

# Workplace Charging to Support One Million Zero Emission Vehicles in California by 2020

---

A Group Project submitted in partial satisfaction of the requirements for the degree of  
Master of Environmental Science and Management  
for the  
Bren School of Environmental Science & Management  
University of California, Santa Barbara

by

Kathryn Collins | Tori Greenen | Adrienne Harris | Heather Martin | Yi (Real) Wen

Faculty Advisors: Dr. Sarah Anderson  
Dr. James Frew

May 2017

## **Workplace Charging to Support One Million Zero Emission Vehicles in California by 2020**

As authors of this Group Project report, we archive this report on the Bren School's website such that the results of our research are available for all to read. Our signatures on the document signify our joint responsibility to fulfill the archiving standards set by the Bren School of Environmental Science & Management.

---

Kathryn Collins

---

Tori Greenen

---

Adrienne Harris

---

Heather Martin

---

Yi (Real) Wen

The Bren School of Environmental Science & Management produces professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principal of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

---

Dr. Sarah Anderson

Date

---

Dr. James Frew

Date

# Acknowledgements

We would like to thank everyone who assisted us with this project. We are especially grateful to the following people:

## **Advisors**

Dr. Sarah Anderson (Bren School)  
Dr. James Frew (Bren School)  
Jessica Perkins, PhD Candidate (Bren School)

## **Client: Governor's Office of Business and Economic Development**

Tyson Eckerle, Deputy Director of Zero Emission Vehicle Infrastructure  
Taylor Jones, Advisor  
Gia Brazil Vacin, Project Manager

## **External Advisors:**

James Hall, General Motors  
Commissioner Janea Scott, California Energy Commission

## **External Assistance:**

Rhetta deMesa, California Energy Commission

## **Funding:**

Yardi

We would to extend our gratitude to all the faculty at the Bren School of Environmental Science & Management for their advice and support.

Finally, we would like to thank all of the businesses that we interviewed for this project.

# Table of Contents

List of Tables.....	iv
List of Figures.....	iv
Acronyms.....	v
Terminology.....	vii
Abstract.....	viii
Executive Summary.....	1
<b>1 Project Objectives.....</b>	<b>4</b>
<b>2 Significance and Background.....</b>	<b>5</b>
2.1 Significance.....	5
2.2 Motivation.....	6
2.3 Background.....	7
<b>3 Methodology.....</b>	<b>9</b>
3.1 Business Interviews.....	9
<b>4 Results &amp; Findings.....</b>	<b>12</b>
4.1 Barriers to Workplace Charging Adoption.....	12
4.2 Business Categories.....	16
4.3 Distribution Analysis.....	26
<b>5 Recommendations.....</b>	<b>32</b>
5.1 Immediate Recommendations.....	33
5.2 Long-term Recommendations.....	36
<b>6 Summary and Conclusion.....</b>	<b>38</b>
<b>7 Appendices.....</b>	<b>40</b>
A1: Summary of Literature Review.....	40
A2: Summary of Stakeholders.....	57
A3: Environmental Impact Assessment.....	59
A4: Interview Data.....	60
A6: Distribution Analysis Data.....	68
A7: Cost Benefit Analysis.....	70
A8. First Charger Rebate Program Details.....	77
A9. Additional References.....	78

# List of Tables

- Table 1. Responses to MTURK barrier survey .....7
- Table 2. Description of charging level, supply power, and average cost charging unit.....8
- Table 3. Percentage of California employment in the top five business sectors.....10
- Table 4. Distribution of sizes of businesses interviewed in this study .....12
- Table 5. Response to hypothesis testing for barriers to workplace charging adoption.....13
- Table 6. Barriers to workplace charger installation for three business categories...19
- Table 7. Number of chargers needed by businesses .....29
- Table 8. Proposed solutions organized by targeted barrier .....32
- Table 9. Expanded responses to hypothesis testing for barriers .....60
- Table 10. Responses to hypothesis testing for government agencies .....64
- Table 11. Cost-benefit analysis assumptions .....70
- Table 12. Benefits of installing workplace charging stations .....73
- Table 13. Costs of installing workplace charging stations .....75
- Table 14. Summary of costs and benefits of installing workplace charging.....76
- Table 15. Funding structure for the first charger rebate program .....77

# List of Figures

- Figure 1. Technology Adoption Curve for workplace charging stations.....17
- Figure 2. Distribution of Early Adopters’ use of outside funding in installing chargers .....20
- Figure 3. Reported revenue for Early Adopters .....21
- Figure 4. Parking experiences for Early Adopters .....22
- Figure 5. Reported revenue for Early Majority.....23
- Figure 6. Parking lot experiences of Early Majority .....24
- Figure 7. Relative distribution of workplace chargers across all California businesses .....30
- Figure 8. Number of chargers needed by businesses .....68
- Figure 9. Calculations for distribution analysis .....69

# Acronyms

**AFDC:** Alternative Fuels Data Center

**BEV:** Battery Electric Vehicle

**CARB:** California Air Resources Board

**CBA:** Cost Benefit Analysis

**CEC:** California Energy Commission

**CER:** Corporate Environmental Responsibility

**CSR:** Corporate Social Responsibility

**DOE:** Department of Energy

**EV:** Electric Vehicle

**EVSE:** Electric Vehicle Supply Equipment

**FCEV:** Fuel Cell Electric Vehicle

**GHG:** Greenhouse Gases

**GO-Biz:** California Governor's Office of Business & Economic Development

**GO-Zero:** The Research Group from Bren School, UC Santa Barbara

**HEV:** Hybrid Electric Vehicle

**ICV:** Internal combustion vehicle

**NEV:** Neighborhood Electric Vehicle

**PEV:** Plug-in Electric Vehicle

**PHEV:** Plug-in Hybrid Electric Vehicle

**PZEV:** Partial Zero Emission Vehicle

**REEV:** Range-extended Electric Vehicle

**RFID:** Radio-frequency Identification Device

**WPC:** Workplace Charging

**ZEV:** Zero Emission Vehicle

# Terminology

**Convenience sampling:** A non-probability sampling technique where subjects are selected because of their convenient accessibility and proximity to the researcher

**Decarbonize:** To reduce the amount of gaseous carbon compounds released from a process

**Early Adopter:** A person or business that is at the forefront of new technology adoption and whose main motivations for adopting are because the technology is new, cool, or applies uniquely to them

**Early Majority:** A person or business that is part of the first major wave of technology adoption once that technology begins to saturate the market. They come after the Early Adopters and often have more barriers that must be overcome before they adopt.

**Electric Vehicle Supply Equipment (EVSE):** Any equipment that can recharge an electric vehicle, including Level 1, Level 2, DC Fast Charging, and portable charging stations

**Late Adopter:** A person or business that is in the last wave of adoption of a new technology. Adoption is usually in response to a changing world or status quo where lack of adoption will leave them behind.

**Range Anxiety:** A driver's fear that their electric vehicle will not be able to drive far enough on a single charge

**Snowball survey:** A non-probability sampling technique where existing study subjects help recruit future subjects from among their acquaintances

**Workplace Charging:** A charging station that is accessible for use by employees during the workday

**Zero Emission Vehicle:** A vehicle that emits zero tailpipe pollutants from the onboard source of power



# Abstract

As a leader in climate policy, California recently established targets to reduce its greenhouse gas emissions (GHGs) to 40% below 1990 levels by 2025 and 80% below 1990 levels by 2050. However, the state will not meet these ambitious goals without decarbonizing the transportation sector, a major contributor to the state's GHGs. To incentivize cleaner transportation Governor Jerry Brown signed an executive order in 2013 mandating that 1 million zero-emission vehicles (ZEVs) be on California roadways by 2020. The bulk of these 1 million ZEVs will be plug-in electric vehicles and as such California must work to develop a robust network of charging stations to support these electric vehicles. This project studies an important part of that charging network—workplace charging which allows employees to plug in at the office—to determine how to incentivize more businesses to install charging stations for their employees. The motivations and barriers businesses face when looking to install charging stations were uncovered by interviewing and testing funding and policy strategies on businesses across California. Based on these findings, this report lays out a set of targeted policy recommendations to be implemented by the California Governor's Office of Business and Economic Development to help overcome the barriers and further workplace charging installation throughout the state.

# Executive Summary

Currently in California commercial and personal vehicles account for well over half of the emissions that contribute to local air pollution and roughly 40% of the state's greenhouse gas (GHG) emissions. As the country's leader in climate policy, California has set ambitious targets of reducing its GHG emissions to 40% below 1990 levels by 2025 and 80% below 1990 levels by 2050 (CARB, 2014). California cannot meet this goal without decarbonizing the transportation sector, so Governor Jerry Brown signed a 2013 executive order (B-16-2012) to help bring one million zero emission vehicles (ZEVs) onto the road by 2020 and 1.5 million by 2025 (Governor's Interagency Working Group on Zero Emission Vehicles, 2013; CARB, 2014). Most of these will be plug-in electric vehicles (PEVs).

The lack of a robust charging network is a widely acknowledged deterrent to purchasing a PEV. A 2014 study conducted by the California Energy Commission (CEC) and the National Renewable Energy Laboratory (NREL) confirmed a generally accepted order of charging priorities: PEV drivers will use home charging first, workplace second, and public charging last. NREL's analysis also uncovered a significant gap in workplace charging—crucial infrastructure for the 34% of Californians who live in multiunit dwellings and may not have access to home charging (NREL, 2014), or for those who drive far enough that they must charge at work.

Therefore, this project aims to accelerate the installation of workplace charging infrastructure throughout California. This project delivers policy recommendations and funding strategies that our client, the Governor's Office of Business and Economic Development (GO-Biz), tasked with enabling workplace charging in the 2013 California ZEV Action Plan, can implement to reach 100,000 workplace charging stations by 2020.

The data used in this project was collected through strategic interviews with businesses throughout California, both with and without charging stations. The results from these interviews were used to determine the most significant barriers to installing workplace chargers in California which are:

1. **Lack of data.** Little information exists on workplace chargers in a format that is useful for studying, tracking, and understanding the deployment of this infrastructure. Because there does not exist a single, coherent database with information on where workplace chargers are installed, how many there are, and which companies have installed them, it is difficult for projects such as this one to advise on ways to increase workplace charger installation.
2. **Costs sensitivity.** Installing workplace charging can be expensive, especially if a

business must lay new conduit or upgrade their electrical panel to accommodate the chargers. Particularly for smaller businesses, these costs can be prohibitive, meaning a business cannot install chargers even if employees are demanding them.

3. **Lack of parking control.** Except for those businesses located on “campuses” where a single business either owns or leases the buildings and parking lots in their entirety, many businesses either share parking with other companies (referred to as “business parks”) or rely on offsite parking, controlled by a third party or by the local government, for their employees’ parking needs. Shared parking, or not having onsite parking at all, presents a challenge for businesses that want and can afford to install chargers but must work with other parties to install the charging infrastructure.
4. **Lack of demand.** Businesses whose employees do not drive EVs and therefore do not currently need workplace charging have little incentive to install workplace charging infrastructure. However, this lack of demand is a circular issue: businesses won’t install chargers if employees don’t drive EVs but employees are hesitant to drive EVs if there is no way to charge them at work.

Three categories of businesses emerged based on their ability to overcome these barriers to installation:

- **Early Adopters:** Businesses that have overcome all four barriers and are already installing chargers without outside incentives.
- **Early Majority:** Businesses where there is potential for employee demand but that still must overcome cost and/or parking barriers before providing workplace chargers for their employees.
- **Late Adopters:** Businesses where there is little potential for employee demand because employees are unlikely to drive EVs to work by 2020 due to the business’s location. These businesses will not contribute to meeting the first goal of 100,000 chargers.

We developed three immediate recommendations for funding and policies that will support workplace charging adoption among Early Majority businesses, who will be critical to meeting the goal of 100,000 workplace chargers. Our recommendations address the adoption barriers faced by the Early Majority:

- To address lack of data, we recommend establishing a state-run database of the exact number and location of workplace chargers, and what companies have installed these chargers.
- To address lack of demand, we recommend targeting businesses that have yet to install their first charger. We have found, and the literature confirms, that once

a business installs its first charger, employees are much more likely to purchase EVs and demand more chargers.

- To address cost sensitivity, we recommend launching a first-charger rebate program to encourage Early Majority businesses to adopt their first workplace charger.
- To address lack of parking control, we recommend that cities create their own EV workplace charging plans to encourage workplace charging on a voluntary basis.

We also developed two long-term recommendations to help GO-Biz expand their workplace charging program: updating utility and charger company workplace charging programs to better serve Early Majority businesses, and promoting alternative charging technologies such as mobile chargers or solar-powered chargers.

# 1 Project Objectives

While California's *2013 ZEV Action Plan* called for dramatic expansion of workplace charging infrastructure, there are still very few policies or specific incentive programs to help businesses rise to the challenge. Therefore, this project seeks to evaluate how GO-Biz can best use government resources to facilitate the rapid installation of workplace chargers to meet California's goal of 1 million zero emission vehicles (ZEVs) on the road by 2020.

Our primary project objectives are to:

1. Uncover the barriers preventing more California businesses from installing EV chargers.
2. Categorize businesses based on their likeliness to install workplace charging infrastructure, to determine which businesses to target.
3. Recommend strategies or policies to incentivize increased workplace charger adoption in California.

## 2 Significance and Background

### 2.1 Significance

California's transportation sector accounts for 40% of state's GHG emissions, making it the largest single-sector source of emissions in the state (Governor's Interagency Working Group on ZEVs, 2013). Due to the volume of GHGs produced by the transportation sector, ZEV adoption is considered a critical component of this larger GHG emission reduction target. With zero tailpipe emissions, ZEVs will significantly reduce GHG emissions from California's mobile sources and help to improve the state's overall air quality. Improving local air quality in California is particularly important, as California still has 40 counties in nonattainment status for hazardous air pollutants, and transportation is the primary source of hazardous air pollutants that contribute to local health effects (GIWGOZEV, 2013; California Air Resources Board, 2016).

The Electric Power Research Institute (EPRI) and Natural Resources Defense Council estimate that ZEVs will be able to reduce annual statewide GHG emission at least by 45% (EPRI, 2015). The term 'ZEVs' refers to "*vehicles which produce no emissions from the on-board source of power*" (CARB, n.d.). This designation includes plug-in electric vehicles (PEVs): pure battery electric vehicles (BEVs), such as the Tesla Model S, and plug-in hybrid electric vehicles (PHEVs), such as the Chevrolet Volt (GIWGOZEV, 2016). As PEVs are generally referred to as electric vehicles, encompassing both BEVs and PHEVs, we will use the nominative title "EV(s)" throughout this report.

Since enacting its first ZEV program in 1990, California is committed to the successful deployment of ZEVs throughout the state (CARB, 2014). In 2013, Governor Jerry Brown expanded the ZEV program by establishing the goal of 1 million ZEVs on California roadways by the year 2020 and 1.5 million by 2025 (Executive Order B-16-2012, 2012).

As of January 2017, California has around 250,000 ZEVs on the road, representing the world's single largest market for EVs (CARB Midterm Report, 2017). California is a global leader in climate policy, and its ZEV program will likely be used as an example for other states and countries to follow.

## 2.2 Motivation

### *Why Workplace Charging?*

There are three reasons that workplace charging will be necessary to reach the one million ZEV goal in California.

First, consumers tend to purchase EVs as commuter vehicles, making workplaces a prime space for charging infrastructure. In 2014, the California Center for Sustainable Energy (CCSE) reported that there were more than 45,000 EVs in California, and that almost 90% of the owners drove their EV to work (CCSE, 2012). Adding workplace charging would allow drivers to double their daily driving range, making EVs accessible to those whose long daily commute had previously rendered an EV inadequate.

Second, even if drivers live close enough to their workplace to travel to and from work on a single charge, they still report experiencing range anxiety during their commute. Along with costs and charging time, range anxiety (the worry that the EV will not reach the intended destination on a single full charge) is one of the main barriers to EV purchasing identified in the literature (Carley et al., 2013; Neubauer and Wood, 2014). This suggests that the adoption and growth of EVs is contingent on having a comprehensive charging network in place (Huang and Zhou, 2015).

Third, workplace charging is critical to expanding EV adoption to include potential drivers who do not live in a single-family home with access to regular charging. As indicated in the *California Plug-in Electric Vehicle Driver Survey Results – May 2013*, 96% of 2,039 respondents among EV drivers in California had a designated Level 2 (240 V) electric vehicle charger and 90% of the survey population lived in a single-family detached house (California Center for Sustainable Energy, 2013). However, as California works to increase the number of EVs on the road, it will need to attract new drivers beyond those who own single-family homes. Thus, workplace chargers are a key component of this comprehensive network, especially for those future EV drivers who may not have access to home charging (Philipson et al. 2015; Carley et al. 2013).

In fact, in a survey of 160 respondents on Amazon's Mechanical Turk we find that a lack of workplace charging was perceived as the biggest barrier to purchasing an electric vehicle among driving age Californians. We asked them on a scale from (1) Strongly Disagree to (5) Strongly Agree if they felt that lack of access to workplace charging, lack of access to home charging, upfront cost, EVs not fulfilling driving needs, and unhappiness with current EV models were significant barriers to buying an EV (Table 1).

Our survey results show that lack of workplace charging, upfront vehicle cost, and lack of access of home charging are statistically significant barriers to EV adoption (Table 1).

**Table 1.** Comparison of barriers to neutral response using a one-sample one-sided t-test ( $n = 160$ ,  $\mu = 3.00$ ,  $\alpha = 0.05$ ).

Barrier	Mean	p-value
Lack of access to workplace charging	3.88	< .01
Upfront cost is more than a normal car	3.84	< 0.01
Lack access to home charging	3.45	< 0.01
EVs do not fulfill driving needs	3.11	0.15
Unhappy with current EV car models	3.00	1

## 2.3 Background

### *Charger Installation*

Workplace charger adoption can be broken down into three steps: an internal valuation, planning and executing the installation, and implementing an operational plan after chargers are installed (California Plug-in Electric Vehicle Collaborative, 2013. *Plugging In*). An internal valuation encompasses any steps an organization takes prior to deciding to install a workplace charging station. This may include surveying employee needs, or the time and effort required to get executive support for the project.

