CONSUMER ADOPTION OF ELECTRIC VEHICLES

AN EVALUATION OF LOCAL PROGRAMS IN THE UNITED STATES

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Master's Project
School for Environment and Sustainability
University of Michigan
April 2022

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Abstract

While transportation electrification is critically important for reducing greenhouse gas emissions, light duty electric vehicle adoption by individuals is still very low in the United States. The Biden administration has begun taking major actions to support the electric vehicle transition, particularly through the Infrastructure Investment and Jobs Act, and many state governments have also taken actions like offering electric vehicle purchase rebates and providing funding for charging infrastructure. Less is known about actions being taken to advance electric vehicle adoption on the local level, as municipal government EV programs have historically been a patchwork of uncoordinated efforts. This study is aimed at understanding local electric vehicle adoption programs, including the types of actions that they use and the demographic and geographic characteristics of municipalities with electric vehicle programs. The study involved examining a random sample of more than 2,000 municipalities of all sizes from all 50 states and documenting any electric vehicle-related actions; these actions were then analyzed qualitatively using a codebook of common electric vehicle adoption actions in the categories of infrastructure, policy, financial incentives, information and outreach, and equity. Additionally, a sample of 30 investor-owned utilities was analyzed to understand how utilities support consumer electric vehicle adoption. The results of this research include a report, an interactive map of local-level electric vehicle programs, and a searchable database containing the codebook, the sampled municipalities and utilities, and descriptions of all of the electric vehicle actions identified. The goals of this research are to create a better understanding of the measures taken to support consumer electric vehicle adoption at the local level and to ultimately accelerate the nationwide transition to electric vehicles.

Acknowledgements

We would like to acknowledge and sincerely thank our advisors, Professor Michael Moore of the University of Michigan School for Environment and Sustainability and Dr. Dana Jackman of the U.S. Environmental Protection Agency Office of Transportation and Air Quality. This study was made possible by your support, feedback, excellent ideas, and thoughtful questions. It has been wonderful to work with and learn from you both during the course of this project.

We would also like to thank our family and friends for their support throughout the research process and for allowing us to share the interesting things that we learned along the way.

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INTRODUCTION

Consumer Adoption of Electric Vehicles

Electrification of transportation systems is imperative for reducing greenhouse gas emissions, but consumer adoption of electric vehicles is still very low in the United States. Electric vehicles make up less than 1% of passenger vehicles in the United States,[1] and although the electric vehicle market is growing rapidly, it may still take several decades to advance electric vehicles beyond their current marginal position on American roads. Infrastructure and affordability are major obstacles slowing adoption, particularly for rural and low-income communities. Charging stations are not broadly available in all regions and are frequently located only in high-income and densely-populated areas.[2] Electric vehicle prices are falling and there have been efforts at increasing affordability through rebates and incentives, but electric vehicles are generally still inaccessible to lower-income drivers.[3]

Research on existing electric vehicle adoption programs and policies can inform policymakers and public and private sector institutions about ways to accelerate electric vehicle adoption. Although state-level programs and city-level programs in the largest American cities have been studied extensively, there have been no comprehensive reviews, to our knowledge, of electric vehicle adoption programs at the local level. This research on local-level programs can be used to inform policymakers, make policies and programs more effective, and advance electric vehicle adoption and equity.

[1] Feilding Cage, "The long road to electric cars," Reuters, February 7, 2022.
[2] Abby Brown et al., "Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: Second Quarter 2020," *National Renewable Energy Laboratory*, January 2021.
[3] Gordon Bauer, Chih-Wei Hsu, and Nic Lutsey, "When might lower-income drivers benefit from electric vehicles? Quantifying the economic equity implications of electric vehicle adoption," *International Council on Clean Transportation*, February 2021, 17.

Background

Electric vehicles have begun to gain a foothold in American minds and markets in recent years, with more than half of Americans expressing a probable or definite intention to buy an electric vehicle in the next ten years.[4] Electric vehicle sales jumped 72% year-over-year to reach a record 4.5% of sales in the final quarter of 2021.[5] There has been a surge in electric vehicle interest in early 2022 due in part to geopolitical events and high gas prices, with March 2022 setting a record for Google searches about electric vehicles.[6] However, electric vehicle adoption is still progressing more slowly than is necessary to meet greenhouse gas emissions reduction goals. Based on 2022 industry projections, about half of U.S. vehicles will be electric by 2050,[7] but in order to stay on track with the Paris Accord goals, 90% of U.S. vehicles must be electric by 2050.[8] Light-duty vehicles produce 59% of greenhouse gas emissions for the transportation sector in the U.S. and approximately 16.5% of U.S. greenhouse gas emissions overall.[9] Thus, electrification is a top concern for policymakers committed to climate mitigation.[10]

Electric vehicles produce no tailpipe emissions, which includes pollutants such as nitrogen oxide, carbon monoxide, and particulate matter. This has major benefits for local air quality and public health, especially for low-income communities and communities of color that have been significantly and disproportionately affected by vehicular air pollution.[11] A caveat to this is that there are almost certainly some upstream greenhouse gas emissions and other air pollutants produced in the process of generating electricity to

[4] Nathan Bomey, "Are electric vehicles poised to kill the gasoline engine car? Welcome to the 'golden age' of EVs," USA Today, March 11, 2021.
[5] "Electric Vehicle Sales Hit New Record in Fourth Quarter of 2021, According to New Kelley Blue Book Report," Kelley Blue Book, January 28, 2022.
[6] Maggie Astor, "As Gas Prices Went Up, So Did the Hunt for Electric Vehicles," The New York Times, April 8, 2022.
[7] Feilding Cage, "The long road to electric cars," Reuters, February 7, 2022.
[8] Alexandre Milovanoff, I. Daniel Posen, and Heather L. MacLean, "Electrification of light-duty vehicle fleet alone will not meet mitigation targets," *Nature Climate Change* 10, (2020).
[9] Fast Facts on Transportations Greenhouse Gas Emissions," Environmental Protection Agency, 2018.
[10] Benjamin Leard and Virginia McConnell, "Progress and Potential for Electric Vehicles to Reduce Carbon Emissions," *Resources for the Future*, December 2020.
[11] Maria Cecilia Pinto de Moura and David Reichmuth, "Inequitable Exposure to Air Pollution from Vehicles in the Northeast and Mid-Atlantic," *Union of Concerned Scientists*, June 2019.

power electric vehicles. However, the amount of emissions and pollutants differs depending on the electricity sources used in a given grid, and the EPA has found that electric vehicles typically have a smaller carbon footprint than gasoline-powered vehicles, even when accounting for manufacturing and the emissions from the electricity used to charge them.[12]

The transition to electric vehicles involves complex behavioral considerations related to the purchase and ownership of electric vehicles. For example, "consumers who have purchased PEVs [Plug-in Electric Vehicles] express a different prioritization of their reasons for acquisition than buyers of traditionally-fueled vehicles."[13] Top reasons for purchasing electric vehicles, in order of importance, include fuel cost savings, contribution to the achievement of environmental and energy goals, policy incentives, vehicle performance, and advanced technology.[14]

Electric vehicles are a relatively new technology, so people are still forming opinions about them through the process of translation, or the "negotiation of a new product's perceived benefits and meanings in a social context."[15] Common reasons for avoiding electric vehicles are cost, unfamiliarity with technology, range anxiety, lack of knowledge of electric vehicle benefits, political values and social image, and concerns about safety and dependability.[16] Addressing these concerns about electric vehicles may thus be a goal of many education and outreach efforts.

Shifting consumer behavior related to electric vehicles may become less important in the near future, as some state governments have passed or considered legislation to ban the sale of new gas-powered vehicles entirely

[12] "Electric Vehicle Myths," U.S. Environmental Protection Agency.
[13] Margaret Taylor and K. Sydny Fujita, "Consumer Behavior and the Plug-In Electric Vehicle Purchase Decision Process: A Research Synthesis," *Ernest Orlando Lawrence Berkeley National Laboratory*, January 2018, 50.
[14] Ibid.
[15] John Axsen, Caroline Orlebar, and Stephen Skippon, "Social influence and consumer preference formation for pro-environmental technology: The case of a U.K. workplace electric-vehicle study," *Ecological Economics* 95, (2013).
[16] Margaret Taylor and K. Sydny Fujita, "Consumer Behavior and the Plug-In Electric Vehicle Purchase Decision Process: A Research Synthesis," 37.

in the next two decades.[17] Likewise, several automakers have announced plans to phase out the production of gas-powered vehicles on a similar timeline, if not sooner.[18] However, the true impact of such commitments is uncertain, and the Biden administration has not announced any commitment to institute a national ban on gas-powered vehicles.[19] Only 17 million new passenger vehicles are sold in the United States each year, so even a national ban on the sale of gas-powered vehicles would not immediately remove these vehicles from American roads.[20] Thus, policies and programs aimed at incentivizing voluntary adoption of electric vehicles will continue to be of importance.

On average across the United States, electric vehicle charging infrastructure is being built rapidly, to the point that it is surpassing demand.[21] However, this infrastructure is not distributed evenly across regions of the country or, on a lower level, across cities and neighborhoods. For example, California contains 31.7% of all public charging infrastructure in the United States, while large regions like the South have relatively little infrastructure.[22] Urban areas have seen more infrastructure development than rural areas,[23] but development is uneven within urban areas, too. Infrastructure has generally been built to meet current need, not potential need, meaning it tends to be built in areas where electric vehicle adoption is already high.[24] Not all infrastructure is accessible to all electric vehicle drivers, as some chargers are private and available only for residents or employees of the institutions where the chargers are located. Even public charging infrastructure is sometimes restricted; 54.9% of public DC fast charging stations are owned by Tesla and thus only accessible to Tesla owners.[25]

[17] David Shepardson, "U.S. transport chief not endorsing banning gas-vehicles after 2035," Reuters, March 25, 2021.
[18] Ibid.
[19] Ibid.
[20] Feilding Cage, "The long road to electric cars," Reuters, February 7, 2022.
[21] Abby Brown et al., "Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: Second Quarter 2020," *National Renewable Energy Laboratory*, January 2021, 20.
[22] Ibid, 12.
[23] Benjamin Leard and Virginia McConnell, "Progress and Potential for Electric Vehicles to Reduce Carbon Emissions," 6.
[24] Anh Bui, Peter Slowik, and Nic Lutsey, "Update on electric vehicle adoption across U.S. cities," *International Council on Clean Transportation*, August 2020, 18.
[25] Abby Brown et al., "Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: Second Quarter 2020," 20.

Notably, more than 80% of electric vehicle charging is done at home, whether that is a single-family home or multi-family housing like an apartment building.[26] Installing a home charger typically requires an initial investment of $1,000-$2,500 for the equipment and installation costs,[27] and making the decision to install a charger is generally out of the control of those who rent homes or rent a unit in multi-family housing. Homeowners are far more likely to own electric vehicles than renters, even when controlling for income,[28] and 36% of Americans are renters,[29] so this is a significant issue for electric vehicle adoption. Some states and cities are working to overcome the homeowner-renter gap[30] through right-of-way charging programs, amending codes to require multifamily properties to install chargers, or giving tenants the authority to install their own chargers through right to charge laws.[31]

In terms of affordability, electric vehicles typically have a purchase price 10-40% higher than similar models of gas-powered vehicles.[32] Lower fuel and maintenance costs mean that electric vehicles may end up being more affordable than gas-powered vehicles in the long run, but the higher purchase price may still be insurmountable or at least discouraging for some consumers. About two-thirds of American households that owned electric vehicles or plug-in hybrids vehicles in 2017 had an annual income higher than $100,000.[33] In addition to prohibitive purchase prices, this income gap could be caused by factors like the targeted marketing of electric vehicles as luxury vehicles and the finding that people may be more likely to buy an electric vehicle if they already own multiple vehicles.[34]

[26] "Charging at Home," U.S. Department of Energy Office of Energy Efficiency and Renewable Energy.
[27] "The True Cost of Powering an Electric Car," Edmunds, March 29, 2022.
[28] Lucas W. Davis, "Evidence of a homeowner-renter gap for electric vehicles," *Applied Economic Letters* 26, no. 11 (2019): 929.
[29] "Electric Vehicle Charging Access for Renters: A Guide to Questions, Strategies, and Possible Next Steps," *Urban Sustainability Directors Network*, November 2020, 2.
[30] Ibid.
[31] Shannon Osaka, "Think apartment-hunting is frustrating? Try doing it with an electric car," Grist, December 20, 2021.
[32] Benjamin Preston, "EVs Offer Big Savings Over Traditional Gas-Powered Cars," Consumer Reports, October 8, 2020.
[33] Feilding Cage, "The long road to electric cars," Reuters, February 7, 2022.
[34] Scott Hardman and Gil Tal, "Understanding discontinuance among California's electric vehicle owners," *Nature Energy* 6, (2021): 538.

