Spring 5-1-2021

Ability of Bay Area Cities to Accommodate Plug-in Electric Vehicles: A Process Evaluation

Chi-Pei Fang
San Jose State University

Follow this and additional works at: https://scholarworks.sjsu.edu/etd_projects

Part of the [Policy Design, Analysis, and Evaluation Commons](#), and the [Transportation Commons](#)

Recommended Citation

Fang, Chi-Pei, "Ability of Bay Area Cities to Accommodate Plug-in Electric Vehicles: A Process Evaluation" (2021). *Master's Projects*. 984.
DOI: <https://doi.org/10.31979/etd.xj2s-nz3c>
https://scholarworks.sjsu.edu/etd_projects/984

This Master's Project is brought to you for free and open access by the Master's Theses and Graduate Research at SJSU ScholarWorks. It has been accepted for inclusion in Master's Projects by an authorized administrator of SJSU ScholarWorks. For more information, please contact scholarworks@sjsu.edu.

**Ability of Bay Area Cities to Accommodate Plug-in Electric Vehicles:
A Process Evaluation**

By
Chi-Pei Fang

A Thesis Quality Research Project
Submitted in Partial Fulfillment of
the Requirements for the
Master's degree in
PUBLIC ADMINISTRATION

Professor Frances Edwards, Ph.D.
Advisor

The Graduate School
San José State University
Spring 2021

TABLE OF CONTENTS

LIST OF FIGURES	4
LIST OF TABLES	6
INTRODUCTION	7
BAY AREA NEEDS MORE ELECTRIC VEHICLES	7
CITY-LEVEL GOVERNMENT NEEDS TO BE FOCUSED ON	8
RESEARCH QUESTIONS	8
BACKGROUND	10
THE BASICS AND BENEFITS OF ELECTRIC VEHICLES	10
THE CALIFORNIA AIR RESOURCES BOARD AND ZERO-EMISSION VEHICLE (ZEV) PROGRAM.....	12
GOVERNOR EXECUTIVE ORDER AND THE ZERO-EMISSION VEHICLES ACTION PLAN	13
GAP BETWEEN GOAL AND REALITY IN BAY AREA.....	14
PROVIDING READINESS GUIDEBOOK FOR THE CITIES	15
LITERATURE REVIEW	17
CITY, READINESS VARIABLES AND ELECTRIC VEHICLES	17
CITY, INCENTIVES AND ELECTRIC VEHICLES.....	19
CITY, CHARGING STATIONS AND ELECTRIC VEHICLES	20
CITY, EDUCATION (OUTREACH) AND ELECTRIC VEHICLES.....	21
METHODOLOGY	23
SYLVIA & SYLVIA'S FOUR-PHASE PROCESS EVALUATION.....	23
ANALYZE SAMPLE: 42 SELECTED CITIES IN BAY AREA	25
OPEN DATA COLLECTION AND IRB EXCLUSION	27
FINDINGS	28
PART 1: CITIES AND TEN INSTRUMENTS WHICH WERE BASED ON THE <i>GUIDEBOOK</i> (2013)	28
<i>No Single City Ignored the Instruments Provided by the Guidebook (2013)</i>	28
<i>Most of the Cities Adopted Nine or Ten Instruments</i>	30
<i>"Incentives Provided by City" was Only Adopted by Five Cities</i>	36
PART 2: CITIES AND OTHER SIX INSTRUMENTS GENERALIZED FROM OFFICIAL WEBSITES.....	40

<i>Six Instruments Generalized from Official Websites</i>	<i>40</i>
<i>Number of Instruments that the Cities Adopted Varied</i>	<i>46</i>
<i>Only 57% of the Cities Adopted the Instrument of “Holding Workshops”</i>	<i>50</i>
PART 3: CITIES AND PUBLIC CHARGING STATIONS.....	58
<i>A Significant Variation in the Number of Public Charging Stations Each City Set</i>	<i>58</i>
<i>The Number of Public Charging Stations and the City Population Seems to Correlate</i>	<i>58</i>
<i>Most Cities had 10 to 50 Public Charging Stations</i>	<i>60</i>
<i>Only Three Cities Have More than Ten Public Charging Stations per 10,000 People</i>	<i>62</i>
PART 4: PROVIDING ELECTRIC VEHICLES INFORMATION: OUTREACH AND EDUCATION	64
<i>Three Items to Understand How the Cities Convey Electric Vehicle Information</i>	<i>64</i>
<i>About Half of the Cities Choose Three Items to Convey Electric Vehicle Information</i>	<i>65</i>
<i>Most Cities Adopted “Providing the Link of Alternative Fueling Stations Locator”</i>	<i>69</i>
ANALYSIS	71
SUMMARIZING THE FINDINGS & ANSWERING THE RESEARCH QUESTIONS	71
<i>The Research Structure and the Summary of Findings</i>	<i>71</i>
<i>Answering Research Questions</i>	<i>78</i>
DISCUSSION AND RECOMMENDATIONS	80
<i>Does the Guidebook (2013) Work?</i>	<i>80</i>
<i>Encouraging the Cities Leaders to Show the Determination</i>	<i>82</i>
<i>Finding Synergy Needs Resource: “Combining Programs” and “Holding Workshop”</i>	<i>83</i>
<i>It May be Normal to Show Difference on Setting Public Charging Stations</i>	<i>84</i>
<i>The Importance of Creating an Electric Vehicle Website Section</i>	<i>86</i>
LIMITATION AND FUTURE STUDY	88
CONCLUSION	89
REFERENCE	90
APPENDICES	99
APPENDIX A: TEN INSTRUMENTS BASED ON THE GUIDEBOOK (2013).....	99
APPENDIX B: DETAILS OF EACH CITY ADOPTED INSTRUMENTS BASED ON THE GUIDEBOOK (2013)	101
APPENDIX C: DETAILS OF EACH CITY ADOPTED INSTRUMENTS GENERALIZED FROM OFFICIAL WEBSITES	

.....	104
APPENDIX D: DETAILS OF EACH CITY ADOPTED THREE ITEMS THAT CONVEY ELECTRIC VEHICLE	
INFORMATION	106

LIST OF FIGURES

Figure 1: Number of Instruments that each City Adopted Based on the <i>Guidebook</i> (2013)	29
Figure 2: Seven Instruments were Fully Adopted by 42 Cities	33
Figure 3: The Instrument of “Working with the Utilities” and “Partnering with Community Stakeholders”	35
Figure 4: The Instrument of “Incentives Provided by City”	37
Figure 5: Example of Combining Electric Vehicle Program with Other Projects	41
Figure 6: Example of Holding Workshops for Promoting Electric Vehicles Adoption	42
Figure 7: Example of Bringing Electric Vehicle Program into City Plans	43
Figure 8: Example of Creating a Specific Website Section Providing Information	45
Figure 9: Number of Instruments each City Adopted Generalized from Official Websites	47
Figure 10: Group One: 57% of the Cities Adopted the Instrument of “Holding Workshops”	51
Figure 11: Group Two: “Combining with other Projects” and “Creating a Specific Website Section for Electric Vehicles”	53
Figure 12: Group Three: “Bring Electric Vehicle Program into City Plans” and “Supporting from the Leaders”	55
Figure 13: Group Four: “Setting Up Public Charging Stations” was Fully Adopted by 42 Cities	57

Figure 14: Number of Public Charging Stations in Each City.....	59
Figure 15: Number of Outreach Items each City Adopted	68
Figure 16: “Providing the Link of Alternative Fueling Stations Locator” is the one that Most Cities Chose to Adopt	70
Figure 17: The Research Structure and the Summary of Findings	73
Figure 18: Number of Total Sixteen Instruments each Cities Chose to Adopt.	75

LIST OF TABLES

Table 1: Sylvia & Sylvia's four-phase Process Evaluation	24
Table 2: 42 Selected Cities.....	26
Table 3:Percentage of Cities that Adopted Different Number of Instruments..	31
Table 4: Percentage of Cities that Adopted Different Number of Instruments.	49
Table 5: Percentage of the Cities that Have Different Number of Public Charging Stations.....	61
Table 6: Number of Public Charging Stations per 10,000 People by City	63
Table 7: Percentage of the Cities that Chose Different Number of Outreach Items.....	66
Table 8: Percentage of Cities that Adopted Different Number of Total Instruments.....	77

INTRODUCTION

For the last 30 years, California has made a significant improvement in air quality (Nordgren et al., 2016; Ogden, 1999; Bedsworth et al., 2013). However, facing the threat of climate change, California not only needs to continue fighting for clean air and a healthy life, but also has to defeat the greenhouse gas (GHG) (Bedsworth & Hanak, 2013; London et al., 2013; Brown et al., 1995).

Where are greenhouse gas emissions coming from? According to the United States Environmental Protection Agency (EPA) (2019), the most significant source of greenhouse gas emissions is transportation (29%), which primarily comes from burning fossil fuel for cars, trucks, ships, trains, and planes. The second and the third go to electricity (28%), and industry (22%) (EPA, 2019). Therefore, it is clear that the “transportation sector” generates the largest share of greenhouse gas emissions, and it is the one that the state has to deal with (Witt et al., 2012; Wesseling et al., 2014; Stokes & Breetz, 2018; Shaheen et al., 2002).

Bay Area Needs More Electric Vehicles

Bay Area region, composed of nine counties, has 3.1 million people who travel to school or to work every day, and some of them choose to use public transportation, but most of them do not, according to the Silicon Valley Leadership Group (2019).

Moreover, based on the statistics collected by the California Department of Motor Vehicles (DMV) (2019), in Bay Area, there are about 6.3 million cars on the road; however, only 165,000 are electric vehicles. It means that most of the cars on the road are still burning fossil fuel, generating greenhouse gas, and creating air pollution. Therefore, if the state intends to decrease greenhouse gas from the transportation sector, enhancing “electric vehicle adoption” is the essential solution (Bakker & Jacob, 2013).

City-Level Government Needs to be Focused on

Numerous studies have mentioned that there are lots of factors that may affect electric vehicle adoption, including residents' income, manufactures' behavior, mass transportation system, and so on (Larson et al., 2014; Majumdar, 2005; Millard-Ball, 2012; Azevedo et al., 2017; Liao, 2018). While the issue of electric vehicle adoption has been explored in a wide range of contexts, there is a limited number of studies to understand how the policies are implemented from the perspective of a “city.”

In recent years, several studies have started to pay more attention to a city's role in electric vehicle adoption (Baker et al., 2012; Clark-Sutton, et al., 2016; Armstrong, 2019; Azevedo et al., 2017). For example, according to Clark-Sutton et al. (2016), “a city does play a critical role in electric vehicles adoption, because it can facilitate the building of electric vehicle infrastructure and it also has a tremendous influence on educating their constituents on the benefits of these types of cars” (p. 30).

However, there is still a lack of research addressing the issue of electric vehicle adoption from the city-level. Therefore, the aim of this study is to provide more empirical evidence to understand the instruments that the cities have chosen to enhance electric vehicle adoption.

Research Questions

Accordingly, this study addresses the following four research questions to understand the instruments that Bay Area cities adopted and the difference between the cities:

1. Based on the *Guidebook* (2013), what kinds of instruments do Bay Area cities choose? What are the differences between the cities regarding the chosen instruments?
2. Aside from the *Guidebook* (2013), do Bay Area cities have other kinds of

instruments? If any, what are they? Do the cities vary from each other?

3. About “Setting up Public Charging Stations,” how many of them have been set up in each city? How does the number of public charging stations in each city vary?
4. Regarding the instrument of “Outreach and Education,” what have Bay Area cities done to enhance this instrument? What are the differences between the cities?

The remainder of this study is organized as follows. A brief history of electric vehicle policies is in the Background section. Next, the Review of the Literature is presented, and after that is the Research Methodology. The later section reports the Findings of this study. The Analysis is addressed next. Finally, the Conclusion is presented.

BACKGROUND

This section includes two parts, one is the basics of electric vehicles, and another is a brief introduction of the state's electric vehicles policies.

The Basics and Benefits of Electric Vehicles

Different from conventional vehicles that use gasoline or diesel-powered engines, electric vehicles use “an electric motor powered by electricity from batteries or a fuel cell” (Greene et al., 2014, p. 34). The above definition is a general understanding of an electric vehicle. Electric vehicles, sometimes called electric cars, are of three types: Hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and Battery electric vehicles (BEVs) (Alternative Fuels Data Center, 2019).

According to the Alternative Fuels Data Center (2019), Hybrid Electric Vehicles (HEVs) and Plug-In Hybrid Electric Vehicles (PHEVs) are both “powered by an internal combustion engine and an electric motor that uses energy stored in a battery.” However, there is a difference between these two.

Hybrid Electric Vehicles (HEVs) are “fueled with gasoline to operate the internal combustion engine, and the battery is charged through regenerative braking, not by plugging in,” and Plug-In Hybrid Electric Vehicles (PHEVs) “can operate in all-electric mode with a larger battery, which can be plugged into an electric power source to charge; after running out the electricity, it then will operate solely on gasoline” (Alternative Fuels Data Center, 2019).

The third type is Battery Electric Vehicles (BEVs), also known as All-Electric Vehicles, which “have a battery that is charged by plugging the vehicle into charging equipment and always operate in all-electric mode” (Alternative Fuels Data Center, 2019).

As a result, according to the above definition, the last two types - Plug-In Hybrid Electric Vehicles (PHEVs) and Battery electric vehicles (BEVs) – are the ones that are “capable of drawing electricity from off-board electrical power sources and storing the energy in batteries” (Alternative Fuels Data Center, 2019). With the feature that the engine can be powered by electricity only, no need for gasoline, Plug-In Hybrid Electric Vehicles (PHEVs) and Battery electric vehicles (BEVs) are the ones that this study focuses on.

Moreover, according to several studies, this study generalizes three main benefits of driving electric vehicles (Thomas et al., 1998; Majumdar, 2005; Graham et al., 2014; Wesseling et al., 2014; Breetz & Salon, 2018; Borgstedt et al., 2017; Liao, 2018; Ogden, 1999; Bergek & Berggren, 2014; Collantes & Sperling, 2008).

First, more electric vehicles on the road can improve air quality. Without using a gasoline or diesel-powered engine, the exhaust emission will not be created (Majumdar, 2005; Graham et al., 2014). Therefore, driving electric vehicles can indeed reduce air pollution. Moreover, electric vehicles can also reduce noise pollution, due to their quieter engines (Thomas et al., 1998; Majumdar, 2005).

