Charging Forward: Creating A Productive Framework for Promoting Electric Vehicle Adoption Among U.S. Cities Based on Development Stage

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Abstract

Electric vehicles are among the most promising innovations to date for their role in minimizing human-induced carbon emissions and combating climate change. Despite the clear need for this technology, the U.S. is struggling to promote its adoption, with electric vehicles accounting for a dismal 2% of the new automobile market—less than half of the global average. This disparity raises the logical question: "What can U.S. cities do to increase electric vehicle use?" To address this, I conducted a comparative analysis of the 2020 electric mobility action plans for two U.S. cities (San Jose, California and Denver, Colorado). These cities were selected because of their state, adoption rate, promotion efforts, and digitally-accessible action plans. To compare the action plans from both cities, I used a discourse and word cloud analysis and identified four areas of focus from both cities: (i) vehicle cost, (ii) charging infrastructure, (iii) fleet electrification, and (iv) public awareness. Due to significant variation between U.S. cities, I categorized cities into five levels of development: L1: Rural, L2: Town, L3: City, L4: Advanced City, and L5: Future City. Based on criteria such as population, adoption rate, charging infrastructure, and adoption goals, I used Denver as a reference point for Level 3 and San Jose for Level 4. From this analysis, I establish best practices for electric vehicle promotion efforts for cities at each of the five development stages. By creating this productive framework, I hope to facilitate and accelerate efforts for electric vehicle promotion among U.S. cities.

Keywords: Electric Vehicle(s), Adoption, Development, U.S., Cities, Climate Change, Discourse Analysis, Word Cloud Analysis, Framework, Best Practices, Guidelines, San Jose, California, Denver, Colorado, Cost, Charging, Fleet, Awareness

Introduction

There is a great deal of excitement and intrigue surrounding electric vehicles today. Much of the enthusiasm around it stems from its potential to revolutionize transportation, energy, and climate policy (Barkenbus, 2020). As a result, automobile companies are working aggressively to innovate and release new electric models every year. For example, the global leader in electric vehicle technology, Tesla, is aiming to release a fully electric and autonomous car in two years priced below 25,000 USD (Bauer, 2021). The world is beginning to recognize electric vehicles as a viable and even necessary asset in the fight against climate change (Graham, 2021).

The widespread adoption of electric vehicles has immense potential for mitigating greenhouse gas emissions and alleviating the harms of air pollution and climate change. Given that the transportation sector—especially passenger vehicle driving—is the largest contributor to emissions, an electric transition would have a tremendous impact (Barkenbus, 2020). Additionally, among the sustainable forms of transportation, electric vehicles are the most feasible to adopt since they function within a similar landscape as traditional gasoline-powered vehicles (Barkenbus, 2020). Consequently, many European countries (e.g. Norway, Iceland, Sweden, etc) as well as China are effectively transitioning to electric transportation, with Norway achieving an adoption rate of over 75% (Graham, 2021).

However, in the U.S., electric vehicle use remains extremely limited. According to the International Energy Agency, electric vehicles make up merely 2.0% of new cars sold in the U.S., which is less than half of the global rate of 4.6% and far below the federal goal of 30% by 2030 (IEA, 2021; The White House, 2021). The only areas with noteworthy electric vehicle adoption rates (~4% or higher) are cities in the state of California and a few others, including Portland, OR; Seattle, WA; Denver, CO; etc (Bui, 2020).

This gap in electric vehicle use between U.S. cities prompts further comparison between cities with various adoption rates. Therefore, in this study, I perform a comparative analysis of the electric vehicle policies of two U.S. cities to synthesize best practices for promoting its use.

Literature Review

Climate change is the greatest threat humans face (UN, 2021; WHO, 2021). It is rigorously documented that the primary cause of global warming is the emission of greenhouse gasses, particularly carbon dioxide (EPA, n.d.a). In the U.S., nearly 30% of these emissions can be attributed to the transportation sector, where the vast majority (72%) are released by passenger vehicles (Barkenbus, 2020; EPA, n.d.a; The City of San Jose, 2020). Therefore, to mitigate emissions and the impact of climate change, it is critical that a more sustainable alternative to gasoline-powered transportation is adopted (Singh, 2020). In this section, I will address the

(i) necessity for electric vehicles; (ii) disparities in adoption among U.S. cities; and (iii) barriers to adoption.