It is currently predicted that electric vehicles will achieve price parity with gas-powered vehicles by 2025, but this has historically been a moving target.[35] In comparison, it is anticipated that electric vehicles won't reach price parity with the average vehicle purchased by a low-income household until 2029.[36] Federal and state programs offer tax incentives and point-of-sale rebates, but this varies greatly depending on the state and typically applies only to the purchase of new vehicles. The used car market for electric vehicles is still small and underdeveloped, which presents another barrier to adoption for lower-income consumers and for consumers in general.[37] Twenty-eight states also impose registration fees for electric vehicles that are in some cases higher – as much as four times higher[38]– than the gas taxes paid by gas-powered vehicle owners, which may be a disincentive.[39]

The Biden administration has committed to taking major actions to support the electric vehicle transition, including setting a goal of reaching 50% of electric vehicle sale shares by 2030.[40] The Infrastructure Investment and Jobs Act passed in November 2021 includes $5 billion in funding for states to build charging infrastructure, in order to achieve the administration's goal of building a national network of 500,000 chargers by 2030.[41] As there were approximately 50,000 public chargers in the United States in 2022, this massive infrastructure expansion will likely outpace the growth of charging demand in that timeframe.[42] The Department of Energy and the Department of Transportation formed a Joint Office of Energy and Transportation in 2021 to carry out the administration's EV Charging Action Plan.[43]

[35] Dan Gearino, "Inside Clean Energy: How Soon Will An EV Cost the Same as a Gasoline Vehicle? Sooner Than You Think," Inside Climate News, July 30, 2020.
[36] Gordon Bauer, Chih-Wei Hsu, and Nic Lutsey, "When might lower-income drivers benefit from electric vehicles? Quantifying the economic equity implications of electric vehicle adoption," International Council on Clean Transportation, February 2021, 17.
[37] Aarian Marshall, "To Save the Planet, Get More EVs Into Used Car Lots," Wired, October 27, 2020.
[38] Chris Harto and Shannon Baker-Branstetter, "Rising Trend of Punitive Fees on Electric Vehicles Won't Dent State Highway Funding Shortfalls but Will Hurt Consumers," Consumer Reports, 2019.
[39] Kristy Hartman and Laura Shields, "Special Fees on Plug-In Hybrid and Electric Vehicles," National Conference of State Legislatures. October 12, 2021.
[40] "FACT SHEET: The Biden-Harris Electric Vehicle Charging Action Plan," The White House, December 13, 2021.
[41] Ibid.
[42] Feilding Cage, "The long road to electric cars," Reuters, February 7, 2022.
[43] "Federal Funding Programs," U.S. Department of Transportation.

Such federal electric vehicle actions may be planned at a high level, but their actual implementation will occur mainly at the state and local levels. States will each receive a portion of the $5 billion federal investment through the National Electric Vehicle Infrastructure Formula Program and will develop their own implementation plans.[44] There is also $2.5 billion in funding for a grant program on the community level to ensure that charging infrastructure is available in rural areas and disadvantaged communities.[45] Details about this grant program are still forthcoming, but it demonstrates that local-level electric vehicle actions can fill in the gaps left by state and federal programs, especially in communities that have not historically been prioritized or included in electric vehicle adoption efforts.

The context for electric vehicle adoption varies greatly from place to place, even within individual cities and towns, and thus the local level should be studied further in order to support the work municipalities and utilities are doing to advance the electric vehicle transition. Local-level electric vehicle adoption programs can be influential both in the presence and absence of supportive federal and state policies.

Federal-level electric vehicle investments may be carried out locally, especially for charging infrastructure, and state-level funding like the Volkswagen settlement funds is often distributed to municipal governments. When there is an absence of federal or state policy supporting electric vehicle transition, "local actions become more important."[46] Also, programs aimed at advancing electric vehicle equity often operate at the local level in order to best meet the needs of a community, given that "each locale will likely encounter different local obstacles and opportunities for making EVs accessible for all."[47] Thus, local-level programs and actions are highly relevant research subjects in the field of electric vehicle transition.

[44] "Federal Funding Programs," U.S. Department of Transportation.
[45] Ibid.
[46] Anh Bui, Peter Slowik, and Nic Lutsey, "Update on electric vehicle adoption across U.S. cities," 2.
[47] "Electric Vehicles for All: An Equity Toolkit," The Greenlining Institute, 2021.

Research Objectives

Our research focused on local-level actions intended to increase consumer adoption of electric vehicles, in the hope that our findings will assist in the development of future electric vehicle programs by helping to inform local-level officials about the actions taken by other municipalities and electric utilities. Thus, this research was guided by a principle of creating products with the most utility for local governments, power providers, and other institutions.

Through this research project, we aimed to accomplish the following objectives:

- Identify actions that may increase electric vehicle awareness, acceptance, access, and adoption;
- Find and analyze electric vehicle programs and actions occurring at the local level in each state; and
- Create a database of local-level actions and an interactive mapping tool to facilitate increased understanding of local-level electric vehicle adoption programs.

Research Questions

The following research questions guided our research design, analysis, and production of interactive tools:

- What are municipalities and electric utilities across the United States doing to promote and facilitate a transition to electric vehicles?
- Are there statistically significant relationships between municipalities' demographic and geographic characteristics and their action on electric vehicles?
- Which types of actions are most common, and which types of actions have yet to be broadly utilized?
- What types of electric vehicle actions are taken by utilities, and how do they compare with actions taken by municipalities?

RESEARCH METHODS

Consumer Adoption of Electric Vehicles

Codebook Development

Municipal Codebook

We used a literature review to build a codebook of local government actions commonly used or recommended to encourage consumer electric vehicle adoption. The coding technique is used in qualitative analysis to condense data into identifiable topics and to derive patterns from the data. A codebook is a list of codes with definitions, which helps standardize the coding process. We developed the codebook for this project using a review of previous research on electric vehicle adoption actions, particularly the International Council on Clean Transportation's 2020 "Update on electric vehicle adoption across U.S. cities" report[48] and the Greenlining Institute's Electric Vehicles for All Equity Toolkit.[49]

We included only actions that we believed would encourage consumer electric vehicle adoption, which we defined as individuals or families purchasing or leasing a passenger electric vehicle; this means that we excluded actions that were related to municipal fleet electrification (such as municipalities buying electric buses and heavy-duty trucks) or encouraging businesses to electrify their fleets. While these actions are certainly important for transportation electrification and emissions reductions, they do not necessarily relate to consumer electric vehicle adoption and were thus outside the scope of this study.

The items included in the codebook are grouped into five thematic categories: policy; infrastructure; financial; information, outreach, and other; and equity. In the codebook, equity actions are distributed across the four other

[48] Anh Bui, Peter Slowik, and Nic Lutsey, "Update on electric vehicle adoption across U.S. cities," *International Council on Clean Transportation*, August 2020.
[49] "Electric Vehicles for All: An Equity Toolkit," The Greenlining Institute, 2021.

categories and given the signifiers of a different color and the label “EQ.” Table 1 provides some examples of the 48 actions included in the municipal codebook.

Municipal Codebook: Examples of Actions by Category	
Policy	Quantitative electric vehicle goal
	Infrastructure-related policy (examples: zoning ordinances, building codes & requirements)
Infrastructure	Electric vehicle chargers installed
	Performing community mobility needs assessment
Financial	Free or discounted charging at public chargers
	Direct rebate after purchase of electric vehicle
Information, Outreach, and Other	Online informational materials
	Procedural knowledge programs / events (example: ride and drive events)
Equity	Equitable placement of charging infrastructure
	Direct rebate at point of sale of electric vehicle

Table 1: Examples of electric vehicle actions in the municipal codebook

Electric Utility Codebook

Based on this municipality codebook and initial exploratory research on electric vehicle actions taken by utilities, we developed a second codebook for utility electric vehicle programs. These actions followed similar parameters as the municipal actions, in that they were required to be aimed at consumer electric vehicle adoption; actions related to utility fleet electrification or commercial fleet electrification were excluded.

The items included in this codebook are grouped into six thematic categories: planning and partnerships, infrastructure, charging rates and rewards, rebate and financial incentives, information and engagement, and equity. Similar to the municipal codebook, equity actions are distributed across the five other categories and signified by a different color and the label "EQ." Table 2 provides some examples of the 17 actions included in the utility codebook.

Electric Utility Codebook: Examples of Actions by Category	
Planning and Partnerships	Electric vehicle strategic planning
	Partnerships (examples: dealerships, governments, businesses, community organizations, etc.)
Infrastructure	Electric vehicle chargers installed
	Electric vehicle chargers planned
Charging Rates and Rewards	Time of use rates (preferential electricity rates for home charging during certain times of day) (EQ)
	Additional incentives for charging during certain times of day
Rebates and Incentives	Electric vehicle purchase incentive
	Home charger incentive (EQ)
Information and Engagement	Online information, tools, and resources
	Events, outreach, and engagement
Equity	Incentives aimed at low-income populations
	Communication in language of target community

Table 2: Examples of electric vehicle actions in the electric utility codebook. Actions with the (EQ) signifier in this table are equity actions, as are the actions in the equity row.

Municipal Program Review

The municipal program review phase of research involved developing a sampling method for the selection of municipalities, then using online searches to find any electric vehicle actions being carried out by each municipality in the sample. We then added the programs to our database and coded them using the codebook of common electric vehicle actions. Finally, we researched the social-geographical characteristics of each municipality sampled and added this data to the database. The following sections describe this program review process in greater detail.

Sampling Method

In order to acquire a sample of municipalities that was geographically representative of the entire country, we designed a stratified sampling method that divided the 50 states and Puerto Rico into five tiers based on their overall population size. The number of municipalities sampled from a given state could be 20, 30, 40, 50, or 60, depending on which tier the state was in. Each tier has between nine and eleven states, due to some discrepancies in sub-state government structures; the third tier has ten states plus Puerto Rico, and the fourth tier has only nine states due to the omission of Hawaii, which has a county-based structure. Hawaii and Washington, D.C. were included in our sample but lie outside of our sampling system. This sampling system can be seen in Table 3.

Tier	State population range	Number of municipalities sampled	States
1	10+ million	60	California, Texas, Florida, New York, Pennsylvania, Illinois, Ohio, Georgia, North Carolina, Michigan
2	5.8 million - 8.8 million	50	New Jersey, Virginia, Washington, Arizona, Massachusetts, Tennessee, Indiana, Maryland, Missouri, Wisconsin
3	3.2 million - 5.7 million	40	Colorado, Minnesota, South Carolina, Alabama, Louisiana, Kentucky, Oregon, Oklahoma, Connecticut, Utah, Puerto Rico
4	1.4 million - 3.1 million	30	Iowa, Nevada, Arkansas, Mississippi, Kansas, New Mexico, Nebraska, Idaho, West Virginia
5	578,000 - 1.35 million	20	New Hampshire, Maine, Rhode Island, Montana, Delaware, South Dakota, North Dakota, Alaska, Vermont, Wyoming

Table 3: Sampling method for municipal program review. Note: D.C. and Hawaii were sampled differently due to differences in political structure and/or size.

Of the sample for each state, we included the five largest municipalities in each state by population size. By including the five largest municipalities in each state, we expected to cover the municipalities with the most electric vehicle activity. However, most previous studies of local-level electric vehicle actions have been limited to the largest cities in the United States, and we were most interested in filling this gap by analyzing municipalities of all sizes. Thus, for the remainder of each sample beyond the five largest cities, we randomly selected municipalities using the Census Bureau's list of each state's municipalities. For example, Texas' sample includes Austin, Houston,

Dallas, San Antonio, Fort Worth, and 55 randomly selected municipalities.