Secondly, increasing the number of electric vehicles can enhance energy reliability and independence (Borgstedt et al., 2017; Liao, 2018). According to the California Air Resource Board (CARB), “the use of electricity and hydrogen to power vehicles will support domestically produced sources of energy, and this can reduce reliance on imported energy sources and uncertainty over fuel costs, as well” (2019).

Finally, driving electric vehicles can save money (Ogden, 1999; Bergek & Berggren, 2014; Baker et al., 2012; Armstrong, 2019). According to Alternative Fuels Data Center (2019), many electricity providers offer a rate plan that makes filling up on electricity

cheaper than gasoline. Moreover, due to electric vehicles not having a gasoline engine, electric vehicles do not need oil changes, spark plugs, timing belts, or so on, which saves on maintenance costs (Baker et al., 2012; Armstrong, 2019).

The California Air Resources Board and Zero-Emission Vehicle (ZEV) program

The California Air Resources Board's (CARB) primary responsibility is to protect the citizens from the harmful effects of air pollution (Berkeley et al., 2017; Nordgren et al., 2016). Moreover, the CARB is also charged with developing various programs and practical actions to fight climate change (CARB, 2019; Berkeley et al., 2017). For example, the CARB has set different requirements for clean cars and fuels to reduce greenhouse gas emissions (Berkeley et al., 2017; Nordgren et al., 2016). Besides, according to the CARB, its mission is to “promote and protect public health, welfare, and ecological resources through effective reduction of air pollutants while recognizing and considering effects on the economy” (2019).

In 1990, the CARB started the Zero-Emission Vehicle (ZEV) program and became the first one to adopt the zero-emission vehicle requirement (CARB, 2019; Wesseling et al., 2014; Sykes & Axsen, 2017). The Zero-Emission Vehicle (ZEV) program regulations are designed to achieve the long-term emission reduction goals, and its main idea is to demand that auto manufacturers provide for sale specific numbers of the very cleanest vehicles available (Berkeley et al., 2017; Armstrong, 2019; Langbroek et al., 2016). For example, BMW, Fiat Chrysler, Ford, General Motors, Honda, Hyundai, Kia, Mercedes, Nissan, Toyota, and Volkswagen are large manufactures that have to comply with the specific requirements (CARB, 2019; Wesseling et al., 2014; Sykes & Axsen, 2017). The smaller manufacturers, such as Jaguar Land Rover, Mitsubishi, Mazda, Subaru, and Volvo, are also asked to abide by the conditions but can meet other obligations instead

(CARB, 2019; Wesseling et al., 2014; Sykes & Axsen, 2017; Shaheen et al., 2002; Langbroek et al., 2016).

Moreover, over decades, the Zero-Emission Vehicle (ZEV) program regulations have been modified to reflect the development of electric vehicle technology (CARB, 2019; Wesseling et al., 2014;). According to the CARB, a significant modification was adopted in 2012, which “has set California on a path toward ZEV commercialization with the resurgence of battery technology enabling auto manufacturers to offer moderately priced zero-emission vehicles to consumers” (2019).

Governor Executive Order and the Zero-Emission Vehicles Action Plan

In March 2012, Governor Edmund G. Brown Jr. announced an executive order that “laying the foundation for 1.5 million zero-emission vehicles on California’s roadways by 2025” (Sykes & Axsen, 2017, p.447). Along with this executive order, the state government started the Administration’s 2013 Zero Emission Vehicle Action Plan.

Unlike the Zero-Emission Vehicle (ZEV) program that was designed to demand the auto manufacturers comply with the requirements, the Brown Administration’s 2013 Zero Emission Vehicle Action Plan was created to “accelerate the market” to increase the sale number of zero-emission vehicles (Bedsworth & Hanak, 2013; Sykes & Axsen, 2017; Stokes & Breetz, 2018). This plan aimed to “establish several milestones on the pathway toward the goal of 1.5 million zero-emission vehicles in California by 2025” (Larson et al., 2014, p. 299). Moreover, according to several studies, the implementation of the 2013 Zero Emission Vehicle Action Plan was quite a success as the zero-emission vehicle market had grown significantly in years (Larson et al., 2014; Lévy et al., 2017; Lieven, 2015; Rietmann & Lieven, 2019; Sykes & Axsen, 2017).

Later in January 2018, Governor Brown signed an executive order that aimed to “set

200 hydrogen fueling stations and 250,000 chargers to support 1.5 million zero-emission vehicles on California roads by 2025, and moreover, on the path to five million zero-emission vehicles by 2030” (Stokes & Breetz, 2018, p. 76).

Therefore, in order to implement this executive order, the Administration’s 2018 Zero Emission Vehicle Action Plan was developed in the same year. However, differently from the previous plan in 2013, the Administration’s 2018 Zero Emission Vehicle Action Plan initiative was designed to “focus multi-stakeholder efforts on deploying charging and fueling infrastructure as well as making Zero-Emission Vehicles increasingly affordable to own and operate” (Liao, 2018, p. 112).

Gap Between Goal and Reality in Bay Area

The 2013 and 2018 Brown Administration's Zero Emission Vehicle Action Plans were designed statewide. Based on these Action Plans, the local or regional governments would develop their own executive plans to meet the state’s goal (Stokes & Breetz, 2018; Rietmann & Lieven, 2019).

Therefore, in Bay Area, a regional government, known as Bay Area Air Quality Management District (BAQMD), is the one in charge of projecting the number of electric vehicles and estimating the needed infrastructure to support the forecasts (Rietmann & Lieven, 2019; Sykes & Axsen, 2017).

According to BAQMD (2013), it estimated that there should have 250,000 electric vehicles in Bay Area by 2025 to support the state’s goal. However, according to the DMV (2019), there are about 165,000 electric vehicles in Bay Area, which means that Bay Area still needs to put another 85,000 electric vehicles on the road in 6 years.

Besides, regarding the number of charging stations, the BAAQMD (2013) estimated that Bay Area should have 35,000 charging stations to accommodate 250,000 electric

vehicles. However, according to the Alternative Fuels Data Center (2019), there are about 6,000 charging stations in the Bay Area, which is a shortage of 26,000 charging stations.

As a result, the number of electric vehicles and the number of charging stations in the Bay Area seem insufficient to support the state's goal, which indeed shows a gap between the state's goal and reality.

Providing Readiness Guidebook for the Cities

In order to achieve the goal of 1.5 million zero-emission vehicles on California roads by 2025, the federal government, the state government, and the regional government all had issued various readiness guidebooks for the cities (Heidrich et al., 2017; Armstrong, 2019). These guidebooks aimed to help the cities enhance the ability to accommodate the desired number of electric vehicles (Heidrich et al., 2017; Breetz & Salon, 2018).

The following are the readiness guidebooks from the governments, and each of them has its distinguishing feature:

First, released from the federal Government, Department of Energy in 2014, *A Guide to the Lessons Learned from the Clean Cities Community Electric Vehicle Readiness Projects* focused on providing successful experiences from the cities that partnered with the local Clean Cities coalitions (Department of Energy, 2014).

Second, in 2013, California issued *Zero-Emission Vehicles in California: COMMUNITY READINESS GUIDEBOOK - Toward 1.5 Million Zero-Emission Vehicles on California Roadways by 2025*. This guidebook provided lots of primary, practical, and critical measurements for the cities (Governor's Office of Planning & Research, 2013; Armstrong, 2019). It mainly included the tools of how to identify electric vehicle infrastructure needs in communities and how to change the general plans, zoning, and building codes for electric vehicle adoption (Governor's Office of Planning & Research,

2013; Heidrich et al., 2017).

Finally, two Bay Area regional governments also had provided the guidebooks. One was released by Bay Area Air Quality Management District and was known as *Bay Area: Plug-in Electric Vehicle Readiness Plan (Summary 2013)*. The other was issued by the Association of Bay Area Government and called *Ready Set Charge California - A Guide to EV-Ready Communities*. Both these guidebooks paid more attention to combining Bay Area resources to reach the goal of increasing the number of electric vehicles and the number of charging stations (Association of Bay Area Government, 2016; Bay Area Air Quality Management District, 2013; Heidrich et al., 2017; Armstrong, 2019).

LITERATURE REVIEW

This section reviews four issues that most researchers have addressed regarding enhancing electric vehicles adoption: the readiness variables, incentives, charging infrastructure, and education (outreach).

City, Readiness Variables and Electric Vehicles

Numerous studies have indicated that a city can play a critical role in decreasing greenhouse gas emissions to fight climate change (Baker et al., 2012; Clark-Sutton et al., 2016; Shaheen et al., 2002; Azevedo et al., 2017). The main reason is that the city is the one that can carry out the state's policies by adopting different instruments (Bedsworth & Hanak, 2013; Millard-Ball, 2012). Therefore, as enhancing electric vehicles adoption is one of the solutions to decrease greenhouse gas from the transportation sector, the cities play a significant role to get themselves in readiness for deploying electric vehicles (Clark-Sutton et al., 2016; Heidrich et al., 2017; Sykes & Axsen, 2017).

For example, Clark-Sutton, et al. (2016) had provided an index to identify and rank the “readiness” of 36 major U.S. cities for deploying electric vehicles. In one of its conclusions, the article directly pointed out that “a suite of cities' policies such as the ones considered in this index is needed to address all aspects of the electric vehicles adoption decision and create a supportive environment for adoption” (Clark-Sutton et al., 2016, p. 31). It indicated that cities play a key role in accelerating electric vehicle adoption by creating a friendly community or a supportive environment for electric vehicles adoption.

Moreover, Clark-Sutton et al. (2016) also defined “readiness” as “the degree to which adoption of electric vehicles is supported, as reflected in the presence of various types of policy instruments, infrastructure development, municipal investments in electric

vehicles technology, and participation in relevant stakeholder coalitions” (p. 32). In order to determine the readiness rank of the cities, Clark-Sutton, et al. (2016) used weighted scoring methodology on sixteen identified variables as follows:

The 16 variables were grouped into five categories: hard purchase-related incentives (i.e., direct monetary savings to the consumer through a rebate or tax credit), soft incentives (i.e., conditions that make PEVs more attractive and convenient), fuel cost environment (i.e., average price of electricity and gasoline in the city), special fleet programs (i.e., presence of PEVs in municipal fleets or car sharing programs), and additional indicators of whether the general climate is supportive of PEV adoption (e.g., the presence of a Clean Cities coalition and permission for Tesla to sell vehicles directly to consumers rather than through a dealer). (p. 33)

Not only the cities in the U.S. but also the cities in the U.K. believed that the city can support electric vehicles adoption. Heidrich, et al. (2017) investigated the effectiveness of the strategies and infrastructure provision in 30 U.K. cities with a particular emphasis on the strategy within the remit of cities and local authorities. As a result, they found that “there is no statistical difference in the number of charging points or electric vehicles between the cities that have electric vehicles as part of their climate change mitigation strategy and those that do not” (Heidrich et al., 2017, p. 21). However, they found that electric vehicle adoption is more associated with other factors, such as city population, residents’ income, and so on (Heidrich et al., 2017).

The above researchers decided to choose the city as their unit of analysis, which indicates that a city indeed can play a key role in implementing the state policy. Moreover, there are many researchers who still intend to identify the influential factors

which are controlled by the city (Clark-Sutton et al., 2016; Sykes & Axsen, 2017).

For example, in Clark-Sutton, et al. (2016), the “soft incentives,” including charging station count, electric vehicle supply equipment permitting, and parking privileges, were identified as possible instruments that a city can develop for enhancing electric vehicles adoption. Moreover, although Heidrich, et al. (2017) found that whether a city has put the words “electric vehicles” into their strategy documented as an item or not, it has no relationship with the number of electric vehicles a city has. They indeed identified other factors influencing electric vehicle adoption, such as residents’ income and the size of the city’s population (Heidrich et al., 2017).

City, Incentives and Electric Vehicles

A review of literature found that there have been numerous studies mainly focusing on the effect of policy incentives on electric vehicle adoption (Murray, 2011; Lévy et al., 2017; Jenn et al., 2018; Bergek & Berggren, 2014; Brown et al., 1995).

Jenn, et al. (2018) evaluated the effect of incentives on the adoption of electric vehicles from the perspectives of the federal government, the state governments, electric utility operators, and other entities. As a result, they reported that “every \$1,000 offered as a rebate or tax credit increases average sales of electric vehicles by 2.6% “(Jenn et al., 2018, p. 354). This finding indicated that the more financial incentives for electric vehicles, the higher the sales rate was for electric vehicles (Jenn et al., 2018).

However, a city may not be able to provide a number of financial incentives for electric vehicles due to insufficient budget (Bergek & Berggren, 2014; Jenn et al., 2018). Fortunately, Langbroek, et al. (2016) addressed other kinds of incentives that may be suitable for the city to adopt. They found that “the high stated valuation of free parking or access to bus lanes makes those incentives an efficient alternative to expensive subsidies

“(Langbroek et al., 2016, p. 100). In a similar vein, as mentioned previously, Clark-Sutton, et al. (2016) also provided the idea of the “soft incentives,” which may be suitable for the city to develop without financial burden.

City, Charging Stations and Electric Vehicles

Numerous studies have concluded that the setting of “charging infrastructure” is a significant factor for enhancing electric vehicle adoption (Xie et al., 2018; Huang et al., 2012; Clark-Sutton et al., 2016; Egnér & Trosvik, 2018; Rietmann & Lieven, 2019). For example, Clark-Sutton, et al. (2016) had pointed out that “while a broader policy effort like federal fuel economy standards or a national carbon pricing policy may increase the market penetration of electric vehicles, they do not discourse other barriers for mainstream consumers, especially the issue of “lack of charging infrastructure” (p. 35). Similarly, Huang, et al. (2012) also addressed critical issues related to the utilities that may need to be solved before large-scale electric vehicle adoption can be realized, which are “distribution constraints, electricity tariffs incentives, and public charging locations” (p. 450).

Moreover, some researchers had carried out qualitative research to highlight the importance of setting “charging infrastructure.” Rietmann and Lieven (2019) had analyzed the effectiveness of the monetary incentives’ measures in 20 countries, including traffic regulations and the charging infrastructure. As a result, they found that “all policy measures positively influence the percentage of electric vehicles, specifically monetary measures in interaction with the charging infrastructure” (Rietmann & Lieven, 2019, p. 73). In a similar vein, by using panel data between 2010 and 2016, Egnér & Trosvik (2018) tried to estimate the effect of local policy instruments used on the share of newly registered electric vehicles. They found that “an increased number of public

charging points increases the adoption rate, especially in urban municipalities” (Egnér & Trosvik, 2018, p. 593).