Installing workplace chargers can be expensive. The supply power and average costs of each charging level equipment are detailed in Table 2. A simple installation might only include the equipment for a wall mounted Level 1 or 2 unit. Average costs are given for single port charging units. Dual port units, where two cars may be charged at once, double the number of vehicles that may be charged in proximity to the charging unit. Optional equipment for a charging unit may include an RFID card reader which must be accessed using an employee ID card or other credentials This allows an organization to control who uses the charging station at various times.



**Table 2.** Description of charging level, supply power, and average cost for a single port model.

Charging Level	Supply Power	Cost for Single Port
AC Level 1	120VAC/20A	\$300-\$1,500
AC Level 2	203/240VAC/20-100A	\$400-\$6500
DC Fast Charging	208/480VAC 3-phase	\$10,000-\$40,000

Source: New West Technologies, LLC., 2015

Installation can be more complicated and expensive if new electrical wiring or conduit must be installed to connect parking spaces to the electric service. Trenching or boring beneath concrete, laying conduit, and then refilling is often estimated at \$100 per foot (New West Technologies, LLC., 2015). The electrical capacity of a building may also require upgrades to handle the increased electrical load from chargers. This is most common in older buildings, or if multiple chargers are being installed. Improved lighting, signage, and concrete barriers or pedestals for the charging equipment can also contribute to more expensive installations.

Organizations may find it necessary or helpful to use charging installation services provided by charging station companies, or third party installers who specialize in workplace charging, especially if expensive installation requirements come into play. These companies can provide equipment expertise, recommendations for local electricians who are familiar with charging stations, and solutions for ongoing maintenance and management of new chargers.

After installation, operating costs include electricity, maintenance, repairs, billing transaction costs, and network access for usage tracking and accounting services for the charging unit (U.S. Department of Energy, 2013). These costs can either be absorbed by the company or charged through to employees. Alternatively, they can be covered by various available subsidies such as a utility-owned charger.

## 3 Methodology

Our literature review identified a lack of significant, peer-reviewed literature regarding how businesses perceive the costs and benefits of installing a workplace charging station, how sensitive they are to the potential barriers, and what types of financial or policy support they need to overcome these barriers. Existing literature focused more on specific case studies or pilot programs and the specific experience of those businesses, rather than what their experiences might reveal about general barriers to charger installation.

There was also a significant lack of quantitative data regarding the location of and businesses associated with workplace chargers. No complete registry exists for this infrastructure either at the state or federal level. This lack of data is a serious barrier to California's goals for EV infrastructure because currently California will not know if or when it hits its goal of 100,000 workplace chargers.

In response to these data constraints, we conducted interviews with businesses with and without chargers to uncover what they faced or perceived as significant barriers that stop them from putting chargers at their workplaces. We also tested several recommendation strategies in our interviews to evaluate their effectiveness.

### 3.1 Business Interviews

#### *Business Selection Criteria*

The selection criteria for our interviews were designed to maximize the number of interviews we could complete in six months. We pursued contacts through a combination of convenience and snowball sampling. We interviewed businesses from the five largest general NAICS sectors in the state across all business sizes (Table 3) using data from the California Employment Development Department. These sectors were services, retail trade, healthcare, manufacturing, and government. Together the five chosen sectors represent 83.6% of California's workforce.

**Table 3.** Percentage of California employment in the top five business sectors.

Sector Name	Percent of California Employment	Notes
Services	39.7%	Including administrative and waste services and information
Retail Trade	18.0%	Including wholesale trade and food services
Healthcare	9.4%	
Manufacturing	5.8%	Manufacturing itself does not have to occur in-state
Government	10.7%	

Data source: California Employment Development Department

### *Interview Format*

Interviews were conducted over the phone and took between 30 and 45 minutes each. Companies were provided with sample questions in advance via email to allow the representative to gather the types of information we were seeking. All interviews followed a semi-structured interview procedure (the interview outline can be found in Appendix 3), based on a review of the current literature and on preliminary interviews with EV charging experts.

In our businesses interviews, we gathered information on: company demographics (e.g., size, number of employees, revenue), interviewee information (i.e., role in company), quantitative charger info (e.g., cost of installation, number of chargers, number of employees with EVs), and qualitative charger info (e.g., successes or shortcomings of current charging program).

We recorded the role of each interviewee within their company as a measure of how an electric vehicle charging program would be housed within the company's structure. We used our observations from the early interviews to pursue similar level contacts in future interviews, after finding that facilities, capital projects, and businesses development units may all be used to manage a charging program. We also ensured that all information collected from businesses was kept confidential and would not be disclosed beyond our group members.

### *Identifying Barriers to Adoption of Chargers*

During the last portion of each interview, we proposed a set of scenarios and tested their influence on the company's willingness to install additional chargers. We asked the interviewee to rank the scenarios on a scale from 1-10, with 1 being "no change in likelihood of installing additional chargers" and 10 being "extremely likely to install additional chargers." The scenarios include the following:

- Providing funds to cover the upfront cost of charger installation
- Providing funds to cover the ongoing costs of charger use
- Having the local utility company install, manage, and maintain the charger including all upfront and maintenance costs, but excluding the cost of electricity and opportunity cost of parking
- Using alternative charging technology such as mobile charging that allows electric vehicles to charge in non-designated parking spots
- Creating a single easy-to-use online resource for companies to compare charger types, companies, and funding options
- Chargers were eligible for marketable carbon credits
- Chargers were eligible for commuter credits
- Increasing employee demand for workplace charging equipment

# 4 Results & Findings

## *Business Size Demographics*

We interviewed 36 companies and 10 government agencies. Government interviews were analyzed separately because state agencies are under statutory obligations to install workplace charging whenever possible (Appendix 4). Table 4 shows the percentage of the employees in each business size category.

**Table 4.** Distribution of sizes of businesses interviewed in this study.

	Number of Employees		
	0-49	50-249	250+
Percentage of California Businesses	95.9%	3.6%	0.5%
Percentage of Statewide Employees	31.9%	28.3%	39.9%
Percentage of GO-Zero Interviews	16.7%	13.9%	69.4%

Source: California Employment Development Department

While large businesses make up less than one percent of California’s businesses, these businesses with more than 250 employees made up 69.4% of our interviews. We found that large businesses were easier to reach, either because they were common contacts for our team members, they had previously appeared in workplace charging literature, or they were common examples of businesses with workplace charging. Small and medium businesses were much less likely to have knowledge of, or agree to speak with us regarding, workplace charging.

## 4.1 Barriers to Workplace Charging Adoption

### 4.1.1 Hypotheses Testing

During our interviews we proposed a series of scenarios using the phrasing “How much more likely would you be to install chargers if...[proposed scenario]” and responses were given on a scale of 1-10 with 1 as “extremely unlikely to install the first or more

workplace chargers” and 10 as “extremely likely to install the first or more workplace chargers”. The business responses to the scenarios that might increase adoption were averaged and the values are presented in Table 5. Businesses reported that having utilities install, own, and manage the chargers would have the biggest effect on their likelihood of installing more chargers (7.2), followed by increased employee demand for workplace charging (7.1) and if the ongoing cost of the charger was covered (6.9). Businesses reported that having chargers eligible for marketable carbon credits would have the smallest effect on their likelihood to install workplace chargers (5.2).

**Table 5.** Barriers to workplace charging adoption. Responses are on a 1-10 scale to proposed hypotheses with 1 as “extremely unlikely to install the first or more workplace chargers” and 10 as “extremely likely to install the first or more workplace chargers”.

Proposed Scenario	Mean Response (n)
Your utility installed, owned, and managed the chargers	7.2 (37)
Employee demand for a charger increased	7.1 (37)
The charger’s ongoing cost is covered	6.9 (37)
The charger’s upfront cost is covered	6.4 (37)
Alternative technologies such as mobile chargers were available	5.7 (26)
There was a single online portal with charger information	5.6 (31)
Chargers were eligible for commuter credits	5.6 (29)
Chargers were eligible for marketable carbon credits	5.2 (31)

\*Sample size varies due to response validity.

In addition to the quantitative data, we collected qualitative data regarding barriers to workplace charging adoption during the business interviews. We found that businesses often mentioned cost, parking control and employee demand as major barriers to workplace charging adoption.

Finally, three barriers were revealed after analyzing business’ responses to scenarios in which certain funding or policies were hypothetically put in place. Businesses were most likely to install another charger if upfront costs were covered ( $\mu = 6.4$ ,  $n=37$ ), if alternative technologies such as mobile or solar charger were available ( $\mu = 5.6$ ,  $n=31$ ),

and if employee demand for a charger increased ( $\mu = 7.1$ ,  $n=36$ ). The barriers are thus:

1. The cost of purchasing and installing EV charging stations
2. An inability of traditional charging to fulfill a business's needs due to the varied and unique nature of employee parking control
3. A lack of employee demand

### *Cost Sensitivity*

Two important policies tested in our hypotheses covered the upfront and ongoing cost of the charger. Evidence from the literature as well as responses to the business interviews show that installing a charging station ranges \$500 - \$6000; more if the building or parking lot requires large conduit and electrical upgrades. We found that many of the smaller businesses we talked to that hadn't installed chargers cited cost as a barrier that must be overcome.

When speaking with businesses with annual revenues below \$500 million, many cited high upfront cost as a deterrent to installing chargers. For instance, when asked *what would need to happen in order for your company to install chargers*, one company explained that they "would need some sort of subsidy program that can cut costs down a lot." Several others agreed that they would need "outside funding" to successfully install chargers.

### *Parking Control*

Some businesses indicated that they would be more likely to provide workplace charging if alternative chargers such as mobile and solar chargers were available at a competitive price. While this finding on its own does not immediately suggest that a lack of parking control is a barrier, it became clear when we established a connection between businesses that didn't own their own parking and those that highly ranked the alternative technologies option.

The reason for this is two-fold. First, businesses who lease parking space must seek landlord approval to install a charger, especially if it involves digging up concrete for conduit. This hurdle becomes even higher if the leased parking lot is shared amongst businesses, as the costs of time, money, and the inconvenience of construction must be negotiated with multiple parties. A mobile or a solar charging station would not require any conduit to be laid and could ease the process of convincing a landlord or fellow tenants to invest in the new infrastructure.

The second barrier can simply be lack of space. Even companies who own or lease

onsite parking space for their employees can be wary of installing a charger and “losing” a conventional parking space. Additionally, in some industries parking spots are assigned as a hierarchical perk. A Bay Area hospital noted that designating EV charging spots near the building “upsets the hierarchy” and would be resisted by upper level staff. Finally, even companies who were already installing chargers cited a lack of space as a potential future limitation to the number of chargers they could provide. For instance, one Fortune 500 Company explained, “the only thing that would need to happen for [our company] to install additional chargers is acquiring additional real estate. At the moment, [we] cannot add new stations at the existing building because it would take necessary parking spaces from the other drivers.” A mobile charging station, essentially a large battery that is charged overnight and then discharged into employee EVs throughout the day, would allow all spaces to stay open for conventional vehicles while still giving employees with EVs workplace charging services.

The vice president of one company said the biggest challenge to installing more charging stations is communicating with their landlord. When asked what would need to happen for the company to install additional chargers, they stated that, “the firm is willing to bear the cost because it is part of our culture to promote environmental practices. The hardest part is on our campuses that we share with other companies; therefore, we will have to get the landlord on board to let us install chargers that are dedicated to our company.”

### *Demand*

Finally, businesses responded that an increase in employee demand for workplace charging would increase their likeliness to install chargers. For businesses that had not already installed, many cited a lack of employee demand as a reason—simply put, very few employees at these businesses drove EVs to work, so a workplace charging station was not something they were asking for. For those businesses that had installed chargers, employee demand was a main driver for additional installations, with some businesses monitoring charger utilization to determine when more stations are needed.

For the most part, lack of employee demand will be solved via means other than charger installation. Quotas requiring auto manufacturers to sell a designated number of EVs, ZEV rebates for purchasers, and perks like HOV lane access are all motivating more people to purchase EVs. More EVs on the road means more demand from employees.

However, chargers can also play an important role in increasing demand. Many of the companies interviewed found that after installing a charging station, even more of their



employees began purchasing EVs as they saw their coworkers charging up in the parking lot. This phenomenon of “If you build it they will come” implies that simply having a charging station will in fact encourage more people to purchase EVs, thereby increasing employee demand for more stations. This suggests that the installation of the first charger at a workplace in the face of low demand could be a crucial step in mass EV adoption.

To drive the demand for workplace chargers, there are three approaches. The first approach is to drive the demand for EVs, encouraging people to purchase and drive EVs to work. This approach is beyond the scope of this project and it is being taken care of by different levels of available incentives and benefits such as HOV lane access and the Clean Vehicle Rebate Program. A partial list of these incentive programs can be found online at Drive Clean California’s Plug-in Electric Vehicles Resource Center.

The second approach is to drive the demand for EVs and more workplace chargers through the installation of the first charger. According to the Department of Energy (2014), at workplaces with charging stations, employees are 20 times more likely to purchase an EV. This is in line with our finding that when asked *how much more likely a company is to install additional chargers from a scale of 1 to 10 with [1 being least likely and 10 being extremely likely]*, we got an overall response of 8.9 out of 10, indicating that the installation of first workplace charger can drive the demand for more workplace chargers. In addition, we found that 55% of the businesses that we interviewed installed additional workplace chargers due to increased employee demand. Therefore, all the recommendations we propose are essentially addressing the lack of employee demand as a barrier.

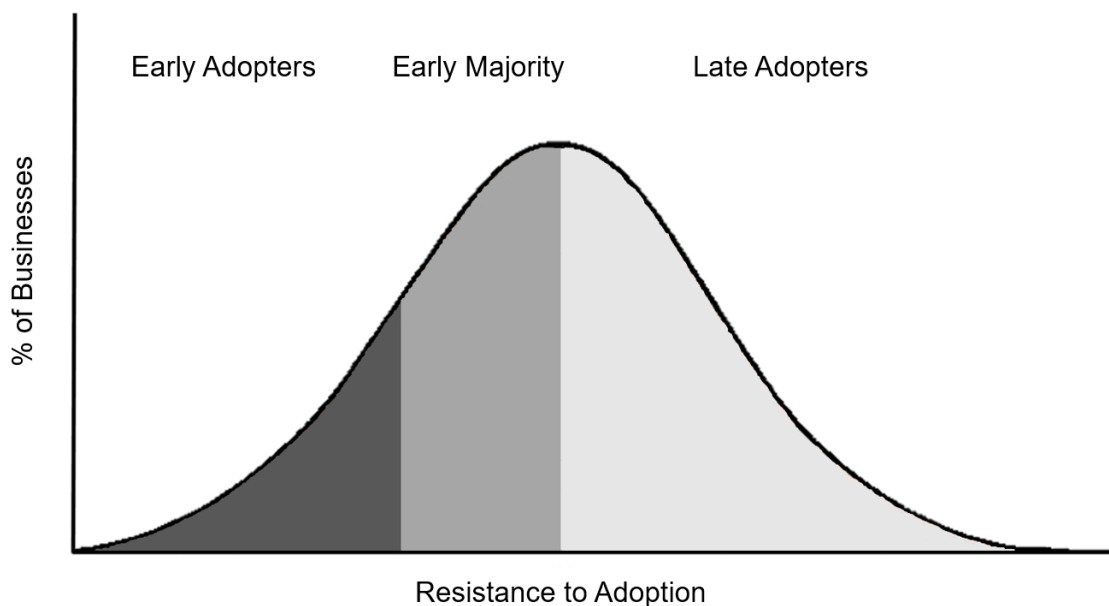
The final approach is to encourage sharing the use of a charger between businesses with chargers and without chargers, and among businesses without chargers. This approach not only cuts costs, but gathers smaller demands to drive the adoption of a first charger.

## **4.2 Business Categories**

Using the barriers to workplace charging that our interviews uncovered, we categorized businesses based on their susceptibility to these barriers to determine which businesses our final strategies should target. The three business categories we established were:

1. Early Adopters
2. Early Majority
3. Late Adopters

These categories are based on the Technology Adoption Model, a way to visualize the adoption of a new technology over time. While every company has different barriers that they must overcome to adopt a new technology, businesses can be generally represented by a normal distribution of proportion of adopters over time as seen in Figure 1 (Beal, G. M. & J. M. Bohlen, 1957).



**Figure 1.** The Technology Adoption Curve adapted for workplace charging stations.

The first firms on the curve, the Early Adopters, are defined by already adopting EV charging equipment for their workplaces. These companies do not see cost, lack of parking control, or employee demand as large barriers. In fact, their willingness to adopt an early technology almost regardless of cost or space constraints distinguishes them from the next group of adopters, who face real barriers to their adoption of workplace charging.

The next firms on the curve, the Early Majority, are critical to the successful launch of new technologies because they face barriers but comprise an important portion of the potential adopters. New technologies that fail to “cross the chasm” between the Early Adopters and the Early Majority do not survive to reach most potential adopters. This is because the Early Majority are more selective than Early Adopters and are considered more reliable sources of information on new technology. These adopters are even capable of reducing others’ uncertainty about a new technology (Ryan B. and N. Gross, 1943). In the case of this project, these Early Majority businesses face one or more

barriers to adoption. However, their barriers are low enough that they could be overcome with proper policy or funding strategies.

The Late Adopter group includes companies for whom the barriers to installing workplace charging are so high that they will likely not be able to be incentivized to install before the 2020 deadline. Typically, these companies' employees will not be part of the next wave of EV adoption because of the availability of public transportation, lower incomes, or their relatively longer commutes.