There were two exceptions to this sampling method, due to variation in sub-state government structures. Hawaii has no formal level of government below the county level, and so the sample for Hawaii consists of five counties. Washington, D.C. is governed by the government of the District of Columbia and has no other municipal governments, so its sample consists of only one municipality.

In total, our sample consisted of 2,016 municipalities across all 50 states, Washington, D.C., and Puerto Rico.

Program Search and Coding

The next step was searching for programs, which typically began with a search of the municipality's website. In addition to using the website's search functions, we examined recent plans related to climate change, sustainability, transportation, or comprehensive planning for any mention of electric vehicles. We also searched municipal codes, ordinances, and other government documents. Then, we conducted general online searches using Google to find any news articles, webpages, or documents we may have missed during our municipal website searches. For municipalities without websites, only the search engine method was used.

We included actions from any year, although it was not always possible to determine the year that an action was taken. Proposed or planned actions were included if they involved the installation of charging infrastructure, as we determined these were the planned actions with the greatest likelihood of coming to fruition. Actions taken in collaboration with other governments,

institutions, and businesses were included, but actions taken within a municipality without involvement of the local government were not included. Finally, we limited our search to actions that could be easily found through online searches, as we were primarily interested in actions that are reasonably accessible to the public.

Any electric vehicle actions found during this search were added to the database. Each entry in the database includes a summary of the actions taken, links to sources of information about the actions, and program characteristics such as the year that action was first taken and funding sources (where information was available). Programs were then coded using the codebook of common municipal electric vehicle actions. It should be noted that an action taken more than once by a municipality (e.g., installing chargers on two separate occasions) was considered to be only one action within the codebook. A link to the database is included in Appendix C.

Municipality Characteristics

Next, we identified certain demographic and geographic characteristics of each sampled municipality, including those without electric vehicle actions. Municipality type was determined based on the Census Bureau's classification. Population size was acquired from the 2020 Census, and population group was determined using the classification system used by the University of Michigan Center for Local, State, and Urban Policy.

Urban-rural classification was determined based on Rural-Urban Commuting Area (RUCA) codes established by the Federal Office of Rural Health Policy, the U.S. Department of Agriculture's Economic Research Service, and the WWAMI Rural Health Research Center at the University of Washington. RUCA codes are based on the size of municipalities and their relationships to other municipalities based on work commuting flows. Thus, it is worth noting that this means some municipalities in our sample could be very small in terms of

Program Search and Coding

Program searches began with a search of the utility's website. Then, we conducted general online searches using Google to find any news articles, webpages, or documents we may have missed.

Any electric vehicle actions or programs found during this search were added to the utility program database. Each entry includes a summary of the actions taken, links to sources of information about the actions, and the states in the utility's service territory. Many IOUs' service territories include multiple states, and in some cases, certain electric vehicle programs or actions did not apply to all states in the service territory. In these cases, the state that the action applied to was denoted in parentheses in the action summary. Finally, programs were coded using the codebook of common utility electric vehicle actions. As with the municipality actions, it should be noted that an action taken more than once by a utility was considered to be only one action within the codebook. A link to the utility database can be found in Appendix C.

Utility Program Review

The utility program review phase of research occurred concurrently with the municipal program review phase but involved different methods. The utility program review involved developing a sampling method, then using online searches to find any electric vehicle actions being carried out by each utility in the sample. We then added the programs to a separate utility programs database and coded them using the codebook of common utility electric vehicle actions.

Sampling Method

The United States contains nearly 3,000 electric distribution companies or utilities, roughly two-thirds of which are publicly-owned utilities at the federal, state, or municipal level.[50] Some of these municipal utilities are represented in our municipal program review, as the actions of a municipal utility are generally coincident with or incorporated in the actions of a municipal government. About 800 utilities are member-owned cooperatives, which often operate in rural areas. While electric cooperatives' actions on electric vehicles certainly warrant attention, we chose to focus on investor-owned utilities (IOUs) because they serve the largest portion of American electricity customers. We randomly selected 30 IOUs from a list of roughly 170 IOUs produced by the Edison Electric Institute. In certain instances, IOUs that were not suitable for this study - either because they had been merged into another IOU on the list or did not provide electric services to residential customers - were replaced in the sample.

[50] "Investor-owned utilities served 72% of U.S. electricity customers in 2017," U.S. Energy Information Administration, August 15, 2019.

Program Search and Coding

Program searches began with a search of the utility's website. Then, we conducted general online searches using Google to find any news articles, webpages, or documents we may have missed.

Any electric vehicle actions or programs found during this search were added to the utility program database. Each entry includes a summary of the actions taken, links to sources of information about the actions, and the states in the utility's service territory. Many IOUs' service territories include multiple states, and in some cases, certain electric vehicle programs or actions did not apply to all states in the service territory. In these cases, the state that the action applied to was denoted in parentheses in the action summary. Finally, programs were coded using the codebook of common utility electric vehicle actions. A link to the utility database can be found in Appendix C.

RESULTS

Consumer Adoption of Electric Vehicles

Municipality Results

The total municipality sample consisted of 2,016 municipalities. Because our sampling method was only semi-random, these findings can not be generalized to the entire country; however, the trends within our sample provide useful insights.

First, we will discuss the demographic and geographic characteristics of all of the municipalities in the sample. Then, we will focus on the municipalities that had at least one electric vehicle action and discuss our findings in the context of two of our research questions:

- Are there statistically significant relationships between municipalities' demographic and geographic characteristics and their action on electric vehicles?

- Which types of actions are most common, and which types of actions have yet to be broadly utilized?

Demographic and Geographic Characteristics

In terms of urban-rural characteristics, about 42.5% of municipalities had a RUCA classification of “Metropolitan area core” and about 15% were classified as “Metropolitan area high commuting.” About 15% were classified as “Rural” and about 9.7% were classified as “Micropolitan area core.” The classification codes with decimals (e.g., 10.1 - Rural) were counted separately but their definitions can be considered synonymous with the non-decimal codes for the purposes of this study. The full breakdown can be found in Table 4.

RUCA Classification	Percent
1 - Metropolitan area core	41.42%
1.1 - Metropolitan area core	1.04%
2 - Metropolitan area high commuting	15.18%
3 - Metropolitan area low commuting	2.18%
4 - Micropolitan area core	9.23%
4.1 - Micropolitan area core	0.45%
5 - Micropolitan area high commuting	4.02%
5.1 - Micropolitan area high commuting	0.05%
6 - Micropolitan area low commuting	1.19%
7 - Small town core	6.05%
7.1 - Small town core	0.45%
7.2 - Small town core	0.20%
8 - Small town high commuting	2.88%
9 - Small town low commuting	0.84%
10 - Rural	12.50%
10.1 - Rural	0.45%
10.2 - Rural	0.79%
10.3 - Rural	0.74%
N/A	0.35%

Table 4: RUCA classification distribution of municipalities sample (n = 2,016)

About 33% of municipalities were in the population group of fewer than 1,500 residents and about 17.5% were between 1,500-5,000 residents; this means that roughly half the municipalities in the sample had fewer than 5,000 residents. This is fairly representative of the country, as 76% of incorporated

places in the United States have fewer than 5,000 residents.[51] About 22.5% of municipalities had greater than 30,000 residents. The full breakdown of population groups can be found in Table 5.

Population Group	Percent
Less than 1,500	33.43%
Between 1,500 and 5,000	17.51%
Between 5,000 and 10,000	10.07%
Between 10,000 and 30,000	16.52%
Greater than 30,000	22.47%

Table 5: Population group distribution of municipalities sample (n = 2,016)

Half of the municipalities in our sample had a Republican outcome in the 2020 presidential election. About 32% of municipalities had a Democrat outcome, leaving about 16% of municipalities either missing or undetermined. It is worth considering that the states for which we were missing some or all political data (Alabama, Alaska, Idaho, Indiana, Kentucky, Louisiana, Missouri, Virginia) were states that voted Republican in 2020, with the exception of Virginia;[52] thus, our sample is likely even more Republican-leaning than we were able to establish with certainty. The political characteristics can be seen in Table 6.

2020 Presidential Election Outcome	Percent
Republican	50.05%
Democrat	31.70%
New Progressive Party	0.99%
Popular Democratic Party	0.99%
Missing	14.58%
Undetermined	1.69%

Table 6: Political distribution of municipalities sample (n = 2,016)

[51] Amel Toukabri and Lauren Medina, "Latest City and Town Population Estimates of the Decade Show Three-Fourths of the Nation's Incorporated Places Have Fewer Than 5,000 People," U.S. Census Bureau, May 21, 2020.
[52] "2020 Electoral College Results," National Archives.

Of the 2,016 municipalities in our sample, 453 municipalities (22.5%) took at least one electric vehicle action, as shown in Figure 1. We found 1,205 total actions, meaning that municipalities with actions took an average of 2.66 actions each. The distribution of these actions across the five categories we established (policy, infrastructure, financial, information/outreach/other, equity) and the most common individual actions will be discussed next.

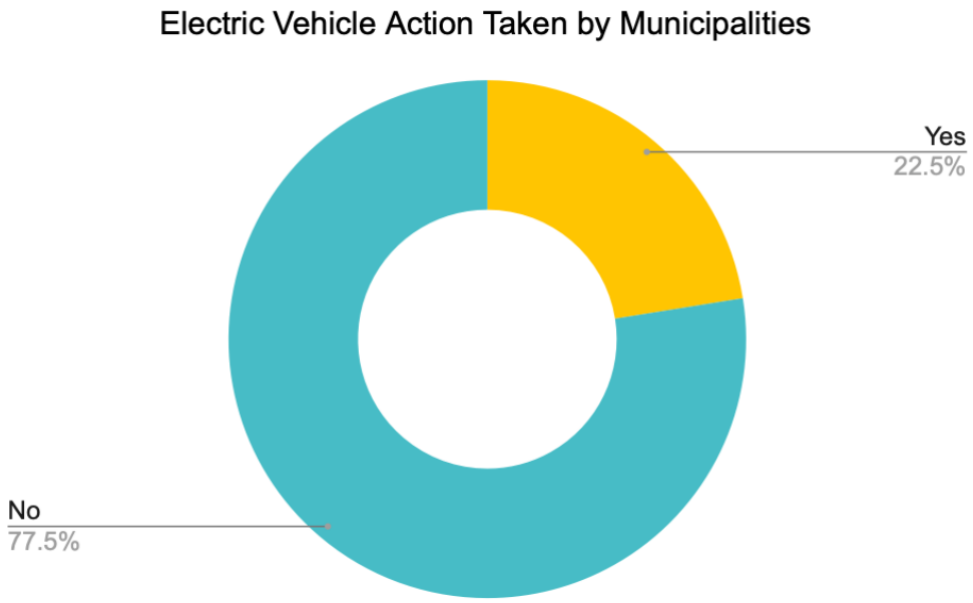


Figure 1: Pie chart showing electric vehicle action by municipalities (n = 2,016)

Are there statistically significant relationships between municipalities' demographic and geographic characteristics and their action on electric vehicles?

We found statistically significant relationships suggesting that municipalities take more electric vehicle actions if they have a larger population size, are more urban, and voted Democrat in 2020.

First, we wanted to know if there was a statistically significant relationship between population size and the number of electric vehicle actions taken by a municipality (including a value of 0 if no actions were taken). For the purpose of this test, we used the municipalities' exact population size rather than population groups. We ran a Pearson's correlation and found a moderate positive relationship between the total number of actions taken by a municipality and its population size (r = 0.50). As population size increases, the number of actions taken increases. There are a few outliers in terms of population size, with the most notable being New York City. This relationship can be seen in Figure 2.

