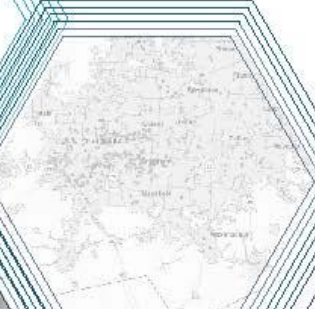


Transportation Policies to Facilitate Electric Vehicle Adoption at the Local Government Level: A Preliminary Study

Ankur Jain, Ph.D.



FINAL REPORT

TRANSPORTATION POLICIES TO FACILITATE ELECTRIC VEHICLE ADOPTION AT THE LOCAL GOVERNMENT LEVEL: A PRELIMINARY STUDY

FINAL PROJECT REPORT

by

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Sponsorship

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16. Abstract The American auto industry is in the midst of a revolution in electric vehicle (EV) technology. While market penetration of EVs is still fairly modest at present, continuing advances in battery materials and charging technology will arguably increase the number of EVs in use going forward. Since EVs require a unique charging infrastructure, the role of local governments in ensuring it is available to EV users is critical. Many local governments have begun using their regulatory and economic powers to encourage EV usage and to prepare homes and commercial buildings for the charging infrastructure necessary to support EV-based transportation. While other studies have examined the technology of EVs and their charging infrastructure, this study stands apart by investigating how large American cities have used the policy process to prepare themselves for broader EV usage over the long term. The study centers on a questionnaire sent to policy leaders in the nation's largest cities, and investigates issues of building codes, city-utility relations, tax incentives for EV users, and social equity. Responses were analyzed to develop an understanding of the most common and most influential policies that were perceived by respondents as having been the most effective at advancing EV adoption and supportive infrastructure in recent years. Findings suggest cities are either not preparing for EVs at all, or are preparing in a very substantive and tech-savvy manner. Policymakers also highlight key areas of needed focus, and also lay out ways in which regulators and electricity providers can aid in EV adoption.			
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1. Introduction

Vehicular technologies in the United States are in the midst of a torrent of new ideas and new systems, particularly in the realm of alternative fuels and electrification. Alternative Fuel Vehicles (AFVs), which are generally powered by ethanol, hydrogen, or compressed natural gas, as well as Electric Vehicles (EVs) that must be plugged in to the electrical grid in order to recharge, have boomed in popularity among American consumers over the past two decades. This growth in demand has been fueled by a host of personal and practical factors, ranging from a personal desire to reduce emissions, to federal and state tax incentives for purchasing such vehicles. Figure 1 shows the dramatic increase in EV sales in the US since 2011 (Edison Electric Institute, 2019). This rapid growth in EVs on American roads is expected to continue in the future (Electric Vehicle Outlook, 2019).