We then assigned each of the businesses or organizations we interviewed to one of the categories based on their characteristics. As we collected demographic and qualitative data from the interviews, we noticed specific characteristics shared, for instance, by all the businesses who had installed workplace chargers or were planning on installing chargers in the next year. These businesses often employed more than 250 employees, had revenue streams of more than \$1 billion, and had some level of control over their parking areas. These businesses fit the category of Early Adopters whose barriers to installing workplace charging are low across all three major barriers.

We also interviewed businesses who had not installed workplace charging. These companies were smaller and less revenue intensive than the Early Adopters. They also did not report as strong of a willingness to install chargers in the next five years as the Early Adopters, 3.2 (n=12) as opposed to 8.9 (n=24) for Early Adopters (average out of a possible 10, see Appendix A3). These businesses typically leased their parking or relied on off-site city owned parking for their employees. These businesses fit the category of the Early Majority because while they face cost, parking control, and demand barriers to installing workplace charging, they are responsive to proposed strategies that would lower these barriers.

Finally, we interviewed one business whose location, downtown San Francisco, and reported employee demand, nonexistent, fit the category of the Late Majority. This business' barriers to workplace charging adoption are so high that even if programs were developed to reduce cost and parking lot control, they would be unlikely to adopt workplace charging because so many of their employees do not drive. Businesses with same or similar characteristics can be considered as Late Majority.

Table 6 includes the three business categories and their relationships with the three common barriers to workplace charger installation uncovered through our interview results. In general, Early Adopters have low barriers in regards to all three common barriers, while Early Majority Adopters have varying levels of cost, parking control, and demand barriers. Late Adopters face high barriers in all three categories of cost, parking

control, and demand.

Common Barriers to Workplace Charger Installation			
Business Category	Cost Sensitivity	Lack of Control of Parking Space	Lack of Demand
1. Early Adopters	Low	Low	Low
2. Early Majority	High - need financial support for capital projects	Variable depending on relationship with parking owner	High but sensitive to change
3. Late Adopters	High	High in urban centers Low in rural	High - few EV drivers in rural, few drivers in urban

**Table 6.** Common Barriers to Workplace Charger Installation for three business categories: 1. Early Adopters, 2. Early Majority, and 3. Late Adopters.

#### 4.2.1 Early Adopters

Early adopting businesses have managed to overcome the three major barriers and successfully install workplace charging stations. From our interviews, we found that all Early Adopters were larger companies with over 250 employees and with 60% of them reporting revenues of over \$1 billion. When asked “How likely is your company to install more chargers in the next five years? [1-10: 1 being highly unlikely and 10 being certain to install more], the average response was an 8.9. We have identified several reasons that Early Adopters will continue to lead in workplace charger adoption. First, larger companies with more employees are more likely to have employees driving EVs to work and requesting workplace charging stations. Second, the upfront cost of installation (including hardware and installation) is less of a burden to larger companies, and therefore they are installing on their own without reliance on financial incentives. And finally, they typically have employee-specific parking that they are likely to own.

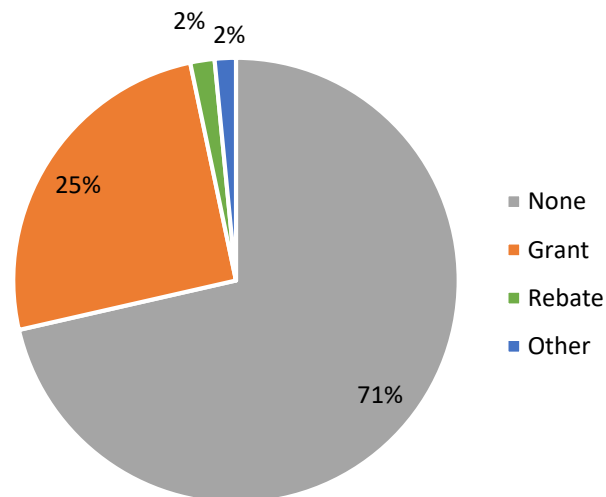
Motivations for installation generally fell in the category of “soft” benefits that are difficult to quantify in monetary terms. Interviewed Early Adopters cited reasons such as workplace chargers aligning with their company’s sustainability values and demonstrating commitment to their employees’ needs. For example, one company simply stated that their “the firm is willing to bear the cost because it is part of our culture to promote environmental practices.” Other companies have seen installing

charging stations lead to increased hiring or retention rates, as charging stations provide “a nice visible statement to visitors and to candidates we are trying to hire to show off another benefit to working at [our company].” This is in line with previous findings from the PEV Collaborative and the DOE, which cite green image enhancement, employee recruitment and retention, and employee satisfaction as benefits of installing a workplace charger. In an equivalent valuation cost-benefit analysis, we found that these benefits to the Early Adopters are of great enough value to overcome substantial monetary costs involved with installing charging stations at the workplace, although how these benefits translate to Early Majority and Late Adopters is yet to be seen (Appendix 7).

*Barrier: Cost Sensitivity*

Early Adopters are not sensitive to the cost of installing and maintaining workplace charging for the benefit of their employees. Our interviews found that 71% of the chargers installed by Early Adopters were installed without the use of grants or rebates (Figure 2). Additionally, in our interviews with these same companies few businesses responded that they needed new sources of funding for their plans to install additional workplace charging.

Types of Funding by Charger (n=2272 chargers for 22 businesses)

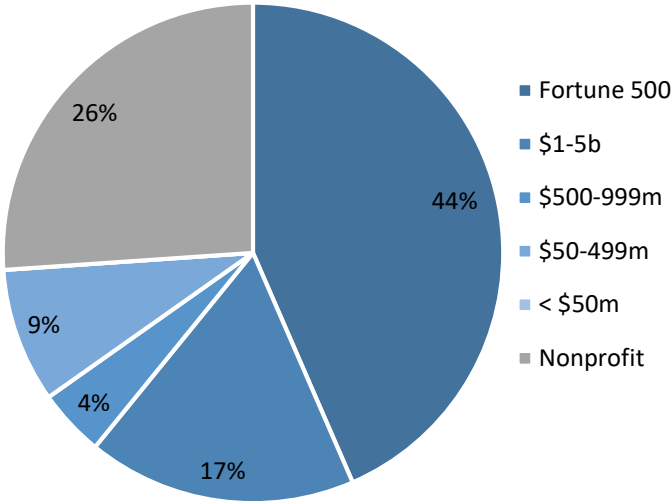


**Figure 2.** Distribution of Early Adopters’ use of outside funding in installing chargers.

This funding security is supported by the reported revenues for the Early Adopters

displayed in Figure 3. 60% of the Early Adopters interviewed reported annual revenue of more than \$1 billion. The 26% of interviewees representing nonprofit organizations were either large hospitals or universities with substantial infrastructure and employee benefit programs. These relatively wealthy organizations, both profit and nonprofit Early Adopters, demonstrated a willingness to fund both initial charger installation and future expansions.

Revenue for Early Adopters Interviewed  
(n=23)

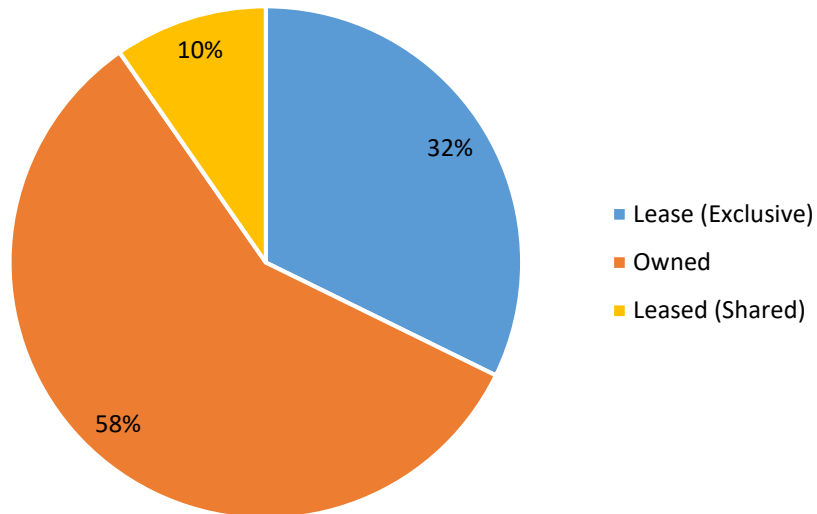


**Figure 3.** Reported revenue for Early Adopters Interviewed. Data source: Fortune 500 List (2016).

*Barrier: Lack of Parking Control*

Early adopters do not generally face a lack of parking control. Only 10% of interviewees reported leasing shared parking while 90% did not share parking, whether leased or owned (Figure 4). Due to the large size of these businesses, the Early Adopters can exert control over even leased or shared parking and install chargers through negotiations with landowners. Early Adopters also seem willing to install chargers in these leased lots even when the equipment must be left behind if the business moves locations. Therefore, the benefit to the business to have the charger must be greater than both the cost of installation and the leverage used to negotiate with parking lot owners.

Parking Lot Status of Early Adopter Interviewees (n= 31 sites for 23 businesses)



**Figure 4.** Percentage of interviewed organizations who reported leasing, owning, or using offsite parking for employees.

*Barrier: Lack of Demand*

We conducted two interviews with Company D, an information company; one with the Employee Transportation Coordinator at the Bay Area office and one with the Global Sustainability Specialist based at a Southern California office.

In the Bay Area location, Company D has 96 level 2 ChargePoint chargers, and two mobile stations from Freewire. The company has noticed a huge benefit with recruiting new employees. The chargers are “a nice visible statement to visitors and to candidates we are trying to hire as a way to show off another benefit to working at [Company D].” Furthermore, in the company’s orientations with new employees, “those who have EVs are excited to hear that charging is free.”

In the company’s Southern California office, the first EV charger was actually the result of a new hire asking during an interview whether the location had a charger for his car. Furthermore, having charging stations has made a large impact in employees’ decisions to buy EVs. The company is already planning on installing more due to employee demand.

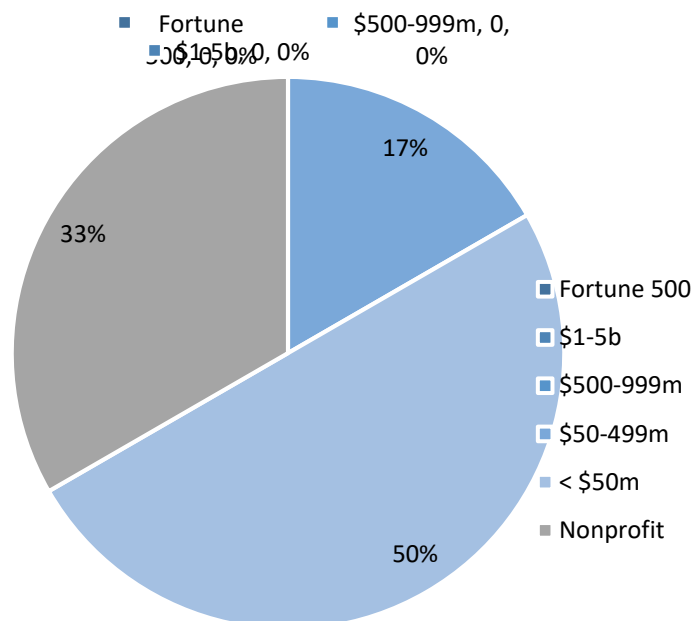
## 4.2.2 Early Majority

Early Majority are the businesses that are currently without workplace chargers but are likely to adopt workplace charging if they manage to overcome the barriers to adoption. Their main adoption barriers are the same as for Early Adopters: cost of installation, lack of parking control and lack of demand. However, compared with Early Adopters, Early Majority businesses perceive these barriers relatively higher because they generally have less revenue, fewer employees driving an EV to work, and less control of their parking.

### *Barrier: Cost Sensitivity*

The Early Majority businesses we interviewed were significantly smaller revenue generators than the Early Adopters, indicating cost could be a barrier for them to move forward (Figure 5). Over half of the Early Majority businesses made less than \$50 million a year, 18% of them made between \$50 to 499 million and the remaining 36% are nonprofits. When discussing the cost of workplace chargers, one restaurant owner said “To be honest, if the cost is more than 1,000 dollars, that is too high for us. If it is 200-300 dollars per year, we may consider doing that”. This sentiment was common in our interviewees with smaller, lower revenue businesses.

Revenue for Early Majority Interviewed (n=12)



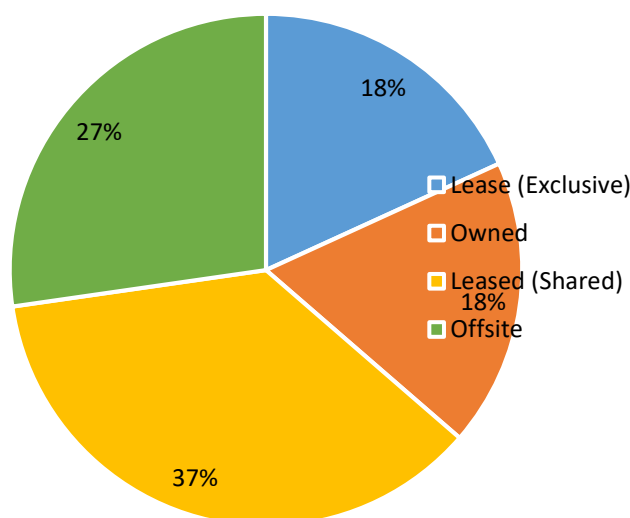
**Figure 5.** Reported revenue for Early Majority businesses interviewed in the study (n=12).



*Barrier: Lack of Parking Control*

Over half of the Early Majority businesses leased their parking lot and may share it with another business. Less than 20% of them own the parking lot and about 30% of them cannot provide onsite parking for their employees (Figure 6). For businesses that lease parking to install a workplace charger, they would require approval from the parking owners (private landlord or cities).

Parking Lot Status of Early Majority Interviewees (n=11)



**Figure 6.** Parking lot experiences of Early Majority businesses interviewed (n=11 businesses).

For instance, one non-profit with fewer than 20 employees that leases a shared parking lot in a downtown responded “I may need to talk to the property manager about this. He is nice but I don’t think he is likely to put in any charger here” when asked about what needs to happen for his business to get workplace charger.

*Barrier: Lack of Demand*

Lack of employee demand is one of the other barriers preventing businesses from installing workplace chargers. If there is no one driving an EV to work in that business, there is no reason for employer to install chargers for the employees who will not be using the chargers. For example, when asked about the demand for workplace

charging, one interviewee responded, “We have only 8 people here and I think 7 of them bike, I don’t see any reason why the only driver would want to put a charger here, and I don’t think he drives an EV either.”

In other words, for businesses who have employees who drive an EV to work, their willingness to install workplace chargers depends on how they perceive the associated benefits and costs. If there are more employees who drive EV to work and need to charge their EVs at workplace, the marginal cost of installing chargers will be decreased but the marginal benefits will be increased.

### **4.2.3 Late Adopters**

This category designates business with various characteristics that make them unlikely candidates for successful workplace charging programs (at least for California’s first 100,000 workplace chargers). Businesses in this category include those in rural areas (fewer than 50,000 people) or in areas where most people commute to work via public transit rather than single-occupancy vehicles (Ratcliffe et al., 2016).

#### *Barriers*

Late Adopters experience all three of the general barriers discovered through our interviews, but the degree to which they face them is much greater than for the other categories of businesses. We identified two main examples of Late Adopters: businesses in densely populated urban areas or businesses in rural areas.

Urban Late Adopters are more likely to lack control of parking space because they do not own or lease parking. Dense urban centers such as San Francisco’s Central Business District also benefit from extensive public transportation that is a popular commuting option for their employees. For example, when we asked a company in San Francisco *if they would ever consider installing workplace chargers*, they responded: “no, there is really no parking space and not enough demand since only 10% of employees drive to work.” Therefore, as many employees rely on public transportation to commute to work, these urban businesses lack the necessary employee demand to motivate charger installation.

Rural Late Adopters are much more likely to have onsite parking for their employees, in part because their employees are much more likely to commute via single-occupancy vehicle. According to a 2013 American Community Survey, 91% of employees in non-metropolitan areas such as Colusa, Mariposa, and Alpine County drive to work. This number decreases slightly in suburban areas such as San Joaquin Valley and Santa

Barbara County where 89% of employees drive to work, and even more so in metropolitan areas where 78% of employees drive to work (McKenzie, 2015).

These Late Adopters experience a lack of demand for workplace charging infrastructure due to their location: either they are located in a highly dense urban city where most employees use alternative means of transportation to get to work (such as buses, trains, walking, or biking); or they are in rural areas where employees drive long distances to work, or park too far from the necessary electrical infrastructure to make a charging station viable.

The basic characterization of the urban business type is a large technology company located in places such as San Francisco's Financial District. While this company seems like the perfect candidate for workplace charging—it has 200 employees, is in a hotspot for EV adoption, and recognizes value in providing soft employee benefits—just under 10% of its employees drive single-occupancy vehicles to work and under 2% drive EVs. This is because San Francisco's Financial District has heavily impacted parking where monthly permits can cost upwards of \$300. This, combined with a comprehensive public transportation network, reduces the inherent demand for both employee parking and associated amenities such as workplace charging stations.

The rural case is documented in the Department of Energy's *Workplace Charging Challenge Progress Update: A New Sustainable Commute* (2016) which reported that out of the 295 surveyed Challenge Partners only 13% were in rural areas. Additionally, the rural EV drivers these stations accommodated accounted for only 2% of the total EV drivers the Workplace Charging Challenge served. This leads to the conclusion that the adoption of EVs in rural areas is much lower than the adoption rate in sub-urban areas, most likely due to longer commutes as well as lower employee incomes.

### **4.3 Distribution Analysis**

The question that arises after identifying the Early and Late Adopters is whether we can simply rely on the Early Adopters to install 100,000 chargers by 2020 or whether we must dip into the Early Majority? To determine this, we estimated whether it was feasible for all 100,000 chargers to be installed in Early Adopter-type businesses.