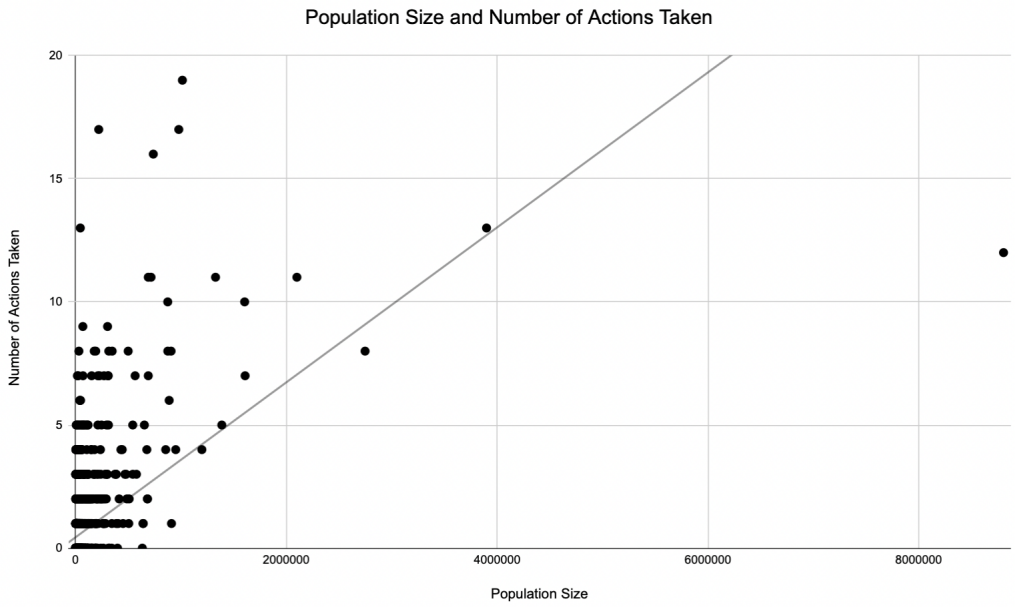


Figure 2: Scatter plot showing the relationship between population size and number of actions taken

Another way of looking at the significance of population size is comparing population groups. Of the 453 municipalities that took at least one electric vehicle action, 60.9% had a population size greater than 30,000. About 20% of municipalities fell between 10,000 and 30,000; 8.8% fell between 5,000 and

10,000; 6.4% fell between 1,500 and 5,000; and 3.5% had a population size less than 1,500. This breakdown can be seen in Figure 3.

It is worth recalling from the population categories in Table 3 that about half of the municipalities in our sample had a population size less than 5,000, but that population group represents only about one-tenth of municipalities with electric vehicle action. Only 22.5% of municipalities in our sample had a population size greater than 30,000, but these municipalities represent more than 60% of those that took electric vehicle action.

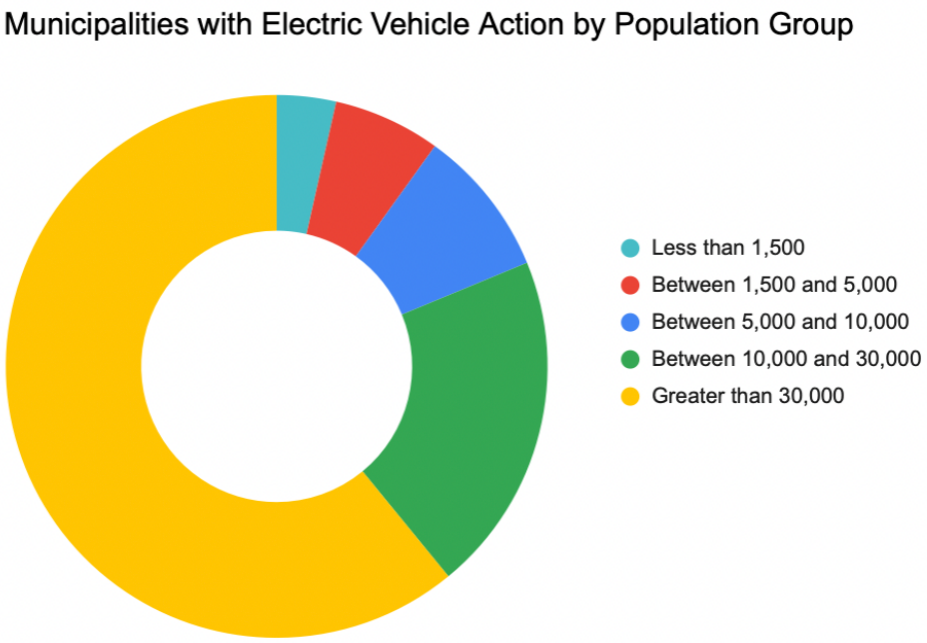


Figure 3: Pie chart showing electric vehicle action taken by population group for municipalities (n = 453)

Next, we wanted to know if there was a relationship between political characteristics and the number of actions taken. We ran a one-way ANOVA and found a statistically significant relationship between 2020 political outcomes and the number of actions taken (p-value < 0.05), meaning that the number of

actions taken by municipalities differs depending on their political outcome. We ran a Tukey multiple comparison of means test and found that Democrat was significantly different than the other outcomes.

About 70% of the 453 municipalities with at least one electric vehicle action had a Democrat outcome in the 2020 presidential election, as can be seen in Figure 4. In contrast, only 22.5% of municipalities had a Republican outcome. The remaining 10% was made up of municipalities with either missing or undetermined political outcomes. The political findings are particularly notable when considering that about half of the sampled municipalities were Republican and about 32% were Democrat, as shown in Table 4; despite making up a smaller portion of the sample, Democrat-leaning municipalities represented the majority of municipalities taking electric vehicle action.

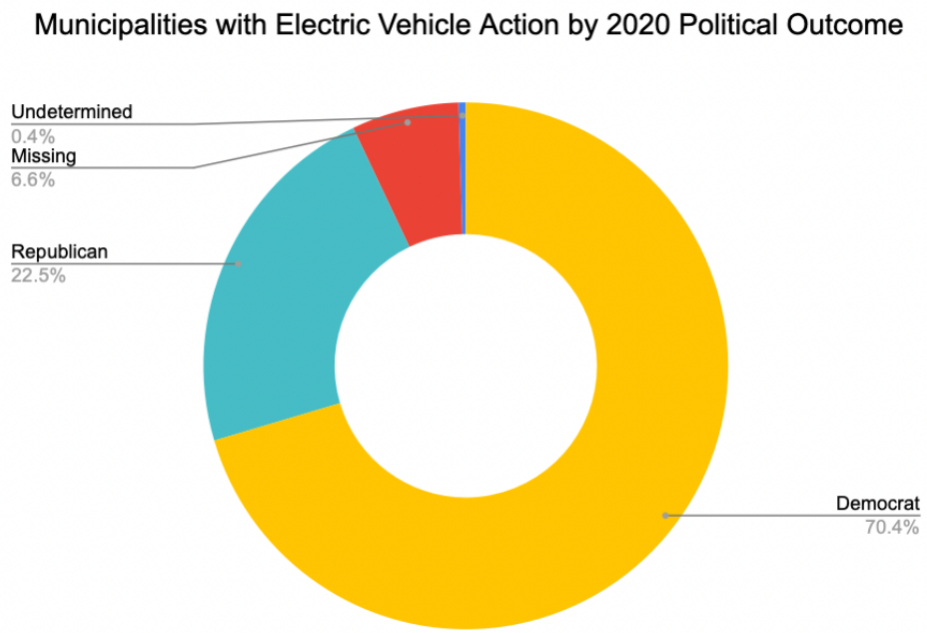


Figure 4: Pie chart showing electric vehicle action taken by 2020 political outcome for municipalities (n = 453)

Finally, we wanted to know if there was a relationship between urban-rural classification and the number of actions taken. We ran a one-way ANOVA and

found a statistically significant relationship between RUCA classification and the number of actions taken, at the level of (p-value <0.05), meaning that the number of actions taken by municipalities differs significantly depending on how urban or rural they are. We ran a Tukey multiple comparison of means test and found that metropolitan area core (code 1) was significantly different than the other outcomes.

The majority (75.5%) of the 453 municipalities with at least one electric vehicle action had a RUCA classification of metropolitan area core, which is the most urban classification. About 83% of municipalities that took electric vehicle action were considered to be in a metropolitan area, meaning they had RUCA codes 1-3. The micropolitan classifications (codes 4-6) represented 9% of municipalities with electric vehicle actions; this was followed by small town (codes 7-9) with 4.3% and rural (codes 10-10.3) with 2.8%. This distribution can be seen in Figure 5. Of the total sample, municipalities with a metropolitan area classification (codes 1-3) made up about 60%, as shown in Table 2. Thus, municipalities with electric vehicle action leaned more urban than the sample as a whole.

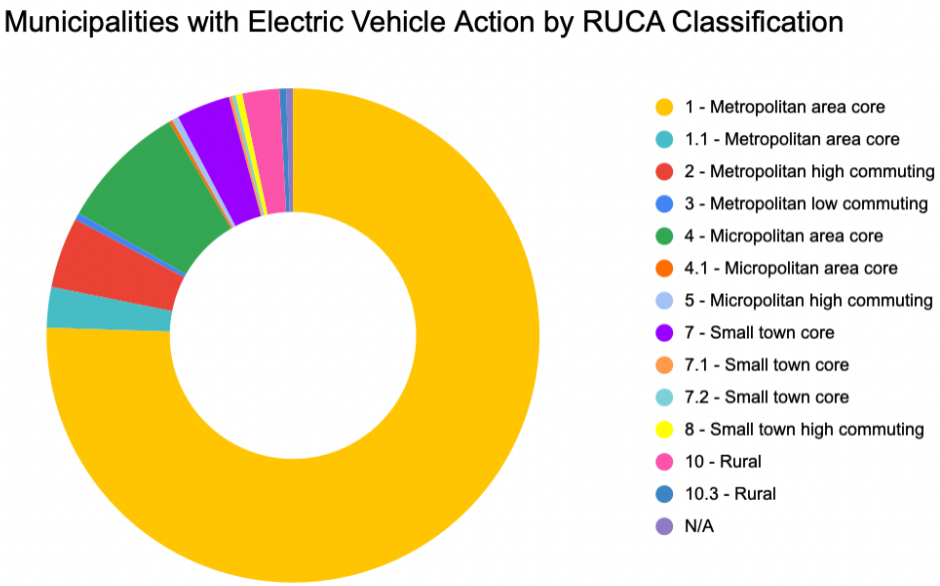


Figure 5: Pie chart showing electric vehicle action taken by population group for municipalities (n = 453)

Which types of actions are most common, and which types of actions have yet to be broadly utilized?

By a wide margin, infrastructure was the category of actions most commonly taken by municipalities. A total of 912 categories was met across the sample of 453 municipalities; this total was reached by adding up all of the categories met by each municipality in the sample. The infrastructure category made up 394 (43%) of the total categories met. To put it differently, 394 of the 453 municipalities (87%) that took action met the infrastructure category. The information, outreach, and other category had the next highest tally, with 42% of municipalities meeting this category. About 26% of municipalities met the policy category and the financial category, while only 21% met the equity category. These results can be seen in Figure 6.