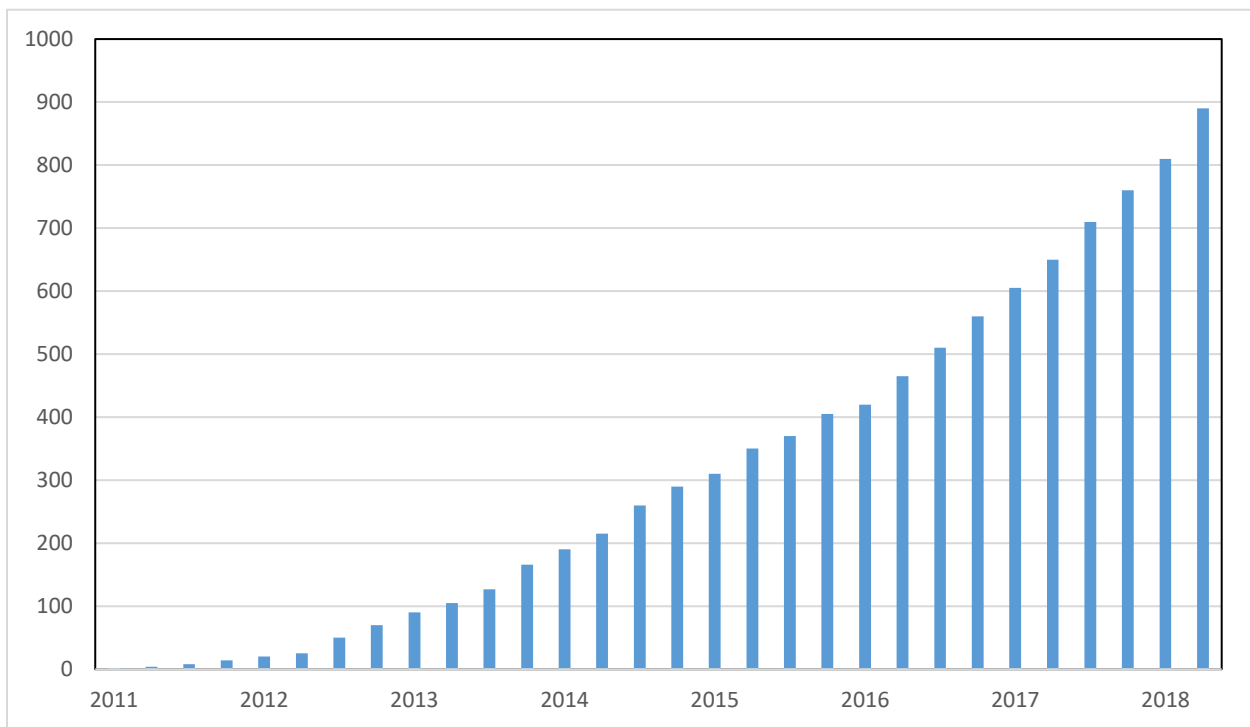


Figure 1: U.S. EV Sales per Quarter (in thousands of units sold)

At the same time, however, the physical infrastructure that accommodates the personal automobile in American cities has arguably not kept pace with the growing demand for these vehicles, particularly EVs. The in-situ electrical equipment required to recharge EVs has yet to be installed in many American parking lots, leaving EV owners to charge their vehicles at home – provided they reside in a structure with the necessary electrical infrastructure installed. These critical issues have a significant and direct impact on the adoption and usage of EVs by consumers on American roadways, and it remains unclear the degree to which local governments can (and do) address these issues through the regulatory process. As the author will assert here, local

governments have the explicit power to set and monitor land-use regulations, vehicle parking lot standards, and the rules governing the placement of critical infrastructure including electrical systems. Thus, the case can be made that a local government can influence, through action or inaction, the wider adoption and usage of EVs by its residents and taxpayers. The critical role that local governments will play in ensuring successful adoption of EVs, with all its associated environmental and sustainability benefits, cannot be over-emphasized.

The growth of EVs as a segment of the American vehicle market has already compelled urban planners and policymakers to reconsider the existing ecosystem of fueling stations, parking lots, and municipal electrical infrastructure. For example, a gasoline-powered vehicle is fueled at a separate location from where it is usually parked, whereas an EV can be refueled/recharged while parked. Two core needs of the vehicle (fuel and a place to park when not in use) are thus combined for EVs. However, knowledge gaps remain among both practitioners and scholars. Studies have explored EV adoption factors among American consumers (Soltani-Sobh et al, 2017; Kim et al, 2019) and the optimal models for constructing EV charging infrastructure (Dong et al, 2014; Davidov and Pantos, 2017). However, little attention has been paid in the literature to the specific actions local governments can take to promote EV adoption and charging within their boundaries. In addition, studies that examine the government-EV relationship through a regulatory or policy lens are also lacking in the literature of both transportation planning and public policy. An exploration of this relationship – how it functions, how the parties inform one another, and its various outcomes for the broader public – is thus badly needed for this growing body of literature. This study undertakes such an exploration, using a chiefly qualitative approach to understand not merely what American cities are doing to prepare their physical infrastructure for EV usage, but also what factors are driving their decision to build (or not build) such infrastructure.