Because there is no way to easily count the number of Early Adopters in California, we used business size as a proxy for whether a business was an Early Adopter. We assumed that, for this analysis only, businesses with more than 250 employees could represent potential Early Adopters. While using size could potentially include some businesses who are not Early Adopters, such as a large business in a dense urban

area, and could exclude some that are Early Adopters but have under 250 employees, this approximation will still yield a ballpark result for whether or not relying on Early Adopters to install all 100,000 chargers is a practical course of action.

This distribution analysis led to two major conclusions. First, we confirmed that 100,000 workplace chargers is indeed a valid target for the ZEV Action Plan to achieve a level of infrastructure to support 1 million ZEVs. Second, we cannot rely upon businesses characterized as Early Adopters to install 100,000 workplace chargers because they do not employ enough potential ZEV drivers.

#### **4.3.1 Assumptions and Methodology**

Several key assumptions went into our analysis. First, as mentioned above, we assumed that we could use business size as a proxy for whether a business was an Early Adopter. Second, Go-Zero assumed that the employees in California reflected the general population of California in both driving habits and EV adoption rates, to allow us to use general EV driver statistics for the state and apply them to the more specific population of California employees.

We then broke down businesses into three size categories, small (0-49 employees), medium (50-249 employees), and large (250+ employees) aggregating data from the California Economic Development Department (California Economic Development Department, 2016) and used the following formula to calculate the number of chargers needed:

$$\begin{aligned} \text{Number of Chargers in Size Category} = & (\text{Number of Employees in Size Category}) \times \\ & (\% \text{ Driving Employees}) \times \\ & (\% \text{ Driving Employees that Own EVs}) \times \\ & (\text{Charger} : \text{EV Ratio}) \end{aligned}$$

This formula bases the number of chargers that are needed in a size category on how many employees work for businesses in that size category, the percentage of employees in California who drive to work, the percentage of those who drive that drive EVs, and finally a predetermined charger to EV ratio that dictates how many chargers you need per electric vehicle.

The number of employees working in each size category was gathered from the same dataset used to break businesses into size categories (California Economic Development Department, 2016). To determine the number of employees driving to work, Go-Zero aggregated the average of the responses to our business interview

questions regarding employee commute behavior (Appendix 4) and determined that 90% of employees in California drive to work. This value is consistent with data from the U.S. Census Bureau published in 2013 which found that 86% of all U.S. workers commute to work by vehicle.

We calculated the percentage of employees who must drive EVs to work in 2020 by dividing the 2020 goal of 1 million electric vehicles by 25 million vehicles, the total number of drivers in California (California Department of Motor Vehicles 2014). Doing so revealed that in 2020, if the goal is met, 4% of California drivers will own EVs and thus 4% of California employees will be driving EVs to work. Finally, we assumed an average ratio of 1 workplace charger need for every 5 EV drivers, based on knowledge from stakeholder and business interviews.

### **4.3.2 Results**

The results of this analysis are detailed in Table 7. Breaking down the number of employees in California by business size and applying the 90% driving rate, 4% adoption rate, and 1:5 charger ratio resulted in the number of chargers needed by each business size category to support the predicted 1 million electric vehicle fleet.

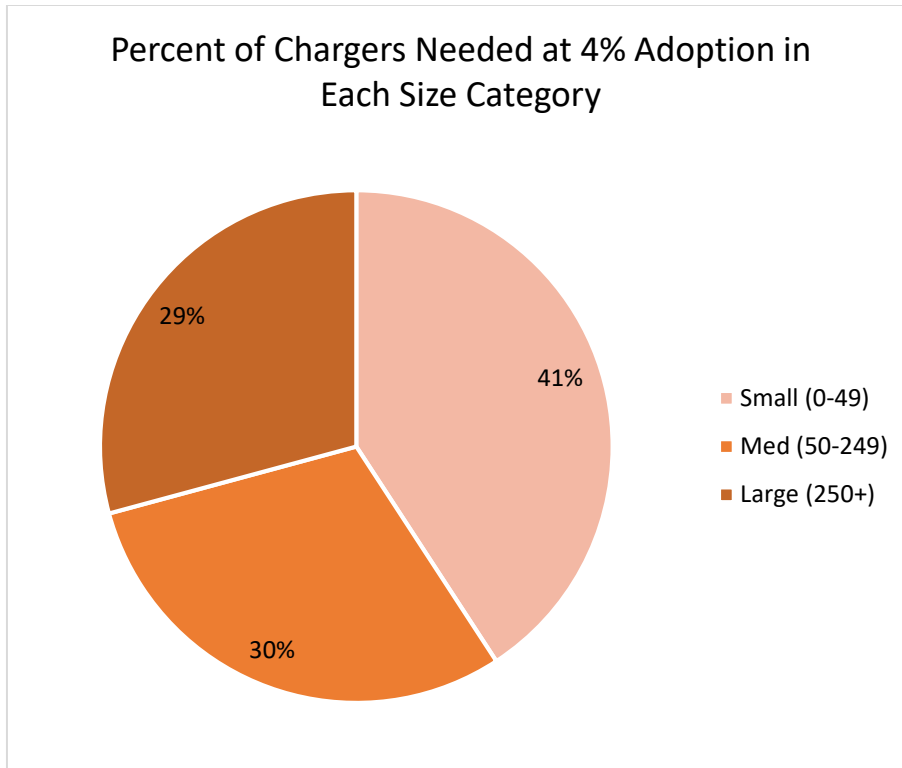
First, we found that due to the prevalence of small businesses in California, almost half of the 100,000 chargers (46,978) would have to be installed in small businesses, with the remaining chargers divided about evenly between medium and large businesses.

Additionally, adding together the chargers in each size category predicted that California will need 115,143 workplace chargers to support 1 million EVs, proving the validity of the 100,000-charger goal as a close estimate of the necessary infrastructure.

**Table 7.** Number of Chargers Needed by Three Categories of Businesses Associated by Size

	Size of Business Categories			
	Total	Small (0 to 49)	Medium (50 to 249)	Large (250+)
<b>Number of Employees</b>	25,992,052	6,524,739	4,796,642	4,670,671
<b>Number of Employees Driving EVs</b> (assumed to be 4%)	575,714	234,890	172,679	168,144
<b>Number of Chargers</b> (ratio of 1 charger to 5 drivers)	115,143	46,978	34,536	33,629

The percentage of chargers required by each business size category using a 4% EV adoption rate across all business sizes is visualized in Figure 7. Under this uniform adoption rate large businesses only account for 33,629 or 29% of necessary workplace chargers. Small and medium businesses require almost three-quarters of the workplace chargers, 46,978 or 41% and 34,536 or 30% of chargers respectively. The significant number of chargers required by employees in small and medium businesses in this analysis undermines any assumption that we should rely on large businesses, and therefore Early Adopters, to install sufficient workplace charging infrastructure to meet the 100,000-charger goal.



**Figure 7.** Relative distribution of workplace chargers across all California businesses. Percent of chargers needed at an equal 4% adoption rate of workplace charging stations across all businesses sizes as measured by employees.

One possibility, however, is that EV adoption rates for the Early Adopter businesses are actually much higher than the average adoption rate of 4%. EV owners are typically wealthier, older, more educated, and use their EVs to drive to work (Tal et. al., Clean Vehicles Rebate Project). Given that individuals fitting this description may be more likely to be associated with Early Adopter-type businesses, we needed to consider the possibility that most EV drivers in 2020 would work at Early Adopter companies and would affect at which businesses workplace chargers should be installed.

To test the validity of this scenario, that EV drivers will almost exclusively work for Early Adopters, we pushed the EV adoption rate for small and medium business employees down to 0%. We then used the following equation to solve for the EV adoption rate required if all employees driving EVs to work were employed at Early Adopter businesses.

$$\frac{\text{Number of people driving EVs to work}}{\text{Number of employees in large businesses}}$$

Under the assumption that the total number of people driving EVs to work would remain the same as our previous analysis (575,714 EV drivers), we would need to see a 14% EV adoption rate among Early Adopter employees who drive to work. This is an extraordinarily large adoption rate compared to the current rate of 5% that we found from our interviews with Early Adopters. This means that the EV adoption rate among employees who work for Early Adopters must almost triple in the next four years for this scenario to play out, a rate of growth that in current conditions seems highly unlikely. Furthermore, efforts are currently underway to move EV adoption into other demographics, especially disadvantaged and low income communities (California Energy Commission, "Tracking Progress"). People falling under these demographics most likely are working for non-Early Adopter companies such as small businesses or restaurants, making the assumption that EV drivers in 2020 will be working primarily for Early Adopters even more unlikely.

This suggests that California must look beyond the Early Adopter companies to meet the workplace charging infrastructure goals. These findings complement similar findings by the DOE that business size should not be a major factor in focusing funding and policy options and determining the likeliness to install (DOE Workplace Charging Challenge Progress Update, 2016).

### **4.3.3 Discussion**

The biggest implication of this distribution analysis is that any recommendations to increase adoption should be targeted at Early Majority businesses that are not already installing chargers, for two reasons. First, as we previously found through our interviews, the Early Adopters will continue to install chargers regardless of incentives, and at a rate that is highly dependent on employee demand and thereby difficult to influence through outside means. Second, the results of our distribution analysis show that even if we were able to influence charger installation rates at the Early Adopters, these companies simply do not employ enough commuters to need 100,000 workplace chargers. Therefore, while the Early Adopters will be important to helping meet the 100,000-charger goal, the Early Majority businesses are the next critical business category that must install workplace charging stations to help California meet its EV infrastructure needs. These businesses are the targets for our recommendations.



## 5 Recommendations

Our recommendations are designed to help overcome the four main barriers we identified that are hindering the deployment of workplace charging:

1. A lack of data on current workplace charger installation
2. A lack of employee demand for workplace charging
3. The cost of purchasing and installing EV charging stations
4. A lack of control over parking, either because parking is leased by the company or employees rely on off-site parking controlled by another entity, such as a city

We propose two different types of recommendations—immediate recommendations that can be implemented in the near-term and for which the costs and outcomes are can be confidently predicted, and long-term recommendations that will be important for the future development of California’s workplace charging network. The two types of recommendations are laid out in Table 8 in the order we will discuss them.

**Table 8.** Proposed solutions organized by targeted barrier.

<b>Immediate Recommendations</b>	
<b>Barrier</b>	<b>Program</b>
Lack of Data	Create Workplace Charging Database
Lack of Demand	Target Early Majority Businesses
Cost Sensitivity	Launch First Charger Rebate Program
Lack of Parking Control	Create Voluntary City EV Readiness Plans
<b>Long-term Recommendations</b>	
Update Utility and Charging Company Workplace Charging Programs	
Promote Alternative Charging Technologies	

## **5.1 Immediate Recommendations**

### **5.1.1 Workplace Charging Database**

As noted in Section 3, currently there is no database that specifically tracks the number, location, and ownership of workplace chargers in California. While the AFDC has a database that keeps tracks of both private and public charging stations nationwide (AFDC, 2017), this database is not exhaustive and is not formatted in a way that makes it easy to manipulate for projects such as this one. Such a deficiency in data hinders the development of a robust workplace charging network in several ways. First, it will make it difficult for California to know whether the 100,000-charger goal is met as there is no easy way to track workplace charger installations. Second, important trends that could help us better understand this new technology and its deployment, such as the overall rate of adoption, the geographic distribution, and the types of companies installing chargers, are difficult to accurately evaluate.

We recommend that California require the registration all workplace chargers and the collection of their usage data. This will help to better match the supply of chargers to the demands of drivers, lead to more efficient planning and funding, and allow for the development of a comprehensive workplace charging infrastructure map, available to government agencies, researchers, and ZEV drivers. We recommend creating this database by mandating that charger companies register all existing and future chargers. Charger companies already keep track of their chargers and many publish their own charger maps, so integration of their information into a new database should be relatively straightforward. Additionally, focusing on charger companies, as opposed to the individual businesses that had the chargers installed, will limit the number of stakeholders who must be brought on board. Charger companies will also benefit from registering their chargers in the database because it will make their brand more visible to potential charger buyers who are researching workplace charging in California.

### **5.1.2 Target Early Majority Businesses**

The lack of demand for workplace charging must be overcome if California is to reach its 100,000-charger goal. Luckily, this barrier can be reduced from multiple fronts. First and foremost, demand for chargers relies on the number of employees driving EVs to work. The more employees there are driving EVs, the more demand there will be for ways to charge during the workday. Part of the solution to getting more EVs on the road is already underway through the various consumer rebates, manufacturer mandates, and incentive programs for EVs at the state and federal level. However, the strategic deployment of workplace charging will also play a key role in incentivizing more people

to drive EVs. Anecdotal evidence from our interviews as well as conclusions from the literature shows that once a business installs a charging station, employees are much more likely to purchase an electric vehicle. In fact, the Department of Energy found that employees with workplace charging are 20 times more likely to drive an electric vehicle than the average employee (DOE).

Therefore, we recommend that the following funding and policy suggestions be targeted towards and implemented for businesses that have yet to install a charging station. Focusing efforts on these “Early Majority” businesses—essentially companies that do not yet have workplace charging but whose employees are good candidates for EV adoption—will have larger impact than efforts targeting the Early Adopters. Targeting these Early Majority businesses to install their first charger should create a positive feedback loop, where the new charging infrastructure will encourage more employees to purchase EVs, thereby increasing demand for even more chargers.

### **5.1.3 First Charger Rebate Program**

We recommend the creation of a First Charger Rebate Program to incentivize the adoption of the first workplace charging unit for Early Majority businesses who need help overcoming this cost barrier. According to interviews with Early Adopters, a workplace charger can cost \$3,000 to \$15,000, including equipment purchasing, installation, signage, etc. For Early Majority businesses, this is a relatively high cost because they make less revenue than Early Adopters. The rebate program emphasizes the first charger, because it is likely that employees will ask for more chargers and businesses will install chargers once the first charger is adopted.

To decrease the cost of the first charger, we propose a new structured rebate program that covers 50% of the equipment and labor cost for Early Majority businesses to install their first charger. Based on cost data collected by the American Recovery and Reinvestment Act’s EV Project, the Electric Power Research Institute, and our interviews, we predicted a low and high cost range for workplace charger installation in California at \$3700-\$4500 per charger (The EV Project, 2015; Electrical Power Research Institute, 2013). Rebating 50% of the cost of 10,000 first chargers would thus require \$18–22 million in funding.

We have targeted the CEC’s yearly budget on EV Infrastructure Development as an example for potential funding for the rebate program (CEC, 2016). The First Charger Rebate Program also takes into consideration the existing Electric Vehicle Charging Station Financing Program that offers very large loans, up to \$500,000, to small businesses and forgives 50% of the loan if workplace chargers are installed with the

money. However, this program has been slow to gain momentum, with only one loan being finalized in February 2017 after one year of negotiation (CEC Interview, 2017). The California Capital Access Program which oversees the Electric Vehicle Charging Station Financing Program believes the current program is not well promoted or easy to find.

The First Charger Rebate Program provides a smaller loan option that can be dispensed quickly to encourage small businesses to install their first charging station. The First Charger Rebate Program can be applied for by both businesses and charging companies. Small businesses can then use the Electric Vehicle Charging Station Financing Program if they see an increase in employee demand for additional workplace charging stations.

#### **5.1.4 City-Owned Parking: City EV Readiness Plan**

We recommend creating voluntary City EV Readiness Plans, based on the voluntary EV Regional Readiness plans. Twelve regions in California have implemented ZEV Regional Readiness Plans, funded by 34 grants totaling \$7.6 million from the CEC. These funds go towards local and regional programs to plan for the necessary ZEV infrastructure and to help streamline the permitting, installation, and inspection of charging stations (California Energy Commission, “Tracking Progress”). While the current Regional Readiness plans help to coordinate infrastructure deployment at the regional level, individual cities may be overlooked. The City EV Readiness Plans would remedy that issue by requiring that workplace-accessible charger installation be included in city planning. Cities that develop acceptable plans would be eligible for funding from the CEC to help cover the costs of plan implementation.

City EV Readiness Plans submitted for funding consideration would have to provide specific information. First, the city would need to include any permitting information—what agencies oversee permits, and the process for permitting charger installations. Second, cities would be required to specify the level of chargers that will be installed (e.g. Level 2 or Fast charging) and any technical equipment specifications to help predict the cost of installation (CEC: GFO-16-603,2016). Cities could use the Alternative and Renewable Fuel and Vehicle Program, Central Coast Appendix R to determine which level of chargers could be used at different sites. Finally, cities would also need to include information about the location and number of chargers, along with the total cost of installation and any contracts the city will need to obtain in order to install the infrastructure (CEC: GRO-16-603, 2016).

To help the CEC evaluate these plans, a baseline requiring that cities install chargers in

at least 10% of all city-owned parking spaces could be set, with cities with high EV demand converting more spaces, as they see fit. For example, a small city, such as Goleta, with about 50 city-owned parking spots, would only have to install 5 EV chargers. Assuming the cost of installation is \$2,223 per charger, the city of Goleta would only require \$11,115. A larger city, such as Los Angeles, with around 11,000 spaces would have to install an additional 950 chargers, costing \$2.1million.

## **5.2 Long-term Recommendations**

These recommendations are designed to guide work GO-Biz may choose to undertake to help California reach future workplace charging goals.

### **5.2.1 Update Utility and Charging Company Charger Programs**

The utility and charging company charger programs that aim to incentivize workplace charger installation currently favor Early Adopters but not Early Majority companies, which require more outreach, funding, and support. According to our interview with ChargePoint (the largest nationwide charger company), most of its network is comprised of larger businesses that are able to install at least 5-10 chargers at their site. In addition, the utility pilot programs favor larger businesses with more property space, by requiring a minimum number of installed chargers per location. For example, SDG&E requires all businesses that use their program to be able to dedicate a minimum of 10 parking spaces for EV charging stations (SDG&E Power Your Drive Program). Likewise, SCE will only deploy charging infrastructure for at least 10 stations per business site (SCE Charge Ready Program).

