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Driving the Future: Improving Electric Vehicle Adoption in Rural California

Prepared by
Benny Corona, MPP, Goldman School of Public Policy, University of California at Berkeley
on behalf of CalCAN

May 2021

Acknowledgements

I want to thank my abundantly wise adviser Erika Weissinger for all her insight, advice, edits, and guidance in completing this advanced policy analysis. I also want to thank my incredible colleagues at the Goldman School of Public Policy for their words of wisdom and edits. Thirdly, I want to thank CalCAN's amazing policy team for their guidance, patience, edits, and support. Lastly, I want to thank all the passionate and welcoming policy experts of the State of California, the stakeholders from rural California, and all the members of my community that gave me the time to interview them. SI SE PUEDE!

Disclaimer:

The author conducted this study as part of the program of professional education at the Goldman School of Public Policy, University of California at Berkeley. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Goldman School of Public Policy, by the University of California or by any other agency.

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I. Introduction to California Governor's Executive Order Banning Gas-Powered Vehicles by 2035:

In September 2020, California Governor Newsom issued an ambitious executive order for the state to achieve 100 percent zero-emission (EV) passenger vehicle and truck sales by 2035[1]. Already a national leader in EVs, California is the first state in the country to set a goal of eliminating sales of new gasoline-powered cars and trucks. To get there, the state will have to address a number of barriers to expand EV adoption, especially for rural Californians.

While California leads the country in EV adoption, overall EV ownership is still relatively low in the state. EVs currently represent about 1.8 percent of all registered vehicles in California, see Figure 2 on page 6. To fulfill the EO, California will need to increase this share of EVs in the long run, although there is already evidence that the total sales of new EVs is increasing over time.

A central EV adoption barrier is that there is no viable option for mass heavy duty EV adoption in California. Although some EV truck prototypes and concepts exist, the current cost of available trucks makes it difficult for California to get to a 100 percent EV truck adoption rate.

When considering EV adoption in California's rural areas it requires looking at social, economic, political, spatial, and environmental conditions and the differences between rural and urban spaces. Rural California is also already behind in various variables that determine the quality of life for Californians including water and wastewater infrastructure, public health outcomes, educational rates, poverty rates, and average income[2]. For example, rural California is home to some of the worst air quality in the nation and represents 1 million Californians without clean drinking water[3]. The state of California will likely find itself reproducing historical inequalities between rural and urban California unless the needs of rural California are directly addressed.

If not, the lack of EVs and related infrastructure will become another of the many social problems rural California is already disproportionately impacted by. Furthermore, unless the barriers against EV adoption in rural California are properly addressed, the Governor's ambitious goals for EV adoption in the state will not likely succeed in part because of rural Californian's having a limited capacity to substitute gas-powered options. Ultimately, to ensure the success of the EO, California needs to center rural EV adoption. This analysis will expand on these unique barriers in rural California and provide

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[1] California, S. of. (2021, April 26). *Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight Against Climate Change*. California Governor. https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/.

[2] Ramirez, S., & Villarejo, D. (2012, September). *Poverty, Housing, and the Rural Slum: Policies and the Production of Inequities, Past and Present*. https://www.ncbi.nlm.nih.gov/. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3482029/.

[3] Guo, E. (2020, November 20). *In California, 1 million people lack access to clean water*. High Country News – Know the West. https://www.hcn.org/issues/52.12/south-pollution-in-california-1-million-people-lack-access-to-clean-water.

policy recommendations that can improve EV adoption in rural California moving forward.

II. Methodology:

In order to identify the barriers that are limiting EV adoption in rural California I conducted a data exploration of the electric vehicle landscape in California, investigated several EV adoption case studies, and conducted interviews with the following stakeholders:

- Staff directing the Clean Assistance Vehicle Program (CAVP), a program already working towards equitable distribution of EV adoption in California.
- Staff in the FARMER program, a program working to equitably distribute clean and low-emission vehicle and agriculture technology in California.
- Staff in the California Air Resources Board (CARB) that have already conducted extensive EV adoption policy reports for the State of California.
- Staff in the Green Raiteros program in the Central Valley that has successfully electrified the "greenest city" in rural California.
- Rural policymakers working on the implementation of EV programs in their cities.
- Rural community members in California who do not yet own an EV.