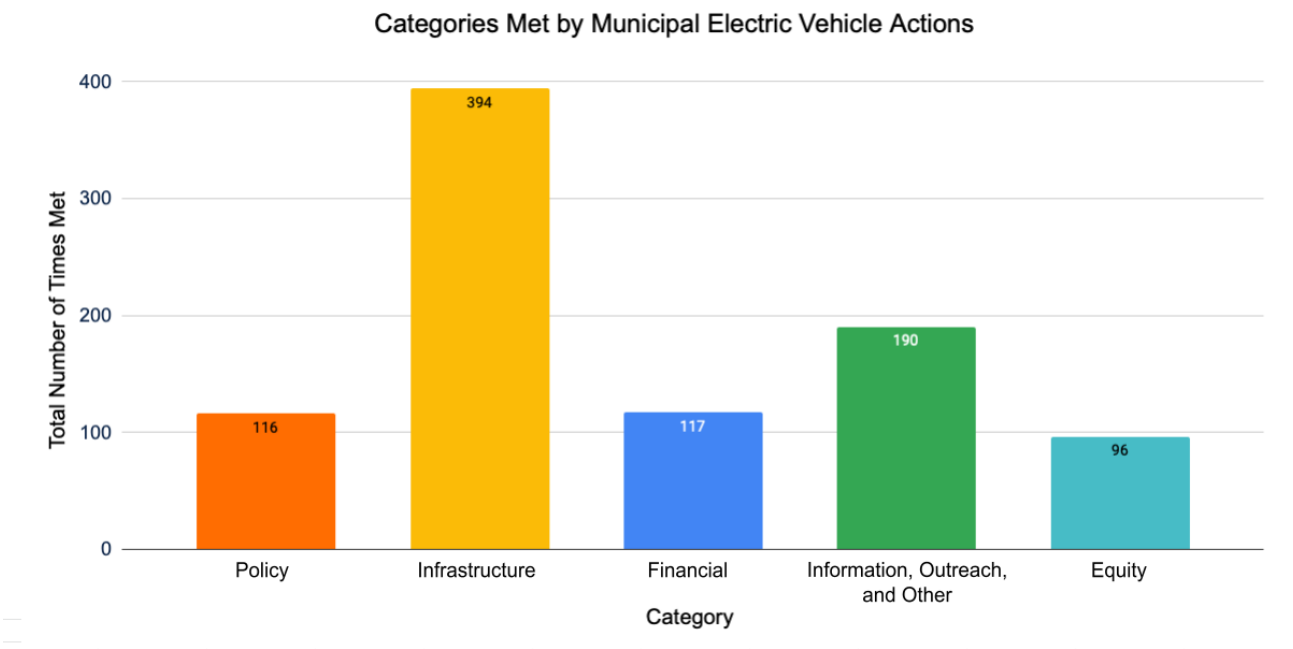


Figure 6: Bar graph showing the number of times each action category was met by municipalities (n = 912)

Perhaps unsurprisingly, the most common individual action by a very large margin was installing a charger. Three-quarters of municipalities that took action installed a charger, which shows that this action is likely the first step taken by municipalities that want to encourage electric vehicle adoption. The next most common action was offering online informational materials, which was done by 31.3% of municipalities. The third most common action was planning to install a charger, which was done by 28.9% of municipalities. Other charging-related actions, such as implementing an infrastructure-related policy (19.9%) or offering free charging (16.1%), were more common than most other actions. It is evident that charging infrastructure is the primary focus of municipalities taking electric vehicle action, which could be due to the emphasis it is given on the federal and state level. Figure 7 shows the frequency with which all 48 electric vehicle actions were taken; Appendix A contains tables with the number of times each action was taken.

The category that was met least frequently by municipalities was equity. Only 21% of municipalities took an action related to equity. Most of the equity-related actions included in the codebook were under the financial category, but the equity-related actions that were taken most commonly were under the policy and infrastructure categories. About 7.5% of municipalities implemented an equity-related policy, and about 7.2% of municipalities ensured that the installation or planned installation of chargers was equitable. Examples of equity actions include instituting right-to-charge laws for renters, targeting financial incentives toward low-income populations, and providing educational materials in the language of a target community.

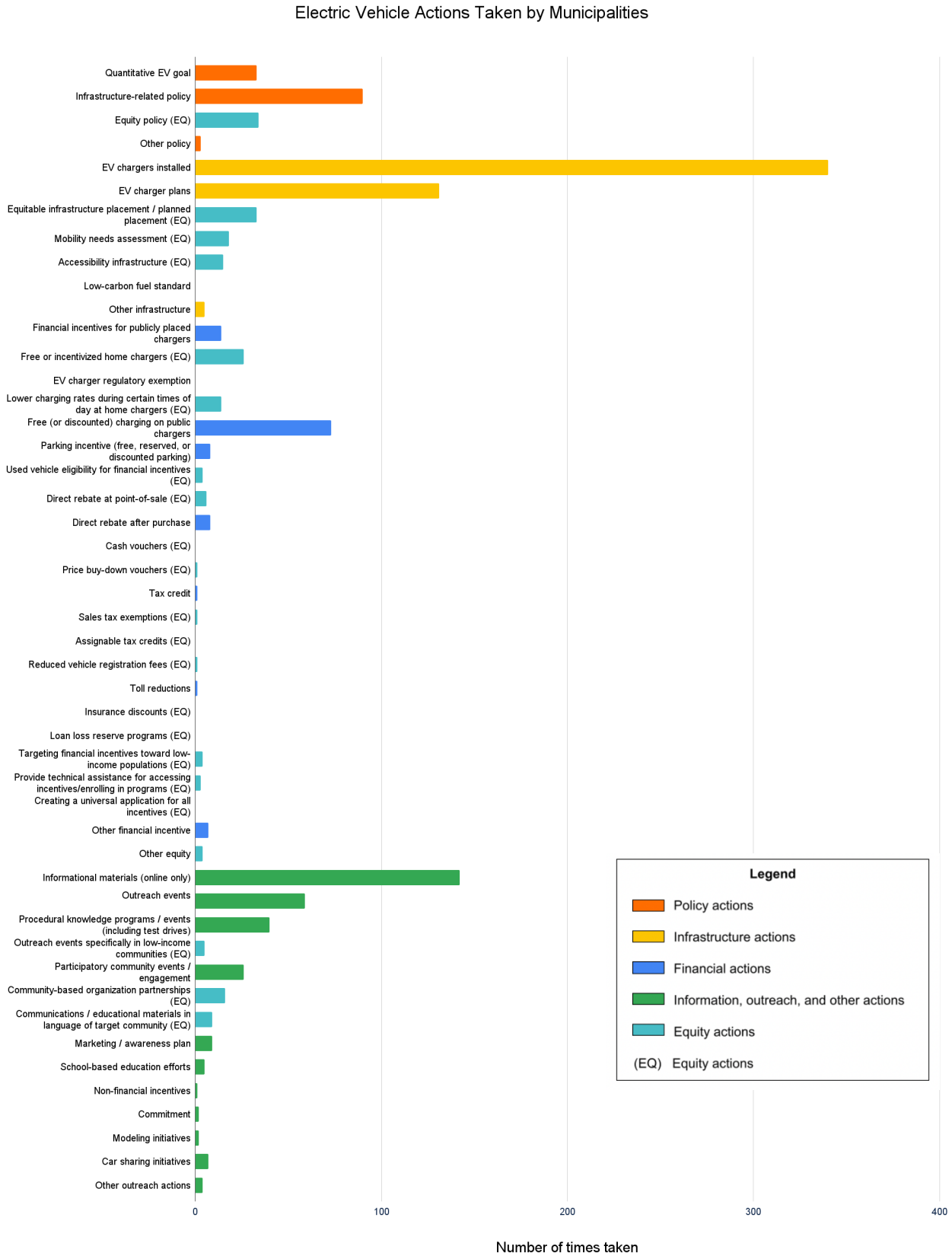


Figure 7: Bar graph showing 48 electric vehicle actions and the frequency with which they were taken

Finally, it is also useful to consider that most municipalities' overall approaches to electric vehicle action were not very complex or varied. Using the number of categories met as a measure of complexity, we can see that the majority of municipalities (44% of the 453 that took action) met only one category of actions. Only about 3.8% of municipalities met all five categories with their electric vehicle actions. Figure 8 depicts this breakdown.

This trend suggests that rather than undertaking comprehensive, multifaceted efforts to encourage consumer electric vehicle adoption, most municipalities are picking a small number of related actions (or just a single action) to take. Possible reasons for this could be a lack of funding, other priorities for the local government, or a lack of knowledge about different ways to encourage electric vehicle adoption.

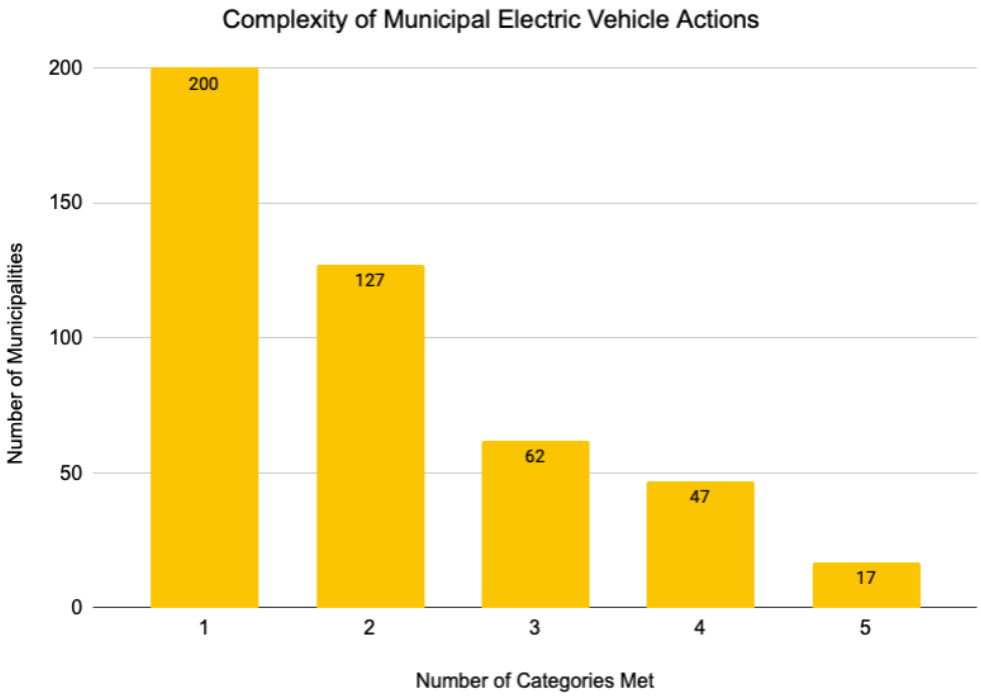


Figure 8: Bar graph showing the number of action categories met by municipalities (n = 453)

Utility Results

The total utility sample consisted of 30 investor-owned utilities. We did not observe any characteristics of these utilities other than the states in their service territories, so the results are mainly oriented around the types of electric vehicle action taken by utilities.

Of the 30 utilities in our sample, 22 utilities (73.3%) took at least one electric vehicle action, as can be seen in Figure 9. There were 144 total electric vehicle actions recorded across the sample, so utilities that took action had an average of 4.8 actions.

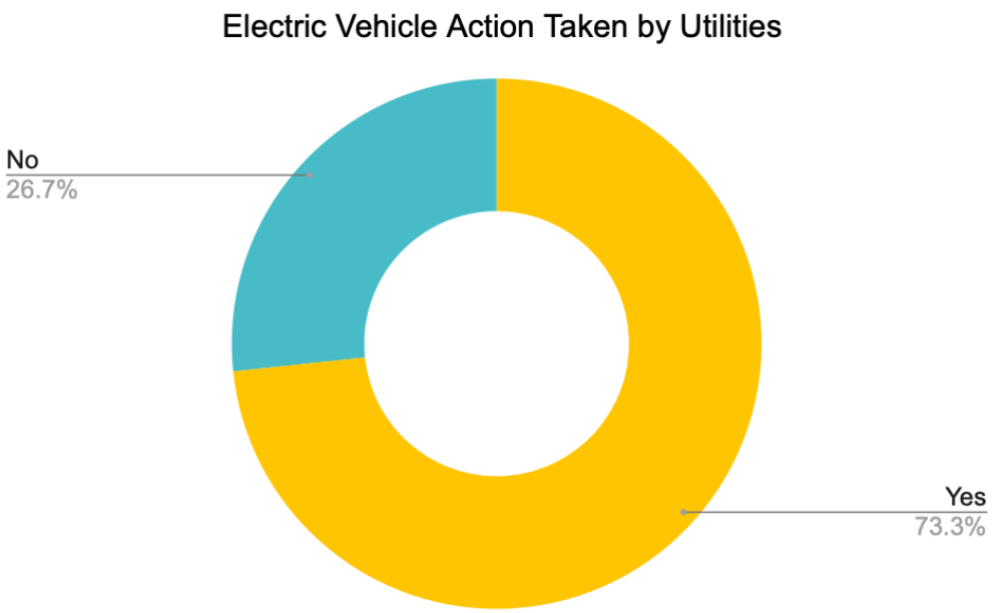


Figure 9: Pie chart showing electric vehicle action taken by utilities (n = 30)

What types of electric vehicle actions are taken by utilities, and how do they compare with actions taken by municipalities?

Utilities met each category of actions a fairly equal number of times, in contrast with the skewed municipality results. The information and engagement category was the most commonly met, with 21 out of 22 utilities taking at least one action in this category. About 82% of utilities that took action met the charging rates and rewards category, and about 77% met the rebates and financial incentives category. Compared to only 21% of municipalities meeting the equity category, about 82% of utilities that took action met the equity category. The planning and partnerships category was met by about 64% of utilities. Interestingly, the category that was met the least by utilities was infrastructure, with only about 45% of utilities meeting this category compared to 87% of municipalities. These results can be seen in Figure 10.