These selection criteria are diverting resources from smaller companies in the Early Majority category who do not need or cannot accommodate 10 chargers, and that could in fact benefit the most from partnering with utility companies. Furthermore, businesses that can designate 10 parking spaces for EV chargers will be larger, almost certainly falling into the Early Adopters category, and therefore will already be installing chargers regardless of utility involvement.

We recommend the California Governor's Office work with the CPUC and utility companies to revise pilot program requirements to target more Early Majority businesses in two ways. One, utility programs can reduce their required minimum number of chargers, to promote participation from smaller businesses and property owners. Two, utilities can be encouraged to target their charger installations at properties, such as business parks, whose parking serves multiple smaller companies that could have a combined need for 10 or more charging stations. Either of these

strategies would require the input and guidance of the CPUC and a revision of the expectations for utility pilot programs. Redirecting existing programs toward Early Majority businesses is a resource-efficient way to help reach the 100,000 workplace chargers goal.

### **5.2.2 Promote Alternative Technologies**

Alternative charging options, such as solar-powered charging stations and mobile charging stations, should be promoted and made more accessible to businesses. This long-term recommendation targets businesses that share parking with other businesses and are worried about traditional charging stations taking up limited parking space, or that do not want to undertake the electrical and conduit-laying projects traditional chargers require. Additionally, these relatively new charging options can help businesses get landlord approval since they require little to no modification of the property, or, in the case of mobile chargers, no increase in the property's electrical capacity.

Currently, there are only a few companies in the U.S. that offer alternative EV charging technologies, including FreeWire (mobile charging) and Envision Solar (solar-powered chargers). FreeWire's Mobi Charger is a battery-supported DC fast charger that can move from vehicle to vehicle so that EVs parked anywhere can be charged (FreeWire 2016). Currently, purchasing a mobile charging station costs \$27,500, which is not competitive with traditional charging options (Freewire n.d). However, in a 3-month pilot program, FreeWire calculated the costs for a business to rent a Mobi charger (\$200 per month) to be competitive with the total hardware, installation, and maintenance costs of a typical charging station (\$189 per month). FreeWire also found that Mobi chargers can increase employee productivity, as they eliminate the need for employees to move their cars throughout the day to make charging stations available (FreeWire 2016).

The California government can take three actions to promote these alternative charging options. First, alternative charging companies can be made more visible by inviting them to major EV events and webinars, publishing articles and fact sheets about them, and promoting alternative charging companies to the EV community. Second, research in alternative charging technologies should be supported. Third, pilot projects that loan out alternative charging technologies to workplaces should be developed and supported, to improve awareness, test functionality, and further develop the technology and business models.

## 6 Summary and Conclusion

### *Summary*

Through intensive literature review and interviews, we identified four main barriers to workplace charger adoption: a lack of comprehensive data collection for this new technology and three business-facing barriers—cost of installation, lack of parking control and lack of demand. Based on their ability to overcome these barriers, business can be considered Early Adopters, Early Majority, or Late Adopters. Early Adopters are businesses that have already overcome all three barriers and are currently installing chargers at their own pace. Early Majority businesses are the ones that need outside support to help them overcome these barriers. Late Adopters are businesses that lack employee demand for workplace chargers due to geographical factors such as being located in a dense urban area that relies on public transportation, or in rural locations with long commute distances, making them poor candidates for contributing to California’s 100,000 workplace charger goal.

We conclude that California cannot solely rely on Early Adopters to achieve the goal of 100,000 workplace chargers, and that the demographics of adopters needs to include the Early Majority businesses which are currently without chargers. To help these Early Majority businesses overcome their barriers, we recommend: establishing a state-managed workplace charging database to keep track of the number of chargers; developing a first charger rebate program; offering funding to cities that develop plans to increase their workplace-accessible charging infrastructure; updating the utility charger program requirements; and promoting alternative charging technologies such as mobile charging to address limited parking control.

### *Conclusion*

From the results of this project, we proposed three immediate recommendations to help overcome the lack of data and two of the main barriers to workplace charger adoption, cost and lack of parking control.

- To solve the barrier of lack of data, we recommend establishing a state-run database that keeps track of the exact number, location, use, and ownership of workplace chargers.
- To solve the barrier of demand, we recommend targeting funding and policy solutions towards Early Majority businesses
- To solve the barrier of cost sensitivity, we recommend launching a first charger rebate program, to encourage Early Majority businesses to install their first workplace charger.

- To solve the barrier of lack of parking control, we recommend cities create their own EV workplace charging plans, to accommodate workplace charging on a voluntary basis.

These recommendations are intended to provide the governor's office with immediate actions that will help achieve the two interconnected goals of 100,000 workplace chargers by 2020 and 1 million EV drivers by 2020. Our recommendations provide a guide for how government funding should be spent and how to prioritize businesses based on the barriers they face. These results and recommendations are designed to fit into California's broader framework for encouraging ZEV adoption as laid out in its *ZEV Action Plan*.

Our findings have revealed new details about the current landscape of workplace charger adoption and found significant gaps where companies are not installing chargers due to an inability to overcome the adoption barriers. We found that an Early Majority of California business could be incentivized to install workplace chargers if the proper policies were adopted to reduce their barriers to adoption, including cost and parking lot control. Programs to increase the demand from employees who drive EVs have been developed by the CEC and private car manufactures. California's *ZEV Action Plan* should incorporate our recommendations to engage the Early Majority who will be critical to achieving the 2020 goal of 100,00 workplace chargers. We also propose long-term recommendations that should be used to develop future projects focused on workplace charging adoption.



# 7 Appendices

## A1: Summary of Literature Review

### A1.1 California ZEV Mandate and Stakeholders

**California Environmental Protection Agency Air Resources Board. CA.gov (2016).**

#### *Zero Emission Vehicle (ZEV) Program*

- The ARB is a leader in developing programs designed to reduce emissions from mobile sources.
- Mobile sources account for well over half of the emissions, which contribute to ozone and particulate matter and nearly 40% of the greenhouse gas (GHG) emissions in California.
- ARB has adopted a new set of standards that combine the control of smog-causing pollutants and GHG emissions into a single coordinated standard. These new standards also include efforts to accelerate the numbers of plug-in hybrids electric vehicles (PHEVs) and zero-emission vehicles (ZEVs) in California.

#### *California ZEV Planning Collaboration Efforts*

- To date, California's ZEV Program has resulted in the placement of several hundred thousand ZEVs and PHEVs on California roads and a growing network of EV charging and hydrogen fueling stations. The ZEV Program has also influenced ZEV policy around the world.
- However, if California is to achieve its long term air quality (criteria pollutant) and climate change (greenhouse gas emissions) goals, ZEVs and PHEVs will have to represent nearly 100% of new vehicle sales in California by 2050.
- To achieve these goals, California's leadership is collaborating with state, national and international partners to address challenges to ZEV market expansion, including global technology development and cost reduction. There is much to learn from each region's experience, and these joint efforts will be important in tackling the remaining hurdles to ZEV growth in California and beyond.

### *2015 Zero Emission Vehicle Credits*

- The ZEV Regulation requires passenger vehicle and light-duty truck manufacturers that operate in California to make a certain percent of ZEVs (such as battery electric, fuel cell, clean plug-in hybrids, clean hybrids, and clean gasoline vehicles with near-zero tailpipe emissions).
- A vehicle manufacturer's ZEV requirement is based on a percentage of all passenger cars and light-duty trucks from 0 to 8,500 pounds (lbs.), delivered for sale in California. In complying with the ZEV Regulation, manufacturers generate varying credits based on vehicle type
- Positive credit balances represent a successful over compliance with the ZEV Regulation. Manufacturers can use these balances to provide flexibility in the timing and production of bringing new clean cars to the market to meet the ZEV requirements in coming years.

**Governor's Interagency Working Group on Zero-Emission Vehicles.** "2016 ZEV Action Plan: An updated roadmap toward 1.5 million zero-emission vehicles on California roadways by 2025." Office of Governor Edmund G. Brown Jr. (2016).

### **Purpose**

This updated 2016 ZEV Action Plan outlines progress to date and identifies new actions state agencies will take in continued pursuit of the milestones in the Governor Brown's Executive Order.

### **Background**

- In 2012, Governor Brown issued Executive Order B-16-12 directing state government to help accelerate the market for zero-emission vehicles (ZEVs) in California. This Executive Order calls for 1.5 million ZEVs in California by 2025, along with several milestones to meet this target
- The 2013 ZEV Action Plan identified specific actions state government would take to meet these milestones. Implementation of the 2013 ZEV Action Plan is successful: California's ZEV market has grown significantly and state agencies have completed a number of important actions. The State Legislature continues to champion ZEV technologies, passing several important laws to facilitate market expansion.
- In addition, the State Legislature has appropriated millions of dollars from the Greenhouse Gas Reduction Fund to advance ZEV technologies, including incentives for purchase of light-duty ZEVs, grants to implement zero-emission drayage truck demonstration projects and incentives for ZEV truck and bus purchases.

**This 2016 Action Plan highlights the following priorities for ZEVs:**

- Raising consumer awareness and education about ZEVs;
- Ensuring ZEVs are accessible to a broad range of Californians
- Making ZEV technologies commercially viable in targeted applications the medium-duty, heavy-duty and freight sectors
- Aiding ZEV market growth beyond California.

*Overview of ZEV Technologies*

- ZEV technologies include hydrogen fuel cell electric vehicles (FCEVs) and plug-in electric vehicles (PEVs), which include both pure battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).
- BEVs are purely electric and offer between 60-300 miles per complete charge.
- PHEVs are compatible with electric charging and conventional gas fueling, generally operating purely on electricity before using gasoline to extend the driving range. Most PHEVs have a driving range between 10-50 all-electric miles and up to 400 gasoline hybrid miles.
- FCEVs use hydrogen to generate electricity using on-board fuel cells. With a maximum driving range of about 300 miles and a quick 3-5 minute fueling time, FCEVs are a promising technology within California's ZEV portfolio.
- BEVs and FCEVs share two fundamental attributes: they use electric drive motors with zero tailpipe emissions. Based on the mix of California's grid electricity and renewable hydrogen requirements, California's PEVs and FCEVs use electricity and hydrogen, respectively, that emit approximately two-thirds less CO<sub>2</sub> compared to gasoline.

*State of the ZEV Market*

- California is one of the world's largest markets for light-duty ZEVs, with PEV ownership in the state exceeding 230,000 vehicles.
- As 2016, Californians drive 47% of all ZEVs on the road in the U.S., while the U.S. comprises about one-third of the world ZEV market.
- BEVs and PHEVs comprise most ZEVs on California's roads today, since FCEVs are just becoming commercially available.
- In 2015, nearly every major automaker announced plans for promising new ZEV models. Currently, there are more than 20 PEV models available in California, with the Nissan LEAF, Chevrolet Volt, Tesla Model S, and the Ford Fusion Energi leading sales in the U.S. in 2015.
- The metropolitan regions of Los Angeles, San Diego and the San Francisco Bay Area lead the state in PEV NOx standards. To date, 18 manufacturers have deployed about 2,500 hybrid and zero-emission vehicles through this program.

- In addition, the Alternative Renewable Fuel and Vehicle Technology Program provides grant funding to develop innovative medium- and heavy-duty technologies.
- ZEV adoption is greatest in Los Angeles County and Santa Clara County, followed by Alameda, Orange, and San Diego Counties. Statewide, nearly 60% of issued rebates are for BEVs, while 40% are for PHEVs.

### *CA Climate Goals*

- In 2015, Governor Brown announced an ambitious set of climate goals, including reducing petroleum use in California by up to 50% from 2015 levels by 2030 and reducing GHG emissions 40% below 1990 levels by 2030. In 2016, Governor Brown signed Senate Bill 32, codifying the 2030 greenhouse gas reduction goal.
- In addition, Senate Bill 350, the Clean Energy and Pollution Reduction Act of 2015, established widespread electrification of the transportation sector as a statewide policy that is necessary to meet the state's 2030 and 2050 climate goals, as well as the state's air quality requirements.
- Implementing these ambitious goals will require sustained investments, ongoing policy innovation and state agency leadership and coordination.

### *State Progress to Date Supporting ZEV Expansion*

- In the three years since the 2013 ZEV Action Plan, state agencies have maintained important ZEV program, while completing several new actions to accelerate ZEV deployment. These efforts include the following actions:
- Maintaining Proven ZEV Incentives
  - ZEV Rebates: The State of California continues to provide sizable monetary rebates for the purchase or long-term (30 months or more) lease of ZEVs: \$5,000 for FCEVs, \$2,500 for BEVs, and \$1,500 for PHEVs.
  - HOV Lane Access: ZEV drivers continue to have access to high occupancy vehicle (HOV) lanes
- In 2013, the State Legislature re-authorized two programs that provide as much as \$100 million annually towards innovative transportation and fuel technologies, including PEV charging and hydrogen station infrastructure, through 2024.
- In 2014, Governor Brown signed the California Charge Ahead Initiative (Senate Bill 1275), a landmark bill supporting consumer incentives and rebates to enable 1 million ZEVs on California's roads by January 2023.
- In 2015, the Governor Brown signed into law the Clean Energy an

- Pollution Reduction Act of 2015 (Senate Bill 350), which established as a statewide policy widespread electrification of the transportation sector. The law promotes additional investments in electrification by investor-owned electric utilities, based on guidance developed by the California Public Utilities Commission (CPUC).

### *Expanding PEV Charging Networks*

- Utility Programs: The CPUC authorized two PEV charging infrastructure pilots in January 2016 in Southern California.
  - The “Charge Ready” Program, administered by Southern California Edison, calls for approximately 1,500 charging stations at 150 workplaces. The “Power Your Drive” Program, administered by San Diego Gas & Electric, authorizes roughly 3,500 charging stations at 350 workplaces and multi-unit dwellings. Pacific Gas & Electric also has an application pending for approximately 7,500 level 2 chargers and 100 fast charging stations.
  - The programs are intended to complement private investments to maintain a competitive PEV market.
- CPUC Settlement Agreement with NRG Energy: The California Public Utilities Commission entered into a settlement agreement with NRG Energy Inc. to bring to California a statewide network of charging stations for PEVs, including:
  - At least 200 public fast-charging stations and the infrastructure for up to 10,000 privately owned charging stubs (make-readies) at multi-family residences, workplaces and other locations.
- Strengthened Building Standards: Newly constructed residential and most non-residential buildings will be PEV-capable as a matter of state law.
  - This requires all newly constructed parking lots and housing to put electrical capacity in place to easily install PEV chargers
  - In January 2017, the number of parking spaces that must be PEV-capable will increase to 6% for most non-residential buildings.

**J. Tomic & T. Bloch-Rubin.** “Employer Policies and Incentives Encouraging EV Adoption.” CALSTART (2014).

### **Purpose**

The purpose of this paper was to chronicle and categorize internal employer policies that aim to incentivize PEV adoption, in addition to providing charging stations. The information presented in this paper provides useful examples for other companies interested in promoting PEVs.

### **Methods**

The incentives described here, both monetary and non-monetary, were collected through research and interviews by CALSTART staff with companies that have workplace charging.

## **Findings**

### *Policies Supportive of EV Charging*

Currently, there are various federal, state, and local incentives for EV adoption and charging infrastructure development. For example, in Los Angeles, residential charging stations can receive up to \$2,000 in rebates. In Texas, some utilities enacted incentive programs that reduce operational costs for businesses with charging stations. Having charging stations can also count as credits toward LEED certification for structures.

In Southern California there are additional regulations from local air quality districts compelling employers to reduce the greenhouse gas impact of their employees and facilities. Rule 2202, enforced by the Southern California Air Quality Management District (SCAQMD), requires employers with 500 or more employees to create plans and enact measures that reduce emissions from their employee commuting habits. Installing workplace charging stations qualify under this rule.

### *Early Adopter Employers*

Many companies within California and nationwide that already installed workplace charging for their employees, such as Evernote, Pomona College, 20th Century FOX, and Warner Brothers Entertainment studios. In addition, over 130 companies signed the DOE Workplace Charging Challenge pledge, indicating their commitment to providing charging access for their employees.

### *Employer EV Policies*

A review of the California Plug-In Electric Vehicle Collaborative publication, *Amping Up California Workplaces*, provided a handful of different company policies relating to PEV incentives and workplace charging. Many case studies had similar motivation stories, in which employees and senior management formally requested charging infrastructure be installed at their site. At this point the company would review the different options and institute some version of a pilot program that allowed for review and future expansion.

Other companies took it upon themselves to provide charging for their employees, many of whom were already using PEVs or had intimated that they were interested in purchase or lease plans. In general, these Early Adopters have proven to be very proactive in responding to employee concerns while creating an environment conducive for self-policing EV forums.

CALSTART, through its Employer Electric Vehicle Initiative (EEVI) program, held a series of informational meetings and webinars that led to further conversations with specific employers on their workplace charging policies. CALSTART staff later interviewed personnel from a wide range of employers to learn about their internal incentives supportive of PEVs.

#### *Monetary Policies*

There are three types of monetary incentives identified in the research process that employers have used to spur adoption of PEVs. They are: assistance for employees acquiring PEVs either through lease or purchasing, fee-based PEV charging access, and fixed daily incentives for PEV usage.

#### *Non-monetary Policies*

Some employers offer free PEV charging to their employees as a non-monetary incentive to spur adoption of these vehicles. The other two non-monetary policies include offering PEV users preferential on-site parking and PEV car-sharing services to all employees.

We also saw multiple examples of solar photovoltaic (PV) arrays used to power the EVSEs and help offset part of the employer site electrical load. This can be a particularly effective way of creating remote charging “islands” that do not require conduit lines run all the way from the nearest building or transformer facility.

### **A1.2 Utilities**

**Silver Spring Networks.** “The Dollars and Sense of EV Smart Charging.” Redwood City, California: Silver Spring Networks. (2010).