Necessity for Electric Vehicles

Electric vehicles are the most promising mode of sustainable transportation found to date. These cars, known as "plug-in electric vehicles," derive energy from the electricity grid and hold environmental, economic, and social benefits over the internal combustion engine vehicles that dominate roads today (Knobloch, 2020; MIT Energy Initiative, 2019).

Environmental Benefit

The primary advantage of electric vehicles is their smaller environmental footprint than traditional gasoline-powered vehicles (EPA, n.d.b; IEA, 2021). Since electric vehicles consume electrical energy from the grid rather than chemical energy from gasoline, this opens potential for these vehicles to operate without relying on fossil fuels. In doing so, electric vehicle use not only paves the road for phasing out fossil fuels but also reduces the air pollution generated by the transportation sector.

Although there is widespread scientific consensus that electric vehicles are more environmentally sound than gasoline-powered, there are two common public misconceptions: electric vehicles have a greater environmental footprint because of (i) the fact that electrical power is often derived from fossil fuels; (ii) the harms of its manufacturing process (i.e. lithium mining required for batteries; EPA, n.d.b). However, these arguments have been refuted. According to the Massachusetts Institute of Technology Energy Initiative, the energy efficiency of electric vehicles during use outweighs the greater emissions produced in manufacturing (EPA, n.d.b; MIT Energy Initiative, 2019). And in 95% of the world, using electric vehicles is cleaner than using gasoline-powered vehicles. Over time, through innovation and a greater reliance on renewable sources, this environmental benefit will only increase (Barkenbus, 2020).

Economic Benefit

Currently, electric vehicles are more expensive to purchase than their gasoline-powered counterparts. Though they pose a greater financial burden for consumers initially, electric vehicles are economically superior in the long term due to significantly lower operating costs (Graham, 2021). In the U.S., even where gasoline prices are relatively low (~2-4 USD per gallon), electric vehicles cost 60-70% less to travel than gasoline-powered. This cost benefit from fuel prices becomes more pronounced in countries with higher gasoline prices and will make operating electric vehicles more economically favorable over time for U.S. consumers as gasoline prices continue to rise.

Electric vehicles also impose fewer maintenance costs on consumers (Graham, 2021). The simpler mechanical designs and lack of an emissions system in these vehicles lead to fewer parts being susceptible to wear. As a result, consumers save money on oil changes and regular maintenance

checkups. Cumulatively, these factors can translate into substantial savings for families. For example, one study estimates that U.S. consumers would save roughly 400 USD per year on maintenance fees when using an electric vehicle rather than a gasoline vehicle (Graham, 2021).

Social Benefit

While other sustainable modes of transportation (e.g. public transportation systems, electric bikes/scooters) should also be promoted, electric vehicles are the most promising alternative to automobiles since they provide a substantial travel range and uphold consumer autonomy. The technology fulfills the existing social expectations for individuals to have greater control over their destinations (Barkenbus, 2020).

Additionally, it is well documented that greenhouse gas emissions, air pollution, and climate change disproportionately affect people of color and of low socio-economic status across the globe (The City of San Jose, 2020; EPA, 2021). Since electric vehicles do not emit tailpipe pollution, transitioning to them can help alleviate these social inequities and improve wellbeing for these populations in specific.

Disparities in Electric Vehicle Adoption Among U.S. Cities

Despite their extensive benefits, electric vehicles remain largely unpopular in the vast majority of the U.S. However, this narrative is not completely consistent throughout the country. In this subsection, I will cover the cities where electric vehicles are most popular.

Areas of Highest Electric Vehicle Adoption

The main U.S. state that has been successfully promoting electric vehicle adoption is California, with an adoption rate (>10%) that is more than double the global rate (Graham, 2021). All of the five major cities with the highest adoption are in California (in order: San Jose, San Francisco, Los Angeles, San Diego, Sacramento; Bui, 2020). This is unsurprising for many factors. The most notable is that California state and city governments have a historical record of pro-electric vehicle initiatives (Tal, 2020; Ye, 2021). According to data from the International Council on Clean Transportation (ICCT), California metropolitan areas are taking the most action at the state, local, and utility levels to promote electric vehicles (Bui, 2020). For example, California cities are among the few to have a state low carbon fuel policy and incentives for low-income consumers, city carpool lane (HOV) access, and utility commercial charger incentives.