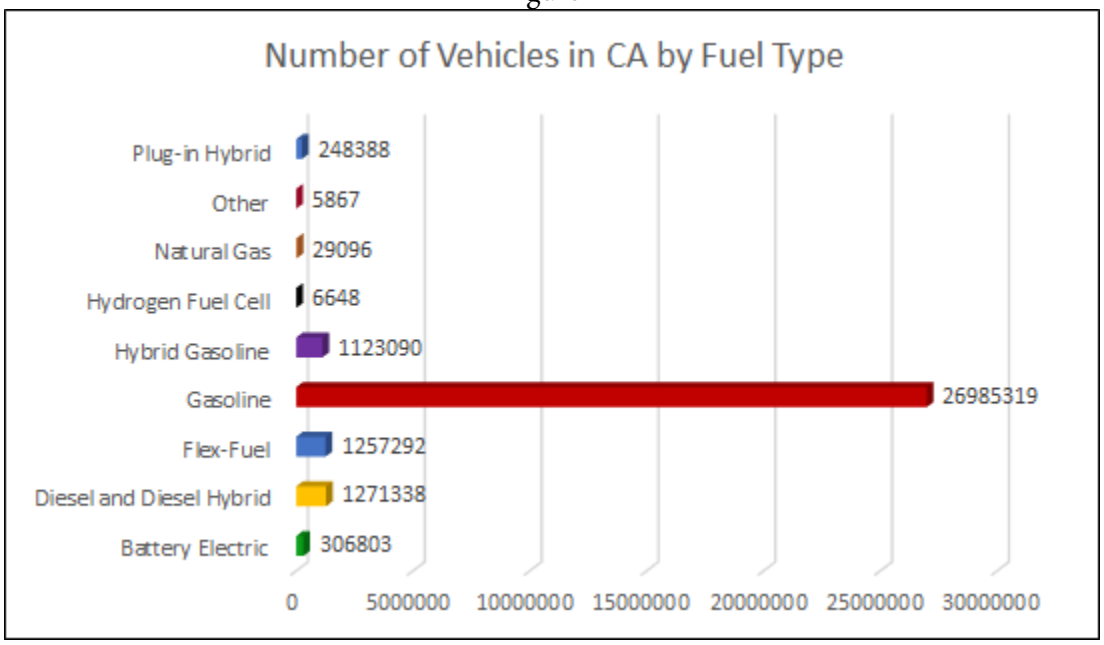
In order to clearly define barriers and policy recommendations for rural EV adoption, it is important to first investigate what research and analysis already exists to prevent replication and to also gain insight into already defined barriers and policy recommendations. Secondly, it is also important to gain insight into the perspectives of everyday rural Californians to understand their motives behind purchasing or avoiding EVs; and see how their feedback measures already defined barriers and policy solutions.

Data Exploration: There are too few electric vehicles in rural California.

To better understand the EV landscape in California, I conducted data analysis using data from the California DMV and from the California Energy Commission[4]. Figure 1 represents the registered vehicle landscape of California up to December 2020 in millions of vehicles:

[4] CA Department of Motor Vehicles. (2020, December 15). *Vehicle Fuel Type Count by Zip Code*. California Open Data. https://data.ca.gov/dataset/vehicle-fuel-type-count-by-zip-code.

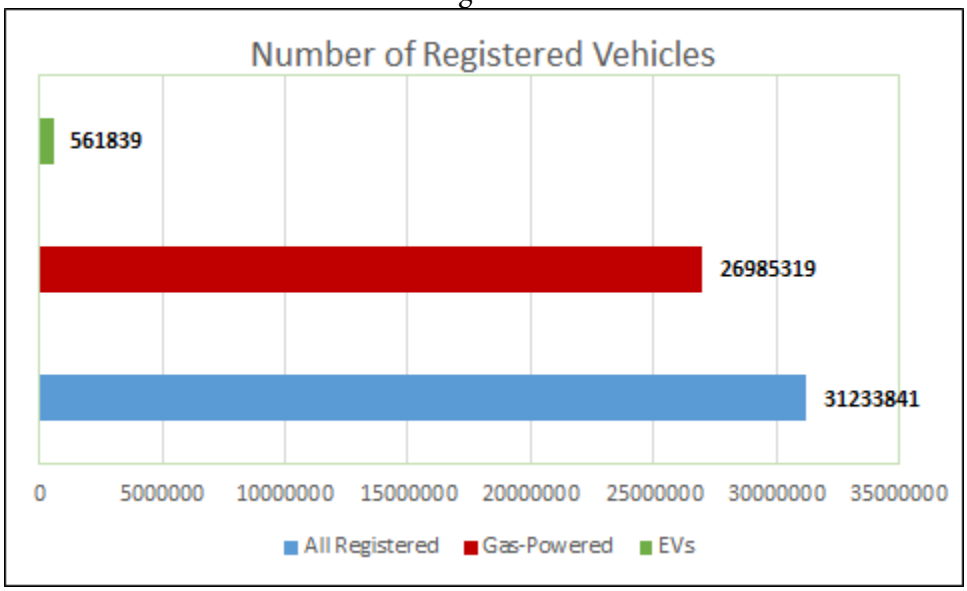
Figure 1



Data Source: California Department of Motor Vehicles

In California, there were 31,233,841 registered vehicles in 2020. Out of those vehicles, 26,985,319 are gas-powered as the above graph shows. The following graph, Figure 2, compares the number of EVs in California to gas-powered vehicles in millions:

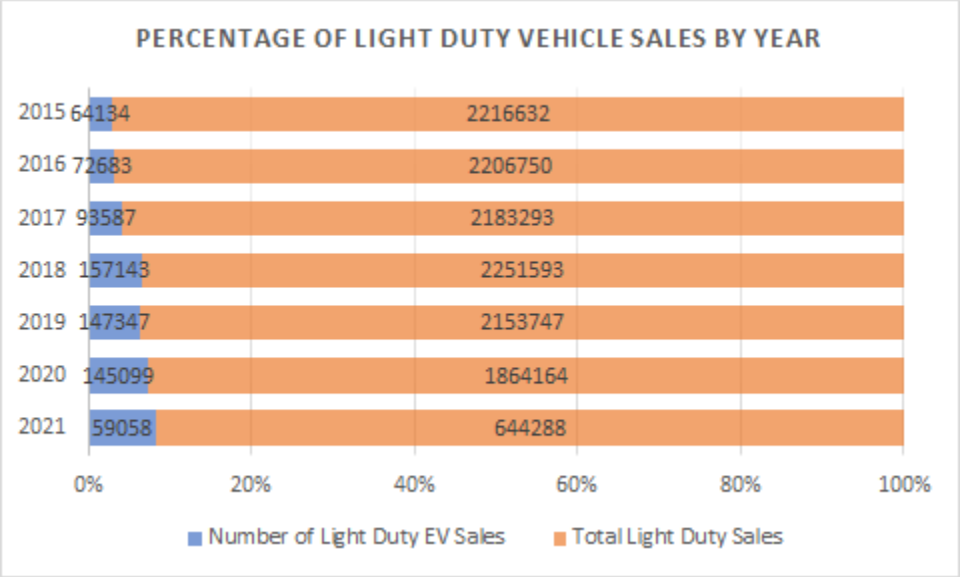
Figure 2



Data Source: California Department of Motor Vehicles

As of December 2020, 561,839 of all registered vehicles are considered battery electric, hydrogen fuel cell, and plug-in hybrid vehicles. This represents about 1.8 percent of vehicles in California. However, Figure 3 shows how the total share of new light duty EVs sales has increased over the years from 2015 to the first quarter of 2021. In 2015, EVs were 2.89 percent of the total light duty vehicle sales, and this has increased progressively to 9.17 percent in the first quarter of 2021.

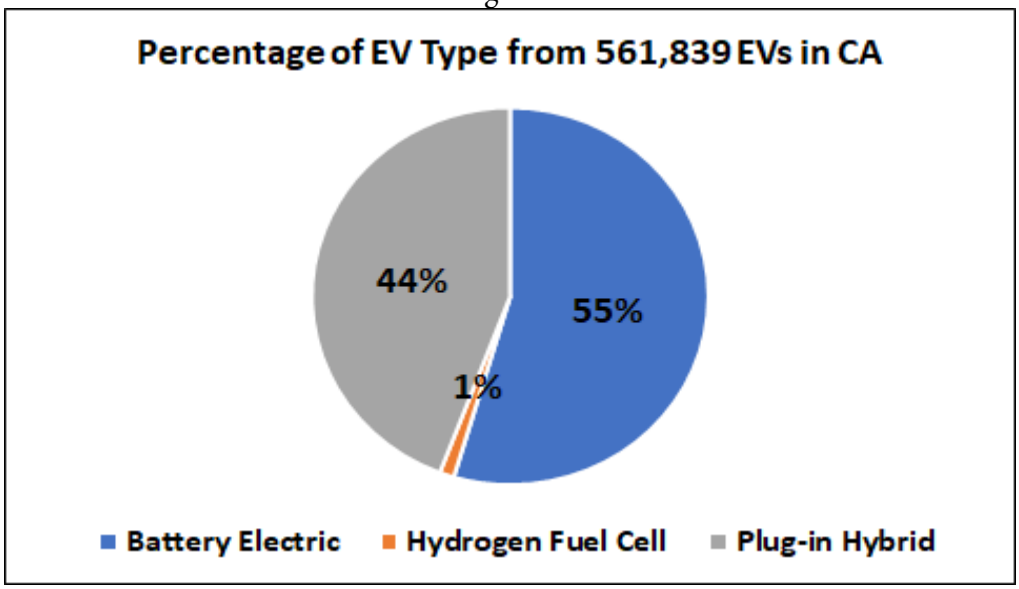
Figure 3



Data Source: California Energy Commission

The following graph, Figure 4, shows the make-up of EVs in California by EV type:

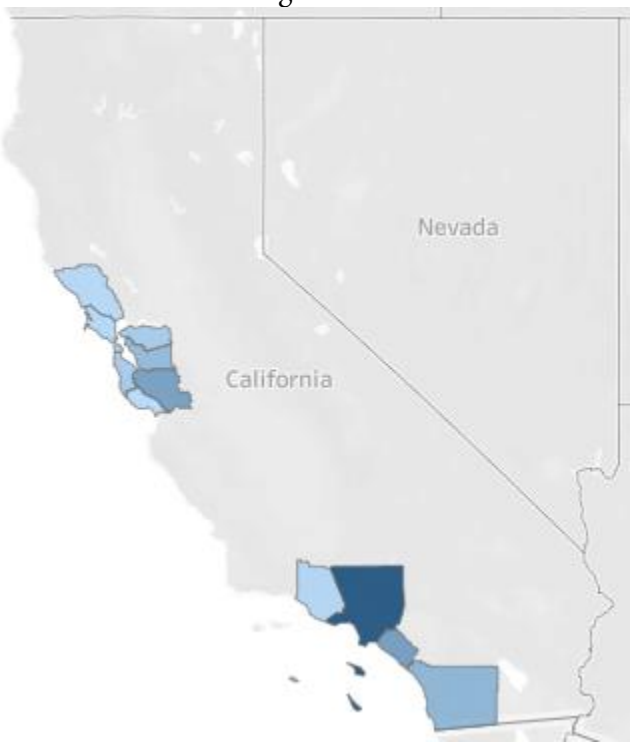
Figure 4



Data Source: California Department of Motor Vehicles

The California Energy Commission currently tracks the sales and population of light duty zero emission vehicles (ZEVs) in California in partnership with the Department of Motor Vehicles. That population of ZEVs is also represented in Figure 3 above. From the California Energy Commission data dashboard, we know that about 80% of all electric vehicles are registered in 12 coastal counties: San Francisco, Contra Costa, Santa Cruz, Santa Clara, San Mateo, Alameda, Sonoma, Marin, Los Angeles, San Diego, Orange, and Ventura. This is shown from the California Energy Commission data dashboard in Figure 5. Meanwhile, the rest of California's EVs are scattered throughout the remaining 46 California counties. This is shown in Figure 6.