This study explores and compares the various methods by which several large American cities have sought to prepare their communities and physical infrastructure to service a growing number of EVs. Previous studies, such as the one completed by Gomez et al (2011), have attempted to illustrate the complex network of regulators, consumers, and physical infrastructure involved in city-dwellers using EVs, but most are technical in tone and centered on innovations to make EVs easier to charge and cheaper to own. The policy perspectives, and the regulatory frameworks necessary to influence long-range building code changes that might more easily accommodate EV charging systems, remain missing. The literature also has little information on the public sector's internal attitudes toward EV adoption, and the degree to which planners' views on the environment and technology might influence their job performance as regulators of both transportation and infrastructure assets in the community. This study sheds light on all of these aforementioned gaps by exploring attitudes as well as regulatory frameworks related to EVs. The findings are useful to planners, energy providers, developers, and EV manufacturers, all of whom may seek to better understand and formalize the local government's role in ensuring our cities are prepared for the full extent of EV adoption predicted to occur in the coming decades.

2. Literature Review

The literature surrounding EV charging technology and adoption by consumers can readily be divided into a few distinct streams, three of which are relevant for this piece. The first stream is the robust and technically-centered literature on the technology of EV charging. Studies on the subject have evolved from general overviews a decade ago (Morrow et al, 2008; Botsford and Szczepanek, 2009) to detailed evaluations of specific technologies and delivery platforms (Budhia et al, 2011; Zheng et al, 2014). The focus of much of this research has been in improving the performance of charging technology, ostensibly for the benefit of manufacturers and the convenience of consumers (who might then become more likely to purchase an EV). This stream of literature, while at times dense with patents and equations, is essential for our shared understanding of what EV charging systems require and what the manufacturers are capable of implementing as the machinery continues to mature.

The second relevant stream of literature focuses on the planning and siting of EV charging stations. While this subset of studies moves somewhat away from technical analyses and more into questions of land use and community access, it lacks the policy focus necessary to truly understand all dimensions of this issue. Studies in this area have thus far focused on the optimal placement of EV charging stations based on electrical grid capacity (Liu et al, 2012; Zheng et al, 2013) or “environmental and economic sensitivity” (Guo and Zhao, 2015). But investigations into the government’s role in planning for EV charging stations remain scarce. The research team feels it is vital for the growth of the EV literature to better link these efficiency-focused studies to a better understanding of the decision-making processes in Western infrastructure planning, to better encapsulate how factors such as energy efficiency and carrying capacity mesh with issues of local politics and long-range regional planning.

The third stream of EV literature, which helps to close the loop with the other two, centers on examining and evaluating the various government incentives and regulations offered by the public sector to boost EV usage by consumers. Of the three streams, this one is the least technical and the most socially-focused, dominated by questions of economics, environmental justice, and public policy. It is also the stream with the least amount of published academic study behind it. The critical role of public policy on EV adoption has been recognized in the context of US (Greene, 2014) and Europe (Tsang, et al., 2012). Most literature in this direction, however, focuses on the role of the federal government in facilitating EV adoption through tax rebates and other federal interventions. A summary of several studies in this direction has been presented (Zhou, et al., 2016). Specifically, federal tax credits have been shown to play a key role in encouraging EV adoption (Clinton, 2014; Jin, et al., 2014). The role of other, non-federal financial incentives such as longer loan terms and securitization has been discussed (Dougherty and Nigro, 2014).

The research team contends that there is indeed a vital role for local governments in encouraging (or at least allowing for) the charging infrastructure necessary in urban areas to

facilitate EV adoption by residents and public agencies. Urban planners and regulators are in a unique position to address the physical and regulatory barriers that make it difficult in many places to charge an EV, and they are also arguably in the position to set and enact policies that advance goals of environmental sustainability, cleaner air, and broader consumer choice. By exploring the policies and practices of EV readiness set forth by many of America's largest cities, the research team aimed to contribute to a beachhead of scholarly knowledge regarding how local governments are preparing cities and the built environment for a growing number of EVs adopted by consumers and businesses.

3. Methodology

This project addressed a sequence of three research questions: First, how have large American cities encouraged the adoption of EVs through regulatory or economic means? Second, how have those efforts been enacted and received over time? And third, what best practices and broader policy lessons can be drawn from these cities' experiences in regulating and promoting the usage of EVs?