Outside of California, there are a few metropolitan areas with notable electric vehicle use, which include Seattle, Portland, Washington, Denver, Austin, Phoenix, and Boston (Bui, 2020). Even so, none of these cities have comparable adoption rates to the major California cities. The ICCT report counted that these cities took 23-29 (of 40 counted) pro-electric vehicle actions, whereas California cities took 31-34. There was a

positive correlation between the number of promotion actions taken and the adoption rate.

Overcoming Barriers to Electric Vehicle Adoption in U.S. Cities

Despite efforts from many U.S. cities to promote electric vehicle use, there have been notable several barriers. In this section, I will discuss the three primary obstacles to adoption: (i) high purchasing cost, (ii) lack of accessible charging infrastructure, and (iii) low community and company awareness (The City of San Jose, 2020). These factors hinder adoption the most in less urbanized areas, leading to rural U.S. regions having the lowest rates (Bui, 2020).

High Purchasing Cost

Many experts contend that purchasing costs for electric vehicles are the most significant obstacle for consumers (Barkenbus, 2020; Singh, 2020). New electric vehicles are approaching the label of "affordable," which Graham and coworkers define as valuing under $40,000—the national median price for new passenger cars (Graham, 2021). Given the expensive nature of electric vehicles, middle to higher-income households dominate the U.S. market (Singh, 2020; Tal, 2020). Though electric vehicle models should appeal to these citizens, a substantial environmental impact cannot be realized without adoption at lower socioeconomic levels (Tal, 2020).

The greatest contributor to high electric vehicle prices is lithium-ion batteries (Graham, 2021). Though battery cell costs have been reduced by 80% in the last decade, experts disagree on how soon prices will decline enough to make electric vehicles cost-competitive with gasoline (Barkenbus, 2020; Graham, 2021). Thus, there have been many state and national programs to provide consumer rebates, such as the 7500 USD national tax credit for Americans who purchase an electric vehicle (Graham, 2021; Tal, 2020). Such financial incentives have proven to be highly effective in boosting adoption (Tal, 2020).

Lack of Accessible Charging Infrastructure

The accessibility of fast-charging infrastructure greatly influences electric vehicle adoption. Although vehicle range is rapidly improving, charging infrastructure (both public and private) remains key when addressing consumer driving "range anxiety" (Barkenbus, 2020; Graham, 2021; Zhang, 2021). It is important, especially for low-income consumers with limited home or workplace charger access, that cities develop a widespread public charging network (City and County of Denver, 2020; The City of San Jose, 2020; Graham, 2021). However, the U.S. is far behind its goals for charging infrastructure. An ICCT white paper explains that "public and workplace charging will need to grow from approximately 216,000 chargers in 2020 to 2.4 million by 2030" to support the increase in electric vehicle prevalence (Bauer, 2021).

Low Community and Company Awareness

The impact of electric vehicle awareness is often underestimated when implementing policies due to its less tangible nature. Nonetheless, researchers found that low awareness is one of the most significant barriers to adoption (The City of San Jose, 2020). For example, Dr. Kurani and Dr. Hardman from the University of California at Davis concluded from awareness studies that "Californians are not deciding they don't want PEVs. Rather, they remain to a great extent unaware of PEVs and anything about them." This lack of awareness is observed throughout the U.S. and even in automobile dealerships, where sales workers are less informed about electric vehicles and are often disincentivized to sell them (Graham, 2021).

Opportunity for Investigation

From exploring the three avenues above, the following ideas become clear. Currently, transitioning to electric vehicles is crucial for combating climate change. Unfortunately, the U.S. is struggling to effectively adopt electric vehicles (except for a few metropolitan areas) due to several key barriers. Applying existing research to overcome these barriers is difficult for cities, especially due to their high variations in development. However, given the stage of development for the U.S. city, what guiding principles can be established for promoting electric vehicle adoption?