Egnér & Trosvik’s (2018) study was not the first to mention that the urban municipalities could play a crucial role in increasing the cities’ ability to accommodate electric vehicles. Xie, et al. (2018) had also stated that “a city can be the one which accelerates the number of charging stations by offering a permitting process that is efficient, timely, consistent and affordable while ensuring the safety of the installations” (p. 273).

City, Education (Outreach) and Electric Vehicles

Many researchers had pointed out that the cities need to educate its residents about the advantage of electric vehicles, in order to successfully capture the attention and acceptance of the broader public (Berkeley et al., 2017; Larson et al., 2014; Lévy et al., 2017; Liao et al., 2019; Krause et al., 2013). For example, Egnér & Trosvik (2018) have empirically examined the impact of local policy instruments on promoting electric vehicle adoption. As a result, they indicated that “by adjusting policy instruments to the specific characteristics of municipalities and making them visible to the public, their effectiveness can be increased” (Egnér & Trosvik, 2018, p. 272). Moreover, while Jenn, et al. (2018) evaluated the effect of incentives on the adoption of electric vehicles from the perspectives of the governments, they also gave a similar conclusion that “raising consumer awareness is critical to the success of electric vehicles incentive programs” (p. 354).

Besides, Krause, et al. (2013) had examined the consumer knowledge about electric vehicles, which included the current policies to encourage the purchase and use. They collected the data via a survey administered to a sample of 2,302 adults in 21 of the

largest cities in the United States (Krause et al., 2013). However, the result showed that “almost two-thirds of the respondents provided incorrect answers to basic factual questions about electric vehicles and, of those, approximately 75% underestimated their private value or advantages” (p. 437). Moreover, the study also found that “the vast majority (94.5%) of respondents were not aware of the current state and local incentives in place in their locale to encourage electric vehicles to purchased and used” (Krause et al., 2013, p. 438).

Based on Krause, et al. (2013), it is obvious that the governments, especially the cities, indeed have a lot of work to do to enhance public acceptance. For example, the cities need to educate the residents about the basics of electric vehicles, particularly the benefit of driving electric vehicles. Moreover, the cities also have to provide more information about the federal and state incentives to encourage the citizen to purchase electric vehicles.

METHODOLOGY

This section includes three parts, which are “Sylvia & Sylvia's four-phase Process Evaluation,” “Analyze Sample: 42 Selected Cities in Bay Area,” and “Open Data Collection and IRB Exclusion.”

Sylvia & Sylvia's Four-Phase Process Evaluation

This study used Sylvia & Sylvia's (2012) four-phase process evaluation to understand what kinds of instruments that Bay Area cities had chosen to enhance electric vehicle adoption. Moreover, the evaluation feedback mainly included three issues: first, the role the guidebook played. This study used the guidebook that California released in 2013, *Zero-Emission Vehicles in California: COMMUNITY READINESS GUIDEBOOK - Toward 1.5 Million Zero-Emission Vehicles on California Roadways by 2025*, to understand whether the state's guidebook had any influence on Bay Area cities' chosen instruments. Second, the evaluation included the meaning of the numbers of public charging stations in Bay Area cities. Finally, the evaluation assessed the outcomes of how Bay Area cities provided electric vehicle information to their residents. Table 1 shows the four-phases identified in the process evaluation.

Table 1: Sylvia & Sylvia's four-phase Process Evaluation

<i>Sylvia & Sylvia's four-phase Process Evaluation</i>	
1. Problem Identification	Bay Area cities are not able to accommodate electric vehicles to reach the goal toward 250,000 by 2025.
2. Solution Development	The state of California provided readiness guidebooks to cities so they may choose instruments.
3. Implementation	Bay Area cities use the recommended instruments to enhance electric vehicle adoption.
4. Evaluation Feedback	Based on the Guidebook (2013), what kinds of instruments do Bay Area cities choose? What are the differences between the cities regarding the chosen instruments?
	Aside from the Guidebook (2013), do Bay Area cities have other kind of instruments? If any, what are they? Do the cities vary from each other?
	About “Setting up Public Charging Station,” how many of them have been set up in each city? How does the number of public charging stations in each city vary?
	Regarding the instrument of “Outreach and Education,” what Bay Area cities have done to enhance this instrument? What are the differences between the cities?

Analyze Sample: 42 Selected Cities in Bay Area

The unit of analysis of this study was the city. This study chose Alameda County, San Mateo County, and Santa Clara County as the research scope. Because this region had a great deal of population and traffic congestion, several studies identified it as the heart of Silicon Valley (Shaheen et al., 2002; Collantes et al., 2008; Witt et al., 2012). As a result, this study acknowledged that these counties indeed were appropriate to investigate whether the instruments had been used proactively to enhance electric vehicle adoption.

Moreover, there was 49 cities in these three counties, and this study chose 42 cities in which the population was over 10,000. Table 2 shows the selected cities: 14 cities in Alameda County, 15 cities in San Mateo County, and 13 cities in San Clara County.

Table 2: 42 Selected Cities

42 Selected Cities with Population Over 10,000 (County of Alanada, County of San Mateo, County of Santa Clara)								
City	County	Population	City	County	Population	City	County	Population
Oakland	Alameda	432,897	Daly City	San Mateo	109,122	San Jose	Santa Clara	1,043,058
Fremont	Alameda	232,532	San Mateo	San Mateo	104,570	Sunnyvale	Santa Clara	155,567
Hayward	Alameda	159,433	Redwood City	San Mateo	85,319	Santa Clara	Santa Clara	128,717
Berkeley	Alameda	123,328	South San Francisco	San Mateo	67,078	Mountain View	Santa Clara	81,992
Livermore	Alameda	91,039	San Bruno	San Mateo	45,257	Milpitas	Santa Clara	76,231
San Leandro	Alameda	89,825	Pacifica	San Mateo	38,674	Palo Alto	Santa Clara	69,397
Pleasanton	Alameda	80,492	Menlo Park	San Mateo	35,790	Cupertino	Santa Clara	59,879
Alameda	Alameda	79,316	Foster City	San Mateo	33,693	Gilroy	Santa Clara	55,928
Union City	Alameda	74,916	East Palo Alto	San Mateo	30,499	Morgan Hill	Santa Clara	45,742
Dublin	Alameda	64,577	Burlingame	San Mateo	30,317	Campbell	Santa Clara	43,250
Newark	Alameda	48,712	San Carlos	San Mateo	29,864	Saratoga	Santa Clara	31,407
Albany	Alameda	19,393	Belmont	San Mateo	27,174	Los Altos	Santa Clara	31,190
Emeryville	Alameda	11,885	Millbrae	San Mateo	23,154	Los Gatos	Santa Clara	30,988
Piedmont	Alameda	11,420	Half Moon Bay	San Mateo	12,631	Los Altos Hills	Santa Clara	8,785
			Hillsborough	San Mateo	11,769	Monte Sereno	Santa Clara	3,787
			Atherton	San Mateo	7,070			
			Woodside	San Mateo	5,615			
			Brisbane	San Mateo	4,691			
			Portola Valley	San Mateo	4,659			
			Colma	San Mateo	1,512			
Total: 14			Total: 15			Total: 13		
Total: 42 Cities								

(Source: U.S. Census Bureau, 2019)

Open Data Collection and IRB Exclusion

This study collected the open data from the cities' official websites. To identify the instruments they chose, including the instruments based on the *Guidebook* (2013) (see Appendix A) and the instruments developed by the cities. As a result, this study had generated the first-hand collected data into three matrix tables to show the difference between the instruments that the cities had chosen (see Appendix B, C, and D).

Moreover, regarding the number of public charging stations each city had, this study collected the data from the Alternative Fuel Data Center, which was maintained by the U.S. Department of Energy.

This study was an IRB exclusion research project because there were no human subjects. All the data that this study used was on the governments' websites that are open to the public.

FINDINGS

This section has been divided into four parts, which are “Cities and Ten Instruments which Were Based on the *Guidebook* (2013),” “Cities and Other Six Instruments Which Generalized from Official Websites,” “Cities and Public Charging Stations,” and “Providing Electric Vehicles Information: Outreach and Education.”

Part 1: Cities and Ten Instruments which Were Based on the *Guidebook* (2013)

Three points of findings are noted as follow:

No Single City Ignored the Instruments Provided by the Guidebook (2013)

As previously mentioned in the Background, the use of the *Guidebook* (2013) was not mandatory. Instead, the *Guidebook* (2013) aimed to provide directions and information to help the cities enhance the likelihood of electric vehicle adoption. Therefore, as can be seen in Figure 1, the results show that all 42 cities had adopted at least seven of these ten recommended instruments, which means no single city ignores the *Guidebook* (2013). See Appendix B for the details of what instruments each city had chosen.

Figure 1: Number of Instruments that each City Adopted Based on the *Guidebook* (2013)

Most of the Cities Adopted Nine or Ten Instruments

Table 3 shows that 11.9% of the cities adopted all ten instruments, and 83.33% of the cities adopted nine instruments. As a total, with a markedly high percentage, there was 95.23% of the cities choosing nine or ten instruments.

However, as shown in Table 3, the City of Livermore adopted eight instruments, and the City of San Bruno chose seven instruments. Appendix B shows that the City of Livermore did not choose the instrument of “Partnering with Community Stakeholders” and “Incentives Provided by City,” and the City of San Bruno also chose neither, nor the instrument of “Working with Utilities” (see Appendix B).

Table 3:Percentage of Cities that Adopted Different Number of Instruments

Index (Number represents the rank of city population)	Name of the Cities	Number of Instruments that Each City Adopted Based on the Guidebook(2013) (Max.:10)	Number of cities / Percentage of Total Cities
1	San Jose	10	5 / 11.9% <u>(About 11.9% of cities adopted total 10 instruments)</u>
7	Berkeley	10	
8	Daly City	10	
13	Mountain View	10	
15	Alameda	10	
2	Oakland	9	35 / 83.33% <u>(About 83.33% of cities adopted total 9 instruments)</u>
3	Fremont	9	
4	Hayward	9	
5	Sunnyvale	9	
6	Santa Clara	9	
9	San Mateo	9	
11	San Leandro	9	
12	Redwood City	9	
14	Pleasanton	9	
16	Milpitas	9	
17	Union City	9	
18	Palo Alto	9	
19	South San Francisco	9	
20	Dublin	9	
21	Cupertino	9	
22	Gilroy	9	
23	Newark	9	
24	Morgan Hill	9	
26	Campbell	9	
27	Pacifica	9	
28	Menlo Park	9	
29	Foster City	9	
30	Saratoga	9	
31	Los Altos	9	
32	Los Gatos	9	
33	East Palo Alto	9	
34	Burlingame	9	
35	San Carlos	9	
36	Belmont	9	
37	Millbrae	9	
38	Albany	9	
39	Half Moon Bay	9	
40	Emeryville	9	
41	Hillsborough	9	
42	Piedmont	9	
10	Livermore	8	1 / 2.38% <u>(About 2.38% of cities adopted total 8 instruments)</u>
25	San Bruno	7	1 / 2.38% <u>(About 2.38% of cities adopted total 7 instruments)</u>

Moreover, from the perspective of instruments, Figure 2 shows that seven instruments were fully adopted by 42 cities, including the instrument of “Changing the Building Codes,” “Outreach and Education,” “Signs and Pavement Markings,” “Permitting Single-Family Residential Charging,” “Permitting Multi-Unit Dwellings Charging,” “Permitting Workplace Charging” and “Permitting Retail and Public Sector Charging.”

This study found that the instrument of “Changing the Building Codes” connected with the instruments of permitting charging installation for different kinds of buildings (i.e., Single-Family Residential, Multi-Unit Dwellings, Workplace, and Retail and Public Sector). As the cities decided to change the building codes, the cities’ next step was to develop a procedure for the building owners to apply for installing the charging stations. This procedure is what this study defined as the instrument of “Permitting (Building) Charging.” Therefore, the instrument of changing building codes and permitting charging installation could be seen as a set.

Figure 2: Seven Instruments were Fully Adopted by 42 Cities

In addition, as shown in Figure 3, the instrument of “Working with Utilities” was adopted by 41 cities. The only city that did not adopt it was the city of San Bruno (see Appendix B). Figure 3 also shows that 40 cities had adopted the instrument of “Partnering with Community Stakeholders.” The city of Livermore and the city of San Bruno were the two that did not adopt it (see Appendix B).

Figure 3: The Instrument of “Working with the Utilities” and “Partnering with Community Stakeholders”

“Incentives Provided by City” was Only Adopted by Five Cities

As can be seen in Figure 4, only five cities adopted the instrument of “Incentives Provided by City.” This instrument not only had the fewest number of cities adopt it, but also had a significant gap between other instruments. The possible explanations will be discussed in the Analysis section. Moreover, as mentioned before, a high percentage of the cities (83%) had chosen nine instruments, and this is the instrument that those cities did not adopt.

Figure 4: The Instrument of “Incentives Provided by City”

In Table 3, the details of these five cities are presented, which are the city of San Jose (1), Berkeley (7), Daly City (8), Mountain View (13), and Alameda (15). The number of these cities represents the rank of city population. It means that the city of San Jose (1) has the largest population among all, and the city of Berkeley (7) is the seventh largest one. Therefore, although being a large city does not guarantee that the incentives will be available. Table 3 implies that the cities which can provide incentives are unlikely to be small ones.

Table 3: Percentage of Cities that Adopted Different Number of Instruments

Index (Number represents the rank of city population)	Name of the Cities	Number of Instruments that Each City Adopted Based on the Guidebook(2013) (Max.:10)	Number of cities / Percentage of Total Cities
1	San Jose	10	5 / 11.9% <u>(About 11.9% of cities adopted total 10 instruments)</u>
7	Berkeley	10	
8	Daly City	10	
13	Mountain View	10	
15	Alameda	10	
2	Oakland	9	35 / 83.33% <u>(About 83.33% of cities adopted total 9 instruments)</u>
3	Fremont	9	
4	Hayward	9	
5	Sunnyvale	9	
6	Santa Clara	9	
9	San Mateo	9	
11	San Leandro	9	
12	Redwood City	9	
14	Pleasanton	9	
16	Milpitas	9	
17	Union City	9	
18	Palo Alto	9	
19	South San Francisco	9	
20	Dublin	9	
21	Cupertino	9	
22	Gilroy	9	
23	Newark	9	
24	Morgan Hill	9	
26	Campbell	9	
27	Pacifica	9	
28	Menlo Park	9	
29	Foster City	9	
30	Saratoga	9	
31	Los Altos	9	
32	Los Gatos	9	
33	East Palo Alto	9	
34	Burlingame	9	
35	San Carlos	9	
36	Belmont	9	
37	Millbrae	9	
38	Albany	9	
39	Half Moon Bay	9	
40	Emeryville	9	
41	Hillsborough	9	
42	Piedmont	9	
10	Livermore	8	1 / 2.38% <u>(About 2.38% of cities adopted total 8 instruments)</u>
25	San Bruno	7	1 / 2.38% <u>(About 2.38% of cities adopted total 7 instruments)</u>

Part 2: Cities and Other Six Instruments Generalized from Official Websites

As mentioned in part 1, the *Guidebook* (2013) had provided ten practical instruments for the cities to adopt; however, the *Guidebook* (2013) indeed also encouraged the cities to develop their own instruments that suit themselves.