The author sought to investigate policies and their impacts in the nation's largest cities by population based on their assertion that larger cities would be reasonably more likely to have both the political incentive and financial means to promote EV usage through formal policy. In order to capture a nationally-relevant sampling of EV policies and regulations, the author developed a questionnaire on EV issues and sent it to the 125 largest American cities by population (according to 2017 Census Bureau data). The questionnaire was aimed specifically at city planners, transportation officials, sustainability officers, municipal utility directors, and anyone at the local level with firsthand knowledge of their city's experiences, needs, and capabilities with regard to electric vehicle adoption, charging, and usage. Contact information for city leaders was obtained from city websites. In some cases, when direct contact information was not available, the departments of Communications or Public Information or equivalent were contacted, which, in some cases were able to route our request to the right city leaders. Multiple reminders were sent out in order to boost the response rate. Topics covered in the questionnaire included the specifics of a city's policies regarding EVs, local efforts to build and manage charging infrastructure, financial incentives offered to EV consumers, and the political lessons learned by each city's experiences in the realm of adapting policies to better serve the needs of EVs and their drivers.

Responses to the questionnaire were analyzed using a form of axial coding, with particular attention paid to text indicating long-term reforms to infrastructure, policy, or the management of transportation services. The study's research questions focused on policy changes over time, so the author focused on those responses that described either a long-range policy action being established in the present or a present-day outcome of a years-active policy regarding EVs and their supporting infrastructure. The unit of analysis is thus the policies themselves and their outcomes (where documented by respondents). The coding process generated numerous findings

of notes, and they are explored in the following section. These findings showcase several recurring trends in the landscape of EV adoption and infrastructure adaptation in American cities, and each provides a clear indication of where major U.S. cities are in terms of infrastructure preparedness and the political/regulatory appetite for deeper adaptation.

4. Results

Of the 125 questionnaires sent to major American cities, a total of 31 were returned to the research team, indicating a response rate of roughly 25%, which the research team found acceptable for the purposes of this study. Responses were submitted from cities across the mainland United States, with no specific pattern of geographic or size clustering. The team also found wide variety in response length and detail among the 31 participants. Some responding officials went into generous detail about the numerous programs and policies their communities are offering in the realm of EV adoption and adaptation, while others were vague or downright flip in their answers to the questionnaire. Still, several solid recurring themes emerged from the dataset, and the lessons derived from those themes inform the bulk of this section.

Cities' EV Policies Vary Widely, Ranging from Dense Regulations to No Regulation at All

The questionnaire's first question, and arguably the most foundational component, centered on what kind of policies related to EV adoption and usage are present in respondents' local government. Roughly a quarter of respondents indicated their city had no written policies regarding EVs, and had no plans to draft them in the near future. Among respondents whose cities did have active EV policies on the books, the specifics varied considerably from place to place. Many city governments have internal policies to prioritize the purchase of EVs and hybrids for city vehicle fleets, while other cities address the issue of EV charging infrastructure by mandating and/or subsidizing the installation of charging infrastructure in public places and residential developments. For example, the City of Seattle has an expansive plan for EV adoption and infrastructure, with over 300 charging stations throughout the region and detailed requirements for all new parking stalls and residential driveways to be built to "EV-ready" specifications. By contrast, cities such as St. Louis, Missouri and Pittsburgh, Pennsylvania have no master plan for EV adoption, but the city governments do purchase EVs and AFVs as a matter of internal policy. At the far end of the regulatory spectrum are cities with no policies related to EVs or AFVs at all, such as Arlington, Texas and Mesa, Arizona. While the team expected to find a broad range of city policies regarding EV adoption and infrastructure – indeed, the purpose of a national-scale questionnaire was precisely to capture this diversity of policies – it remains notable for its potential to inform the broader discussion over the relationship between municipal EV policies and those vehicles' usage in American cities.