Methods

Context and Limitations of Research Study

This study aims to analyze current electric vehicle promotion practices in U.S. cities of varying development. In doing so, I hope to design a framework of best practices for increasing electric vehicle use for U.S. cities based on their stage of development.

To understand the rationale behind the study design, note two primary limitations. First, only two weeks were available for researching and analyzing the documents of interest. Second, there is a very limited number of U.S. cities with noteworthy electric vehicle use, especially outside the state of California. Thus, there are fewer cities to study and it is difficult to standardize variables such as population, weather, dominant political affiliation, etc. This complicates attempts at drawing correlations between cities. Fortunately, however, I believe that the use of non-standardized cities for this study broadens the applicability of the discussion and framework.

Selection of Cities

Due to time constraints, only two cities were chosen for the study: San Jose, California and Denver, Colorado. The selection of these cities was narrowed by three criteria: (i) electric vehicle adoption rate, (ii) number of electric vehicle promotion actions, and (iii) digital access to a 2020 or more recent electric mobility action plan at the time of research. For the data listed in (i) and (ii), a 2020 briefing paper published by the ICCT was

used (Bui, 2020). For criterion (iii), ideally, all of the city action plans could be accessed given adequate time and resources. Unfortunately, the constraints of the study resulted in this final criterion serving as a significant restriction on which cities were eligible for analysis.

According to the ICCT Briefing, for criteria (i), San Jose had the highest adoption rate (~20%) among all major U.S. cities by a notable margin (Bui, 2020). The second-highest adoption rate was 12%, which was in San Francisco. This definitive lead in electric vehicle use attests, in some capacity, to the effectiveness of San Jose's electric vehicle policy—especially considering that the relatively similar city of San Francisco has substantially lower uptake. For criteria (ii), San Jose was one of five cities with the most electric vehicle promotion actions in effect. And fortunately, the City of San Jose released its "Electric Vehicle Roadmap" online in 2020 (The City of San Jose, 2020). Thus, San Jose, CA was selected as the first city.

To choose Denver as the second city, I followed a similar procedure but excluded other California cities. It was important that our study analyzed cities from different states to make the findings more widely applicable and translatable to other U.S. cities. For criteria (i), I gathered the top five cities outside of California with the highest uptake: Seattle, Portland, Washington, Denver, Austin. Since the range of adoption rates was fairly limited between these cities (3-6%), I overlapped this list with the second criteria (Bui, 2020). This list of non-California cities with the highest number of promotion actions contained Portland, New York, Boston, Seattle, and Denver. The cities that excelled in both criteria (i) and (ii) are Portland, Seattle, and Denver. Among these three, Denver was the only city with a digitally-accessible electric mobility plan updated in 2020 (City and County of Denver, 2020). As per the three criteria, Denver was selected as the second city.

Methods

First, the ICCT Briefing was used for a preliminary analysis of each city and its electric vehicle use. To conduct the core analysis of the study, I focused on the 2020 electric mobility plans for each city, which were accessed through the Google search engine. Specifically, I examined the "San Jose Electric Mobility Roadmap: 2020-2022" published by the City of San Jose in January of 2020 and the "Denver Electric Vehicle Action Plan" published by the Denver Office of Climate Action, Sustainability, and Resiliency in April 2020. Both initiatives are designed to achieve prior sustainability goals set by each city in 2017-2018. Secondary studies and review articles on electric vehicle policy, particularly in the two cities, were acquired through search engines and academic databases (e.g. Google, Google Scholar, Scopus, ScienceDirect).