Therefore, in this part, this study first will illustrate the definition of six instruments that generalized from the official websites, which can be seen as what the cities had developed by themselves. Moreover, these six instruments are also important findings of this study because it appears that no previous studies have identified these instruments. Secondly, this section will address two finding points regarding these six instruments.

Six Instruments Generalized from Official Websites

A. Combining Electric Vehicle Program with Other Projects

During collection of the data from the official websites, this study found that many cities chose to combine the electric vehicle program with other related projects to provide more complete information on clean energy.

For example, the Bay Area Sunshares was one of the projects that many cities chose to combine. This project focuses on making “go solar” more affordable and encouraging adding battery storage to homes by pooling homeowners' buying power (Bay Area Sunshares, 2020). Since the Bay Area Sunshares project shared the same idea of clean energy with the electric vehicle program, most cities decided to choose it. Figure 5 shows that the City of San Mateo provided information about a great discount that the Bay Area Sunshares offered while buying electric vehicles.

Figure 5: Example of Combining Electric Vehicle Program with Other Projects

SUNSHARES
Simple. Affordable. Together.

NOVEMBER 10

Three stylized human figures

Solar panel and electric car

Limited Offer + Group Buying = Discounted Solar & Electric Vehicles!

BUSINESS COUNCIL ON CLIMATE CHANGE

SunShares is back for a limited time!

Are you interested in going solar or buying an electric vehicle, but don't know where to start? Come to this free workshop and learn how solar works and how the financials of renewable energy benefit YOU!

SunShares is a limited-time renewable energy program that makes it easier and more affordable for Bay Area residents to go solar or purchase/lease an electric vehicle.

Solar, EV dealers and home energy experts will be on hand to discuss their products and answer any questions you may have about going solar, financing options or buying/leasing an electric vehicle. This workshop is co-hosted by the City of San Mateo, Burlingame, Redwood City and San Carlos.

This workshop features the Sunshares vendors and Home Upgrade, Peninsula Clean Energy, SunWork, Tesla and Ygrene. Get access to discounts on SunShare vendors and education on residential solar, electric vehicles, energy efficiency programs and financing options.

Please [register](https://tinyurl.com/Sunshares2017) for the event.
<https://tinyurl.com/Sunshares2017>

Date: Tuesday, October 17
Time: 6:00pm-8:00pm.
Location: San Mateo Library
Oak Room
55 W 3rd Ave, San Mateo, CA 94402

Simple. Affordable. Together.

Visit [Bay Area SunShares](#) for more program information.

[Share on Facebook](#) [Share on Twitter](#) [Share via Email](#)

Copyright © 2015 City of San Mateo. All Rights Reserved.
330 West 20th Avenue, San Mateo, CA 94403

Powered by **CIVICSEND**

(Source: City of San Mateo, 2017)

B. Holding Workshops for Promoting Electric Vehicles Adoption

Unlike providing electric vehicle information on the websites, a one-way communication, holding a workshop can help the citizen interact with companies to understand more about electric vehicles and their advantages. Also, holding a workshop offers the participants a chance to experience what electric vehicles really are, which a website cannot provide.

However, before the pandemic, this instrument was adopted by some cities based on the advantages mentioned above. During the pandemic, which forbid gathering, some cities still decided to hold a webinar workshop to interact with the citizens who were interested. For example, Figure 6 shows that the city of Sunnyvale held a workshop (webinar) called “Drive Electric.” This workshop aimed to help citizens learn more about the benefit of electric vehicles and assisted them in finding an electric vehicle that meet their needs.

Figure 6: Example of Holding Workshops for Promoting Electric Vehicles

(Source: City of Sunnyvale, 2021)

C. Bringing Electric Vehicle Program into City Plans

Every city develops a city plan to illustrate its prospect future to its residents. This study found that some cities embraced electric vehicle programs to become part of their city plan directly. However, some other cities chose to do detailed research on electric vehicles to enhance the adoption. Both ways may indicate that these cities were willing to pay more attention to carry out electric vehicle programs.

For example, Figure 7 shows that the City of Oakland brought the electric vehicle program into their city plan by creating an action plan to understand the existing condition of the electric vehicle infrastructure.

Figure 7: Example of Bringing Electric Vehicle Program into City Plans

(Source: City of Oakland, 2021)

D. Having Official and Public Support from the Leaders

Generally speaking, all cities' leaders support electric vehicle adoption and try their best to implement the programs. However, this study found that not every leader chose to support the electric vehicle programs "official and public." To illustrate, many leaders were willing to issue press releases to show their support for electric vehicle adoption, and to show their achievements in supporting it. However, for some cities, it was difficult to find the information provided by their websites regarding the leaders' positive intention of electric vehicle adoption.

E. Mapping Out and Setting up the Public Charging Stations

As mentioned in the previous section, all cities had adopted the instrument of permitting charging installation for different kinds of buildings (e.g., single-family residential, multi-unit dwellings, workplace, retail and public sector). However, except for single-family residential, not every building's owner is willing to install nor capable of installing the chargers for the residents/workers who need to charge their electric vehicles. Therefore, setting up the "public charging stations" for the people who do not have their chargers at home becomes one of the cities' essential responsibilities. This study found that most cities chose to set up public charging stations in the public parking garages to solve this problem.

Moreover, through the website of Alternative Fueling Station Locator, which was provided by the U.S. Department of Energy, this study could collect data on how many public charging stations each city had and how the cities mapped out these charging stations. This will be discussed in more depth in the "Cities and Public Charging Stations" section.

F. Creating a Specific Website Section Providing Electric Vehicles Information

While collecting the data, this study found out that not every city had created a specific website section that only provides electric vehicle information.

Most of the cities decided to embed the information in the Department of Transportation's website or the Department of Energy's website, or sometimes in both. Without consistency, the citizens could be easily confused about how to find the information they need. Moreover, some cities only offered electric vehicle information by issuing documents of permitting charging installation. These documents were often provided together with many other kinds of applications, which could make it quite difficult for the residents to get information about electric vehicles.

Therefore, "Creating a Specific Website Section Providing Electric Vehicles Information" can certainly be seen as a meaningful instrument, that helps the people who have interests in electric vehicles to find information.

For example, Figure 8 shows that the City of San Jose offers a website called "San

Figure 8: Example of Creating a Specific Website Section Providing Information

(Source: City of San Jose, 2020)

Jose Clean Energy,” which includes all the information about the clean energy policy.

Without a doubt, “Electric Vehicle” is one of the mains objects on this website. This specific section provides complete and various information, such as the tips on choosing an electric vehicle, the regulation of installing the charging station at home, and the rebates provided by the federal and the State.

Number of Instruments that the Cities Adopted Varied

Based on the definition of the six instruments generalized from the official websites mentioned above, this study had made a matrix presenting the instruments that each city had chosen (See Appendix C).

As shown in Figure 9, by understanding the data from the perspective of the city, the number of total instruments that the cities chose varied considerably. Moreover, the trendline in Figure 9 shows that there was no significant correlation between the city population and the number of instruments that the cities adopted.

Figure 9: Number of Instruments each City Adopted Generalized from Official Websites

Unlike the findings of adopting ten instruments based on the *Guidebook* (2013) which was about 95% of the cities adopting nine or ten instruments, Table 4 presents that only 42.8% of the cities adopted six instruments and 23.8% chose five instruments. The result shows that only 66.6% of the cities adopted six or five instruments, which is much lower than the 95% adoption for the *Guidebook* (2013) items.

Besides, Table 4 also lists that 11.9% of the cities adopted four instruments and two instruments, and about 9.5% of them adopted three instruments, which means that 33.3% of the cities chose two to four instruments.

Table 4: Percentage of Cities that Adopted Different Number of Instruments

Index (Number represents the rank of city population)	Name of the Cities	Number of Instrument Each City Adopted Generalized from Official Websites (Max.:6)	Number of cities / Percentage of Total Cities
2	Oakland	6	18 / 42.8% (About 42.8% of cities adopted total 6 instruments)
3	Fremont	6	
5	Sunnyvale	6	
6	Santa Clara	6	
7	Berkeley	6	
12	Redwood City	6	
15	Alameda	6	
18	Palo Alto	6	
21	Cupertino	6	
28	Menlo Park	6	
29	Foster City	6	
32	Los Gatos	6	
34	Burlingame	6	
35	San Carlos	6	
37	Millbrae	6	
38	Albany	6	
40	Emeryville	6	
42	Piedmont	6	
1	San Jose	5	10 / 23.8% (About 23.8% of cities adopted total 5 instruments)
4	Hayward	5	
9	San Mateo	5	
13	Mountain View	5	
16	Milpitas	5	
19	South San Francisco	5	
20	Dublin	5	
31	Los Altos	5	
36	Belmont	5	
39	Half Moon Bay	5	
11	San Leandro	4	5 / 11.9% (About 11.9% of cities adopted total 4 instruments)
14	Pleasanton	4	
26	Campbell	4	
27	Pacifica	4	
41	Hillsborough	4	
8	Daly City	3	4 / 9.5% (About 9.5% of cities adopted total 3 instruments)
24	Morgan Hill	3	
30	Saratoga	3	
33	East Palo Alto	3	
10	Livermore	2	5 / 11.9% (About 11.9% of cities adopted total 2 instruments)
17	Union City	2	
22	Gilroy	2	
23	Newark	2	
25	San Bruno	2	

Only 57% of the Cities Adopted the Instrument of “Holding Workshops”

In order to understand the data from the perspective of the instrument, this study presented these findings by dividing them into four groups. The first group, as shown in Figure 10, represents the instrument of “Holding Workshops,” which had the least cities adopt it. There was only about 57.1% of the cities that held workshops for electric vehicles. Moreover, compared to other instruments, only 2 cities adopted this instrument, which was significantly less than the others.

Figure 10: Group One: 57% of the Cities Adopted the Instrument of “Holding Workshops”

The second group is shown in Figure 11. It shows that approximately 75% of the cities chose the instruments of “Combining with other Projects” and “Creating a Specific Website Section for Electric Vehicle,” which had the third highest percentage of cities adopt it. Figure 11 shows that 76.1% of the cities adopted the instrument of “Combining with other Projects,” and 73.8% of them adopted the instrument of “Creating a Specific Website Section for Electric Vehicle.” Both instruments had more than 30 cities adopt them (see Appendix C).

Figure 11: Group Two: “Combining with other Projects” and “Creating a Specific Website Section for Electric Vehicles”

The third group, as shown in Figure 12, includes the cities that chose the instrument of “Bring Electric Vehicle Programs into City Plans” and “Official and Public Support from the Leaders,” which were adopted by approximately 85% of the cities. Figure 12 shows that 85.7% of the cities adopted the instrument of “Bring Electric Vehicle Programs into City Plan,” which was the second-highest percentage and only six cities did not adopt it (see Appendix C). Regarding the instrument of “Official and Public Support from the Leaders,” 83.3% of the cities decided to embrace it, while only seven cities did not (see Appendix C).

Figure 12: Group Three: “Bring Electric Vehicle Program into City Plans” and “Supporting from the Leaders”

Finally, Figure 13 shows that the only instrument adopted by 42 cities is “Mapping Out and Setting up the Public Charging Stations.” However, though Figure 13 shows that all the cities had intended to set up the public charging station for the residents, it cannot show how many public charging stations the cities had set up. This issue will be discussed in more depth in the “Cities and Public Charging Stations” section.

Figure 13: Group Four: “Setting Up Public Charging Stations” was Fully Adopted by 42 Cities

Part 3: Cities and Public Charging Stations

This part includes three findings points as follow:

A Significant Variation in the Number of Public Charging Stations Each City Set

Based on the Alternative Fuels Data Center (2019), Figure 14 shows the number of public charging stations each city had. As presented in Figure 14, the City of San Jose had 172 public charging stations, which was the highest number. However, the City of Albany, Hillsborough, and Piedmont each only had one public charging station, which showed a marked difference as compared to the City of San Jose.

Besides, the number of public charging stations that the City of San Jose had was extremely outstanding. As shown in Figure 14, the City of Palo Alto, which had the second-highest number, had 72 public charging stations. However, this number was not even half of what the city of San Jose had.

The Number of Public Charging Stations and the City Population Seems to Correlate

Figure 14 not only shows the number of public charging stations that each city had, but also, at the bottom of this figure, the order of the city names is based on the rank of the city population. It means that the City of San Jose (1,043,058) had the largest population among all, and the City of Piedmont (11,420) had the least (see Appendix B).

Therefore, as shown in Figure 14, a significant decreasing trendline may indicate that the number of public charging stations and the city population correlates. It means that the cities with a larger population may have more public charging stations. The possible explanation of this finding will be discussed in the Analyze section.

Figure 14: Number of Public Charging Stations in Each City

Most Cities had 10 to 50 Public Charging Stations

This study sorted out the data into three categories. First were the cities that had over 50 public charging stations. Second were the cities that had 10 to 50 public charging stations, and the last category was the cities with under ten public charging stations.

As shown in Table 5, only eight cities were in the first group with more than 50 public charging stations, constituting 19.2% of the cities. The average number of public charging stations of this group was 76. However, as mentioned before, the City of San Jose had an extremely outstanding number of public charging stations (172). Therefore, to understand the data without bias, this study provided another average number that excluded the City of San Jose, which was 63. It means that each of these seven cities had approximately 63 public charging stations.

In the second group, Table 5 shows that 20 cities were setting up 10 to 50 public charging stations, constituting 47.62% of the cities. The average number of public charging stations in this group was 20, much lower than the first group.