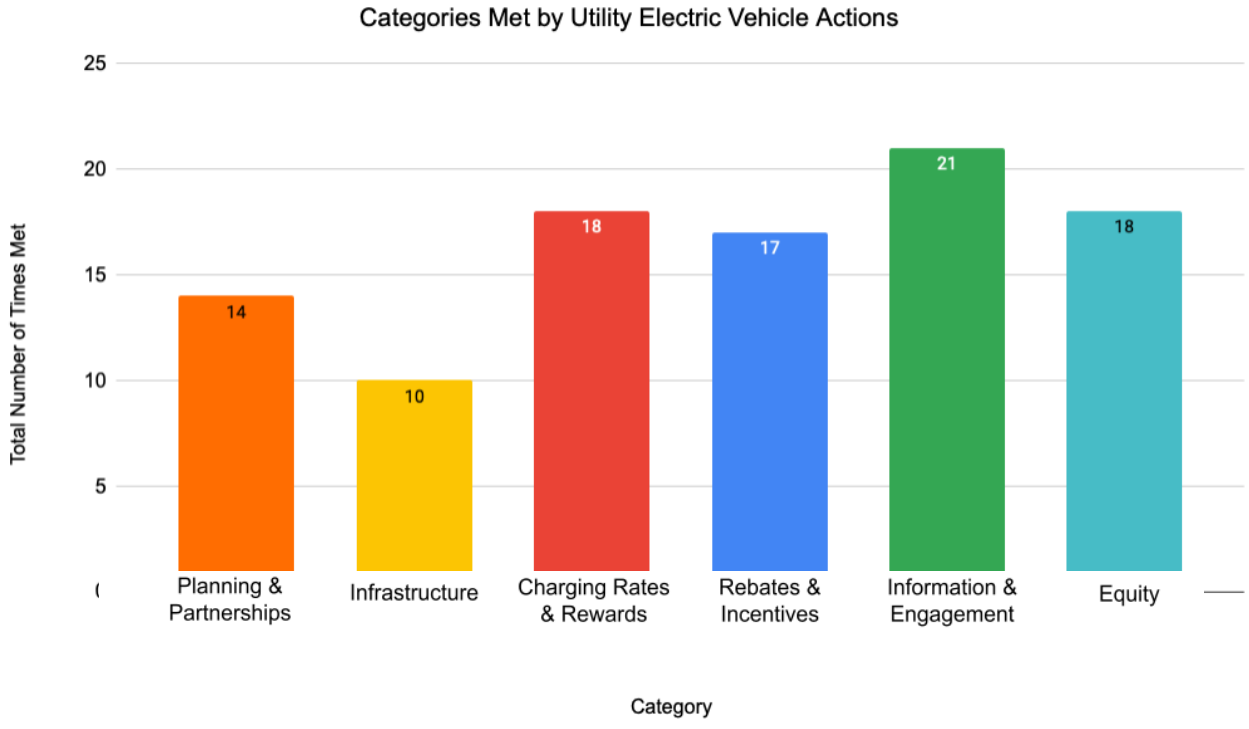


Figure 10: Bar graph showing the number of times each action category was met by utilities (n = 95)

In terms of individual actions, utilities most frequently offered online information and resources, with about 95% of utilities taking this action. Another common action was residential time of use rates, which were offered by 72.7% of the utilities that took action. Offering incentives for charger installation at commercial or multifamily housing (63.6%) and offering home charger rebates (59%) were also popular actions among utilities. These three charging-related actions are considered equity actions because they help increase equitable and affordable access to charging infrastructure. Engaging in partnerships with institutions like governments, businesses, and dealerships was also common, with 59% of utilities taking this action. These results can be seen in Figure 11, and Appendix B contains tables with the number of times each action was taken.

Drawing direct comparisons between the specific actions taken by utilities and municipalities is difficult because they had separate codebooks with different sets of actions. However, for the areas of overlap, it is worth noting that installing chargers was much more common among municipalities, whereas offering online information was much more common among utilities. The lower rate of charger installations among utilities could be because utilities are more likely to support the expansion of charging infrastructure through providing financial support for other institutions that choose to install chargers. Financial actions of all kinds were more common with utilities, which may be because of their greater financial resources and flexibility as corporate entities.

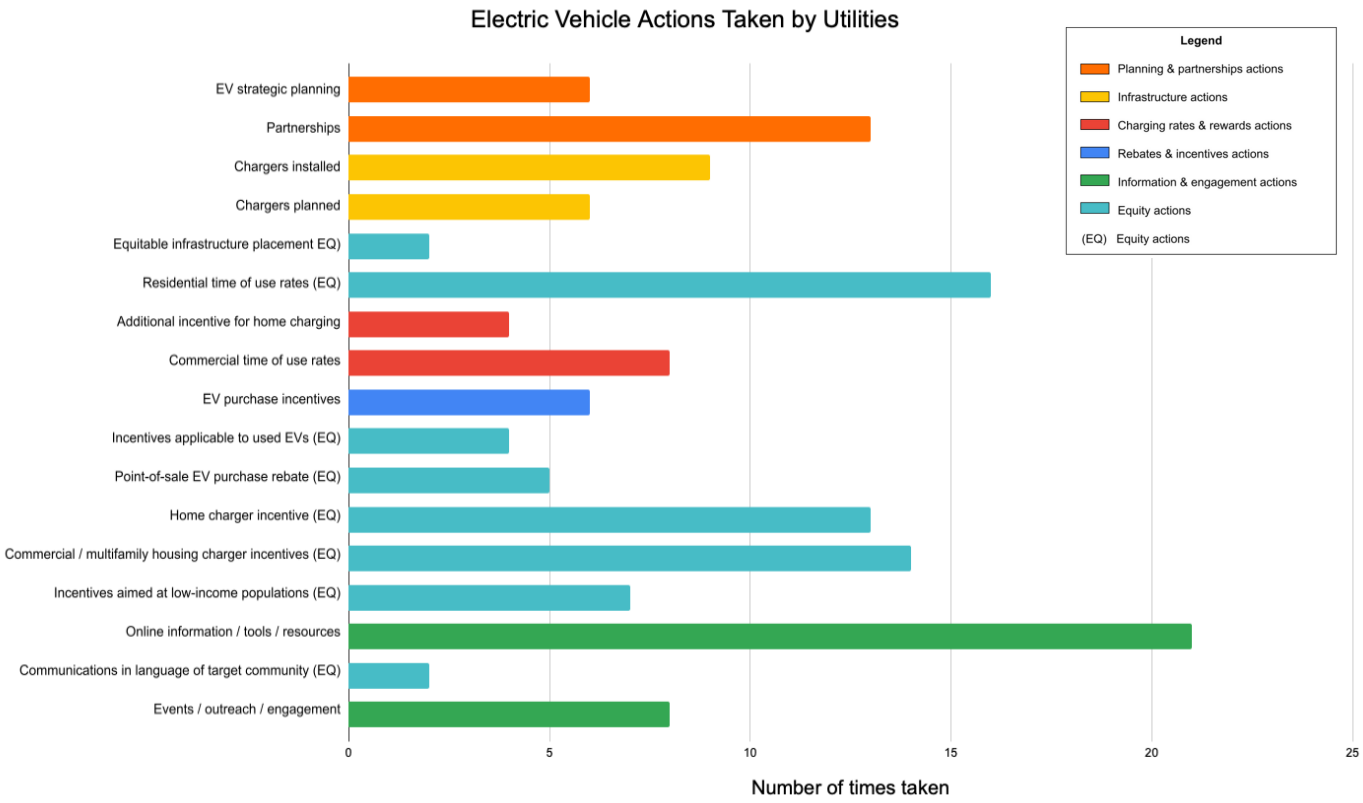


Figure 11: Bar graph showing 17 electric vehicle actions and the frequency with which they were taken

Finally, utilities had far more complex electric vehicle actions than municipalities. It was more common for utilities to meet all six categories of actions than to meet any lesser number of categories; about 36% of the 22 utilities that took action met all possible categories, as can be seen in Figure 12. A potential reason for this is that utilities may have more financial resources available and more knowledge about electric vehicles than municipalities, so they are able to create more complex, varied electric vehicle actions. Many investor-owned utilities are large companies with vast financial resources, and due to being in the energy sector, they are likely more familiar than many municipalities with the factors involved in electric vehicle adoption.

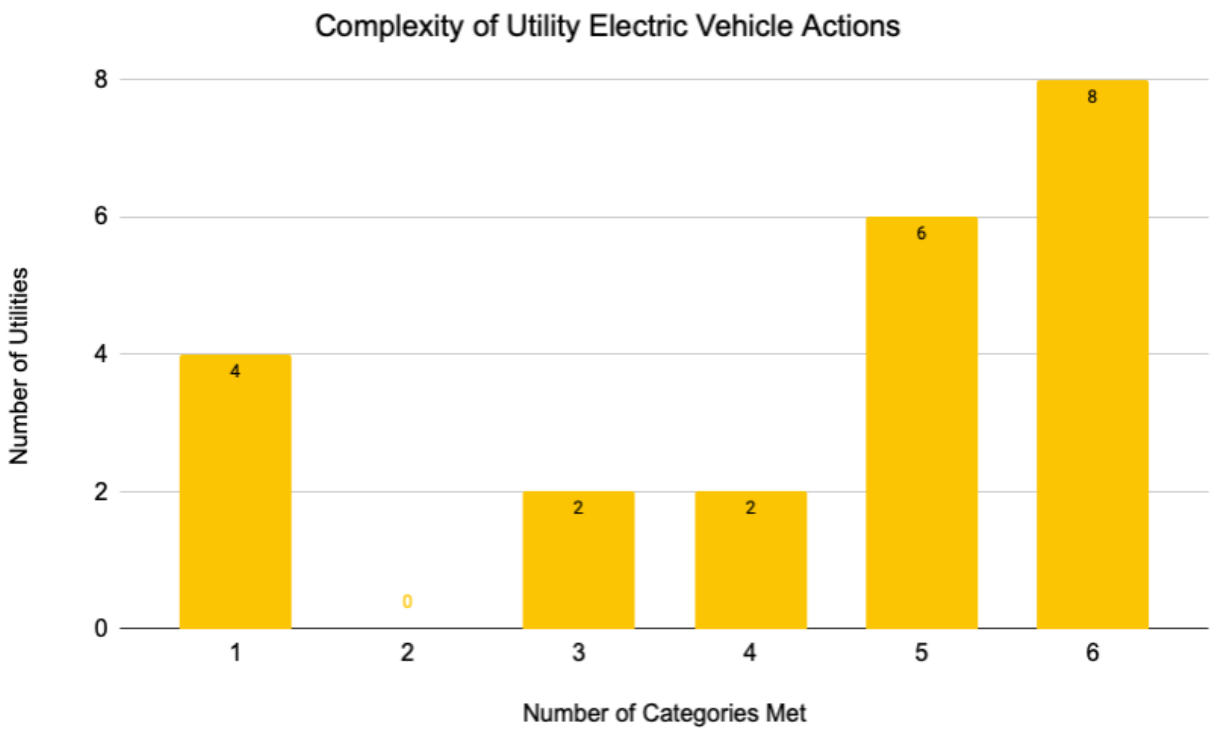


Figure 12: Bar graph showing the number of action categories met by utilities (n = 22)

CASE STUDIES

Consumer Adoption of Electric Vehicles

The five following municipalities and one investor-owned utility were chosen from our sample to illustrate electric vehicle actions taken by governments and utilities with a variety of demographic and geographic characteristics.

The case studies are Pickstown, South Dakota; Lowell, North Carolina; Austin, Texas; Panton, Vermont; Issaquah, Washington; and NV Energy. Additional information about each of these, as well as links to online resources about their electric vehicle actions, can be found in the databases, which can be accessed through the link in Appendix C.

Pickstown, South Dakota

Characteristics

Population: 230

Classification: Rural

2020 politics: Republican

Tribal affiliation: Yankton Sioux

Pickstown is a small rural town located on the Yankton Indian Reservation along the southern border of South Dakota. The reservation is the homeland of the Yankton Sioux Tribe of South Dakota, a federally recognized Indigenous nation. Pickstown is by far the smallest municipality in our sample to take any electric vehicle action, and the town has taken actions in three categories.