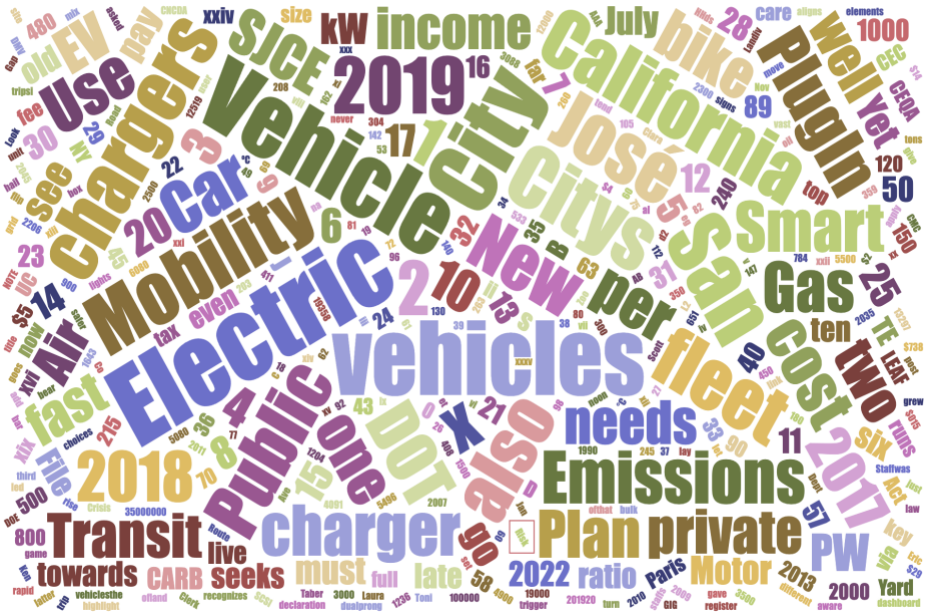
For each action plan document, two types of analysis and data collection were performed. First, a discourse analysis was conducted to identify the key areas of focus, based on the electric vehicle targets and

policies presented. Next, a word cloud analysis was conducted using the Jason Davies word cloud generator. The ten largest words in the cloud (most frequently occurring), were used to validate the focus areas identified in the discourse analysis. To obtain more productive findings, words that refer to (i) the identity of the city, (ii) the subject "electric vehicle action plan," (iii) statistics (e.g. numbers and "per"), and (iv) grammatical words (e.g. also) were omitted from the word cloud analysis. Almost identical words were paired with each other (e.g. charger and chargers). From these two analyses, a list of key areas of focus and best practices within each city were documented.

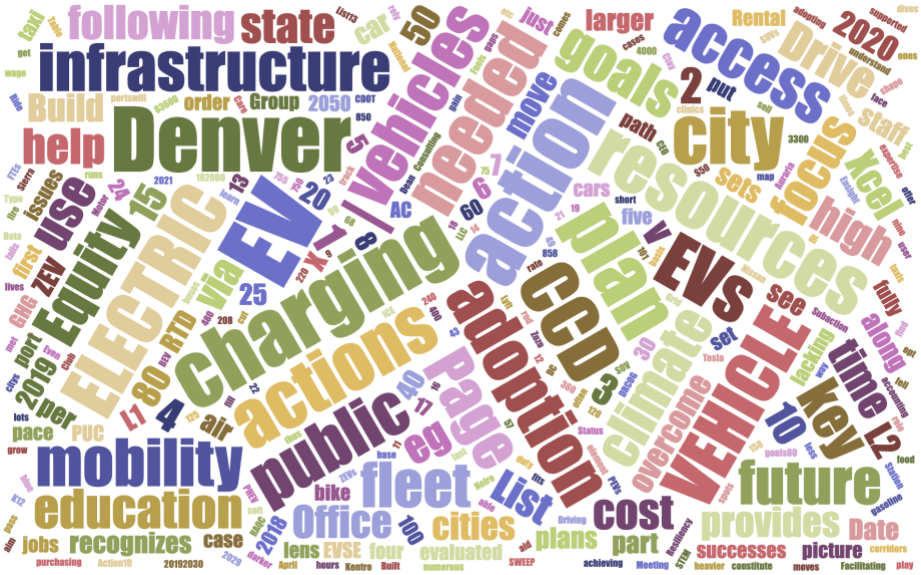
Before organizing the areas of focus by the development stage of each city, the concept of "city development" was defined and a categorization system was established. For this study, "development" was defined by not only city urbanization but also by comparing three additional factors: electric vehicle adoption rate, charging infrastructure availability, and electric vehicle adoption goals. From these four total criteria, I developed a categorization system with five levels of city development: Level 1: Rural, Level 2: Towns, Level 3: Cities, Level 4: Advanced Cities, and Level 5: Future Cities. By these criteria, Denver was classified as Level 3 and San Jose as Level 4, using data in the ICCT Briefing. By arranging the areas of focus identified earlier, I mapped the trajectory of electric vehicle policies for cities of all five development levels, with Denver and San Jose as models for Levels 3 and 4, respectively. By synthesizing guidelines and best practices for increasing adoption, I created a productive framework for promoting electric vehicles in U.S. cities at each development stage.