City Efforts Rely Heavily on Internal Fleet Policies Rather than Construction Regulations

Related to the first finding, the team found the EV policies in the responding cities to be notably centered around internal policies for city vehicle purchases rather than broader or more intensive regulations regarding construction or municipal infrastructure. Fifteen of the 31 respondents indicated their cities had policies in place to prioritize the purchase of EVs and AFVs for city fleets. By contrast, only eight respondents (most of whom are also in the prior group of EV purchasers) stated their communities have enacted any building codes or construction regulations to require EV charging infrastructure in parking areas. Salt Lake City, for example, requires all new construction to incorporate EV-ready electrical infrastructure so that charging stations can quickly be added at a later date. Denver has a similar building code in force, with a particular emphasis on multifamily residential construction being ready for EV charging stations in the future. This apparent focus on internal policies, which are arguably easier to set and manage than long-range construction codes and regulations, was noted by the research team and will be explored in greater depth later in this document.

Cities View EV Infrastructure as the Purview of Utility Companies, but Remain Supportive

The questionnaire did not ask specifically about cities' relations with their electric utility providers, but a number of responses described those relations in detail. In many cases, respondents discussed EV charging infrastructure as being provided (built, operated, and in many cases funded) directly by private-sector utility companies operating in the region. Because electricity in many of these cities is purchased from private companies, city officials contend that the government's role in matching EV users with suitable electrical infrastructure is limited. Electricity to charge EVs is sold at market rates (or occasionally at a city-negotiated discount) directly to the owners of those vehicles. In Kansas City, Missouri, the city has no set of policies governing EV adoption or charging, but officials have worked with the local utility provider (Kansas City Power & Light) to eventually install 1,000 EV charging stations throughout the city. Attitudes toward utility providers as leaders of installing EV infrastructure are generally optimistic and supportive in this set of responses. In cities such as Raleigh, North Carolina, and Phoenix, Arizona, city officials are working with utilities to help manage the demand for EV charging on the electrical grid, encouraging consumers to charge vehicles during off-peak hours. An official with the City of Santa Clarita, California pointed out that EV owners seeking to recharge their vehicle batteries may ultimately find themselves at the economic mercy of private utility companies that may or may not switch to a dynamic-pricing model as demand for EV-scale electricity rises in Southern California. The electrical infrastructure needed to supply power to EV charging stations is generally quite expensive and complex to install, thus giving city governments reason to allow private utility firms to bear those costs and to recoup the investment directly from the consumers of the energy.

City Officials Are Aware of the Costs of EV Infrastructure, Have Ideas for Innovations

Related to the previous point, respondents in several cases noted the costs of EV infrastructure and defended their cities' inaction on EV issues in economic terms – for example, by claiming bike-ped infrastructure was both cheaper and better utilized by the public than any EV infrastructure would be. The questionnaire also gave respondents the opportunity to recommend areas of future innovation and research focus at the intersection of EV technology, infrastructure, and public policy. Respondents provided an extensive list of ideas, ranging from questions about fast-charging batteries for EVs to the exploration of socioeconomic factors such as shared-use EV networks and next-generation mechanical training for blue-collar workers. Several respondents also urged the team to conduct deeper policy-oriented research into lowering the costs of installing and operating EV infrastructure, while at the same time showcasing financial incentives for potential buyers. A consensus emerged on this issue among respondents, namely that the environmental case for EV adoption has already been made for consumers and elected officials, but the economics of EVs have not been readily studied or publicized.

Respondents View State/Federal Tax Incentives as Essential to Broader EV Adoption

Tied to the issue of economics is the matter of tax incentives for the purchase of EVs, ostensibly offered to reduce the cost of an EV for consumers. As of 2019, the United States federal government offers a tax credit of between \$2,500 and \$7,500 per new EV purchased in the U.S. The specific tax credit varies based on the vehicle purchased. In addition, several individual states offer supplemental tax credits and additional non-financial incentives (such as waived inspections and complimentary access to carpool lanes) to consumers purchasing an EV. These tax incentives can significantly reduce the initial costs of purchasing an EV, and are thus a visible and powerful tool in advancing EV adoption nationwide. The questionnaire asked respondents what state or federal policies would help the most in increasing EV usage in their city, and virtually all respondents mentioned the tax credit system as integral to achieving that goal. In many cases, respondents made the case for increasing the tax credit across the board, or boosting the credit for lower-income buyers specifically. Others argued for increasing the state and federal gasoline tax with the twin goals of raising short-term capital to fund EV infrastructure and tax credits alongside a long-term goal of reducing demand for gasoline-powered vehicles over time. Respondents also made the case for adding new incentives to help developers and homeowners reduce the costs of installing EV infrastructure on their property and prepare more “racetrack” conduit for future EV usage. Respondents here saw a clear and robust role for state and federal governments, and perceived the main power of those governments to be that of financial heft and consumer-friendly tax incentives to grow demand for EVs over time.