Bright Energy Solutions is a portfolio of energy efficiency services and incentives offered to members of Missouri River Energy Services, which distributes electricity to municipal utilities in four states. Through Bright Energy Solutions, Pickstown is able to offer residents a $500 rebate for the purchase of a home charger and a $50 reward for filling out a survey about electric vehicles. Additionally, there is a Bright Energy Solutions Pickstown website with information about charging, incentives, models, and benefits, as well as a savings calculator, emissions reduction calculator, and a charger map tool. Through this partnership between Pickstown's municipal utility and the company distributing its electricity, the town is able to take a significantly greater amount of electric vehicle action than most towns with similar demographic and geographic characteristics.

Lowell, North Carolina

Characteristics

Population: 3,654

Classification:
Metropolitan area core

2020 politics: Republican

Lowell is a small city located in the core of the Charlotte metropolitan area. Lowell has passed ordinances requiring hotels, restaurants, and businesses with drive-through service windows to install electric vehicle chargers in their parking lots. Hotels and motels are required to provide chargers in designated parking spaces for a minimum number equal to 4% of guest rooms, while restaurants must install at least one charger in a designated parking space. The most stringent requirement is for drive-through businesses, which must install at least four chargers “to mitigate the air quality impact of a vehicle at idle.”

While it is not unusual for municipalities to require new residential developments or multifamily buildings to install chargers, Lowell’s decision to institute charging infrastructure requirements for specific types of businesses is atypical. In general, it is unusual for municipalities to require private businesses to install public chargers; Lowell’s policy suggests the city wishes to increase access to public charging but may lack the funding, capacity, or political will to use town resources for chargers.

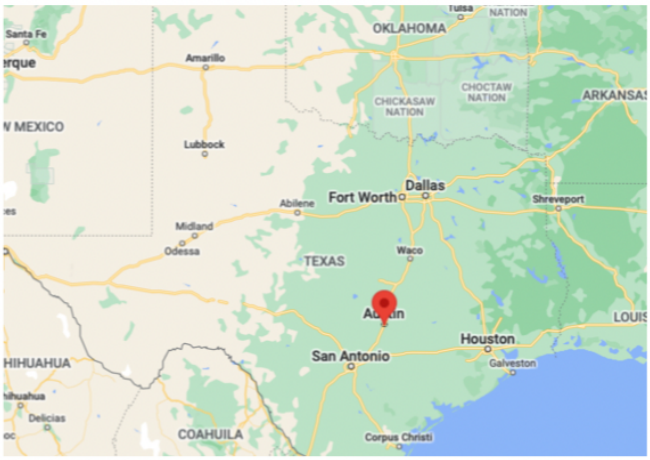
Austin, Texas

Characteristics

Population: 978,908

Classification:
Metropolitan area core

2020 politics: Democrat



Austin has taken a diverse, varied approach to electric vehicle action, resulting in 17 actions taken that meet all 5 categories. Austin's first action was taken in 2012, when the city received DOE funding and led a regional infrastructure planning process called the Texas River Cities Plug-in Electric Vehicle Initiative. In the 2021 Climate Equity Plan, Austin set these goals for 2030: "40% of total vehicle miles traveled in Austin are electrified, and EV ownership is culturally, geographically, and economically diverse."

Most of the city's electric vehicle actions have been led by its municipal utility, Austin Energy. Austin Energy has installed more than 1,000 charging ports in the Austin area through its Plug-In EVerywhere Network and offers an unlimited charging subscription plan for $4.17 per month. The charger network is powered by 100% renewable energy through Austin Energy's GreenChoice program. For home charging, Austin Energy offers a charger rebate ranging from $900-1200. For workplaces and multifamily housing properties, Austin Energy offers charger rebates up to $4,000 for Level 2 chargers or up to $10,000 for fast chargers.

Education and awareness of electric vehicles are emphasized by Austin in a variety of ways. The city website and the Austin Energy website both encourage consumer electric vehicle adoption and offer information about incentives, benefits, and charging; the utility also has an electric vehicle buyer's guide tool to help customers compare models. Additionally, Austin Energy partners with dealerships to educate dealership employees about electric vehicles. In 2017, Austin Energy created Electric Drive, a "showcase for electric mobility" located in Austin's EcoDistrict. It is a functional art piece with outdoor seating, a fast charger, a Level 2 charger, and a solar-powered kiosk that can charge many devices.

The 2021 Climate Equity Plan included a strategy of expanding electric vehicle outreach to "systematically excluded" groups; this aligns with Austin Energy's EVs are for EVeryone initiative, which is intended to bring an equity lens to all of the municipal utility's programs and offerings. Notable among these programs is EVs for Schools initiative, which involves installing chargers for school staff, students, parents, and visitors; and a STEM curriculum to teach students about electric vehicles, renewable energy, and charging technology. Schools receive a teacher kit and specialized training, and the curriculum is available in English and Spanish. A pilot program was run at four Title I schools, and now EVs for Schools lessons are available at 122 schools in Central Texas.

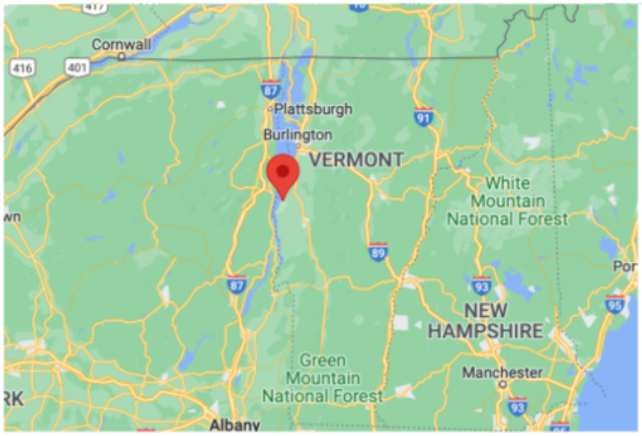
Panton, Vermont

Characteristics

Population: 677

Classification: 10 - Rural

2020 Politics: Democrat



Panton is a small rural town in western Vermont that has taken several electric vehicle actions. Panton installed a public charger at its town hall around 2016-2017, supported by Green Mountain Power (an investor-owned utility) and Efficiency Vermont (a statewide energy efficiency utility). In its 2019 Town Plan, Panton issued recommendations and plans for installing charging infrastructure, amending building codes, and supporting workplace charging.

Notably, the Town Plan also included quantitative goals for electric vehicle adoption, which is an action more commonly taken by large cities. Panton aims to have all personal vehicles powered by renewable energy by 2050; benchmarks for this goal are 55 electric vehicles by 2025, 374 electric vehicles by 2035, and 730 electric vehicles by 2050.

Issaquah, Washington

Characteristics

Population: 40,051

Classification: 1 - Metropolitan area core

2020 Politics: Democrat

Issaquah is a mid-sized city in the Seattle area that has received national recognition for its electric vehicle actions. Mayor Mary Lou Pauly received an honorable mention for a climate protection award from the U.S. Conference of Mayors in 2021 for the city's EV Charging Ordinance, which requires the installation of charging infrastructure in most new construction and substantial retrofits. The ordinance mandates that 5-10% of parking spaces at new developments (both residential and non-residential) have chargers and that 10-30% of parking spaces be made EV-ready. It also sets accessibility requirements for the chargers and requires compliance from affordable housing developments. The U.S. Conference of Mayors' reasoning for recognizing Mayor Pauly was that this ordinance creatively circumvented a restrictive state law that bans local governments from altering the statewide small residential building code.

Issaquah has installed public chargers in two locations, beginning as early as 2011, and plans to install more in 2022. The city included electric vehicle recommendations and plans in its 2021 Mobility Master Plan, 2021 Comprehensive Plan, and 2021 Climate Action Plan. The latter recommended strategically choosing charging locations to ensure equitable access.

NV Energy

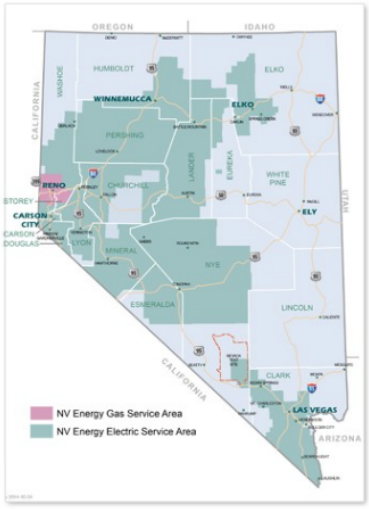
Characteristics

Type: Investor-owned utility

Location: Nevada

Service area: 44,000 square miles

Customers: 1.4 million



[53]

NV Energy is an investor-owned utility in Nevada that has taken 16 out of 17 total electric vehicle actions in our utility codebook. PowerShift by NV Energy is a program that encompasses many of the utility's electric vehicle programs and offerings. This includes strategic infrastructure planning, partnerships, vehicle purchase rebates, time of use rates, charger installation incentives, education, and more.

NV Energy and the Governor's Office of Energy created the Nevada Electric Highway partnership to expand the state's charging infrastructure. Each charging station installed through the program will include two Level 2 charging ports and one fast charger. NV Energy either has built or plans to build about 12 of the stations. Through the Economic Recovery Transportation Electrification Plan, NV Energy will invest nearly $100 million to expand charging access across its service territory between 2022-2024. NV Energy aims to prioritize charger placement in historically underserved communities, increase access to clean energy job opportunities, and support electric vehicle driver tourism. Carrying out the plan involves community outreach and collaboration, and the plan is available to the public in English and Spanish.

[53] "Service Territory," NV Energy. https://www.nvenergy.com/about-nvenergy/our-company/territory.

Through the Lower-Income EV Rebate Program, NV Energy offers a $2,500 rebate on the purchase or intended purchase of a new or used electric vehicle or plug-in hybrid vehicle. Customers must meet income eligibility requirements, and they can apply for and receive rebates prior to the purchase of the vehicle, which is an important equity measure taken by NV Energy. NV Energy also offers time of use rates for both residential and commercial customers, which allow customers to pay a discounted rate for charging electric vehicles on their property during off-peak hours.

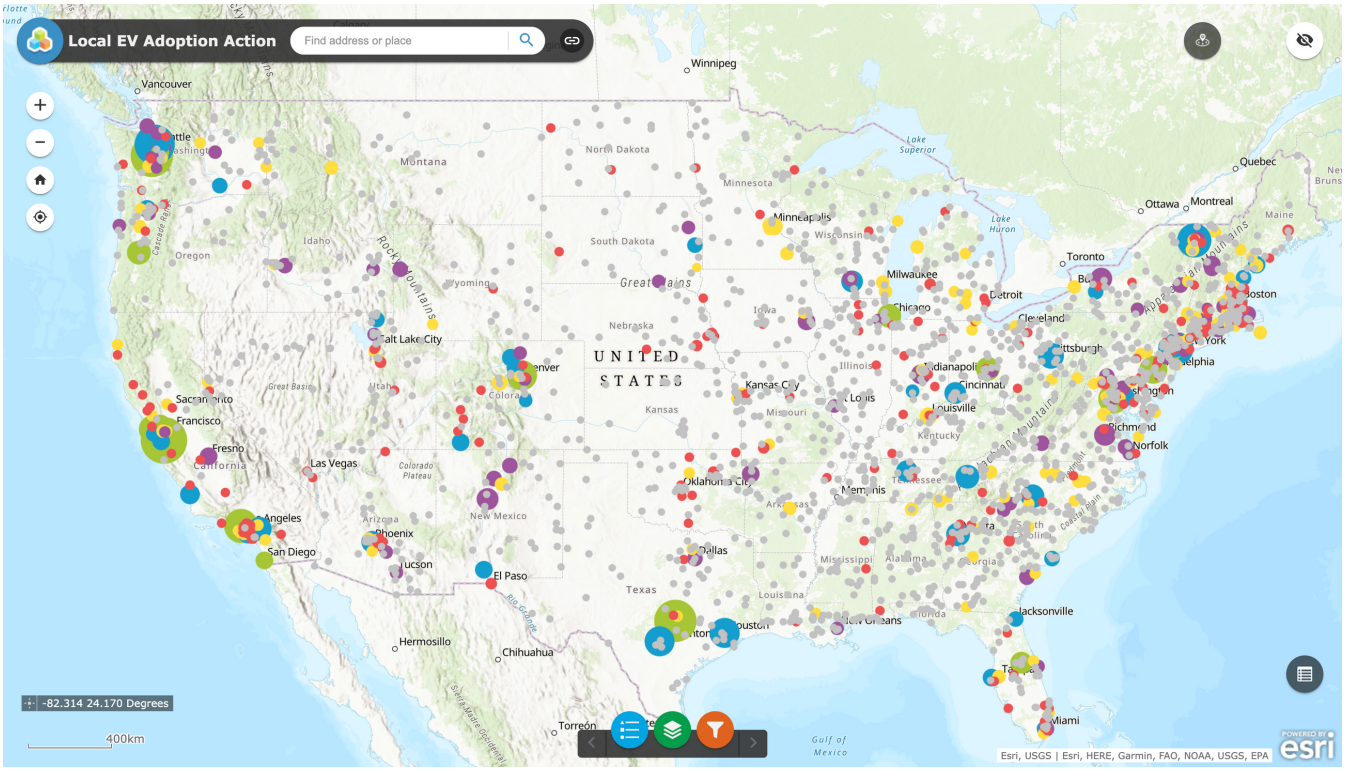
NV Energy has a variety of charging incentive programs. There is a residential charger rebate of up to $500 for single-family homes. Businesses and non-profits that install public chargers can receive up to $3,000 for a Level 2 charger or $40,000 for a fast charger. Multifamily property owners that install chargers for use by residents can receive up to $5,000 for a Level 2 charger or $40,000 for a fast charger. If the multifamily property is considered low-income housing, 100% of costs for Level 2 chargers will be covered by NV Energy and the state government (up to $40,000). Government building incentives are also available to institutions such as cities, state and federal agencies, national parks, and public school districts; 100% of costs for Level 2 chargers will be covered by NV Energy and the state government (up to $40,000). Finally, through the Electric Vehicles Custom Grant Program, NV Energy has up to $1 million in funding available for projects that may not meet the requirements of the other incentive programs.