Findings

Word Cloud Analysis of "San Jose Electric Mobility Roadmap: 2020-2022"



Word Cloud Analysis of "Denver Electric Vehicle [2020] Action Plan"



Top 10 Significant* Frequent Words Among Action Plans:

Frequent Words (not in order)	San Jose	Denver
1	**Charger(s)**	**Charging**
2	Mobility	Mobility
3	Transit	Adoption
4	Emissions	**Needed**
5	**Public**	**Public**
6	**Private**	**Resources**
7	**Fleet**	**Fleet**
8	**Cost**	**Cost**
9	Air	**Infrastructure**

10	Income	**Equity**
Common Words Omitted (Non-significant*)	San, Jose, California, City(s), Electric, Vehicle(s), EV, Plan, Car, also	Denver, CCD (City and County of Denver), City, State, Vehicle(s), Electric, EV, Action(s), Plan

Note: Bolded words are used to support the findings below.

From the document and word cloud analyses, I identified four primary areas of focus within the San Jose and Denver electric mobility plans: (i) vehicle cost, (ii) charging infrastructure, (iii) fleet electrification, and (iv) public awareness. In this section, I will explore these four subtopics in greater detail by comparing the San Jose and Denver plans within each arena and discussing interesting findings from the word cloud analysis.

Cost

The high purchasing cost of electric vehicles is often considered the most significant hurdle for adoption, especially among lower-income groups. Consequently, both the San Jose and Denver plans prioritize making electric vehicles more affordable and accessible. The San Jose plan illustrates this by using data on electric vehicle use among districts and highlighting disparities in low-income communities. Overall, however, there is relatively limited discussion of city plans to combat this. While this may seem dubious, it likely indicates that San Jose is shifting its efforts towards combating other barriers. The city can afford to relax on this because the state government has become increasingly involved in providing consumer incentives through the California "Clean Vehicle rebate program" (CVRP), which adds to the in-place federal tax credits. For low-income families, California is one of three states to provide greater incentives for purchasing an electric vehicle according to the ICCT paper. There are also utility electric vehicle and commercial charger purchase incentives in place in San Jose. On the other hand, Denver is planning on providing tiered financial incentives in the near future. In doing so, the city hopes to support lower-income residents with purchasing and using electric cars, electric bikes, and public transportation.

Interestingly, the word clouds captured Denver's emphasis on planning for equity policies to widen the accessibility of electric vehicles. While San Jose used "cost and income" more frequently, Denver employed more egalitarian language (e.g. "equity" and "access," in addition to "cost"). San Jose currently has equity-centric policies in place and thus, equity is featured less within the plan. Denver, on the other hand,

is working to implement such policies and has made equity a larger focus within the plan.

Charging

San Jose and Denver list increasing charging infrastructure as one of their four main priorities. Given the inequities in forcing consumers to rely on residential chargers, San Jose is adopting a more consumer-centric approach to installing chargers. Through the $14 million "California Electric Vehicle Infrastructure Project (CALeVIP), the city is expanding its public and multi-family residential charging network. The plan estimates that by ICCT projections, the city will need 4091 charging ports by 2022 and 5496 by 2025. In addition, San Jose is working directly with disadvantaged communities to identify ideal locations for more chargers. The city is also leveraging existing partnerships with companies (e.g. Pacific Gas and Electric (PG&E), Volkswagen) to promote public charging. The PG&E Electric Vehicle Charger Network program, for instance, is installing 112 charging ports at five city locations. Denver, however, is mostly aiming to increase the number of chargers by building and strengthening partnerships with charger providers (e.g. Xcel Energy) and other businesses. The details about the number and location of chargers from these installation initiatives have not been thoroughly discussed in the plan.