The last group, the cities with less than ten public charging stations, included 14 cities. As shown in Table 5, this group constituted 33.33% of the cities, and the average number of public charging stations of this group was 4, so much lower than the first (average :63) and the second (average :20) group.

Table 5: Percentage of the Cities that Have Different Number of Public Charging Stations

Index (Number represents the rank of city population)	Name of the Cities	Number of Public Charging Stations	Number of cities / Percentage of Total Cities
1	San Jose	172	8 / 19.05% <u>(About 19.05% of Cities Have Over 50 Public Charging Stations)</u>
18	Palo Alto	72	
6	Santa Clara	71	
2	Oakland	64	
12	Redwood City	64	
3	Fremont	61	
28	Menlo Park	57	
5	Sunnyvale	52	
4	Hayward	49	20 / 47.62% <u>(About 47.62% of Cities Have 10 to 50 Public Charging Stations)</u>
20	Dublin	48	
14	Pleasanton	45	
13	Mountain View	44	
23	Newark	40	
9	San Mateo	37	
19	South San Francisco	28	
16	Milpitas	25	
21	Cupertino	23	
7	Berkeley	21	
32	Los Gatos	19	
26	Campbell	18	
10	Livermore	17	
11	San Leandro	16	
31	Los Altos	16	
40	Emeryville	16	
15	Alameda	13	
8	Daly City	10	
24	Morgan Hill	10	
25	San Bruno	10	
37	Millbrae	9	14 / 33.33% <u>(About 33.33% of Cities Have Under 10 Public Charging Stations)</u>
17	Union City	8	
35	San Carlos	8	
39	Half Moon Bay	8	
22	Gilroy	7	
34	Burlingame	7	
27	Pacific	4	
29	Foster City	4	
36	Belmont	4	
30	Saratoga	3	
33	East Palo Alto	2	
38	Albany	1	
41	Hillsborough	1	
42	Piedmont	1	

Only Three Cities Have More than Ten Public Charging Stations per 10,000 People

In order to take into consideration of the size of the population with the number of public charging stations, this study generated the data of the numbers of public charging stations per 10,000 people in each city. As shown in Table 6, this study also sorted out the data into three categories. First were the cities that had more than ten public charging stations per 10,000 people. Second were the cities with four to eight public charging stations per 10,000 people, and the last category was the cities with zero to three public charging stations per 10,000 people.

As shown in Table 6, the first group only included three cities that had more than ten public charging stations per 10,000 people, which were the City of Menlo Park (15.93), the City of Emeryville (13.46), and the City of Palo Alto (10.38). Moreover, the average number of public charging stations per 10,000 people in this group was 13.25. It means that in each of these three cities, 10,000 of their residents could share about 13 public charging stations.

In the second group, Table 6 shows that 11 cities had four to eight public charging stations per 10,000 people, constituting 26.1% of the cities. The average number of public charging stations per 10,000 people in this group was 5.96, much lower than the first group.

The last group, the cities with zero to three public charging stations per 10,000 people, included 28 cities. As shown in Table 6, this group constituted 66.66% of the cities, and the average number of public charging stations per 10,000 people of this group was 1.92. It means that, more than half of the cities, 10,000 of their residents could share only one public charging station.

Table 6: Number of Public Charging Stations per 10,000 People by City

Index (Number represents the rank of city population)	Name of the Cities	City Population	Number of Public Charging Stations	Public Charging Stations per 10,000 People	Number of cities / Percentage of Total Cities
28	Menlo Park	35,790	57	15.93	3 / 7.1% (About 7.1% of Cities Have Over 10 Public Charging Stations per 10,000 people)
40	Emeryville	11,885	16	13.46	
18	Palo Alto	69,397	72	10.38	
23	Newark	48,712	40	8.21	11 / 26.1% (About 26.1% of Cities Have 4 to 8 Public Charging Stations per 10,000 people)
12	Redwood City	85,319	64	7.50	
20	Dublin	64,577	48	7.43	
39	Half Moon Bay	12,631	8	6.33	
32	Los Gatos	30,988	19	6.13	
14	Pleasanton	80,492	45	5.59	
6	Santa Clara	128,717	71	5.52	
13	Mountain View	81,992	44	5.37	
31	Los Altos	31,190	16	5.13	
19	South San Francisco	67,078	28	4.17	
26	Campbell	43,250	18	4.16	
37	Millbrae	23,154	9	3.89	28 / 66.66% (About 66.66% of Cities Have 0 to 3 Public Charging Stations per 10,000 people)
21	Cupertino	59,879	23	3.84	
9	San Mateo	104,570	37	3.54	
5	Sunnyvale	155,567	52	3.34	
16	Milpitas	76,231	25	3.28	
4	Hayward	159,433	49	3.07	
35	San Carlos	29,864	8	2.68	
3	Fremont	232,532	61	2.62	
34	Burlingame	30,317	7	2.31	
25	San Bruno	45,257	10	2.21	
24	Morgan Hill	45,742	10	2.19	
10	Livermore	91,039	17	1.87	
11	San Leandro	89,825	16	1.78	
7	Berkeley	123,328	21	1.70	
1	San Jose	1,043,058	172	1.65	
15	Alameda	79,316	13	1.64	
2	Oakland	432,897	64	1.48	
36	Belmont	27,174	4	1.47	
22	Gilroy	55,928	7	1.25	
29	Foster City	33,693	4	1.19	
17	Union City	74,916	8	1.07	
27	Pacifica	38,674	4	1.03	
30	Saratoga	31,407	3	0.96	
8	Daly City	109,122	10	0.92	
42	Piedmont	11,420	1	0.88	
41	Hillsborough	11,769	1	0.85	
33	East Palo Alto	30,499	2	0.66	
38	Albany	19,393	1	0.52	

Part 4: Providing Electric Vehicles Information: Outreach and Education

This part will first illustrate three items that can represent how a city provided electric vehicle information. These items were also generalized from the official websites. Next, two findings points will be shown in this part.

Three Items to Understand How the Cities Convey Electric Vehicle Information

A. Creating a Specific Website Section Providing Electric Vehicle Information

This item was the same as the one from the six instruments generalized from the official websites. As mentioned before, not every city had created a specific website section that only provided electric vehicle information. However, the previous definition implies that creating a specific website section is quite crucial for citizens who need electric vehicle information. Therefore, this study chose this item (or instrument) to understand how the cities conveyed the electric vehicle information.

B. Providing the Link of Alternative Fueling Stations Locator

The Alternative Fueling Station Locator is maintained by the Alternative Fuels Data Center, which belongs to the U.S. Department of Energy. The main purpose of this locator is to provide a nation-wide charging stations map for electric vehicle drivers.

On this website, the drivers can easily find the charging stations nearby, and it also helps the residents learn how many charging stations are in their city of residence and where they are. Moreover, this website's most important feature is to assist electric vehicle drivers in drawing up a nation-wide travel route by offering every charging stations' location in the cities and the states. Therefore, if a city can share this link on the official website, it will definitely help the electric vehicle drivers.

C. Informing the federal and the state Incentives of Electric Vehicle Purchase

As mentioned previously in the Background, since enhancing electric vehicle adoption is

a nation-wide policy, the federal and the state governments both provide various and practical incentives to encourage people to purchase electric vehicles. These incentives mainly include “the tax deduction and the rebates for purchasing electric vehicles,” “the discount on the electric fee,” “free installation of home charging,” and so on (Murray, 2011; Lévy et al., 2017; Jenn et al., 2018; Bergek & Berggren, 2014; Brown et al., 1995).

As mentioned in the Literature section, these practical incentives are one of the essential instruments to enhance electric vehicle adoption. Therefore, if the cities could offer information about these incentives to their citizens through official websites, it is believed that there will be a positive effect on electric vehicle adoption.

About Half of the Cities Choose Three Items to Convey Electric Vehicle Information

Table 7 shows that 45.2% of the cities, nearly half of them, adopted all three items to convey electric vehicle information. It means that 19 cities had created a specific website section for the electric vehicle information, providing the link to the Alternative Fueling Stations Locator, and informing the website visitors about federal and the state incentives regarding electric vehicle purchase.

Besides, there were 11.9% of the cities choosing to use two items, as shown in Table 7. As a total, there were 57.1% of the cities, equaling to 24 cities, conveying electric vehicle information by using at least two items (see Appendix D). However, Table 7 also shows that 11.6% of the cities chose only one item, and 26.1% of the cities, more than one-quarter, did not use any of these items to convey information through the official websites (see Appendix D). The possible explanation will be discussed in the Analysis section.

Table 7: Percentage of the Cities that Chose Different Number of Outreach Items

Index (Number represents the rank of city population)	Name of the Cities	Number of Outreach Items Each City Chose to Convey Electric Vehicle Information (Max.:3)	Number of cities / Percentage of Total Cities
1	San Jose	3	<p>19 / 45.2% <u>(About 45.2% of cities adopted total 3 Items)</u></p>
2	Oakland	3	
3	Fremont	3	
4	Hayward	3	
6	Santa Clara	3	
7	Berkeley	3	
15	Alameda	3	
18	Palo Alto	3	
19	South San Francisco	3	
20	Dublin	3	
21	Cupertino	3	
28	Menlo Park	3	
29	Foster City	3	
31	Los Altos	3	
34	Burlingame	3	
37	Millbrae	3	
39	Half Moon Bay	3	
40	Emeryville	3	
42	Piedmont	3	
5	Sunnyvale	2	<p>5 / 11.9% <u>(About 11.9% of cities adopted total 2 Items)</u></p>
11	San Leandro	2	
12	Redwood City	2	
13	Mountain View	2	
24	Morgan Hill	2	
26	Campbell	1	<p>7 / 11.6% <u>(About 11.6% of cities adopted total 2 Items)</u></p>
27	Pacifica	1	
32	Los Gatos	1	
35	San Carlos	1	
36	Belmont	1	
38	Albany	1	
41	Hillsborough	1	
8	Daly City	0	<p>11 / 26.1% <u>(About 26.1% of cities adopted 0 Items)</u></p>
9	San Mateo	0	
10	Livermore	0	
14	Pleasanton	0	
16	Milpitas	0	
17	Union City	0	
22	Gilroy	0	
23	Newark	0	
25	San Bruno	0	
30	Saratoga	0	
33	East Palo Alto	0	

Moreover, Figure 15 shows that the number of items the city adopted may positively correlate with the city population. The trendline shown in Figure 15 indicated that the city with a larger population may adopt more methods of conveying electric vehicle information.

Figure 15: Number of Outreach Items each City Adopted

Most Cities Adopted “Providing the Link of Alternative Fueling Stations Locator”

As shown in Figure 16, 66.6% of the cities adopted the item of “Providing the Link of Alternative Fueling Stations Locator,” which had the highest percentage among all. The second one was the item of “Informing the federal and the state Incentives of Electric Vehicle Purchase,” which was 59.5%. The last one, the item of “Creating a Specific Website Section Providing Electric Vehicle Information,” was 50%, exactly half the cities choosing it.

Moreover, this study found that the average percentage of these three items adopted by the cities was 58.6%, which also means that each item had about 25 cities willing to choose. However, as mentioned previously, for the ten instruments based on the *Guidebook* (2013), the average percentage of instruments adopted by the cities was 90.47%, which means that each instrument had about 38 cities adopting it. For the six instruments generalized from the official websites, their average percentage of instruments adopted by the cities was 79.33%, which means that each instrument had approximately 33 cities that choose to adopt it. Therefore, comparing to the two average percentages of the instruments adopted by the cities that were based on the *Guidebook* (2013) and generalized from the official websites, the average percentage of these three items adopted by the cities seems relatively low.

Figure 16: “Providing the Link of Alternative Fueling Stations Locator” is the one that Most Cities Chose to Adopt

ANALYSIS

This section has been divided into two parts, “Summarizing the Findings & Answering Research Questions” and “Discussion and Recommendations.” The former part will review the research structure and respond to the four research questions. For the latter part, this study will address five points that are the feedback or the discussion of the findings.

Summarizing the Findings & Answering the Research Questions

This part includes “The Research Structure and the Summary of Findings” and “Answering Four Research Questions.”

The Research Structure and the Summary of Findings

Figure 17 shows the structure of this study, which contained four parts that corresponded to the previous Finding section and the four research questions, as well.

The first part, on the upper left of Figure 17, showed the number of the cities that adopted the instruments based on the *Guidebook* (2013). There were seven instruments being adopted by all 42 cities, and the instrument of “Incentives Provided by the Cities” was the one that only had five cities chose to adopt it. As a result, the findings show that no single city ignored the *Guidebook* (2013), and most of them adopted nine instruments.

The second part, on the upper right of Figure 17, presented the number of the cities that adopted six instruments generalized from official websites. As mentioned before, these six instruments were also the important findings of this research, which were “Combining Electric Vehicle Program with Other Projects,” “Holding Workshops for Promoting Electric Vehicles Adoption,” “Bringing Electric Vehicle Program into City Plans,” “Having an Official and Public Support from the Leaders,” “Mapping Out and

Set up the Public Charging Stations,” and “Creating a Specific Website Section Providing Electric Vehicles Information.” The figure also shows that the number of cities that adopted six instruments were varied. Only the instrument of “Setting Up Public Charging Stations” was fully adopted by 42 cities, and the instrument of “Hold Workshops” was the one that least cities choose.

The third part, the number of public charging stations, which was the extension from the six instruments, was on Figure 17's lower right. The figure shows the significant variation of public charging station numbers in each city, and most cities had 10 to 50 public charging stations. Moreover, it also presents that there may be a correlation between the number of public charging stations and the city's population.

The last part was about the outreach and education of electric vehicles. It was the extension from the *Guidebook* (2013), presented on the lower left of Figure 17. As mentioned previously, this study had generalized three items to understand how the cities conveyed electric vehicles information, which were “Creating a Specific Website Section Only Providing Electric Vehicles Information,” “Providing the Link of Alternative Fueling Stations Locator,” and “Informing the federal and the state Incentives of Electric Vehicle Purchase.” As a result, the figure shows that the item of “Providing the Link of Alternative Fueling Stations Locator” was the one that most cities adopted, and about half of the cities chose all three items to convey electric vehicle information.

Figure 17: The Research Structure and the Summary of Findings

Figure 18 presents the total number of instruments that each city had adopted. As a result, two cities, the City of Livermore and the City of San Bruno, adopted the minor instruments may show consistency. As shown in Figure18, the City of San Bruno adopted seven instruments based on the *Guidebook* (2013), which was the one that adopted the least instruments among all, and the City of Livermore chose eight instruments, which was the second least.