Figure 5



Data Source: California Energy Commission. The 12 counties in blue in this spatial map represent 80 percent of all registered EVs in California

Figure 6

Data Source: California Energy Commission. The 46 counties in blue in this spatial map represent 20 percent of all EVs registered in California.

<u>As the figures above make clear, EVs are rarely found in rural counties of California.</u>

<u>Terms and Definitions:</u>

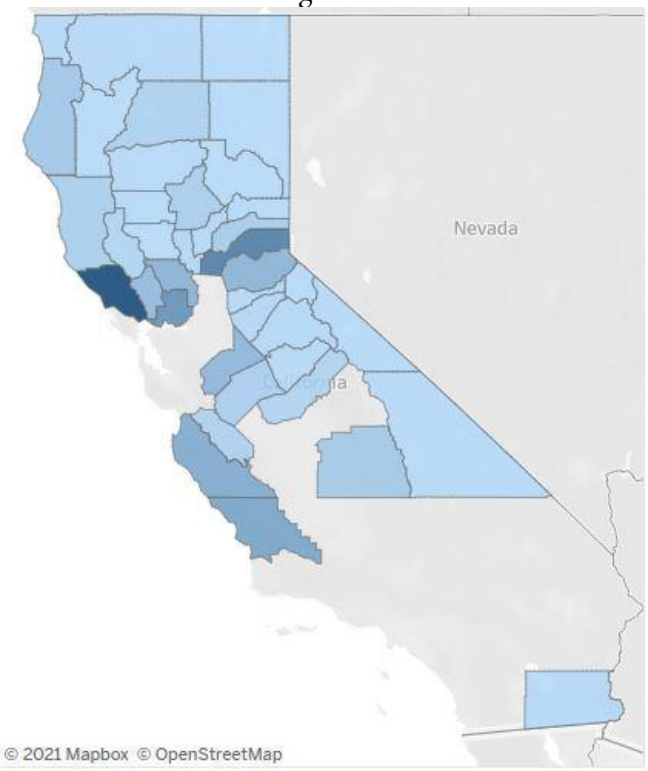
1. **Electric Vehicles:** In this analysis, when I reference electric vehicles, I am specifically referring to battery electric, hydrogen fuel cell, and plug-in hybrid vehicles since these vehicles are considered "light duty zero emission vehicles (ZEVs)" by the California DMV and California Energy Commission[5]. Other non-gas fuel types such as flex fuel and hybrid gasoline are not going to be referenced as electric vehicles in this analysis due to them not being considered zero emission by the State of California.

    - Battery electric vehicles are abbreviated as BEVs
    - Plug-in hybrid vehicles are abbreviated as PHEVs
    - Hydrogen Fuel Cell Vehicles are abbreviated as FCEVs.
    - Electric vehicles in general, are abbreviated as EVs.

[5] California Energy Commission. (2021). Zero Emission Vehicle and Infrastructure Statistics. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics.

2. **Rural California:** It is important to concretely define the term "rural California" since various state and federal agencies have different definitions for "rural California". For example, the Census Bureau defines rural as being a city with 49,999 people or less[6]. Therefore from a policy perspective, it is important to have a clearly defined scope for this term. Due to the fact that there are over 1000 zip codes in California and the limited capacity of this analysis, I've decided to define rural California simply as the same counties that the Rural County Representatives of California (RCRC) define as rural counties[7]. This list of counties is as follows: Alpine, Amador, Butte, Calaveras, Colusa, Del Norte, El Dorado, Glenn, Humboldt, Imperial, Inyo, Lake, Lassen, Madera, Mariposa, Mendocino, Merced, Modoc, Mono, Monterey, Napa, Nevada, Placer, Plumas, San Benito, San Luis Obispo, Shasta, Sierra, Siskiyou, Sonoma, Sutter, Tehama, Trinity, Tulare, Tuolumne, Yolo, and Yuba. Using this definition, rural California represents only 8 percent of EVs in California. This spatial map is shown in Figure 7.

Figure 7



Data Source: California Energy Commission. The 37 counties colored in blue represent rural California for the purposes of this analysis.

I prefer this definition since its spatial map broadly captures the majority of counties and land mass where the state will need to actively intervene to ensure equitable EV adoption for rural

[6] USDA. (2021). California - Rural Definitions: State-Level Maps. United States Department of Agriculture.
[7] Rural County Representatives of California. (2020). *Counties*. Rural Counties. https://www.rcrcnet.org/counties.

Californians. It also conveniently excludes 11 out of 12 counties in California that already comprise 80% of all EVs. Nonetheless, it is important to note that despite the effectiveness of the RCRC's spatial definition, it does exclude counties that rely heavily on their local rural communities such as Fresno, Kern, Kings, and Riverside where farmworkers, farmers, and agriculture businesses have a strong local economy[8]. For this reason, this analysis will loosely use the RCRC's rural definition while still keeping in mind these excluded but heavily ag centered counties. Based on this map definition, Figure 8, depicts the rural California light duty EV landscape and compares it to the total California light duty EV landscape.

Figure 8

Number of light duty EVs in California	Number of total light duty vehicles in California	Light Duty EV percentage of all light duty vehicles in California
635,602	**28,030,332**	**~ 2.27 percent**
Total Number of light duty EVs in rural California	**Total Number of light duty Vehicles in rural California**	**Light Duty EV percentage of all light duty vehicles in rural California**
42,469	**3,594,419**	**~ 1.18 percent**

Data Source: California Energy Commission

3. **EV Chargers:** When I reference EV chargers in this analysis, I am referring to all types of EV chargers including level 1, level 2, and level 3/DC chargers; unless otherwise specified. The following table, Figure 9, distinguishes between the different types of EV chargers in the market.