Fleets

Recent advancements in electric vehicle technology have made the electrification of company or government-owned fleets possible. These initiatives can be highly impactful in two key ways. Firstly, the environmental return on investment is far greater for convincing an organization to electrify their vehicle fleet compared to convincing individual owners. Secondly, the electrification of public and private vehicles plays a meaningful role in advertising and normalizing electric mobility. Witnessing the adoption of electric vehicles at all levels is key for the public to trust the technology and have a greater awareness of it.

For bus fleets, San Jose is working with San Jose Mineta International Airport to electrify its airport shuttle buses and the Valley Transportation Authority (VTA) buses that provide transportation to low-income neighborhoods. The city also has more ambitious aims of electrifying and expanding its rail lines (i.e. the Caltrain by 2040). Future efforts will include transitioning the city's non-police sedans, urban freight vehicles, and eventually private fleets (e.g. Uber, Zipcar). However, further connections, planning, and charging infrastructure are required to make these projects successful. Denver, given its fewer partnerships, is concentrating mainly on its city fleets and passed an EV-First Fleet Policy, which encourages replacing city-owned vehicles with electric. Future efforts also include conducting "targeted outreach campaigns" to form partnerships with companies. The comparison between the two cities

suggests that accessible charging networks and reliable partnerships are prerequisites for successfully electrifying private fleets.

The word cloud analysis matched these findings and indicated that San Jose frequently used "public" and "private" compared to Denver, which mainly used "public." This corroborates the notion that while both cities are striving for public fleet electrification, San Jose is placing a greater emphasis on private fleets than Denver. Furthermore, the higher incidence of the words "resources" and "needed" in the Denver plan (from the frequently used label "Resources & partners needed") highlights the lack in partnerships between the city and companies.

Awareness

In the San Jose action plan, Dr. Ken Kurani and Dr. Scott Hardman from the University of California at Davis' Institute of Transportation Studies propose four overarching guidelines for increasing electric vehicle awareness: (i) "inform... through social media," (ii) provide "hands-on exposure," (iii) "incorporate… into shared and rental vehicle services," and (iv) create "automobile dealer education and motivation programs" (The City of San Jose, 2020). Within these guidelines, San Jose is channeling their efforts under (ii) through "ride and drive" events that allow the public to experience and inquire about electric vehicles and (iv) by working with dealerships to provide education and sales incentive programs. For low and moderate-income consumers, the city plans on developing programs to assist consumers. Denver, with fewer resources, is prioritizing (i), through informative websites, campaigns for city employees, and educational resources for K-12 schools. The ICCT paper indicates that Denver is also organizing city outreach events in low-income communities.

Discussion

In this section, the areas of focus previously highlighted will be discussed with respect to each stage of city development. Our categorization system for development consists of five levels: (i) Rural, (ii) Town, (iii) City (e.g. Denver), (iv) Advanced City (e.g. San Jose), and (v) Future City. Since data was acquired only from cities of Levels 3 and 4, further research is necessary to establish more Level 1 and 2 guidelines.

Level 1: Rural

The main barriers to electric vehicle adoption are most prevalent in rural areas. Thus, these regions will likely be the final and most difficult areas to electrify. Nonetheless, there are two key trends to consider. For electric vehicles to become popular in these areas, they must appeal to rural consumers, who hold different needs and preferences than most electric vehicle users now. The first step in developing effective promotion policies is to research the area and its population. In doing so, local governments can start to understand the specific hurdles that need to be

overcome for electric vehicles to take root there. Regardless, rural area adoption will likely increase over time, as the growing electric market begins featuring more suitable vehicles for rural consumers.

Level 2: Town

Towns can vary greatly in people and development (for example, industrial vs. college towns). Thus, the main assumptions for this stage are that basic research has been conducted on the town and/or the population has demonstrated interest in electric vehicles. This interest could be present through adoption from a few residents or through relevant discussion in local governments. Where these assumptions are met, further efforts may include using past data to establish goals and an action plan for the area, which ideally address the most significant barriers for uptake first (i.e. cost, charging accessibility, awareness).