Moreover, regarding the six instruments generalized from the official websites, both these cities only adopted two instruments, and no other city had a lower number than theirs. Therefore, this finding may imply that no matter how many instruments are recommended by the state or other cities, if a city decides not to support electric vehicle adoption, it would not adopt these instruments actively.

Figure 18: Number of Total Sixteen Instruments each Cities Chose to Adopt

In addition, Table 8 lists the total number of instruments that each city adopted. As a result, with the maximum number of total instruments being 16, most cities had chosen 15 instruments.

As shown in Table 8, there were 18 cities adopting a total of 15 instruments, constituting 42.8% of the cities. Only two cities adopted all 16 instruments: the City of Berkeley and the City of Alameda. Moreover, 19% of the cities (8 cities) adopted 14 instruments, and 14.2% of the cities (6 cities) adopted 13 instruments. Three cities adopted 12 each and 11 each instrument. However, there were only two cities adopting ten instruments or less, one was the City of Livermore (10 instruments) and the other was the City of San Bruno (9 instruments)

Table 8: Percentage of Cities that Adopted Different Number of Total Instruments

Index (Number represents the rank of city population)	Name of the Cities	Number of Instruments Each City Adopted Based on the Guidebook(2013) (Max.:10)	Number of Instruments Each City Adopted Generalized from Official Websites (Max.:6)	Total Number of Instruments Each City Adopted (Max.: 16)	Number of cities / Percentage of Total Cities
7	Berkeley	10	6	16	2 / 4.7% (About 4.7% of cities adopted total 16 Instruments)
15	Alameda	10	6	16	
1	San Jose	10	5	15	18 / 42.8% (About 42.8% of cities adopted total 15 instruments)
2	Oakland	9	6	15	
3	Fremont	9	6	15	
5	Sunnyvale	9	6	15	
6	Santa Clara	9	6	15	
12	Redwood City	9	6	15	
13	Mountain View	10	5	15	
18	Palo Alto	9	6	15	
21	Cupertino	9	6	15	
28	Menlo Park	9	6	15	
29	Foster City	9	6	15	
32	Los Gatos	9	6	15	
34	Burlingame	9	6	15	
35	San Carlos	9	6	15	
37	Millbrae	9	6	15	
38	Albany	9	6	15	
40	Emeryville	9	6	15	
42	Piedmont	9	6	15	
4	Hayward	9	5	14	8 / 19% (About 19% of cities adopted total 14 instruments)
9	San Mateo	9	5	14	
16	Milpitas	9	5	14	
19	South San Francisco	9	5	14	
20	Dublin	9	5	14	
31	Los Altos	9	5	14	
36	Belmont	9	5	14	
39	Half Moon Bay	9	5	14	
8	Daly City	10	3	13	6 / 14.2% (About 14.2% of cities adopting total 13 instruments)
11	San Leandro	9	4	13	
14	Pleasanton	9	4	13	
26	Campbell	9	4	13	
27	Pacifica	9	4	13	
41	Hillsborough	9	4	13	
24	Morgan Hill	9	3	12	3 / 7.1% (About 7.1% of cities adopting total 12 instruments)
30	Saratoga	9	3	12	
33	East Palo Alto	9	3	12	
17	Union City	9	2	11	3 / 7.1% (About 7.1% of cities adopting total 11 instruments)
22	Gilroy	9	2	11	
23	Newark	9	2	11	
10	Livermore	8	2	10	1 / 2.3% (About 2.3% of cities adopting total 10 instruments)
25	San Bruno	7	2	9	1 / 2.3% (About 2.3% of cities adopting total 9 instruments)

Answering Research Questions

Based on the Findings section, the responses to the research questions as follow:

Research Question 1: Based on the Guidebook (2013), what kinds of instruments do Bay Area cities choose? What are the differences between the cities regarding the chosen instruments?

Regarding the first part of the question, the findings show that all 42 selected Bay Area cities had chosen the instruments of “Changing the Building Codes,” “Outreach and Education,” “Signs and Pavement Markings,” “Permitting Single-Family Residential Charging,” “Permitting Multi-Unit Dwellings Charging,” “Permitting Workplace Charging” and “Permitting Retail and Public Sector Charging.” Moreover, 41 cities adopted the instrument of “Working with the Utilities,” and 40 cities chose the instrument of “Partnering with Community Stakeholders.” However, only five cities adopted the instrument of “Incentives Provided by the City.”

For the second part, due to a markedly high percentage (83.33%) of the cities adopting nine instruments, there was no significant difference between the cities. Moreover, the findings also show that 11.9% of the cities adopted all ten instruments, which made the difference between the cities even smaller. However, the only difference was regarding the City of Livermore and the City of San Bruno. The former only adopted eight instruments, and the latter chose seven, which were the least and the second least number of instruments adopted.

Research Questions 2: Aside from the Guidebook (2013), do Bay Area cities have other kinds of instruments? If any, what are they? Do the cities vary from each other?

Yes, Bay Area cities had developed other kinds of instruments different from the *Guidebook* (2013). While collecting the data, this study had generalized six instruments

from cities' official websites, which were "Combining Electric Vehicle Program with Other Projects," "Holding Workshops for Promoting Electric Vehicles Adoption," "Bringing Electric Vehicle Program into City Plans," "Having an Official and Public Support from the Leaders," "Mapping Out and Set up the Public Charging Stations," and "Creating a Specific Website Section Providing Electric Vehicles Information."

Moreover, according to the findings, the numbers of cities adopting these six instruments were varied. The results showed that 42.8% of the cities adopted all six instruments, 23.8% of the cities chose five instruments, 11.9% of the cities adopted four instruments and two instruments, and about 9.5% of the cities used three instruments.

Research Questions 3: About "Setting up Public Charging Station," how many of them have been set up in each city? How does the number of public charging stations in each city vary?

For the first part of the question, according to the Alternative Fuels Data Center (2019), the number of public charging stations in each city had been shown in Table 5 clearly. Moreover, the findings showed a significant variation of public charging station numbers between the cities. As a result, only eight cities had more than 50 public charging stations, and most cities (20 cities) had 10 to 50 public charging stations. However, there were 14 cities with less than ten public charging stations, and these 14 cities' average number of public charging stations was only 4. Moreover, the findings also imply that there may be a correlation between the number of public charging stations and the city population, as shown in Figure 15.

Research Questions 4: Regarding the instrument of “Outreach and Education,” what have Bay Area cities done to enhance this instrument? What are the differences between the cities?

While collecting the data, this study found that, in order to enhance the instrument of “Outreach and Education,” the cities had developed three items to convey electric vehicle information. These three items were “Creating a Specific Website Section Only Providing Electric Vehicles Information,” “Providing the Link of Alternative Fueling Stations Locator,” and “Informing the federal and the state Incentives of Electric Vehicle Purchase.” The findings showed that 45.2% of the cities (19 cities), nearly half of them, adopted all three items to convey electric vehicle information, and 11.9% of the cities chose to use two items. However, seven cities chose only one item, and 11 cities did not use any of these items to convey information through the official websites.

Discussion and Recommendations

Based on the findings, this study addressed five points as the discussions and recommendations. In each point, this study would illustrate the possible explanations of the results, including the difference from unexpected findings. Moreover, this study would also connect each point with the literature. Finally, each point may include the practical implication and feedback of the results.

Does the Guidebook (2013) Work?

According to this study's result, the answer to this question could be “Yes, the *Guidebook* (2013) worked.” Especially with the instruments of “Changing the Building Codes” and “permitting charging installation for different kinds of buildings” being adopted by all cities, the *Guidebook* (2013) indeed successfully helped the state to gain a firm foothold in achieving the large-scale electric vehicle adoption by revising the regulations and

ordinances.

Moreover, the findings showed that, except for “Incentives Provided by City,” all nine instruments were generally adopted by the cities. For the possible explanations for this result, this study evaluated that it was the *Guidebook* (2013) that had played a key role. The *Guidebook* (2013) not only addressed the importance of electric vehicle adoption but also provided lots of practical directions and offered plenty of related document examples to help the city officials to carry out the instruments.

Regarding the instrument of “Incentives Provided by City,” which was only adopted by five cities, it did reach the same conclusion with Langbroek, et al. (2016) that a city indeed had difficulty providing a number of financial incentives for electric vehicles. Therefore, what they could propose were free parking and access to bus lanes, which were also the efficient incentives that they could afford. Similarly, Clark-Sutton, et al. (2016) also suggested some “soft incentives” that cities were capable of implementing, including setting charging stations, electric vehicle supply equipment permitting, and parking privileges.

Finally, based on the findings, the instrument of “Working with Utilities” and “Partnering with Community Stakeholders” were not fully adopted by all cities. Therefore, this study suggested that the state could pay more attention to understanding why these cities could not execute these instruments. With the feedback, the state could modify the *Guidebook* (2013) and help more cities carry out the instruments. Besides, this study suggested that the cities’ leaders should continue developing the “creative” incentives, stopping relying on federal and state financial incentives.

Encouraging the Cities Leaders to Show the Determination

Regarding the six instruments generalized from the official websites, the results showed that from the highest adopted percentage of the cities to the lowest were “Setting up the Public Charging Stations (100%),” “Bring Electric Vehicle Program into City Plan (85.7%),” “Having Official and Public Support from the Leaders (83.3%),” “Combining Electric Vehicle Program with other Projects (76.1%),” “Creating a Specific Website Section Providing Electric Vehicle Information (73.8%),” and the last one, “Holding Workshops (57.1%).”

At this point, this study was going to discuss the instruments that had over 80% of the cities adopted, which were “Bring Electric Vehicle Program into City Plans (85.7%)” and “Having Official and Public Support from the Leaders (83.3%).” The rest of the instruments would be discussed in the following paragraphs.

The instrument of “Bring Electric Vehicle Program into City Plans (85.7%)” was adopted by the second highest percentage of the cities. This result corresponded to Heidrich, et al. (2017). They investigated the effectiveness of the city strategies and found that there was no statistical difference in the number of the cities that had electric vehicles as part of the strategic plan and those that did not (Heidrich et al., 2017). The main reason why Heidrich, et al. (2017) decided to research this topic was that they found that many cities had adopted this instrument, and they intended to understand if this instrument was effective or not. In a similar vein, this study's findings indeed showed the same result that, this was the instrument that most cities would choose.

Although Heidrich, et al. (2017) found that there was no statistical difference in the number of the cities that brought electric vehicles into their city plan and those that did not, many studies still revealed the importance of making the electric vehicle information

visible to the public to raise consumers awareness (Clark-Sutton et al., 2016; Egnér & Trosvik, 2018; Jenn et al., 2018). Moreover, comparing to other instruments, implementing the instrument of “Bring Electric Vehicle Program into City Plans (85.7%)” and “Having Official and Public Support from the Leaders (83.3%)” may be more effective due to the fewer challenges and the lower cost.

Therefore, this study suggested that the state should strongly encourage or require all cities to adopt these two instruments to show the government’s determination to encourage electric vehicle adoption and also to make more people recognize the value of electric vehicles.

Finding Synergy Needs Resource: “Combining Programs” and “Holding Workshop”

Based on the findings, the instrument of “Holding Workshop for Electric Vehicles (57.1%)” had the lower percentage of cities adopted, much lower than “Combining Electric Vehicle Program with Other Projects (76.1%)” and “Creating a Specific Website Section Providing Electric Vehicle Information (73.8%).”

According to the studies (Majumdar, 2005; Lieven, 2015; Borgstedt et al., 2017), holding a workshop was the one action that could let the citizens directly interact with the electric vehicle companies and the officials to learn more about their needs, even during the pandemic. Moreover, a meaningful workshop that put the electric vehicle companies, the dealers, the utility officials, and the citizens all together to understand each other’s needs could show the synergy of government communication (Bergek & Berggren, 2014; Langbroek et al., 2016).

However, in order to hold a successful workshop, the cities needed to do a lot of preparations, including inviting different related groups, scheduling the time, renting a place, advertising, and so on. Therefore, the possible explanation of the result was that

holding a workshop indeed needed more resources and was more complicated to implement than other instruments.

Speaking of the need for resources and creating synergy, the instrument of “Combining Electric Vehicle Program with Other Projects (76.1%)” may be the one that could show the power of synergy. As mentioned previously, Clark-Sutton, et al. (2016) found that one of the essential variables enhancing electric vehicle adoption was if any special fleet programs were existing, such as car-sharing programs. Moreover, several studies also indicated that if the electric vehicle program could combine with other related projects, the synergy could be created due to the following two reasons (Bakker & Jacob, 2013; Bergek & Berggren, 2014; Graham et al., 2014; Greene et al., 2014). One was that combining these related programs together could prevent scattering the resources; the other reason was that by combining the programs, the cities could provide integrated and complete information to the residents and show the consistency of the state's clean energy policies.

Therefore, this study suggested that the state could pay greater heed to understanding why many cities could not adopt these two instruments – “Holding Workshop for Electric Vehicles” and “Combining Electric Vehicle Program with Other Projects.” After that, the state should help those cities overcome the difficulties and create the synergy of implementing these instruments.

It May be Normal to Show Difference on Setting Public Charging Stations

Based on the findings, the number of public charging stations in each city correlated with the city population. A significant decreasing trendline in Figure 14 indicated that the cities with a larger population had more public charging stations. This finding was consistent with those of Egnér & Trosvik (2018), whose study also found that the number

of public charging points in urban municipalities was higher than in suburban. According to several studies (Xie et al., 2018; Huang et al., 2012; Clark-Sutton et al., 2016; Egnér & Trosvik, 2018; Rietmann & Lieven, 2019), there were several possible explanations for this finding.

First, a large city usually had a number of high-density buildings to accommodate the population, and these high-density buildings may not have enough charging stations for the residents. Therefore, it was natural to find the public charging stations in high demand, which forced the cities to set up more of them. Next, a large city would often attract more tourists who also needed public charging stations to complete their journey. Finally, as single-family homes were often the primary type of housing in the cities with less population, the residents may have more chance to install their charging station home.

There was a significant variance in the number of public charging stations that each city had. 19.2% of the cities had more than 50 public charging stations, and 47.62% of them had 10 to 50 public charging stations; however, about 33.33% of the cities, one-third of them, had less than ten public charging stations.

