recognition with the United States Department of Energy.

Lastly, the extent to which a company is environmentally compliant is a trending issue in the corporate world. With standards and regulations of environmental compliance becoming more robust, companies are making internal goals to surpass the authoritative goals set in place. These goals are being achieved in a variety of ways, one of which being an attempt to control the



carbon footprint made in these companies everyday activities. From our carbon reduction analysis described above, we found that on average 16.06 tons of CO<sub>2</sub> would be saved from a single level 2 charger per year and 128.47 tons of CO<sub>2</sub> would be saved from a single DC Fast charger. The implementation of EV chargers and calculated emissions reductions shows forward thinking, environmental compliance, and potential candidacies for certifications and awards for the company through a feasible method. Companies that incorporate sustainability into their values also see a higher stakeholder interest because an organization's environmental, social and governance (ESG) metrics, as they have been shown to contribute to a company's financial success over time (CECP, 2017).

### *Barriers*

Our project encountered many barriers early in the process when defining our research scope and finding specific data for various costs and benefits. As many business professionals have full schedules, it was difficult to communicate with industry leaders in order to ask about their specific costs for electricity, employee acquisition costs, and overall interest in implementing the project. The majority of our costs were taken from averages found from reliable web sources, such as the US Department of Energy and Transportation. There was also a lack of data available to the public on the utilization of these chargers. We were also unable to attain data from the few companies who have installed EV charging stations at their workplace.

### *Recommendations*

After completing a cost and a benefit analysis on the implementation of workplace EV chargers, the value derived from these chargers seems to balance the initial capital investment and over time, outweighed it. It is recommended that firms considering the installation of on-site

EV chargers implement both Level 2 and DC Fast chargers. The Level 2 chargers serve as a sensible option for employees to use during the day as they spend many hours on site, and the DC Fast chargers offer a great resource to draw in customers to the location.

Although some companies may prefer to act on this later after others have proven its worth, there are many reasons why installing early is beneficial. Electricity is predicted to be the main source of energy consumption by 2040 (National Geographic, 2017). However, there is rapid growth of electricity coming from renewable energy (wind and solar assets), and Production Tax Credits (PTC's). Early adopters will reap the benefits that come from tax incentives, reduced energy costs, new customer acquisition, employee retention, as well as corporate environmental leadership. Workplace EV chargers are a smart investment for any company looking to brand itself as a sustainability leader, or that wants to improve stakeholder value.

We recommend that the City of Columbus use our analysis to show the Columbus Partnership and any interested organizations the costs, benefits, and incentives for installing EV charging stations at their workplace. The city may use our data to further their own research in providing incentives and bridging current gaps in adoption.

#### **IV. Conclusions**

Though there is a large upfront investment in installing workplace charging stations, private companies will benefit from cost savings for employee recruitment and retention and brand themselves as corporate leaders in sustainability efforts. The City of Columbus and the Columbus Partnership Corporate leaders that implement workplace charging will create a culture of sustainable innovation, and be on the forefront of Columbus's transition into a Smart City.

## Appendices

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## ***Datasets***

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- "EV Solutions." *Electric Vehicle Charging Products*, 2018. Retrieved from <https://www.evsolutions.com>

Description: This dataset includes a summary of the costs, benefits, and NPV of the cash flow for an investment in 10 Level 2 chargers and 2 DC Fast chargers. It also includes data used to create the graphs for carbon savings, turnover rate, and employee acquisition.

2. Art Interview.docx

Sources:

- Art Hersey, Facility Director, State Auto Insurance Companies. February 8, 2018. Phone: 614-917-5267. [Art.Hersey@StateAuto.com](mailto:Art.Hersey@StateAuto.com)

Description: Notes from a set of questions that were asked to Art Hersey about State Auto's interest in installing chargers on site in Columbus, Ohio.