### **Purpose**

The purpose of this paper was to outline and describe three possible scenarios that fall along the spectrum of utility involvement in ownership and funding of EV infrastructure. These scenarios include: (1) Utility ownership of smart grid charging infrastructure; (2) Utility subsidy of customer-owned EV charging station, either with or without a separate smart meter for billing; and (3) Customer ownership of charging stations, where the EV is treated like an appliance and metered through the existing residential meter.

### **Methods**

This is a white paper.

### **Key Findings**

- This analysis found the scenario where the utility owns the charging station to yield the highest costs but also the greatest benefits for utility companies.
- When the utility owns or subsidizes the charging stations, the utility has peak load control and therefore can avoid increases in peak demand and the associated costs of added generation, transmission & distribution capacity. Also, when the utility owns the charging stations, the utility also can perform load scheduling during off-peak times to shift EV charging in real time to balance energy supply and demand. This flexibility enables utilities to integrate more intermittent renewable sources (such as more solar during afternoon), reduce grid reliability risks & charge EVs at times when the cost to obtain energy is lowest.
- In the scenario where the customer owns the charging station, the cost to the utility is lower, since customers pay for installation. However, customer ownership of creates risks with regard to billing or metering accuracy. If utilities treat EVs like an appliance, they lose the ability to do smart charging and are more likely to incur costs for adding generation, transmission, and distribution capacity to the grid & supplying additional energy during peak times for EV charging.

**Melton, M.** “Utility Involvement in Electric Vehicle Charging Infrastructure: California at the Vanguard.” Center for Strategic and International Studies (2016).

### **Purpose**



The purpose of this article was to explain the current landscape in California in terms of utility involvement in EV charging infrastructure. This article presented a brief history of utility involvement in charging infrastructure and how this involvement will increase to help advance EV adoption. Finally, this article outlines the three pilot programs set forth by the three large investor-owned utilities in California: Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Pacific Gas and Electric (PG&E).

## **Key Information**

### *History of Utility Involvement*

- In 2011, the California's Public Utilities Commission (CPUC) banned utilities from investing in EV charging infrastructure, due to worry that utilities would monopolize the market
- In 2014, the CPUC lifted this ban, as regulators realized that utilities were well-positioned to "accelerate PEV infrastructure market and can improve the business case for third parties."
- Currently, after years of debate about the role utilities should play in owning EV charging infrastructure, CPUC is set to approve proposals from all of its investor-owned utilities to invest ratepayer money in EV charging infrastructure.
- All parties agreed that utilities should have expanded role in EV infrastructure development, but disagreed as to the appropriate degree of utility involvement. Therefore, the CPUC declined to predetermine an appropriate level of utility activities, maintaining that it would evaluate proposals on a case-by-case basis, bearing in mind a balancing test between competitive limitation and the benefits of utility involvement.
- Each of the three pilot programs will be testing different models of utility involvement in EV charging infrastructure
- Following the CPUC's order, all three investor-owned utilities in the state submitted plans. After reviewing these proposals, the CPUC directed the utilities to submit more achievable and smaller-scale proposals, all of which are approved for implementation.

### *Supporters of Utility involvement*

- Proponents of significant utility involvement argue that utilities are the most well-positioned players to finance and build the necessary infrastructure to support EV growth and adoption. deployment on an immediate time scale.

- The argument is made that utilities are able to overcome two related problems that currently exist for third-party investors: cost and risk. Utilities, it is argued, can overcome both of these obstacles by accessing low-cost capital (backed by ratepayers) while ensuring investors on both the supply and demand side that there is a future market. Thus, due to their regulated nature, utilities are able to overcome the problems of business and financial risk that may hamper other market participants.
- Additionally, utilities' investments are overseen by state regulatory commissions which can monitor deployment, direct it where it is needed, and make sure capital outlays are prudent and in the public interest.
- Lastly, proponents of utility involvement argue that utilities will have to be engaged in the business of EV infrastructure anyway, given that EV charging will have an impact on the dynamics of the grid and alter the way that utilities manage demand, supply, and load. Having utilities involved early can encourage the adoption of new rates structures that will be necessary for grid optimization of distributed and intermittent energy resources.

#### *Opponents of Utility involvement*

- Opponents of utility involvement are often concerned about costs of EV charging falling on ratepayers who will not benefit from these investments. They argue that EV charging infrastructure is a large investment, and the enormous costs (which are born by all ratepayers) benefit a relatively small group of people (those who can afford expensive EVs) and provide few other benefits.
- There is also concern about building out infrastructure before enough is known about future EV adoption and how much infrastructure is ultimately needed. In addition, it is argued, utilities will (intentionally or not) crowd out competition in the nascent infrastructure charging market.

#### *EV Adoption Outside of California*

- California is not the only jurisdiction trying to figure out how to promote EV adoption, how much EV charging infrastructure is needed, and how to finance it. Legislatures and public utility commissions in a other states are grappling with how utilities should be involved in the charging business, including: Oregon, Washington, Illinois, Kansas, and Kentucky.
- Washington, which has a goal of 50,000 EVs on the road by 2020, is considering a bill encouraging utilities to build EV charging infrastructure.
- Oregon, already one of the country's largest EV markets, has specific policy goals encouraging EVs and has passed legislature to improve EV infrastructure.
- The three utility pilot programs in California are likely to have widespread implications for how other states and jurisdictions tackle this issue.

## Utility Pilot Programs:

### **Southern California Edison:** Application of Southern California Edison Company (U 338-E) for Approval of its Charge Ready and Market Education Programs

- In October 2014, SCE proposed to spend \$355 million to install 30,000 chargers
- In January 2016, the CPUC approved SCE's "Charge Ready" program proposal to spend \$22 million for 1,500 stations.
- This program allows customers to select, own, and maintain the charging stations, while SCE will own and oversee the supporting electrical infrastructure and provide financing for the charging stations
- As an incentive to participate in the program, SCE will also offer rebates of between 25-100% of the base cost of the charging stations and their installation, depending on location and market segment.
- The program calls for at least 10% of the charging stations to be installed in disadvantaged communities.
- The program also provides funding for education and outreach to develop awareness about the benefits of electric vehicles and charging from the power grid

### **SDG&E:** Application of San Diego Gas & Electric Company (U902E) for Approval of its Electric Vehicle-Grid Integration Pilot Program

- In April 2014, SDG&E proposed to spend \$103 million on 5,500 charging stations
- In January 2016, the CPUC approved SDG&E's proposal to spend \$45 million on its "Vehicle-Grid Integration (VGI) Program" to install 3,500 units at 350 locations
- Sites are to be installed at multi-unit dwellings (MUDs) or workplaces, since cars are parked in these places for long periods of time. Both locations provide opportunity for grid-integrated charging during off-peak periods & when there is high output of solar generation. MUDs comprise about 50% of the residential units in San Diego
- Unlike SCE, SDG&E will own the charging stations will contract with third parties to build, install, operate, and maintain EV charging infrastructure
- This program plans to integrate the charging of plug-in electric vehicles (PEVs) with the electric grid through the use of an hourly time-variant rate. This rate would incentivize EV owners in SDG&E's service territory to use energy during non-peak periods to charge their EVs, or when there is a surplus of electricity such as excess solar radiation in the afternoon. This will reduce spending on the need for more infrastructure and power plants anticipated load growth from EV charging

- The CPUC estimates that a typically ratepayer (utility user) will see an increase in about 18 cents over the 1st year (about 0.02% increase).

**PG&E:** Decision Directing Pacific Gas & Electric Company to Establish an Electric Vehicle Infrastructure and Education Program. Decision 16-12-065.

- On February 9, 2015, PG&E filed an application seeking approval of its proposed Electric Vehicle Infrastructure and Education Program (EV Program)
- After five additional proposals, the CPUC and PG&E reached a Settlement Agreement
- The Settlement Agreement provides for the installation of 7,500 Level 2 ports and 100 DC Fast Chargers at an estimated cost of \$160 million in Phase 1, which will run for 3 years after construction of the first installation.
- PG&E will own the charging stations, but third-party vendors will install and maintain them, and handle billing.

### **A1.3 Technology and Installation Logistics**

**ChargePoint, Inc.** “Leading Silicon Valley Corporation Partners with ChargePoint to Manage EV Charging Needs.” (2015).

Case study based on ChargePoint customer (name is changed for privacy).

ChargePoint was awarded a contract for potentially hundreds of chargers across a large campus. This required not only good EV charging stations, but a networked solution to manage the chargers and their employee users.

#### **Stated Goals and Results**

##### Goals

- Attract and retain talent by providing electric vehicle charging exclusively for employees
- Install and maintain hundreds of EV charging stations and manage them easily and efficiently
- Monitor usage and provide detailed reporting to meet sustainability goals

##### Results

- Increased employee satisfaction in face of growing workforce
- Easy management of all the EV charging stations that meet the needs of the company without increasing headcount for the program
- Reports generation on demand to track sustainability initiatives

**Tomic, Jasna.** “Employer Policies and Incentives Encouraging EV Adoption.” CALSTART. (2014).

**Electrical Power Research Institute.** “Electric Vehicle Supply Equipment Installed

Cost Analysis". Electrical Power Research Institute. (2013). Rev 2014.

**National Renewable Energy Laboratory.** "Plug-In Electric Vehicle Handbook for Workplace Charging Hosts." U.S. Department of Energy. (2013).

PEV and charging basics, benefits of workplace charging, how-to evaluate and plan for workplace charging, management and policy planning, installation, and fleet conversion.

**New West Technologies, LLC.** "Costs Associated with Non-Residential Electric Vehicle Supply Equipment." U.S. Department of Energy. (2015).

Outlines costs associated with purchasing, installing, and operating non-residential EVSE. Cost information is compiled from national studies as well as installers, owners, and manufacturers. The cost of a single port EVSE unit reportedly ranges from \$300-\$1,500 for Level 1, \$400-\$6,500 for Level 2, and \$10,000-\$40,000 for DC fast charging. Installation costs vary greatly from site to site with a ballpark cost range of \$0-\$3,000 for Level 1, \$600-\$12,700 for Level 2, and \$4,000-\$51,000 for DC fast charging.

**Plug-in Electric Vehicle Collaborative.** "Amping Up California Workplaces: 20 case studies on plug-in electric vehicle charging at work."(2013).

This report presents information collected from the PEV Collaborative's spring 2013 statewide survey (Appendix A) of 79 public and private employers located in California. Survey results provide a glimpse of current workplace charging infrastructure in California as well as the challenges and solutions employers have developed to bring EVSE to their offices. The report features 20 case studies of workplaces that have already installed charging and highlights their successes and challenges.

**Plug-in Electric Vehicle Collaborative.** "Plugging in at Work: How to Effectively Install, Share and Manage Electric Vehicle Charging Stations." (2015).

Addresses new best practices for introducing chargers to employees, managing use of the EVSE, and planning for expansion to meet expected increases in demand.

**Plug-in Electric Vehicle Collaborative.** "Why Employers Should Install Workplace Charging for Plug-in Electric Vehicles." (2013).

A pamphlet prepared for businesses to enumerate the benefits of and incentives available for workplace charging. Lists employer, employee, and community benefits associated with installing workplace charging.

**The EV Project.** "How do Publicly Accessible Charging Infrastructure Installation Costs Vary by Geographic Location?" Idaho National Laboratory. (2015).

#### **A1.4 Technology Adoption Model**

**Bohlen, J. M. and G. M. Beal.** "The Diffusion Process". *Special Report No. 18.* Agriculture Extension Service, Iowa State College. 1 (1957) 56-77.

### **Purpose**

The paper is a summary of 35 studies on how farmers adopt new agricultural technology. The findings of these studies are presented in a new framework, the diffusion process for new ideas and practices.

### **Findings**

There are two major generalizations from these studies: first is that the process by which people accept new ideas is not a single act but a complex series of acts and a conscious mental process, second is the fact that people do not adopt new ideas at the same time.

This second generalization is the basis for the adoption or diffusion curve. The diagram lays out the different kinds of adopters of a new idea, practice, or technology from innovators to non-adopters as well as characteristics associated with each category.

**Kurani, K. S., N. Caperello, and J. TyreeHageman.** "New Car Buyers' Valuation of Zero-Emission Vehicles: California." University of California, Davis, Institute of Transportation Studies. In partial fulfillment of ARB Agreement 12-332. (2016).

### **Purpose**

This study had three objectives:

1. Measure new car buyers' awareness, knowledge, experience, consideration, and valuation of PHEVs, BEVs, and FCEVs;
2. Describe new car buyers' decision making regarding prospective PHEV, BEV, and FCEV purchase decisions; and,
3. Compare new car buyers in California and other states with zero emission vehicle (ZEV) requirements or sales.

### **Methods**

An online survey of new car buying households and follow-up interviews with a subset of survey respondents were conducted. The survey was administered to samples of new car-buying households from mid-December 2014 to early January 2015 in thirteen states: California, Oregon, Washington, Delaware, Maryland, New Jersey, New York, Massachusetts, Connecticut, Rhode Island, New Hampshire, Vermont, and Maine. Follow-up interviews with subsets of survey respondents were conducted in California, Oregon, and Washington from January to March 2015.

Survey data were analyzed both to describe the sample and to model ZEV valuation. Four categories of explanatory variables were tested:

- 1) respondent socio-economic and demographic measures,
- 2) prior vehicle purchase, ownership, and travel,
- 3) prior awareness and assessments of ZEVs, ZEV policy instruments, and technology, and
- 4) attitudes toward ZEV policy goals and tools.

The logistic regression model describes correlations of drivetrain types with these four categories of variables.

## **Findings**

Even in California, despite marketing PEVs and deploying PEV charging infrastructure since 2010 as well as federal, state, and local incentives for PEV purchase and use, new car-buyers' valuations of ZEVs are largely unformed. 77% of respondents representing new car-buying households in California have yet to seriously consider a PHEV or BEV for their household. Within this context of generally low levels of awareness of, and almost no experience with, PHEVs, BEVs, and FCEVs, 38% of the CA sample had a sufficiently positive valuation to design a PHEV (21%), BEV (11%), or FCEV (6%) as their next new vehicle. Expanded to a population level estimate, this is the equivalent of nearly 1.5 million households.

Households who have the infrastructure to charger or fuel at home are more likely to design a PHEV, BEV, or FCEV.

**Saarenpää, J., M. Kolehmainen, and H. Niska.** "Geodemographic analysis and estimation of early plug-in hybrid electric vehicle adoption." *Applied Energy* 107 (2013) 456-464.

## **Purpose**

The purpose of this study is to study the interrelationships between early hybrid electric vehicle adoption and different demographics and socio-economic characteristics of the areas.

## **Methods**

2010 Finish census data was used to capture the demographic and socio-economic characteristics of different geographical areas. Final data set contains 36,990 statistic squares and 1227 HEVs.

## **Results**

Characteristics related to income level, education level, the amount of children and the size of the residence are highly interrelated with the amount of HEVs adopted per

household in the studied areas.

Greater uncertainty of the low adoption or low population cases can be noticed from the greater

**Sierzchula, W., S. Bakker, K. Maat, and B. van Wee.** “The influence of financial incentives and other socio-economic factors on electric vehicle adoption.”

### **Purpose**

The purpose of this study was to explore the relationship between financial incentives and other socio-economic factors to electric vehicle adoption across several countries.

### **Methods**

The researchers collected and analyzed data from 30 countries for 2012. statistical analysis used data from the following countries: Australia; Austria; Belgium; Canada; China; Croatia; the Czech Republic; Denmark; Estonia; Finland; France; Greece; Germany; Iceland; Ireland; Israel; Italy; Japan; the Netherlands; New Zealand; Norway; Poland; Portugal; Slovenia; Spain; Sweden; Switzerland; Turkey; the United Kingdom, and the United States. These countries were selected for the availability of data, specifically EV adoption and charging infrastructure figures.

Data was collected for the following variables for each country in our study: EV market share, financial incentives, urban density, education level, an environmentalism indicator, fuel price, EV price, presence of production facilities, per capita vehicles, model availability, introduction date, charging infrastructure,5 and electricity price. EV adoption was operationalized as national market shares of electric vehicles. To compare country-specific financial incentives, policies were standardized relative to CO<sub>2</sub> emissions and 2012 US dollars.

The variables were incorporated into an ordinary least squares regression with a logit transformation of the dependent variable to normalize distributions of EV market share.

The final model specification is given as

$$\begin{aligned} \log\_MarShr_i = & \alpha + \beta_1 Incentive_i + \beta_2 Urban\ density_i \\ & + \beta_3 Education_i + \beta_4 Env_i + \beta_5 Fuel_i + \beta_6 ChgInf_i \\ & + \beta_7 Elec + \beta_8 PerCapVehicles + \beta_9 EV\_Price \\ & + \beta_{10} Availability + \beta_{11} Introduction + \beta_{12} HQ + \varepsilon_i \end{aligned}$$

where the subscript  $i$  denotes the country, and  $\varepsilon$  is an error term.

### **Findings**

The study found that financial incentives, the number of charging stations, and the presence of a local EV manufacturing facility were positive and significant in predicting



EV adoption rates for the countries in the study. Of those variables, charging infrastructure was the best predictor of a country's EV market share. However, descriptive analyses indicated how country-specific factors such as government procurement plans or the target recipient of subsidies could dramatically affect a country's adoption rate.

A second finding is that EV-specific factors were discovered to be significant while broader socio-demographic variables such as income, education level, and environmentalism were not good predictors of adoption levels. This may be that while many EV consumers may have high levels of education and be passionate about the environment, within the perspective of a country such individuals still represent a tiny portion of the overall population.

## **A2: Summary of Stakeholders**

### *Charging Companies*

There are many companies on the market that provide, install, and manage electric vehicle supply equipment (EVSE). The most commonly mentioned charging station companies include Blink, EVgo, Charge Point, Aerovironment, and Tesla Superchargers. These companies all cater to a variety of customers including residential, workplace, and public charging solutions. Charging companies often give customers access to their infrastructure network, where drivers can pay to charge at other company-installed chargers. Ownership models differ, though most companies sell the charging station to the customer who then assumes the sole responsibility of the charger including installation and upkeep.