Numerous studies (Xie et al., 2018; Huang et al., 2012; Clark-Sutton et al., 2016; Egnér & Trosvik, 2018; Rietmann & Lieven, 2019) had indicated that the setting of “charging infrastructure” was an essential factor for enhancing electric vehicle adoption. However, this study found that not every city needed plenty of public charging stations. It would be unnecessary to have hundreds of public charging stations in a small city.

Therefore, this study suggested that the cities should first complete the self-evaluation to determine how many public charging stations they truly needed. After that, the state should assist the cities that were having difficulties reaching their goal.

The Importance of Creating an Electric Vehicle Website Section

As mentioned previously in the Literature section, many researchers had pointed out that a city needed to provide information about the advantage of electric vehicles to successfully capture the attention and acceptance of the broader public (Berkeley et al., 2017; Larson et al., 2014; Lévy et al., 2017; Liao et al., 2019; Krause et al., 2013). Therefore, while collecting the data, this study also tried to understand how a city offered electric vehicle information.

The findings showed that “Providing the Link of Alternative Fueling Stations Locator” had the most cities (66.6%) adopt it. The second was “Informing the federal and the state Incentives of Electric Vehicle Purchase,” which was 59.5%. The last one, the item of “Creating a Specific Website Section Only Providing Electric Vehicle Information,” was 50%. According to several studies (Berkeley et al., 2017; Larson et al., 2014; Lévy et al., 2017), the possible explanation for why most cities adopted the item of “Providing the Link of Alternative Fueling Stations Locator” was that it may be the easiest one to implement. The website of Alternative Fueling Stations Locator was maintained and developed by the US DOE, compared to the other two items that needed more work. All that a city needed to do to implement this item was to share the link.

However, the findings also showed that 26.1% of the cities, more than one-quarter, did not use any of these items to convey information through their official websites, even just sharing a federal link. Moreover, as mentioned previously, some cities only issued permitting charging installation documents, and a lot of them embedded the electric vehicle information in different departments’ websites, which made it quite difficult for the residents to get information. As a result, it was not surprising that this study found that the average percentage of three items adopted by the cities was 58.6%, much lower

than the ten instruments based on the *Guidebook* (2013) (90.47%) and the six instruments generalized from the official websites (80%).

Therefore, based on the above findings, this study indicated that the cities may not have provided electric vehicle information effectively, which corresponded to Krause, et al. (2013) research. Their research showed that the vast majority were not aware of basic information about an electric vehicle, including the incentives provided by the governments (Krause et al., 2013).

In order to solve the problem, this study's analysis suggested that each city could create a space on the website, even just one page, that only provided electric vehicle information. It is clear that developing a "complete website" only for electric vehicles needed a lot of resources to maintain. Moreover, as people gained their information often from the internet, this platform could indeed help the citizens find what they need easily, which may increase the effectiveness of conveying electric vehicle information.

Limitation and Future Study

Some limitations of this study should be noted as follows.

First, this study collected the data only from the selected cities' official websites. Therefore, it was possible that the cities may have adopted the instruments, but they did not show what they had done on their websites.

Second, except for the number of public charging stations each city had was based on the Alternative Fueling Stations Locator (2019), the findings of instruments each city adopted (see Appendix B, C, and D) were coded as Yes/No answers. It means that, for some instruments, this study only found whether a city had adopted these instruments or not, instead of showing "How much a city had done?" For example, the finding (see Appendix C) showed that the City of Oakland had adopted the instrument of "Holding Workshops;" however, this study did not collect the data of "How many workshops has the City of Oakland held since 2013?"

Regarding the future study, as mentioned above about the limitation, this study's analysis suggested that a more in-depth study is required to fully understand how a city implements these instruments, and what the outcomes are, in order to develop more effective instruments for the cities.

Moreover, a further investigation that is only focusing on a single city is also recommended. Since every city has its unique characteristic, studying single cities can practically help them overcome their difficulties. Besides, with enough understanding of each city, the collected data can also help the state revise the guidebook in the future.

CONCLUSION

This study had focused on the instruments that Bay Area cities had chosen to enhance electric vehicle adoption, including the ten instruments provided by the *Guidebook* (2013) and six instruments developed by the cities; moreover, as the number of public charging stations and strengthening the outreach were also playing a crucial role in enhancing electric vehicle adoption, this study had examined the relationship between these issues and the cities.

The findings showed that, with a markedly high percentage of the cities that adopted the ten instruments recommended by the *Guidebook* (2013), the state indeed helped the cities deploy readiness for electric vehicles. Moreover, the six instruments that the cities developed may be the driving factors to enhance electric vehicle adoption, especially the instrument of “Combining Electric Vehicle Program with Other Projects,” which showed the most synergy, compared to other instruments.

Next, regarding the number of public charging stations, this study found that it indeed correlated with the city population. Moreover, this study suggested that not every city needs a large number of public charging stations; and that what the state should do is to assist those genuinely in need to increase the charging stations.

Finally, based on the findings of conveying electric vehicle information (outreach), this study’s analysis suggests that the most effective way is to adopt the instrument of “Creating a Specific Website Section Providing Electric Vehicles Information,” which can help the residents find the information they need easily.

To sum up, this was designed to yield findings that could contribute to a more thorough understanding of how Bay Area cities chose the instruments to enhance electric vehicle adoption.

REFERENCE

- Alternative Fuels Data Center. (2019). Alternative Fueling Station Locator. Retrieved from <https://afdc.energy.gov/stations/#/find/nearest>
- Armstrong, J. H. (2019). Modeling effective local government climate policies that exceed state targets. *Energy Policy*, 132, 15-26. doi-
org.libaccess.sjlibrary.org/10.1016/j.enpol.2019.05.018
- Association of Bay Area Government. (2016). Ready Set Charge California - A Guide to EV-Ready Communities. Retrieved from <https://www.prospectsv.org/wp-content/uploads/2016/12/Ready-Set-Charge-California-EV-Communities-Guide.pdf>
- Azevedo, I., Horta, I., & Leal, V. (2017). Analysis of the relationship between local climate change mitigation actions and greenhouse gas emissions – empirical insights. *Energy Policy*, 111, 204-213. doi-
org.libaccess.sjlibrary.org/10.1016/j.enpol.2017.09.032
- Baker, I., Peterson, A., Brown, G., & McAlpine, C. (2012). Local government response to the impacts of climate change: An evaluation of local climate adaptation plans. *Landscape and Urban Planning*, 107(2), 127-136. doi-
org.libaccess.sjlibrary.org/10.1016/j.landurbplan.2012.05.009
- Bakker, S., & Jacob, T. (2013). Policy options to support the adoption of electric vehicles in the urban environment. *Transportation Research Part D: Transport and Environment*, 25, 18-23. doi-org.libaccess.sjlibrary.org/10.1016/j.trd.2013.07.005
- Bay Area Air Quality Management District. (2013). Bay Area: Plug-in Electric Vehicle

Readiness Plan (Summary 2013). Retrieved from <http://www.baaqmd.gov/plans-and-climate/bay-area-pev-program/bay-area-pev-ready>

Bay Area SunShares. (n.d). Electric Vehicles. Retrieved from <https://www.bayareasunshares.org/electric-vehicles>

Bedsworth, W., & Hanak, E. (2013). Climate policy at the local level: Insights from California. *Global Environmental Change*, 23(3), 664-677. doi-
[org.libaccess.sjlibrary.org/10.1016/j.gloenvcha.2013.02.004](https://doi-org.libaccess.sjlibrary.org/10.1016/j.gloenvcha.2013.02.004)

Bergek, A., & Berggren, C. (2014). The impact of environmental policy instruments on innovation: A review of energy and automotive industry studies. *Ecological Economics*, 106, 112-123. doi-
[org.libaccess.sjlibrary.org/10.1016/j.ecolecon.2014.07.016](https://doi-org.libaccess.sjlibrary.org/10.1016/j.ecolecon.2014.07.016)

Berkeley, N., Bailey, D., Jones, A., & Jarvis, D. (2017). Assessing the transition towards battery electric vehicles: A multi-level perspective on drivers of, and barriers to, take up. *Transportation Research Part A: Policy and Practice*, 106, 320-332. doi-
[org.libaccess.sjlibrary.org/10.1016/j.tra.2017.10.004](https://doi-org.libaccess.sjlibrary.org/10.1016/j.tra.2017.10.004)

Borgstedt, P., Neyer, B., & Schewe, G. (2017). Paving the road to electric vehicles – A patent analysis of the automotive supply industry. *Journal of Cleaner Production*, 167(20), 75-87. doi-
[org.libaccess.sjlibrary.org/10.1016/j.jclepro.2017.08.161](https://doi-org.libaccess.sjlibrary.org/10.1016/j.jclepro.2017.08.161)

Breetz, L., & Salon, D. (2018). Do electric vehicles need subsidies? ownership costs for conventional, hybrid, and electric vehicles in 14 U.S. cities. *Energy Policy*, 120, 238-249. doi-
[org.libaccess.sjlibrary.org/10.1016/j.enpol.2018.05.038](https://doi-org.libaccess.sjlibrary.org/10.1016/j.enpol.2018.05.038)

- Brown, B., Canzler, W., Fischer, F., & Knie, A. (1995). Technological innovation through environmental policy: California's zero-emission vehicle regulation. *Public Productivity & Management Review*, 19(1), 77-93. doi:10.2307/3380822
- California Air Resources Board. (2019). Zero-Emission Vehicle Program. Retrieved from <https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program>
- California Department of Motor Vehicles. (2019). California Motor Vehicle Fuel Types by County. Retrieved from https://www.dmv.ca.gov/portal/wcm/connect/e52e6d02-6fa6-483a-bbcd-d888f1b4035b/MotorVehicleFuelTypes_County_190913.pdf?MOD=AJPERES&CVID=
- City of Oakland. (2021). Zero Emission Vehicle Action Plan. *City of Oakland, California*. Retrieved from <https://www.oaklandca.gov/projects/zero-emission-vehicle-action-plan>
- City of San Jose. (2020). Electric Vehicles. *City of San Jose, California, San Jose Clean Energy*. Retrieved from <https://sanjosecleanenergy.org/ev/>
- City of San Mateo. (2016). Sunshares- Simple, Affordable, Together. *City of San Mateo, California, Business Council on Climate Change*. Retrieved from <https://www.cityofsanmateo.org/CivicSend/ViewMessage/message/42322>
- City of Sunnyvale. (2021). Drive Electric. *City of Sunnyvale, California*. Retrieved from <https://sunnyvale.ca.gov/people/sustainability/driveelectric.htm>

- Clark-Sutton, K., Siddiki, S., Carley, S., Wanner, C., Rupp, J., & Graham, D. (2016). Plug-in electric vehicle readiness: Rating cities in the united states. *The Electricity Journal*, 29(1), 30-40. doi.org/10.1016/j.tej.2015.12.006
- Collantes, G., & Sperling, D. (2008). The origin of California's zero emission vehicle mandate. *Transportation Research Part A*, 42(10), 1302-1313. doi:10.1016/j.tra.2008.05.007
- Egnér, F., & Trosvik, L. (2018). Electric vehicle adoption in Sweden and the impact of local policy instruments. *Energy Policy*, 121, 584-596. doi.org/10.1016/j.enpol.2018.06.040
- Governor's Office of Planning and Research. (2013). *Zero-Emission Vehicles in California: COMMUNITY READINESS GUIDEBOOK - Toward 1.5 Million Zero-Emission Vehicles on California Roadways by 2025*. Retrieved from http://opr.ca.gov/docs/ZEV_Guidebook.pdf
- Graham, J., Cisney, J., Carley, S., & Rupp, J. (2014). No time for pessimism about electric cars: The national push to adopt electric cars should be sustained until at least 2017, when a review of federal auto policies is scheduled. *Issues in Science and Technology*, 31(1), 33.
- Greene, L., Park, S., & Liu, C. (2014). Analyzing the transition to electric drive vehicles in the US. *Futures*, 58, 34-52. doi:10.1016/j.futures.2013.07.003

- Heidrich, O., Hill, A., Neaimeh, M., Huebner, Y., Blythe, T., & Dawson, J. (2017). How do cities support electric vehicles and what difference does it make? *Technological Forecasting and Social Change*, 123, 17-23. doi.org/10.1016/j.techfore.2017.05.026
- Huang, S., Safiullah, H., Xiao, J., Hodge, S., Hoffman, R., Soller, J., & Pekny, F. (2012). The effects of electric vehicles on residential households in the city of Indianapolis. *Energy Policy*, 49, 442-455. doi.org/10.1016/j.enpol.2012.06.039
- Jenn, A., Springel, K., & Gopal, R. (2018). Effectiveness of electric vehicle incentives in the united states. *Energy Policy*, 119, 349-356. doi.org/10.1016/j.enpol.2018.04.065
- Krause, M., Carley, R., Lane, W., & Graham, D. (2013). Perception and reality: Public knowledge of plug-in electric vehicles in 21 U.S. cities. *Energy Policy*, 63, 433-440. doi-org.libaccess.sjlibrary.org/10.1016/j.enpol.2013.09.018
- Langbroek, M., Franklin, P., & Susilo, O. (2016). The effect of policy incentives on electric vehicle adoption. *Energy Policy*, 94, 94-103. doi-org.libaccess.sjlibrary.org/10.1016/j.enpol.2016.03.050
- Larson, D., Viáfara, J., Parsons, V., & Elias, A. (2014). Consumer attitudes about electric cars: Pricing analysis and policy implications. *Transportation Research Part A: Policy and Practice*, 69, 299-314. doi-org.libaccess.sjlibrary.org/10.1016/j.tra.2014.09.002
- Lévay, Z., Drossinos, Y., & Thiel, C. (2017). The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership.