Figure 9

Type of Charging	Voltage (V)	Miles Range per Hour of Charge (miles/hr)	Locations	Installation Cost
Level 1	110 - 120	2 - 5	Home	$0 - $3000
Level 2	208 - 240	10 - 20	Home, Workplace, and Public	$600 - $12,700
Level 3/DC Fast	240 - 480	180 - 320	Public	$4,000 - $51,000

[8] CDFA. (2019). (rep.). *COUNTY AGRICULTURAL COMMISSIONERS' REPORTS CROP YEAR 2018-2019*. CDFA. Retrieved from https://www.nass.usda.gov/Statistics_by_State/California/Publications/AgComm/2019/CAC_2019_actual_final.pdf

Data Source: Center for American Progress

III. Barriers Limiting EV Adoption in Rural California:

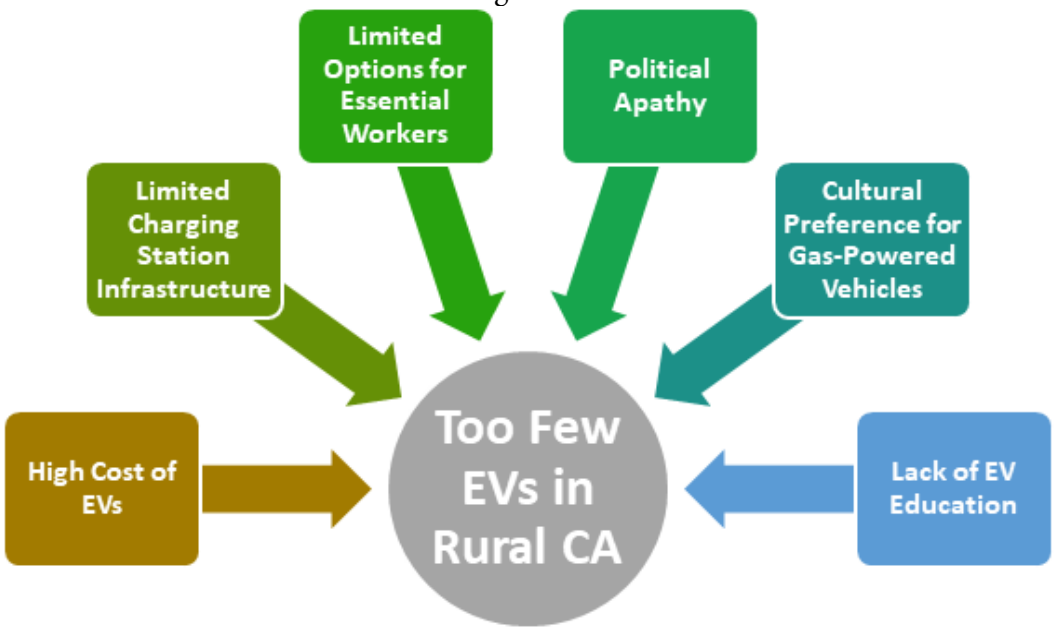
By conducting a review of the literature, interviews, reviewing program evaluations, reviewing public data, and my own lived experience as a rural community member; I have identified social, political, and economic barriers that have limited EV adoption in rural California.

In order to successfully implement the Governor's EO, California needs to effectively address the existing barriers that limit EV adoption in rural California. Even more importantly for equitable EV adoption, California needs to center rural EV adoption by implementing rural-centric policy solutions. I expand on these policy recommendations later on page 31. However, the barriers I have identified are the following:

- High Cost of EVs
- Limited Charging Infrastructure
- Limited EV Options for Essential Workers & Agriculture in Rural California
- Political Apathy
- Cultural Preference for Gas-Powered Vehicles
- Lack of EV Education

The following Figure 10, describes the barrier system that limits EV adoption in rural California:

Figure 10



High Cost of EVs

EVs tend to be more expensive than their gasoline-powered counterparts. As a consequence, we mostly see higher rates of EV adoption in urban, middle, and upper income communities. For example, the top 20 zip codes with the most battery electric vehicles are all concentrated in the Silicon Valley area of California, with some of the highest educated and highest income zip codes in the state. A table demonstrating these data is shown in Figure A in appendix B. There also appears to be a linear relationship between the number of Battery Electric Vehicles (BEVs) and Plug-in Hybrid Vehicles (PHEVs) by zip code as shown in Figure D in appendix B.

One of the prevailing themes of these interviews and literature review is that the high cost of EVs has been the central limiting factor in rural EV adoption. The state has attempted to address the financial barriers of EVs with programs aimed at providing financial support for their purchase. One of those programs is the Clean Assistance Vehicle Program (CAVP) which provides low-income to moderate-income individuals and families with grants and loans to purchase an EV[9]. Over 50 percent of this program's grantees are low-income Californians[10], and they have so much traffic they are having trouble keeping up with demand according to interviews from staff. Although this program demonstrates how financial support is incentivizing EV purchases even for the lowest income brackets, the majority of these customers are likely from urban areas according to interviews conducted with CAVP staff. Furthermore, reports prepared by the CAVP and the California Air Resources Board (CARB) have both identified in their community surveys that low-income to medium-income households rate affordability as the most important factor in purchasing an EV[11][12]. Currently it is easier to find affordable gas-powered vehicles than EVs in rural California.