### *Utilities*

There are essentially three scenarios of varying levels of utility involvement in EV charging infrastructure:

1. Utility ownership of charging infrastructure
2. Utility subsidy of customer-owned charging station
3. Customer ownership of charging station where the EV is treated like an appliance and metered through the existing residential meter (Silver Spring Networks, 2014).

Each of these scenarios presents utilities and their customers with various trade-offs: high utility involvement yields the highest costs but also the greatest benefits for utilities. When the utility owns or subsidizes the charging stations, the utility has peak load control and therefore can avoid increases in peak demand, as well as the associated costs of added generation, transmission, and distribution (Silver Spring Networks, 2014). In the scenario where the utility owns the charging stations, the utility can also perform load scheduling during off-peak times to shift EV charging times to balance energy supply and demand. This flexibility enables utilities to integrate more intermittent renewable sources (such as more solar during afternoon), reduce grid reliability risks, and charge EVs at times when the energy costs are lowest. Furthermore, increased utility involvement has the potential to significantly reduce the impact of EV charging on the grid.

All three investor-owned utility companies in California have proposed pilot projects with varying levels of utility involvement in developing EV infrastructure. A detailed description of each of these projects can be found in Appendix A1.2. The outcome of

these pilot projects will provide insight for future strategies in California as well as for other states working to accelerate EV adoption.

### *Government*

Besides GO-Biz, other agencies play a significant role in the adoption of EVs. In 2012, the California Air Resources Board (CARB) adopted the Advanced Clean Cars program, which seeks to control the smog causing pollutants and greenhouse gas emissions. The Advanced Clean Car program has a ZEV regulation, mandating that car manufacturers increase the number of ZEVs produced (CARB, 2017). Working alongside CARB, the California Energy Commission (CEC) created a program to help fund the EV infrastructure. CEC is anticipating rewarding about \$17 million in grants for charging installation. Recently the California Public Utilities Commission (CPUC) has gotten involved with EV infrastructure by allowing investor-owned utilities to become involved.

### *Charger Consulting Firms*

Several smaller third party companies have also entered the market to provide intermediary services between businesses, charging companies, and independent installation firms. These firms operate like renewable development firms and earn revenue from optimizing the rebates and tax credits available for installing workplace charging stations. For example, Clean Fuel Connection is a third party company that provides these intermediary services by helping their clients navigate through the incentives to find the best rebate or tax credit available and even installing the chargers (Clean Fuel Connection, 2011).

### *Nonprofit Groups*

Organizations such as the Plug-In Electric Vehicle Collaborative (PEV Collaborative) and Plug-In America are actively promoting the adoption of electric vehicle charging stations across California businesses. The role they serve is to keep the businesses updated about current ZEV policies and regulations. The role and power of these organizations are limited because they are not capable of providing large amounts of capital to cover the cost of installing chargers. Therefore, they are more likely to approach businesses that already have a higher chance of installing chargers, such as a large and wealthy company, than businesses that need robust outside support with workplace charger adoption and ultimately compose a larger part of the market.

### A3: Environmental Impact Assessment

One million EVs produce one-fifth the GHG emissions of internal combustion vehicles (ICVs). This decrease in emissions has two benefits: 1) help California reach its climate target laid out in AB 32 and 2) reduce local the concentration of local pollutants from tailpipe emissions. Exposure to these pollutants, such as ozone can result in lung and heart disease (EPA, n.d.)

We used a life cycle assessment (LCA), which is a tool that allows decision makers to compare to products. A LCA has three major parts: the construction phase, the use phase and the disposal phase. Several LCA studies have been conducted on EVs and ICVs, determining that EVs overall release less greenhouse gas emissions. However, during the construction phase EVs have a large environmental impact than ICVs, due to the mining, refining of the raw materials to produce the battery (Nealer et al 2015; Hawkins et al. 2013; Renault 2011). As for the disposal phase, there is limited data, because EVs are relatively new to the market. There have been a couple of studies that include disposal phase. One study concluded that even without recycling an EV still has a smaller environmental impact than an ICV (Renault 2011). The Nealer et al. (2015) study ignored the recycling of the battery, focusing on recycling components; concluding that as the number of EVs expands, so will the amount of recycling, potentially decreasing the environmental impact even further. Even though all three parts are crucial to the LCA of EVs, the focus of this environmental impact will be on the use phase of these two types of vehicles EVs and ICVs.

Data on California's grid mix and carbon dioxide (CO<sub>2</sub>) emissions was taken from the Alternative Fuels Data Center (AFDC), run by the Department of Energy. The AFDC estimates that one EV annually releases 1.022 million metric tons of CO<sub>2</sub>eq; while an ICV releases 5.18 million metric tons of CO<sub>2</sub>eq annually. Studies have concluded that the impact of EVs during the use phase is driven by the grid mix (Hawkins et al. 2013 and Nealer et al 2015). California derives approximately half of the electricity from natural gas, and approximately half from renewable sources. Using the following formula, we found one million EVs saves 4.16 million metric tons of CO<sub>2</sub>eq from entering the atmosphere.

$$\begin{aligned} \text{CO}_2 \text{ savings: } N_{\text{vehicles}} * (\text{CO}_{2\text{ICV}} - \text{CO}_{2\text{EV}}) &= \text{emissions savings from PEVs} \\ 1,000,000 * (5.18682452 \text{ MmtCO}_2 - 1.02255751 \text{ Mmt CO}_2) & \\ &= 4.16 \text{ MmtCO}_2\text{eq emissions} \end{aligned}$$

## A4: Interview Data

### A4.1 Hypothesis Results

**Table 9.** Average responses on 1-10 scale to proposed hypotheses: How much more likely would you be to install workplace chargers (or additional chargers) if...

	Total w/o Government (n)	Early Adopters (n)	Early Majority (n)	Government (n)
Baseline (current circumstances)	6.9 (37)	8.9 (24)	3.2 (12)	6.6 (8)
Upfront cost of installation was covered	6.5 (37)	8.1 (24)	3.5 (12)	7.0 (10)
Ongoing costs were covered for 5 years	7.0 (37)	9.2 (24)	2.8 (12)	6.0 (10)
Your utility company owned, installed, and maintained your company's charging stations at no cost	7.4 (37)	8.0 (23)	6.7 (12)	5.5 (8)
Alternative technologies such as mobile or solar powered chargers were viable, affordable options	5.8 (26)	8.5 (14)	2.1 (11)	6.2 (7)
A single portal for permitting, as well as information on grants, funding, and other resources existed	5.8 (31)	6.5 (24)	2.7 (6)	4.8 (10)
EV chargers counted towards marketable carbon credits	5.3 (31)	5.9 (24)	3.3 (7)	4.2 (10)
EV chargers counted towards commuter credits	5.8 (29)	6.7 (21)	3.0 (7)	3.3 (9)
There was an increase in employee or tenant demand for more charging stations	7.1 (37)	8.4 (23)	5.0 (13)	7.2 (10)

## A4.2 Interview Template

*The following section includes our full interview template for business who have already installed chargers or otherwise have chargers at their facilities. The numbering system is for consistent coding. Therefore, the first baselining question for the later hypothesis is out of order numerically.*

5.1. Given your current circumstance, how likely is your company to install more chargers in the next five years with 1 being completely unlikely and 10 being certain chargers will be installed?

1. Interviewee Demographics
  - 1.1. Title
  - 1.2. Level: [Senior Exec (VP and above, Director, Manager, Junior]
  - 1.3. Function: [Facilities, Sustainability (EHS), HR, etc.]
  - 1.4. Interviewee's geographic responsibility: [National, California, NorCal, SoCal, single facility, etc.]
  - 1.5. MESM? [yes, no]
  
2. Company Demographics (collect as many as possible beforehand):
  - 2.1. Revenue of (parent) business? [Fortune 500, \$1-5bn, \$500-999m, \$50-499m, =<49m, Government]
  - 2.2. Interviewee Location [city]
    - 2.2.1. Notes on other locations influenced
    - 2.2.2. Number of employees [at each location of interest]
  - 2.3. Number of locations (within CA)
  - 2.4. Sector [Government, Healthcare, Manufacturing, Retail, Information, Services]
  - 2.5. Property ownership [lease, own]
  - 2.6. Parking lot ownership [lease, own, shared, none]
  - 2.7. Do they have a CSR department? [yes, no]
  - 2.8. How do your employees normally commute to work? [Car, public, bike, walk,]
  - 2.9. How many employees drive EVs to work?
    - 2.9.1. How confident is interviewee in answer? [1-5, 1 being guess, 5 being has data]
  
3. EV charger program information
  - 3.1. Who championed/motivated the installation of your EV chargers?  
[employees, single champion, management]
    - 3.1.1. Title of champion and management level if applicable [Senior Exec (VP above), Director, Manager, Junior]

- 3.2. How many chargers do you have?
- 3.3. What kind of chargers do you have? [Level 1, Level 2, DC]
- 3.4. Which charging company supplies your chargers? [evGO, Blink, ChargePoint, etc.]
- 3.5. What is the ownership model for chargers? [complete ownership, own but does not maintain, does not own, other]
- 3.6. What is the payment system for employee charging? [Free to use, employees pay employer, employees pay charging company, other]
- 3.7. Who has access to the chargers? [employees only, limited public sharing, open access]
- 3.8. Approximately how much was the installation and current maintenance cost for your chargers? (Specify if cost per charger or total project) [
- 3.9. What grants, rebates, funding, or other resources if any, were used in the project?
- 3.10. Who manages the charger project currently? [Title, Department]

#### 4. Qualitative

- 4.1. With your company's current chargers, what worked/is working well?
- 4.2. What would you have done differently?
- 4.3. Have you heard of programs that might be better to use in the future?
- 4.4. Are chargers being used?
- 4.5. If so, are there enough chargers?
- 4.6. Are you considering installing more chargers? Why or why not?
- 4.7. What would need to happen to incentivize the installation of more chargers?
- 4.8. Who would need to get on board for more chargers to be installed?
- 4.9. If you were to take on a project to install more chargers are there other programs that this would take resources away from?
- 4.10. Is there an allocated budget for EV chargers? How sensitive is your budget to changes in revenue?

#### 5. Hypotheses – Following section must be read verbatim (excluding 5.1. line)

We will now propose a set of scenarios that may influence your company's change in likelihood to install more chargers. Rankings will be from 1-10, with 1 being no change in likelihood and 10 being extremely more likely to install chargers.

##### 5.1. *Baseline set at top of page*

- 5.2. If the upfront cost of installation were covered, how much more likely would your company be to install additional chargers? (1-10)
- 5.3. If your company received funding for ongoing costs for five years, how much more likely would your company be to install additional chargers? (1-10)
- 5.4. If your utility company owned, installed, and maintained your company's

charging stations at no cost, how much more likely would your company be to install additional chargers? (1-10)

5.5. If alternative technologies such as mobile or solar powered chargers were viable, affordable options, how much more likely would your company be to install additional chargers? (1-10)

5.6. If there was a single portal for permitting for all of your facilities as well as information on grants, funding, and other resources, how much more likely would your company be to install additional chargers? (1-10)

5.7. If EV chargers counted towards marketable carbon credits, how much more likely would your company be to install additional chargers? (1-10)

5.8. If EV chargers counted towards commuter tax credits for your business how much more likely would your company be to install additional chargers? (1-10)

5.9. If there were an increase in employee demand for more charging stations how much more likely would your company be to install additional chargers? (1-10)

## 6. Final Responses

6.1. We just talked about covering costs, providing all-in-one resources, credit programs, and internal demand. Is there anything we missed that would influence your company to install more chargers?

6.2. In a perfect scenario (no cost, no upkeep, significant demand) why wouldn't your company install more chargers?

6.3. Is there anything we're missing about your company's interest in installing more chargers?

6.4. We are also trying to contact as many businesses as possible. Through your network do you know of anyone with similar positions in other companies that would be worth reaching out to?



## A5. Government Analysis and Recommendation

Interviews were conducted at the state, county and local level. Overall, government agencies are less likely to install chargers. When asked why the agencies are installing chargers Agency A responded “the mandate [Executive order B-16-2012] to purchase EVs. The government mandate was the main reason.” Executive Order B-16-2012 mandates that at least 10% of fleet purchases are ZEVs by 2015, and increases the number of fleet ZEVs to 25% by 2020. We removed two hypotheses because government organizations are tax exempt, and would not receive the benefits of commuter and carbon credits. Another hypothesis was added, about the creation of a revolving door fund, to provide year-long funding for the installation of chargers. Analysis was conducted by comparing all three levels to each other, allowing us to observe any potential differences among all three. As seen in Table 10, the baseline was the same between state and city two groups indicating that number of sites did not influence the likeliness of installing more charging stations. The county scores were consistently lower than state agencies and cities. The only exception was when asked about employee demand.

**Table 10.** Average responses on 1-10 scale to proposed hypotheses: How much more likely would you be to install workplace chargers (or additional chargers) if...

Hypotheses	State	County	City
Baseline	6	4	6
Upfront Cost	7.4	3.5	6.8
Ongoing Cost	6.6	4	5.8
Utilities	2.75	4	6.25
Alternative Technologies	3.5	3.5	6.8
Single Portal	5.5	3	5.4
Employee Demand	8.2	7.5	6.8

### Cost Sensitivity

The first barrier any government agency must overcome is cost. All the government agencies either used a rebate or a grant to purchase their charger.

### *State Level*

Government agencies are cost sensitive, because they only have a certain amount of money that they can spend a year, and chargers fall low on the priority list. Agency A, was asked what would need to happen to get agencies to install more chargers and responded “It all comes down to funding. Chargers are not top priorities”. According to Agency B “the choice is between building maintenance and chargers. [Installing chargers would take away resources from other projects that need to happen as well].”

### *County Level*

Like the state, county organizations are cost sensitive. According to Agency C, the cost per year for the chargers they have is too high. Due to the high maintenance costs of the chargers, Agency C has decided not to expand their network.

### *City Level*

Cities also have limited funds. Some cities even have a city council, which would decide how to spend the city’s money. When we asked cities, who would need to support the installation of more chargers, Agency D, “the city council would need to be on board.” Without the city council’s support the chargers would not be installed.

## **Lack of Parking Control**

Parking control is not a barrier to the installation of workplace chargers.

### *State*

Parking control appears not to be an issue, for the state agencies. Even though most agencies have a combination of leased and owned properties, no one mentioned problems with the landlord. This could be the result of the state paying for the charger installation. At the state level, only the employees have access to the chargers.

### *County*

90% of county property is owned. The 10% that is leased, is rarely shared with other organizations. This allows the county to demonstrate control over parking.

### *City*

Cities own their parking lots and can decide to install chargers or not.

### **Lack of Employee Demand**

During our interviews, employee demand was the highest reason to install workplace chargers. However increasing employee demand is out of the scope of this project. During the interview with Agency A, they recounted an encounter with an employee who wanted to have a charger installed so that they could charge their vehicle. Once the charger was installed the employee was bought an EV. In another interview, Agency E stated that if you install chargers, then people will purchase EVs. However, creating recommendations to overcome the barrier of employee demand is out of the scope of this project. The recommendation proposed for government agencies will focus on overcoming the cost barrier.

### **Recommendation**

The goal of the revolving fund is to reduce the dependence on external funding to install chargers. Since every government agency uses some form of funding, they are limited by the amount of money available. By introducing this fund, agencies are no longer constrained by external funding resources. A revolving fund allows the agency to deposit money to then use for a specific task (Office of General Counsel, 2008). For this purpose, the money that is collected from EV charging use, will then be placed in a fund for future purchases of EV chargers. This allows the state agencies to have the chance to install chargers as needed, instead of in chunks when funding is available. This fund would apply to state agencies and counties.

The fund would be basic in design, any money made from the chargers, would be placed into a fund that is accessible by state agencies and counties. The organizations would have only had access to the amount of money that they have contributed to the fund. For example, if the state agency contributed 10% that agency would only be able to spend 10% from the fund. The agencies could then distribute the funds among their facilities as they see fit. This fund would be supplemental, meaning that agencies can continue to seek and use external funding opportunities, but are not required to only use external funding.

### *Financial Impact*

Calculations were based on the number of state vehicles. Two basic calculations were performed to see how many chargers would be needed and the total cost. The first calculation was only looking at fleet vehicles, with three key assumptions. We assumed

that approximately 38,000 state vehicles, and about 25% of these vehicles are ZEVs for a total of 8,222 ZEVs. of 1 charger for every 5 vehicles, with every charger costing about \$3000 to install. It would require 1645 chargers, and cost \$4.93 million. However, these chargers would most likely be available for government employees to use. The calculation then included all government employees and state fleet vehicles.

$$\begin{aligned}
 & \text{Number of ZEVs} = \text{current number of fleet vehicles} * 25\% \\
 & \text{Number of chargers} = \text{Number of Zevs} * \frac{1 \text{ charger}}{5 \text{ EVs}} \\
 & \text{Number of Chargers} * \frac{\$3000}{\text{charger}} = \text{cost to install chargers}
 \end{aligned}$$

A similar calculation was performed again, now including government employees' personal vehicles. Using the similar assumptions as the distributional analysis, that 90% of government employees drive to work and by 2020 4% of those employees will drive. We also assumed that there is a 1 to 5 charger to vehicle ratio, and every charger cost \$3000 to install. We found that the government would need to install 18,481 chargers and it would cost about \$55.4 million.

$$\begin{aligned}
 & \text{Number of Govnerment Employees} * .90 = \text{number of employees that drive to work} \\
 & \text{Number of Employees that drive} * .04 \\
 & \quad = \text{number of employees that drive an EV in 2020} \\
 & \text{Number of EV drivers} + \text{number of ZEV fleet} = \text{total number of vehicles} \\
 & \text{Number of chargers} = \text{total number of vehicles} * \frac{1 \text{ charger}}{5 \text{ EVs}} \\
 & \text{Costs of total chargers} = \text{number of chargers} * \frac{\$3000}{\text{charger}}
 \end{aligned}$$

This fund would require a significant amount of money. However, this fund is not replacing external funding, but supplementing it, allowing for government agencies to purchase chargers at a rate that makes sense for them.