Energy Policy, 105, 524-533. doi-

org.libaccess.sjlibrary.org/10.1016/j.enpol.2017.02.054

Liao, F., Molin, E., Timmermans, H., & Wee, B. (2019). Consumer preferences for business models in electric vehicle adoption. *Transport Policy*, 73, 12-24. doi-org.libaccess.sjlibrary.org/10.1016/j.tranpol.2018.10.006

Liao, Z. (2018). Environmental policy instruments, environmental innovation and the reputation of enterprises. *Journal of Cleaner Production*, 171(10), 111-117. doi-org.libaccess.sjlibrary.org/10.1016/j.jclepro.2017.10.126

Lieven, T. (2015). Policy measures to promote electric mobility – A global perspective. *Transportation Research Part A: Policy and Practice*, 82, 78-93. doi:10.1016/j.tra.2015.09.008

London, J., Karner, A., Sze, J., Rowan, D., Gambirazzio, G., & Niemeier, D. (2013). Racing climate change: Collaboration and conflict in California's global climate change policy arena. *Global Environmental Change*, 23(4), 791-799. doi-org.libaccess.sjlibrary.org/10.1016/j.gloenvcha.2013.03.001

Majumdar, R. (2005). A prospect theory analysis of California's initiatives in implementation of its zero emission vehicles (ZEV) mandate. *Review of Policy Research*, 22(2), 157-169. doi:10.1111/j.1541-1338.2005.00127.x

Millard-Ball, A. (2012). Do city climate plans reduce emissions? *Journal of Urban Economics*, 71(3), 289-311. doi-org.libaccess.sjlibrary.org/10.1016/j.jue.2011.12.004

- Murray, C. (2011). Do you sympathize with the automakers? California's zero-emission vehicle mandate could affect automakers, but do we care. *Design News*, 66(9), 16.
- Nordgren, J., Stults, M., & Meerow, S. (2016). Supporting local climate change adaptation: Where we are and where we need to go. *Environmental Science & Policy*, 66, 344-352. [doi-org.libaccess.sjlibrary.org/10.1016/j.envsci.2016.05.006](https://doi.org/10.1016/j.envsci.2016.05.006)
- Ogden, J. (1999). Developing an infrastructure for hydrogen vehicles: A southern California case study. *International Journal of Hydrogen Energy*, 24(8), 709-730. doi:10.1016/S0360-3199(98)00131-1
- Rietmann, N., & Lieven, T. (2019). How policy measures succeeded to promote electric mobility – Worldwide review and outlook. *Journal of Cleaner Production*, 206(1), 66-75. doi:<https://doi.org/10.1016/j.jclepro.2018.09.121>
- Shaheen, S., Wright, J., & Sperling, D. (2002). California's zero-emission vehicle mandate - linking clean-fuel cars, carsharing, and station car strategies. *Transportation Research Record*, 1791(1), 113-120. doi:10.3141/1791-17
- Silicon Valley Leadership Group. (2019). Housing, Health & Transportation. Retrieved from <https://www.svlg.org/housing-health-transportation/>
- Stokes, L., & Breetz, H. (2018). Politics in the U.S. energy transition: Case studies of solar, wind, biofuels and electric vehicles policy. *Energy Policy*, 113, 76-86. doi.org/10.1016/j.enpol.2017.10.057

- Sykes, M., & Axsen, J. (2017). No free ride to zero-emissions: Simulating a region's need to implement its own zero-emissions vehicle (ZEV) mandate to achieve 2050 GHG targets. *Energy Policy*, 110, 447-460. doi-org.libaccess.sjlibrary.org/10.1016/j.enpol.2017.08.031
- Sylvia, R., & Sylvia, K. (2012). *Program planning and evaluation for the public manager*. Illionis: Waveland Press.
- Thomas, C., James, B., & Lomax, F. (1998). Market penetration scenarios for fuel cell vehicles. *International Journal of Hydrogen Energy*, 23(10), 949-966. doi:10.1016/S0360-3199(97)00150-X
- US Census Bureau. (2019). City and Town Population Totals: 2010-2019. Retrieved from <https://www.census.gov/data/tables/time-series/demo/popest/2010s-total-cities-and-towns.html>.
- US Department of Energy. (2014). A Guide to the Lessons Learned from the Clean Cities Community Electric Vehicle Readiness Projects. Retrieved from https://afdc.energy.gov/files/u/publication/guide_ev_projects.pdf
- US Environmental Protection Agency. (2019). Sources of Greenhouse Gas Emissions. Retrieved from <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>.
- Wesseling, J., Farla, J., Sperling, D., & Hekkert, M. (2014). Car manufacturers' changing political strategies on the ZEV mandate. *Transportation Research Part D: Transport and Environment*, 33, 196-209. doi.org/10.1016/j.trd.2014.06.006

Witt, M., Bomberg, M., Lipman, T., & Williams, B. (2012). Plug-in electric vehicles in California review of current policies, related emissions reductions for 2020, and policy outlook. *Transportation Research Record*, 2287(1), 155-162.

doi:10.3141/2287-19

Xie, F., Liu, C., Li, S., Lin, Z., & Huang, Y. (2018). Long-term strategic planning of inter-city fast charging infrastructure for battery electric vehicles. *Transportation Research Part E: Logistics and Transportation Review*, 109, 261-

276. doi.org/10.1016/j.tre.2017.11.014

APPENDICES

Appendix A: Ten Instruments Based on the Guidebook (2013)

1. *General Plans, Zoning, and Building Codes for Plug-In Electric Vehicles:*

Whether a city decides to incorporate electric vehicles' regulations into a general plan, addressing electric vehicles in the zoning and building code, which can help ensure that communities become electric vehicles ready. To illustrate, according to the state guidebook, “zoning policies can be created for electric vehicles that enable ease of charging throughout a jurisdiction, and building codes allow a community to incorporate electric vehicles readiness into the building process.”

2. *Electric Vehicles Incentives Provide by the City:*

Whether a city has provided any incentives that encourage individuals to use electric vehicles, such as offering electric vehicles with free parking.

3. *Outreach and Education for Electric Vehicles:*

Whether a city can direct engagement with residents and local businesses about electric vehicles and electric vehicle incentives in order to successfully capture the attention and acceptance of the broader public. Moreover, it also includes whether a city has to create training or education activities relating to electric vehicles, charging services and the usage of infrastructure.

4. *Working with Utilities for Plug-In Electric Vehicle Readiness:*

Whether a city has interacted with California utilities to let them anticipate and plan for the widespread deployment of electric vehicles to manage the growing electrical load.

5. *Partnering with Community Stakeholders:*

Whether a city has created partnerships with local associations and community

stakeholders. According to the state guidebook, creating partnerships with business or environmental groups can provide “an opportunity to leverage existing private and nonprofit expertise and experience in government planning and outreach for electric vehicles readiness.”

6. *Electric Vehicle Signs and Pavement Markings:*

Whether a city has placed the electric vehicle signs and markings in uniform and consistent in appearance, allowing them to be clearly recognizable to motorists.

According to the state guidebook, "signs and pavement markings are essential elements of electric vehicles infrastructure, serving to inform the drivers of available charging and fueling services and to help enforce related rules and laws.

7. *Charging Infrastructure Permitting-Single-Family Residential Charging:*

Whether a city has approved to install electric vehicle charging stations for single-family residential and what the permitting processes are.

8. *Charging Infrastructure Permitting- Multi-Unit Dwellings Charging:*

Whether a city has approved to install electric vehicle charging stations for Multi-Unit Dwellings and what the permitting processes are.

9. *Charging Infrastructure Permitting -Workplace Charging:*

Whether a city has approved to install electric vehicle charging stations for the workplace and what the permitting processes are.

10. *Charging Infrastructure Permitting -Retail and Public Sector Charging:*

Whether a city has approved to install electric vehicle charging stations for the retail and public sector and what the permitting processes are.

No.	City	Population (2010 Census)	Community Readiness Guidebook (2013) Instruments										Total
			1	2	3	4	5	6	7	8	9	10	
			Changing Building Codes	Incentives Provided by City	Outreach and Education	Working with Utilities	Partnering Community Stakeholder	Signs and Pavement Markings	Permitting- Charging				
									Single- Family Residential	Multi-Unit Dwellings	Workplace	Retail and Public Sector	
41	Hillsborough	11,769	☑	☒	☑	☑	☑	☑	☑	☑	☑	☑	9
42	Piedmont	11,420	☑	☒	☑	☑	☑	☑	☑	☑	☑	☑	9
Total			42	5	42	41	40	42	42	42	42	42	

Appendix C: Details of each City Adopted Instruments Generalized from Official Websites

No.	City	Population (2010 Census)	Six Instruments Generalized from Official Websites						Total
			1	2	3	4	5	6	
			Combining with Other Projects	Holding the Workshops	Bring EV Program into the City Plans	Support from the Leaders	Setting up Public Charging Stations	Creating a Specific Website EV Section	
1	San Jose	1,043,058	☑	☒	☑	☑	☑	☑	5
2	Oakland	432,897	☑	☑	☑	☑	☑	☑	6
3	Fremont	232,532	☑	☑	☑	☑	☑	☑	6
4	Hayward	159,433	☑	☑	☒	☑	☑	☑	5
5	Sunnyvale	155,567	☑	☑	☑	☑	☑	☑	6
6	Santa Clara	128,717	☑	☑	☑	☑	☑	☑	6
7	Berkeley	123,328	☑	☑	☑	☑	☑	☑	6
8	Daly City	109,122	☒	☒	☑	☑	☑	☒	3
9	San Mateo	104,570	☑	☑	☑	☑	☑	☒	5
10	Livermore	91,039	☒	☒	☒	☑	☑	☒	2
11	San Leandro	89,825	☑	☒	☒	☑	☑	☑	4
12	Redwood City	85,319	☑	☑	☑	☑	☑	☑	6
13	Mountain View	81,992	☑	☑	☒	☑	☑	☑	5
14	Pleasanton	80,492	☑	☒	☑	☑	☑	☒	4
15	Alameda	79,316	☑	☑	☑	☑	☑	☑	6
16	Milpitas	76,231	☑	☑	☑	☑	☑	☒	5
17	Union City	74,916	☒	☒	☑	☒	☑	☒	2
18	Palo Alto	69,397	☑	☑	☑	☑	☑	☑	6
19	South San Francisco	67,078	☑	☑	☒	☑	☑	☑	5
20	Dublin	64,577	☑	☒	☑	☑	☑	☑	5

No.	City	Population (2010 Census)	Six Instruments Generalized from Official Websites						Total
			1	2	3	4	5	6	
			Combining with Other Projects	Holding the Workshops	Bring EV Program into the City Plans	Support from the Leaders	Setting up Public Charging Stations	Creating a Specific Website EV Section	
21	Cupertino	59,879	☑	☑	☑	☑	☑	☑	6
22	Gilroy	55,928	☒	☒	☑	☒	☑	☒	2
23	Newark	48,712	☒	☒	☑	☒	☑	☒	2
24	Morgan Hill	45,742	☒	☒	☑	☒	☑	☑	3
25	San Bruno	45,257	☒	☒	☑	☒	☑	☒	2
26	Campbell	43,250	☑	☒	☒	☑	☑	☑	4
27	Pacifica	38,674	☑	☒	☑	☒	☑	☑	4
28	Menlo Park	35,790	☑	☑	☑	☑	☑	☑	6
29	Foster City	33,693	☑	☑	☑	☑	☑	☑	6
30	Saratoga	31,407	☑	☒	☑	☒	☑	☒	3
31	Los Altos	31,190	☑	☒	☑	☑	☑	☑	5
32	Los Gatos	30,988	☑	☑	☑	☑	☑	☑	6
33	East Palo Alto	30,499	☒	☒	☑	☑	☑	☒	3
34	Burlingame	30,317	☑	☑	☑	☑	☑	☑	6
35	San Carlos	29,864	☑	☑	☑	☑	☑	☑	6
36	Belmont	27,174	☒	☑	☑	☑	☑	☑	5
37	Millbrae	23,154	☑	☑	☑	☑	☑	☑	6
38	Albany	19,393	☑	☑	☑	☑	☑	☑	6
39	Half Moon Bay	12,631	☑	☒	☑	☑	☑	☑	5
40	Emeryville	11,885	☑	☑	☑	☑	☑	☑	6
41	Hillsborough	11,769	☒	☒	☑	☑	☑	☑	4
42	Piedmont	11,420	☑	☑	☑	☑	☑	☑	6

Appendix D: Details of each City Adopted Three Items that Convey Electric Vehicle Information

No.	City	Population (2010 Census)	Three Items Conveying Electric Vehicle Information			Total
			1	2	3	
			Creating a Specific Website Section Providing EV Information	Providing the Link of Alternative Fueling Stations Locator	Informing the federal and the state Incentives of EV Purchase	
1	San Jose	1,043,058	☑	☑	☑	3
2	Oakland	432,897	☑	☑	☑	3
3	Fremont	232,532	☑	☑	☑	3
4	Hayward	159,433	☑	☑	☑	3
5	Sunnyvale	155,567	☒	☑	☑	2
6	Santa Clara	128,717	☑	☑	☑	3
7	Berkeley	123,328	☑	☑	☑	3
8	Daly City	109,122	☒	☒	☒	0
9	San Mateo	104,570	☒	☒	☒	0
10	Livermore	91,039	☒	☒	☒	0
11	San Leandro	89,825	☒	☑	☑	2
12	Redwood City	85,319	☑	☑	☒	2
13	Mountain View	81,992	☒	☑	☑	2
14	Pleasanton	80,492	☒	☒	☒	0
15	Alameda	79,316	☑	☑	☑	3
16	Milpitas	76,231	☒	☒	☒	0
17	Union City	74,916	☒	☒	☒	0
18	Palo Alto	69,397	☑	☑	☑	3
19	South San Francisco	67,078	☑	☑	☑	3
20	Dublin	64,577	☑	☑	☑	3

No.	City	Population (2010 Census)	Three Items Conveying Electric Vehicle Information			Total
			1	2	3	
			Creating a Specific Website Section Providing EV Information	Providing the Link of Alternative Fueling Stations Locator	Informing the federal and the state Incentives of EV Purchase	
21	Cupertino	59,879	☒	☒	☒	3
22	Gilroy	55,928	☐	☐	☐	0
23	Newark	48,712	☐	☐	☐	0
24	Morgan Hill	45,742	☒	☒	☐	1
25	San Bruno	45,257	☐	☐	☐	0
26	Campbell	43,250	☐	☐	☒	1
27	Pacifica	38,674	☐	☒	☐	1
28	Menlo Park	35,790	☒	☒	☒	3
29	Foster City	33,693	☒	☒	☒	3
30	Saratoga	31,407	☐	☐	☐	0
31	Los Altos	31,190	☒	☒	☒	3
32	Los Gatos	30,988	☐	☒	☐	2
33	East Palo Alto	30,499	☐	☐	☐	0
34	Burlingame	30,317	☒	☒	☒	3
35	San Carlos	29,864	☐	☒	☐	2
36	Belmont	27,174	☐	☒	☐	2
37	Millbrae	23,154	☒	☒	☒	3
38	Albany	19,393	☐	☐	☒	1
39	Half Moon Bay	12,631	☒	☒	☒	3
40	Emeryville	11,885	☒	☒	☒	3
41	Hillsborough	11,769	☐	☐	☒	1
42	Piedmont	11,420	☒	☒	☒	3