NV Energy has several webpages dedicated to sharing electric vehicle information and resources, including charging information, an electric vehicle comparison tool, and a dealership map. Through the Dealer Partner Program, NV Energy works with dealerships to provide support for electric vehicle sales and to increase public awareness of electric vehicles. NV Energy is also surveying customers about their electric vehicle preferences and opinions about the utility's electric vehicle programs; the survey is available in English and Spanish.

INTERACTIVE MAP

Consumer Adoption of Electric Vehicles

In order to present the findings of this study in a more accessible and interactive way, we created a map tool featuring all of the municipal and utility data in our databases. Providing a visual representation of the data makes it easier to see geographic trends and to interact more easily with our large dataset. This tool is available to the public, with the intention that it be used by other researchers or those involved in advancing customer electric vehicle adoption at the local level. It can be used as a tool for analysis, with the ability to look at variation within a state or region or to layer and compare utilities and municipalities, for example.



Users can filter by population size, politics, RUCA classification, whether or not electric vehicle action was taken, whether or not equity action was taken, and more. There is also the option to add and remove layers to the map, including political outcomes and utility service territories.

Methods

We created the map using ESRI's ArcGIS programs. To create the layer of municipalities, we exported the database to an Excel file and geocoded the municipalities using the "Geography" data type, which is a tool included in Excel 2019 that parses web sources for information on a geographic location. The geocoding process attached the latitude and longitude information associated with a municipality to its entry and EV action data within the file. We then exported the geocoded municipality data to a CSV file. Next, the precinct-level 2020 presidential election results from The New York Times was open source, so we downloaded this data through the associated repository on GitHub. We then uploaded this data to ArcGIS Pro, where it was converted into a shapefile. Finally, we downloaded the electric utility territories from the Homeland Infrastructure Foundation Level Database (HIFLD) created by the U.S. Department of Homeland Security.

All three of these datasets were then mapped using ArcGIS Online. The municipalities were filtered to display the most relevant fields, which include the following: State; Community Name; Community Type (City, Township, Village, Town, Borough); Community Type (Rural, Urban, Suburban) - According to RUCA Classification; Population Size; 2020 Politics; Adoption Actions Taken (Y/N); Categories Met; Count of Actions (Out of 48 possible); Equity Actions Taken; Policy Actions Taken; Infrastructure Related Actions; Financial Interventions; and Information, Outreach, and Other; Summary of Actions; and Links to Resources. We made these fields visible as pop-ups when users interact with a municipality on the map. Using ESRI's ArcGIS Web AppBuilder, we formatted the map for web display, including various filters to allow the user to easily interact with the data, including selecting specific demographics and action categories.

CONCLUSIONS + FUTURE RESEARCH

Consumer Adoption of Electric Vehicles

Transitioning to electric vehicles is a priority for reaching national and international climate goals, and local-level actors play a critical role in encouraging consumer electric vehicle adoption and filling in gaps left by state and federal actions. In this study, we found that 22.5% of the 2,016 municipalities we sampled had taken electric vehicle action. We found statistically significant relationships between demographic and geographic factors and municipal electric vehicle actions, with action being more frequently taken by cities with larger population sizes, a metropolitan classification, and Democrat-leaning politics. We found that the majority of actions taken by municipalities were related to infrastructure, while equity and financial actions were less common. We also found that nearly three-quarters of the 30 utilities we sampled had taken electric vehicle action, and that utilities took a wider variety of actions, including equity.

We identified four areas of future research that could build upon this study and further improve understanding of local-level electric vehicle actions. The first would be to measure the impact of municipal electric vehicle actions, which was outside of the scope of this study because municipal governments rarely tracked or publicized the impacts of their electric vehicle actions or policies. This research could be based on comparisons of electric vehicle adoption rates before and after the action was taken, but it would likely need to involve a more complex analysis that takes into account the various factors impacting electric vehicle adoption. Understanding the impacts of actions could help municipalities and utilities decide which actions are worth pursuing and hold the most value for their constituents and customers.

Another area of future research would be to study the influence that federal, regional, and state electric vehicle policies actions (or the lack thereof) have on local-level actions. Federal and state funding, climate and sustainability goals, and supportive or restrictive electric vehicle policies almost certainly play a significant role in shaping the actions taken by governments on the local level. Similarly, utility parent companies and regional/national networks of electric utilities shape the actions taken by utilities on the local level.

Addressing rural gaps in electric vehicle infrastructure and adoption is a growing priority for electric vehicle equity, and we believe that rural electric cooperatives likely factor significantly into closing these gaps. While including the nearly 900 electric co-ops was outside of the scope of this study, our initial research revealed that electric co-ops often offer electric vehicle information and incentives to their customers. In rural areas that may not be addressed by state and municipal actions, electric co-ops may be the primary actors encouraging electric vehicle adoption.

Finally, future research could address electric vehicle actions taken by Indigenous communities and governments. While these governments were not included in this study, we found numerous examples of Indigenous communities and leadership taking actions like building charging networks and purchasing electric vehicles for use by commercial and government institutions on reservations. One example is the Upper Midwest Inter-Tribal Electric Vehicle Charging Community Network, which was formed in 2021 by tribal communities in South Dakota, North Dakota and Minnesota to install 120 chargers across 500 miles.[54] These local-level actions are worth considering, as they support electric vehicle equity and Indigenous environmental justice more broadly.

During the fifteen month course of this study, we found that accurately depicting the position of electric vehicles in the United States was a moving target. As the federal government announced massive investments and cities continuously rolled out new actions and policies, our sample was changing faster than we could research. From our project proposal in 2021 to our final report in 2022, electric vehicle sales doubled from 2% to more than 4% of total U.S. vehicle sales. Widespread electric vehicle adoption is underway in the United States, and it is our hope that this research will contribute to accelerating an equitable electric vehicle transition for all.

[54] Miguel Yañez-Barnuevo, “Indigenous Communities to Launch EV Charging Network in Midwest,” Environmental and Energy Study Institute, January 21, 2022.

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APPENDICES

Consumer Adoption of Electric Vehicles

Appendix A

This appendix contains tables showing the total number of times each individual electric vehicle action was taken by the sampled municipalities. Equity actions are spread across the other four categories and signified by a pale turquoise color and the (EQ) notation.

Financial Category	
Action	**Total**
Financial incentives to construct publicly placed chargers	14
Incentivized or free home chargers (EQ)	26
EV charger regulatory exemption	0
Lower charging rates during certain times of day for home chargers (EQ)	14
Free (or discounted) charging on public chargers	73
Parking incentive (free, reserved, or discounted parking)	8
Used vehicle eligibility for financial incentives (EQ)	4
Direct rebate at point-of-sale (EQ)	6
Direct rebate after purchase	8
Cash vouchers (EQ)	0
Price buy-down vouchers (EQ)	1
Tax credit	1
Sales tax exemptions (EQ)	1
Assignable tax credits (EQ)	0
Reduced vehicle registration fees (EQ)	1
Toll reductions for EVs	1
Insurance discounts (EQ)	0
Loan loss reserve programs (EQ)	0
Targeting financial incentives toward low-income buyers / reserving spots in financial programs for low-income buyers through income caps (EQ)	4
Provide technical assistance for accessing incentives/enrolling in programs (EQ)	3
Creating a universal application for all incentives (EQ)	0
Other financial incentive	7
Other equity (EQ)	4

Policy Category	
Action	**Total**
Quantitative electric vehicle goal	33
Infrastructure related policy (example: zoning ordinance, building codes & requirements)	90
Equity related policy (including right-to-charge laws/policies, multifamily property infrustructure policy, etc) (EQ)	34
Other Policy	3

Infrastructure Category	
Action	**Total**
EV chargers installed	340
EV and EV charging infrastructure plans	131
Intentionally equitable placement / planned placement of EV chargers in low-income communities and/or access by multifamily properties (Includes incentives for businesses/institutions to build them) (EQ)	33
Perform community mobility needs assessment (EQ)	18
Accessibility infrastructure	15
Low-carbon fuel standard	0
Other infrastructure	5

Information, Outreach, and Other Actions	
Action	**Total**
Informational materials (online only)	142
Outreach events (No test drive / ride and drive)	59
Procedural knowledge programs/events (Test drive / ride and drive available)	40
Outreach events specifically in low-income communities (EQ)	5
Participatory community events / engagement	26
Community-based organization partnerships (EQ)	16
Communications / educational materials in language of target community (EQ)	9
Marketing / awareness plan	9
School-based education efforts	5
Non-financial incentives	1
Commitment	2
Modeling initiatives	2
Car sharing initiatives	7
Other non-financial initiatives	4

Appendix B

This appendix contains a table showing the total number of times each individual electric vehicle action was taken by the sampled utilities. Equity actions are spread across the other five categories and signified by a pale turquoise color and the (EQ) notation.

Planning and Partnerships	
Action	**Total**
EV strategic planning	6
Partnerships (dealerships, community organizations, businesses, governments, etc)	13

Infrastructure	
Action	**Total**
Chargers installed	9
Chargers planned	6
Intentionally equitable placement / planned placement of EV chargers in low-income communities and/or at multi-family properties (EQ)	2

Charging Rates and Rewards	
Action	**Total**
Time of use rates / preferential electricity rates for home charging (EQ)	16
Additional incentive for home charging and/or charging at certain times	4
Commercial time of use rates or discounts	8

Rebates and Financial Actions	
Action	**Total**
EV purchase incentives	6
EV purchase incentives applicable to used EVs (EQ)	4
Point-of-sale EV purchase rebates (EQ)	5
Home charger incentive (EQ)	13
Commercial / multifamily housing charger incentive (EQ)	14
Incentives or programs aimed at low-income populations or areas (EQ)	7

Information / Non-Financial Actions	
Action	**Total**
Online information / tools / resources	21
Communications / educational materials in language of target community (EQ)	2
Events / outreach / engagement	8

Appendix C

This appendix contains links to the municipality and utility databases and to the interactive map tool. The databases are in a public Google Sheets document and the map tool is on ArcGIS Online.

Databases: https://docs.google.com/spreadsheets/d/10UoOZOqtuLOkxKsOsj6n0QLUHnFEJ_JY/edit#gid=1340509949

Interactive Map: https://arcg.is/0TDrDG0