It is likely that in the coming years leading up to the EO deadline, EVs will reach price parity with gas-powered vehicles[13]. In the meantime, it is necessary to ensure that low and moderate income Californians for whom the higher cost of EVs is most likely to be prohibitive, have the resources to comply with the order. This is because rural Californians in general are composed of low-income and working-class people[14]. In short, rural Californian's will likely not be able to comply with the order unless the price of used and new EVs is practical for Calfornians of all economic brackets.

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[9] CVAP. (2021, April 26). Clean Vehicle Assistance Program. https://cleanvehiclegrants.org/.

[10] Clean Vehicle Assistance Program. (2021, April 29). *Program Data*. Clean Vehicle Assistance Program. https://cleanvehiclegrants.org/program-data/.

[11] Center for Sustainable Energy. (2019, September). Clean Vehicle Assistance Program Adoption Survey Report. San Diego, CA; California Air Resources Board and Beneficial State Foundation .
Retrieved from https://409x7yggc5ekrbd32lf9ajv2-wpengine.netdna-ssl.com/wp-content/uploads/2020/08/BSF-CVA-Program-Evaluation-Report-2019-Final.pdf

[12] Center for Sustainable Energy. (2019, September). Clean Vehicle Assistance Program Adoption Survey Report. San Diego, CA; California Air Resources Board and Beneficial State Foundation. Retrieved from https://409x7yggc5ekrbd32lf9ajv2-wpengine.netdna-ssl.com/wp-content/uploads/2020/08/BSF-CVA-Program-Evaluation-Report-2019-Final.pdf

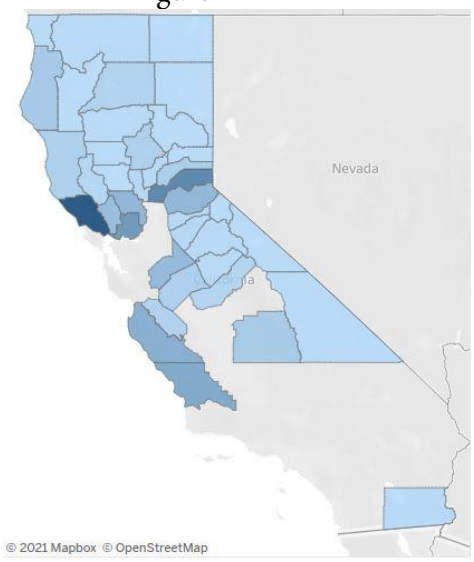
[13] Hanley, B. S. (2020, October 22). *UBS Predicts EV Price Parity In 2024*. CleanTechnica. https://cleantechnica.com/2020/10/22/ubs-predicts-ev-price-parity-in-2024/.

[14] California State Office of Rural Health. (2020, November 18). Rural Health Information Hub. Rural health for California Introduction.
https://www.ruralhealthinfo.org/states/california#:~:text=According%20to%20the%20USDA%20Economic,per%20capita%20income%20at%20%2450%2C267.&text=The%20unemployment%20rate%20in%20rural,USDA%2DERS%2C%202019).

Limited Charging Infrastructure

The development of rural charging infrastructure is a crucial step in rural EV adoption. As of now, there are only 5,494 public and privately-shared EV chargers in rural counties according to data from the California Energy Commission. These chargers are spread across the land mass shown in Figure 11. These represent about 7.5 percent of all public and privately-shared EV chargers in California. Meanwhile, just 12 coastal counties represent about 85 percent of all public and privately-shared EV chargers. These counties are shown in Figure 12. This leaves rural California in the precarious circumstance of charging stations being tailored to support urban travelers and not the residents of rural communities. Based on these data the location of charging technology is mostly centered in urban areas with high population concentrations or along transportation corridors that connect those communities. These transportation landscapes can be seen in Figure F of appendix B from data shared by the alternative fuels data center.

Figure 11



According to data from California Energy Commission 5,494 public and private-shared EV chargers are spread throughout these counties marked in blue. About 7.5 percent of chargers in California.

Figure 12

According to data from California Energy Commission 62,143 public and private-shared EV chargers are spread throughout these counties marked in blue. About 85 percent of chargers in California

Interestingly, to address the lack of charging stations in rural America: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico Utah, and Wyoming have signed on to a Memorandum of Understanding (MOU) to improve regional EV infrastructure in rural areas[15]. One notable state not included in this MOU is California. While this plan is an important milestone in developing EV infrastructure in the western United States region, it emphasizes EV access along highways and in tourist-heavy rural communities, which ultimately does not address EV adoption for the majority of rural communities who are not in tourist destinations. When rural charging infrastructure is located along major highways but not within rural communities themselves, this prevents the normalization of EVs. And instead, chargers serve the role of being appendages for urban communities and tourists that travel along these major highways.

According to a report by the CAVP, there are two primary challenges to EV charger infrastructure expansion in the state: "closing the EV charging infrastructure gap to meet growing demand and equitably distributing EV charging sites, funds, and types of chargers"[16]. California is trying to meet these challenges by making financial commitments for EV infrastructure in low-income and disadvantaged communities. For example, the Clean Energy and Pollution Reduction Act of 2015 requires the California Public Utilities Commission and the California Energy Commission to create "the Disadvantaged Communities Advisory Group (DACAG)". The DACAG determines the utility of clean energy programs for disadvantaged communities and makes recommendations based on their analysis. Additionally, Senate Bill 1000 that was passed in 2016, requires the CEC and CARB to assess

[15] Powers, C. (2021). Electric Vehicle Charging Needs Assessment. National Association of State Energy Officials. Retrieved from https://www.naseo.org/data/sites/1/documents/publications/EVWest_NeedsAssessment_Final.pdf

[16] Laird, B. (2020). (rep.). barriers to clean vehicle adoption in rural communities in CA (pp. 1–15). Oakland, CA: CAVP.

disproportionality of EV charger distribution, specifically in regard to population density, geographical area, and income level[17]. It is important to note that these distribution of EV infrastructure funds are beneficial to rural California because so many of these communities are also considered low-income and/or disadvantaged. Although the data shows that there is still a significant gap to fill for equitable distribution of EV infrastructure between rural and urban California, these funding proposals demonstrate a hopeful trend for the future.