### *Legality Requirements*

To ensure the legality of this fund, it would follow any federal and state requirements. As well as receiving approval from the State Controller's Office and State Attorney. Following federal law, some of the chargers must be made available for the public to use, and could only be used for the installation of charging stations (Office of the General Counsel, 2008). The State Controller's office would oversee the distribution of funds, ensuring that each agency uses their proper allotment.

## A6: Distribution Analysis Data

**Figure 8.** Number of chargers required to fulfill a 1:5 charger to EV Driver ratio.

	Business Size Categories		
	Small (0-49)	Medium (50-249)	Large (250+)
Number of Employees in CA	6524739	4796642	4670671
Number of EVs	234891	172679	168144
Number of Chargers	46978	34536	33629
<b>Percentage of 100K chargers</b>	<b>41%</b>	<b>30%</b>	<b>29%</b>
Required EV Adoption rate if all 1M EV drivers worked for that business category	17%	23%	24%

**Figure 9.** Calculations for the distribution of workplace chargers across California businesses at a 4% adoption rate.

	Size of Business Categories						
	Total	0 to 49	50 to 99	100 to 249	250 to 499	500 to 999	1000 +
Number of Businesses	1,374,723	1318105	33180	16897	4045	1527	969
Percent of total	100.0%	95.9%	2.4%	1.2%	0.3%	0.1%	0.1%
Number of Employees	15,992,052	6524739	2274368	2522274	1376155	1049618	2244898
Percent of total	100%	41%	14%	16%	9%	7%	14%
Percentage Employees Driving to Work	90%	90%	90%	90%	90%	90%	90%
Total Employees Driving	14392847	5872265	2046931	2270047	1238540	944656	2020408
EV Adoption Rate	4%	4%	4%	4%	4%	4%	4%
Total Driving EVs (4%)	575,714	234,891	81,877	90,802	49,542	37,786	80,816
EV:Charger Ratio	5	5	5	5	5	5	5
Total Chargers needed	115,143	46,978	16,375	18,160	9,908	7,557	16,163

## A7: Cost Benefit Analysis

To determine the break-even point for charging station installation we used an Equivalent Valuation Cost Benefit Analysis to assess the alignment of the costs and benefits of installing workplace-charging stations for businesses from a firm's perspective. With workplace charging stations, as with many green initiatives, while the monetary cost of implementation is quantifiable the benefits are often "soft" and not easy to place a dollar value on. The equivalent valuation method is used to place a value on these soft benefits by assuming any business that installs a workplace charging station will incur a benefit that is at least equal to the monetary cost of installation (Kotchen & Burger 2007).

Using the cost data collected from the Go-Zero's business interviews, and potential benefits as stated in the literature, the cost-benefit analysis (CBA) reports the approximate minimum value of the hidden non-monetary benefits of installing PEV charging infrastructure which will help to uncover the various ways to incentivize and motivate the adoption of workplace chargers by private companies. In addition, the analysis reveals the perspectives of multiple stakeholders in the industry and determines where Go-Biz can influence the cost-benefit equation to incentivize workplace charger installation.

### A7.1 Methodology

#### *Assumptions*

There are multiple factors that will affect the costs and benefits of installing workplace charging for businesses. For example, depending on what types of chargers a business would like to put at workplace, the costs vary. A Level 2 charger (220 V) that charges a PEV faster costs more than a Level 1 charger (110 V). For the ease of calculation, some assumptions are necessary to make. A list of assumptions this CBA used is provided below in Table 11.

**Table 11.** Assumptions used in this Cost-Benefit-Analysis

<b>Assumption</b>	<b>Explanation</b>
<b>Each charger will charge 2 vehicles per day</b>	Level 2 charging operates at voltage high enough to charge multiple vehicles throughout the day (2013).
<b>Vehicles will draw 12 kWh per charge</b>	A cited average for electric vehicle battery

	capacity is 24kWh. Drivers will most likely arrive to work with a partially depleted battery so 12kWh is chosen (2016).
<b>Electricity rates based on average local commercial electricity cost</b>	Electricity costs vary by region and will affect the total cost paid by a company for workplace charging
<b>Workplaces offer charging to their employees free of charge</b>	Most businesses interviewed by Go-Zero offer free charging to employees
<b>Maintenance costs are negligible unless otherwise specified</b>	Most businesses interviewed by Go-Zero expressed little to no maintenance costs
<b>Chargers assumed to operate for n = 10 years without need for replacement</b>	Electric vehicle charging infrastructure is a new technology whose life has yet to be tested. 10 years based on previous study by UCLA's Luskin Center for Innovation (Snyder).
<b>Discount rate of r = 12.2% applied</b>	Based on rate used by Luskin Center for Innovation report (Snyder).
<b>Opportunity cost of parking is set at \$95/space/month</b>	A common constraint cited in interviews to expanding ZEV charging is the loss of parking for traditional vehicles as spaces with access to charging are usually reserved for ZEV's. Value of \$36/month taken from a study on the value of parking extricated from California's solo-vehicle commuter cash-out requirements which paid employees to not drive solo vehicles to work (Shoup).
<b>50-week work year and 5-day work week assumed</b>	Accounting for vacation time

### *Quantifying Benefits and Costs*

As mentioned, the quantification of costs associated with installation of a workplace charging station for electric vehicles is relatively straightforward compared to the quantification of its benefits. At this stage there are studies attempting to quantify the environmental benefits of driving electric vehicles and installing workplace chargers, however there is no study that calculates and translates the monetary values of the benefits of installing workplace chargers specifically for firms. Installing chargers at workplaces can be considered a corporate environmental responsibility (CSR) effort of



the firms, but research on identifying the benefits of these CSR efforts is mostly qualitative rather than quantitative.

One method of quantifying these “soft” benefits is to look at the monetary values of losing the benefits and multiplying the values by the likelihood of losing the benefits. However, there are two challenges with this approach. First, while the monetary value of a certain benefit, such as employee retention, is quantifiable, the possibility of losing this benefit, e.g. how likely an employee is to leave due to lack of ZEV chargers, remains unknown. For example, Cascio (2006) and Mitchell et al (2001) estimated that the total costs of replacing an employee can cost a company up to 200% of the annual salary of that employee. But the most important data is missing in this formula – the possibility of losing this employee. In fact, based on GO-Zero’s research, it seems that most companies that already have chargers do not keep track of how these CSR investments may positively affect employees’ performance.

Therefore, this CBA uses the methodology proposed by Kotchen & Burger (2007), where benefits are determined as an equivalent value that would generate a breakeven result against the known costs. In this approach we used data gathered from companies that had already installed chargers for costs such as hardware, installation, and maintenance as well as if they required employees to pay for charging or if any outside funding was used for the project. Next we assumed since these firms had installed chargers, they felt that in some way the chargers were bringing benefits at least equal to the costs. This assumption is based on the fact that private companies are profit driven and will not invest in projects with a cost-benefit ratio (CBR) of less than one where  $CBR = \text{Benefits}/\text{Costs}$ , a common metric against which to financially measure projects. Thus, by measuring the quantifiable costs, the monetary value of the benefits must be at least equal to those costs for all installed projects.

#### *Benefits of Installing Workplace Charging Stations*

As stated in the current relevant literature, there are multiple benefits that workplace charging stations confers onto businesses. The California Plug-in Electric Vehicle Collaborative (PEV Collaborative) summarized these benefits into three categories: benefits to employees, benefits to companies, and benefits to communities (2013). Similarly, the U.S. Department of Energy (DOE) summarized benefits for employees, employers, and building owners (2013). Many of these benefits were also supported in the responses Go-Zero received to the business interview survey. Table 2 in Appendix 4 is a summary of these key benefits from these studies and the GO-Zero research.

**Table 12. Benefits of Installing Workplace Charging Stations**

<b>Category</b>	<b>Benefits</b>	<b>Explanation</b>
<b>Employer Benefits</b>	Employee Recruitment and Retention	Provides incentive for hiring and retention to high-performance employees who drive PEVs (PEV Collaborative, 2013)
	Green Image Enhancement	Market the company as environmentally and socially responsible (PEV Collaborative, 2013)
	Employee Productivity Improvement	Increase the productivity of high-performance employees who drive PEVs to work by helping them arrive at work faster with PEVs carpooling benefits (PEV Collaborative, 2013)
	Local Regulation Compliance	Installing workplace charging stations may count towards local GHG mitigation efforts or goals (PEV Collaborative, 2013)
	Requirement for Leadership in Energy & Environmental Design certificates(LEED)	Installing workplace charging stations can help satisfy the strictest level of LEED certification (PEV Collaborative, 2013)
	Sustainability Achievement	Installing workplace chargers can help businesses achieve its environmental/sustainability goals (DOE, 2013)
	Employee Satisfaction	Employees are more likely to be grateful for employer's efforts to augment their working at workplace (DOE, 2013)
	Attracting and Retaining Tenants and Customers	Installing workplace chargers are more likely to attract future tenants for building owners (DOE, 2013) and attract potential customers for businesses.
	Revenues from Charging Users to Charge	Depending on the operation model, businesses can generate revenues from charging users of charging stations
	Advertising	Free recognition when the media reports on the

	Savings	company for its corporate social responsibility (CSR) efforts (McWilliams & Siegel, 2010)
	Investment Likelihood Increase	Investors may evaluate a business's CSR efforts to decide to invest or not. (McWilliams & Siegel, 2010) A better CSR performance may increase the likelihood of receiving external investment
<b>Employee Benefits</b>	Range Security and Extensions	Workplace charging can extend miles to drive for PEV drivers (DOE, 2013)
	Carpool Lane Benefits	Employees with PEVs can adopt HOV/carpool lanes, saving driving time for them (PEV Collaborative, 2013)
	Federal Tax Credits	A maximum of \$7,500 income tax credits can be given to PEV buyers (PEV Collaborative, 2013)
<b>Community Benefits</b>	Air Quality and Public Health Improvement	Workplace charging can encourage the adoption of PEVs, which contribute less to the air pollution (PEV Collaborative, 2013)
	Reduction in GHG emission	With more PEVs on road, less GHGs will be emitted (PEV Collaborative, 2013)
	Encouraged Use of Domestic Fuel	Increased number of PEVs will reduce the reliance on imported fuels from other countries (PEV Collaborative, 2012)

Source: California Plug-in Electric Vehicle Collaborative. (2013, November). Why Employers Should Install Workplace Charging for Plug-in Electric Vehicles Benefits to Employees, Companies and Communities; California Plug-in Electric Vehicle Collaborative. (2012, May). Workplace Charging: Why and How?; U.S. Department of Energy. (2013, August). Plug-In Electric Vehicle Handbook for Workplace Charging Hosts. McWilliams, A. & Siegel, D. (2010). Creating and Capturing Value: Strategic Corporate Social Responsibility, Resource-Based Theory, and Sustainable Competitive Advantage.

### *Costs of Installing Workplace Charging Stations*

The costs of installing a workplace charging station were likewise tabulated from a review of the current literature and validated through interview response data. Table X is a summary of the costs from previous studies and the GO-Zero research.

**Table 13. Costs of Installing Workplace Charging Stations**

<b>Costs</b>	<b>Explanation</b>
<b>Hardware (i.e. chargers) cost</b>	The cost of purchasing the charging equipment itself. The cost varies depending on what type of charger it is (Level 1, Level 2, DC Fast)
<b>Installation costs</b>	The installation of the physical chargers may include labor cost as well as the cost to upgrade the existing facilities to the required electricity capacity for chargers.
<b>Electricity cost</b>	The business will pay for the electricity used by the chargers.
<b>Administrative cost</b>	Chargers often incur an administrative cost or project management cost. For some companies, this is a sunk cost already covered in their annual facilities or maintenance budget while for others it will be an additional administrative cost.
<b>Maintenance and upgrade cost</b>	This refers to the potential maintenance and upgrade cost for installed electric vehicle chargers.
<b>Membership cost</b>	Depending on the operation contract some charging companies require businesses to pay a yearly membership for the chargers.
<b>Opportunity cost of parking</b>	Given that the parking spaces are limited, designating electric vehicle only parking spaces may take away valuable regular parking spaces (Chang et al, 2012).

Source: Chang, D., Erstad, D., Lin, E., Rice, A., Goh, C., Tsao, A., & Snyder, J. (2012, August). Financial Viability of Non-Residential Electric Vehicle Charging Stations.

## **A7.2 Results**

Based on the Equivalent Valuation Cost Benefit Analysis methodology, below is a summary of the average benefits and costs of installing workplace chargers for electric vehicle for a firm.

**Table 14.** Summary of average, high, and low costs and benefits of installing workplace charging.

	Average	High	Low
Per Charger Installation and hardware cost	\$ 6,214	\$ 20,000	\$ 100
Per Charger Electricity cost for n years	\$ 4,403	\$ 4,734	\$ 3,971
Per Charger Loss of Parking cost for n years	\$ 2,421	"	"
<b>Per Charger Total Cost</b>	<b>\$ 13,251</b>	<b>\$ 28,174</b>	<b>\$ 9,541</b>
Total Project Cost (number of chargers installed varies)	\$ 1,500,185		
Net Project Cost	\$ 1,509,073	\$ 17,017,734	\$ 12,984
Average Number of Chargers	113	1400	2
<b>AVG TOTAL/AVG NUM</b>	<b>\$ 13,328.39</b>		

The results in Table 14 uncover that with the current assumptions in place installation is the largest cost, followed by the cost of electricity, and then the loss of parking. The per-charger total cost is calculated in two ways. First, the average of the individual costs are added up to reveal a per charger cost of \$13,251. For comparison's sake, this cost is also calculated by dividing the average net project cost by the average number of chargers per project, resulting in a value of \$13,328. The difference in these two figures (\$77) is quite small and gives confidence in using a value in this range as an average cost per charger.

Except for a few outstanding situations where outside funding was used or companies made employees pay to charge there were no quantifiable benefits recorded. Therefore, it can be stated that the average minimum benefit provided by a charger to a workplace is \$13,251.

It is notable that while most of the costs of installing workplace chargers are a burden on the firms, no quantified benefits go directly towards them. Yet through a cost-benefit analysis of installed workplace charging, this paper has begun to uncover the potential monetary value of workplace charging stations to a firm.

For those parties potentially installing chargers but not able to reap the soft benefits to employees (such as private parking garages or cities that own parking spaces), Go-Biz must consider ways to either reduce the cost stream to these parties through targeted rebates or streamlined permitting, or increase the benefits with a creative benefits transfer scheme if workplace charger adoption in these areas is to increase.

## A8. First Charger Rebate Program Details

Currently several states and the District of Columbia provide rebate or income tax credits towards the cost of installation of EVSE. We recommend an income tax credit program similar to these other programs, but scaled to promote first charger adoption and reduce costs to the state government as businesses install additional chargers. The proposed rebate system is laid out in Table 15. Businesses, including property management firms, could apply for the tax credit multiple times if they were installing a first charger at multiple locations.

**Table 15.** Funding structure for the first charger rebate program.

	Description	Limits	Average Predicted Rebate
<b>Rebate for 1<sup>st</sup> Charger Installed</b>	50% rebate for equipment and labor costs of 1 <sup>st</sup> charger	Up to \$15,000 and 10 chargers per location; limit 10 locations	\$1800-2250 for 1 <sup>st</sup> charger;

Based on studies of average installation costs for workplace Level 2 EVSE across California as well as our cost-benefit analysis, we can predict the average credits available for a basic installation (Electrical Power Research Institute, 2013; The EV Project, 2015). The Electrical Power Research Institute EVSE installed cost analysis and The EV Project installation costs white paper were developed from hundreds of workplace EVSE installations and included data representing simple wall mounted units to projects requiring expensive electrical upgrades. These two studies found an average equipment and labor costs of \$3081 (EPRI) and \$4273 (EV Project). Because our CBA found a much higher average installation price of \$6214 (GO-Zero), we included a range of average predicted credits with EPRI and EV Project's representing the lower bound and all three studies representing the upper bound.

## **A9. Additional References**

**Alternative Fuels Data Center.** “Electric Vehicle Charging Station Locations.” (2017).

**California Energy Commission.** “Funding Strategies for Electric Vehicle Infrastructure.” (2016).

**California Energy Commission.** “Tracking Progress”. (2016)

**California Pollution Control Financing Authority.** “California Capital Access Program (CalCAP) Electric Vehicle Charging Station (EVCS) Financing Program.” (2016).

**Clean Vehicles Rebate Project.** “California Plug-In Electrical Vehicle Driver Survey Results”. (2013)

**Freewire Technologies.** “Case Study: Mobile EV Chargers for Workplace Charging” (2016).

**Freewire Technologies.** “Mobi Charger L2TW.” (n.d.).

**DriveClean Plug-In Electric Vehicle Resource Center.** “Define Your Incentives Search.” (n.d.).

**Department of Energy.** “Workplace Charging Challenge Progress Update 2014: Employers Take Charge.” (2014).

**EV Match.** “Who are we?” (2017).

**JustPark.** “About us.” (2017).

**California Air Resources Board.** “California GHG Emission Inventory.” (2016).

**Fortune Magazine.** “Fortune 500 List for Year 2016.” (2017).

**McKenzie, Brian.** “Who Drives to Work? Commuting by Automobile in the United States: 2013.” American Community Survey Reports. (2015).

**Tal, Gil et. al.** “Who Is Buying Electric Cars in California? Exploring Household and Vehicle Fleet Characteristics of New Plug-In Vehicle Owners”. Institute of Transportation Studies, University of California, Davis (2013).