Respondents List a Range of Obstacles to Broader EV Adoption, but Have Solutions in Mind

In describing what they perceive as the greatest obstacles to broader EV adoption in their cities, respondents listed several specific factors that engineers and policymakers have the power

to investigate and address over time. Common factors include battery capacity (the time an EV can operate between charging events), electrical grid improvements (so EVs can be charged more rapidly and in more locations), affordability (particularly for lower-income city-dwellers), and a broader catalog of electric vehicles. Several respondents expressed a desire to see electrically-powered utility trucks, emergency service vehicles, taxis, and transit vehicles, rather than just personal automobiles. To address these, respondents recommend specific fixes from a technical as well as a policy perspective. To put more electric-powered service vehicles on the road, a few respondents suggested broadening the federal grant programs used by cities to purchase fire engines and transit vehicles to more explicitly cover electric versions of those vehicles, which would optimally spur development of cheaper and more effective versions going forward. For lower-income residents, city employees recommend a mix of incentives and a shared-use model of EVs. This latter idea was particularly popular among respondents. Improving battery capacity and charging station availability would aid the public image of EVs and reduce discrete demand during charging events, but would also address a concept that emerged repeatedly throughout the questionnaires: “Range anxiety.” This concept, loosely defined, refers to the tendency of some EV drivers to underestimate their EV’s remaining electric charge while driving. This supposed anxiety is said to lead many EV drivers to plug in their vehicle for charging long before it truly needs it, which several respondents claimed is ultimately an unnecessary drain on the electrical grid and something that must be overcome through education and/or direct financial costs that compel EV drivers not to recharge their vehicles until they truly need it. The range of obstacles listed in the questionnaire responses, and the depth of participants’ thinking on the issue, reflects a growing technical and policy understanding of EVs in American cities. The research team did not expect such a deep knowledge of EVs among local government employees, and found the suggested policy solutions a welcome addition to this analysis.

5. Discussion

These findings indicate a broad diversity of policy with regard to EV adoption and infrastructure in American cities. By allowing each respondent to describe not only their community’s EV-related policies but also the origins and outcomes of them, the research team was able to capture the broader story of how these communities are grappling with the changes related to EV usage by consumers, businesses, and government agencies. While this study did not incorporate an element of policy evolution or time-series progression simply because of how nascent this technology is, it is evident from the analysis that many of these policymakers are already conceptualizing the future of EVs on their own streets, with or without any broader guidance from industry or elected officials. Planners and policymakers (at least in the cities where EV policies have been proposed or enacted) seem to the team to be committed to the long-range goals of EV adoption. Their questionnaire responses often rely on long-term language, and one gets the distinct impression of two forces at work: First, that many policymakers are aware of EVs’ present novelty and slow adoption, and second, that these officials are willing to wait a long time for EVs to become widespread enough to justify their cities’ investments on EV-related

infrastructure. The questionnaire gave respondents the opportunity to expound on what they wish their city had done earlier with regard to electrical infrastructure for transportation, and well over half of the respondents clearly stated a wish that their city government had installed this infrastructure sooner, as it might have spurred quicker adoption of EVs by area consumers. The author was intrigued by this optimism among policymakers, and was also surprised to observe the technical knowledge of respondents, many of whom wrote with clarity about specific technical components of EV mechanics and charging.

The author recommends deeper study into the economics of EV adoption and infrastructure, both from a government perspective (for example, incentives and public charging infrastructure) as well as from a consumer perspective (for example, questions of how lower-income families might have access to EV technology, as well as EV owners' willingness to pay for electricity to charge their vehicles). As electric vehicles mature and become more mainstream in the coming decade, it is recommended to analyze how transportation policies in major US cities have evolved over time in response.