Limited EV Options for Essential Workers & Agriculture in Rural California

Rural communities face a variety of unique barriers for EV adoption due to socioeconomic factors. With the heavily rural Central Valley supplying 8 percent of the United States' agricultural output[18], many rural communities that span between Sacramento and Bakersfield rely on agriculture as the dominant industry. High amounts of agricultural employment result in multiple barriers to EV adoption, including vehicle design limitation, distance traveled to work, and the absence of charging infrastructure at the place of employment.

At this time, there are limited hybrid options for trucks and currently no EV trucks on the market[19]. Even though there are designs underway for EV trucks and few limited hybrid truck options, there are large economic barriers presented by the cost of these models. For people who need a truck for their job, an EV vehicle is not a viable option at this time.

Furthermore, the range potential of EVs is essential for workers in rural California where the average commute time to work is higher than their urban counterparts[20]. For many rural residents, these higher rates of distance traveled lead to pushing people away from considering EVs since workers fear that their batteries will run out before they reach their site according to surveys by CAVP and CARB. For residents of rural communities, it is also less likely that they will be able to charge an EV during their workday, especially for those working in agriculture as we know there are only a few thousand public and private-shared EV chargers in rural California.

One bright spot for non-gas powered vehicles is California's FARMER program that helps fund agricultural replacement equipment including heavy duty vehicles with EVs or low-carbon emitting

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17 Leyva, C. (2021, March 4). SB 1000 - Environmental Justice in Local Land Use Planning. State of California - Department of Justice - Office of the Attorney General. https://oag.ca.gov/environment/sb1000

18 California Water Science Center, U. S. G. S. (2020). *California's Central Valley*. California's Central Valley | USGS California Water Science Center. https://ca.water.usgs.gov/projects/central-valley/about-central-valley.html#:~:text=Using%20fewer%20than%201%25%20of,nuts%2C%20and%20other%20table%20foods.

19 Duffer, R. (2020, October 22). *Where are the affordable electric pickup trucks?* The Car Connection. https://www.thecarconnection.com/news/1130049_where-are-the-affordable-electric-pickup-trucks.

20 Baatar, B., Heckmann, K., Hoang, T., Jarvis, R., & Sakhiya, P. (2019). Preparing Rural America for the Electric Vehicle Revolution. https://epm.ucdavis.edu/. https://epm.ucdavis.edu/sites/g/files/dgvnsk296/files/inline-files/Preparing%20Rural%20America%20for%20the%20Electric%20Vehicle%20Revolution.pdf.

alternatives[21]. Most of this funding goes to the San Joaquin Valley due to the high concentration of agricultural equipment in the region and it being a non-attainment zone for the Clean Air Act. Utility terrain vehicles (UTVs) are the most popularly replaced vehicle through this program with EVs. Nonetheless, the replacement of other agricultural equipment with electric options such as tractors and freight trucks are still rare. Although the FARMER program is funding demonstration projects (e.g. to see how electric tractors compare to diesel powered ones) for the eventual replacement of these equipment with electric options, the options themselves are still not practical to the masses. The most practical use for these funds as of now is to replace older diesel powered freight trucks with newer ones that are less polluting.

Furthermore, according to interviews with FARMER staff, heavy duty EVs are still not cost effective enough for the agriculture workers in rural California. It is also well known that agriculture is the largest employer for hundreds of thousands of workers in rural California. While costs for electric heavy duty vehicles remain impractical, the workers that need these vehicles for the jobs will continue purchasing non-electric options. For example, according to staff from CARB, many small farmers still cannot afford new tractors even if they were to get incentives from programs like FARMER.

Political Apathy

While mitigating climate change and reducing reliance on fossil fuels may be a prevailing issue throughout California as a whole[22], rural communities have different political priorities[23]. For example, water access is of great concern in rural California since agricultural economies depend on it, and hundreds of thousands of rural Californians lack clean drinking water[24]. Additionally, air quality remains another area of concern in California's Central Valley, a region home to many of Calfornian's rural communities[25]. As these basic necessities continue to be priority issues for rural Californians, more abstract issues like the role EVs play in mitigating climate change will continue to be backburner issues.

Furthermore, the priorities of rural populations are ultimately reflected in their political

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[21] *California Air Resources Board*. FARMER Program | California Air Resources Board. (2021). https://ww2.arb.ca.gov/our-work/programs/farmer-program.

[22] Baldassare, M., Bonner, D., Dykman, A., & Lawler, R. (2020, October 22). *PPIC Statewide Survey: Californians and the Environment*. Public Policy Institute of California. https://www.ppic.org/publication/ppic-statewide-survey-californians-and-the-environment-july-2019/.

[23] Parker, K., Horowitz, J. M., Brown, A., Fry, R., Cohn, D. V., & Igielnik, R. (2020, May 30). *How urban, suburban and rural residents' view social and political issues*. Pew Research Center's Social & Demographic Trends Project. https://www.pewresearch.org/social-trends/2018/05/22/urban-suburban-and-rural-residents-views-on-key-social-and-political-issues/.