Level 3: City

These urbanized areas are characterized by having electric vehicle goals and action plans in effect, even if they are under-developed. Cities (i.e. Denver) also demonstrate a primary objective of boosting electric vehicle use. To confront the barrier of purchasing costs, city and state governments tend to provide incentives and subsidies for consumers and even producers. Because of the lack of accessible charging ports, cities tend to strongly prioritize increasing the number of stations, station charging speed, and public accessibility to permits. More developed Level 3 cities strive towards electrifying public city fleets and forging partnerships with companies for eventually reaching private fleets as the city approaches Level 4. While the word cloud analysis validated this focus on public fleets over private fleets for Denver as a Level 3 city, it is necessary that further research is conducted to determine the applicability of this word cloud trend for other electric vehicle action plans. To supplement this, public awareness can also be boosted through informative campaigns for electric vehicle benefits and incentives.

Level 4: Advanced City

"Advanced cities" can be characterized by large populations, significant urbanization, and a strong history of electric vehicle promotion efforts. In the U.S., only a few major California cities fulfill this role (e.g. San Jose, San Francisco, Los Angeles, San Diego). Level 4 cities must use their momentum with electric vehicle policy as they venture into and define Level 5. First, Level 4 cities ought to continue expanding their electric vehicle cost-reduction programs observed in Level 3. For charging infrastructure, these cities have the resources and insight to be strategic with charger speed and placement throughout the city. This is often accompanied by more targeted awareness efforts, such as electric vehicle "ride and drive" public events and school and dealership education programs.

Beyond increasing electric vehicle use, Level 4 cities also focus on providing alternate electric transportation and disincentivizing the use of single-passenger, gasoline-powered cars. To accomplish this, cities at this stage must leverage their existing partnerships with companies to focus on private fleet electrification in addition to the ongoing efforts with public fleets. The immense resources of private companies are necessary for cities to have a meaningful impact on emissions.

Level 5: Future City

The label "Future" signifies two ideas. First, I assume that the higher development of Level 5 cities would derive from more widespread electric vehicle access, infrastructure, awareness, and adoption—rather than further urbanization. Second, since San Jose is considered Level 4 and has the highest adoption rate, there are currently no U.S. cities that have attained Level 5 development. Thus, the two Level 5 city characteristics mentioned below are predictions for the trajectory of advanced electric vehicle promotion efforts.

First, Level 5 cities must largely focus on making electric vehicles and transportation more accessible for disadvantaged groups. Though this emphasis on equity may be observed in cities of earlier stages (i.e. Denver), the transition beyond Level 4 cities demands improving electric vehicle access to all socioeconomic groups. This can be achieved through tiered or targeted incentives that most reduce electric vehicle costs for low-income individuals. Cities can also introduce alternative forms of incentives, such as parking benefits or HOV lane access for consumers and manufacturing incentives for producers (previously implemented in California). Additionally, cities in Level 5 must continue to strengthen ties with companies to set and meet more ambitious charger installation and fleet electrification goals. As the development stage increases, cities need to exercise greater influence in the private sector through partnerships with more influential companies and conduct larger-scale projects.

Conclusion

For modeling technological adoption among the public, researchers often defer to the Rogers curve for product diffusion (Barkenbus, 2020). In this model, the first 2-3% of the population to adopt the technology are labeled as "Innovators"—those who are more receptive to experimenting with new products. This initial phase of adoption is critical since "Innovators" play an important role in advertising products to their communities. Through word of mouth, social media access, and influence within smaller organizations, this initial group holds significant influence in pitching a product to the wider population. The U.S. now stands at this critical stage for the adoption of electric vehicles. The actions taken by U.S. cities in the coming years will define the success of the country in mitigating emissions. To facilitate these efforts, I proposed a framework of best practices for promoting electric vehicle adoption among U.S. cities, based

on city development. It was evident from our findings that, within the four areas of focus I identified, communities of all stages of development must mobilize to electrify the transportation sector. Only through collective action to promote electric vehicles will the U.S.—and the world—have a chance at succeeding in the fight against climate change.

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