Given the slow rise of EV adoption among American consumers, as well as the uneven ways in which major American cities are adding EV infrastructure, it remains unclear just how influential city-level policies can be on EV adoption by consumers and businesses living in those cities. This study documented several ways in which individual governments are advancing political and environmental goals through EV infrastructure and incentives, but deeper study is needed regarding the degree to which an EV-supportive (or an EV-skeptical) city government influences residents to buy an EV rather than an AFV or gasoline-powered automobile. Still, the study remains highly relevant to those seeking to understand local governments' preparations and regulations for EV infrastructure. It also represents a colorful glance into how many communities are working with utility providers, tax regulators, and the building-code process to prepare their cities for a wider national adoption of EV technology that, in their eyes, is soon to come.

6. Conclusions and Future Research Directions

The results presented in this study represent one examination of the state of EV adoption and infrastructure policies in America's largest cities as of 2019. While a number of questionnaires were completed by representatives of dozens of cities, much work remains to be done in truly capturing the spirit and scope of EV-related local government actions. This is arguably pressing, given the rate at which policies will need to adapt to coming changes. The expected growth in EV usage among American consumers is sure to be a key motivator in reforming the nation's building codes, electrical infrastructure, parking regulations, and financial incentives packages for vehicle purchase. EVs as an enduring component of American automobility is a relatively young concept, and regulations and building codes on the subject will arguably take time to mature.

The EV literature, in all its streams and technical or policy directions, is growing but still largely unwritten. A tremendous amount of additional study is needed in order to fully flesh out the various angles and issues of this topic area. This study constitutes one small contribution to that broader goal. In the course of analyzing questionnaire responses and cataloging ideas for future research, the research team documented a few key concepts ripe for deeper study at a later point, and these are presented here for the benefit of other scholars. The team also wishes to point out that many of the boldest research ideas came directly from the audience of practitioners. First and most pressing is the need for deeper technical study into the time and usage aspects of EV charging systems. For example, innovators must work toward fast-charging technology, so that EVs can be recharged more expeditiously in public places. At the same time, social scientists must do more to investigate and ameliorate the concept of “range anxiety” among EV users, given its potential to add needless strain to the electrical grid. Many city officials also expressed a desire to see more research and creativity in the area of electrically-powered service vehicles, such as fire engines and delivery trucks. Given those vehicles’ size, expense, and capacity to pollute with diesel engines, efforts to electrify those vehicle fleets will arguably lead to cleaner air in the same way EVs for personal autos would. One final area of deeper research recommended by this study is that of EV accessibility for lower-income consumers. Several respondents described the concept of an “EV carshare” program as being ideal in this situation, as it would likely require far less financial investment on the part of individual drivers than buying a single EV. Studying and implementing such a concept would be a complex undertaking from a research perspective, and a scholar wishing to do so would likely have to work directly on a pilot project involving a local government as well as a manufacturer of EVs. Still, the potential for a shared pool of EVs for on-demand transportation is a captivating idea to reduce the ownership costs of EVs while also providing vulnerable populations with a zero-emission means of transportation.

The author also encourages the scientific community and the nation’s urban policymakers to continue to work together in order to develop flexible best practices that can be adapted to virtually any cityscape contending with EV adoption. The author anticipates a greater degree of friction (chiefly motivated by financial concerns) between cities and utility providers with regard to EV charging infrastructure. As it stands, many of the cities investigated in this study rely on utility companies to provide energy for charging at virtually no cost to the consumer. As more and more EVs enter the nation’s roadways, and demand for this “free” electricity grows, both cities and utility providers will be faced with the dilemma of how best to set a reasonable price for an energy source that formerly cost EV drivers nothing. There must also be more explicit and detailed guidelines on universal building codes for EV infrastructure in the construction industry. While only a handful of places in the US require newly-constructed dwellings to have EV-ready electrical infrastructure in place, the sooner the nation’s homebuilders can develop safe and affordable best practices for installation and maintenance of such infrastructure, the easier it will be to adapt structures in other parts of the nation at a later date. As interest in EVs continues to grow in

American cities, the literature on the subject will no doubt mature and diversify, and the author looks forward to ways in which new knowledge can contribute to a cleaner transportation system.

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