[24] Guo, E. (2020, November 20). *In California, 1 million people lack access to clean water*. High Country News – Know the West. https://www.hcn.org/issues/52.12/south-pollution-in-california-1-million-people-lack-access-to-clean-water.

[25] Baldassare, M. (2017, June 12). *Special Survey Of The Central Valley: There's No Place Like Home!* Public Policy Institute of California. https://www.ppic.org/press-release/special-survey-of-the-central-valley-theres-no-place-like-home/.

representation. Several rural political representatives such as Devin Nunes (R-CA 22), Tim McClintock (R-CA 4), and Doug LaMalfa (R-CA 1) are just some of the rural heavy political representatives that have called into question the need to mitigate climate change[26]. And these already biased political ideologies will often end up aligning with the fossil fuel industry and other major donors that often clash with efforts to mitigate climate change[27][28]. For example, rural lawmakers in 2020 clashed with Minnesota Gov. Tim Walz over a similar effort as the California EO. Minnesota's "plan would require auto manufacturers to offer more hybrid and electric vehicles for sale in the state", yet several rural lawmakers were quoted as saying this was against the best interests of their rural communities[29].

Without politically inclined policymakers pushing for EV infrastructure and other EV-friendly local policies in their communities, the state may find it difficult to succeed in implementing the ambitious EO. For this reason, finding policymakers in rural California that will prioritize EV adoption will be a necessary component for a 100% EV adoption rate. As I expand later in the analysis, the strongest programmatic example of rural EV adoption in California came about because of the political pressure from an environmentally conscious Mayor Rey Leon, and the local nonprofit he runs named Green Raiteros.

Cultural Preference for Gas-Powered Vehicles

Another significant rural adoption barrier is that EVs have yet to be normalized in rural communities to the same extent that they have in urban California. This has to do with the total number of EVs present in rural CA which according to State data only equates to 43,584 EVs[30]. But also because the spread of EVs appears to follow a pattern of hierarchical diffusion of technology based on demographic, economic, and environmental characteristics. And it appears that the higher educated the county, and the higher income the county, the more EVs the region tends to have. For example, Figure A in the appendix, lists the top 20 zip codes with the most EVs and how they are all located in counties within the Silicon Valley area. Figure D also shows a correlation between the number of EVs and their zip codes spread across California.

The presence of EVs and EV infrastructure leads to the normalization of EV usage in urban parts of

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[26] Grandoni, D. (2020, September 18). Analysis | The Energy 202: Many California Republicans side with Trump in dismissing climate change as wildfire cause. The Washington Post. https://www.washingtonpost.com/politics/2020/09/18/energy-202-many-california-republicans-side-with-trump-dismissing-climate-change-wildfire-cause/.

[27] Kotch, A. (2019, April 30). California Climate Change Denier Has a Progressive House Challenger. Sludge. https://readsludge.com/2019/04/30/california-climate-change-denier-has-a-progressive-house-challenger/.

[28] Brownstein, R. (2020, September 17). *Why Republicans Still Don't Care About Climate Change*. The Atlantic. https://www.theatlantic.com/politics/archive/2020/09/california-wildfires-and-politics-climate-change/616380/.

[29] Kraker, D. (2020, February 20). Rural lawmakers push back against 'clean cars' proposal. MPR News. https://www.mprnews.org/story/2020/02/20/rural-lawmakers-push-back-against-clean-cars-proposal.

[30] California Energy Commission. (2021). *Zero Emission Vehicle and Infrastructure Statistics*. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics.

the state, while rural communities are less likely to view EVs as a transportation norm. Instead, gas-powered vehicles are the transportation norm, and in rural areas where a significant portion of the population are essential workers, heavy duty gas-powered vehicles become the ideal market preference. In rural communities, heavy duty trucks and diesels become market preferences because of their utility in the local economies of agriculture, construction, and transportation services; in addition to satisfying the cultural aesthetic of working-class bootstrapping.

Data also shows that drivers in rural America have a preference for heavy and medium-duty pickup trucks. Figure E from a study done by UC Davis in the appendix demonstrates this preference[313233]. For example, in 2017, the most popular vehicles in rural households were all pickup trucks: Ford F-Series, Chevy Silverado, Ram Pickup, GMC Sierra, and other Medium/Heavy Pickups.

Nonetheless, my stakeholder interviews were consistent with the feedback that EVs would be preferable if they were actually cheaper than gas-powered vehicles. Community members also universally liked the idea of saving money on gas. One community member in particular, mentioned having a preference for the Tesla Cybertruck concept that still satisfies a rural cultural aesthetic while preventing them from getting "killed by gas here because of long driving distances".

Lack of EV Education

A consistent theme of the interviews conducted in this analysis and of the literature review, is that the lack of EV education in rural communities is limiting EV adoption. Even if someone is interested in purchasing an EV, they likely will not be aware of the environmental and financial opportunities associated with an EV which include various state, federal, and local grants and rebates, tax credits and HOV lane access when driving on freeways. Furthermore, rural Californians likely will not be aware of the local EV charging infrastructure in their surrounding area. For example, all of my interviewees were not aware of the financial support available to them by the state and federal government to help purchase an EV. Additionally, in an interview with Green Raiteros staff, a program providing EV rideshare to community members in rural Huron, CA; staff mentioned that the number of individual EV owners has not increased much in their community due to folks not knowing how to make them more affordable.

Although websites such as the alternative data fuels center and the California Energy Commission provide interactive maps of EV charging stations at a state and national level, community members

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[31] Washington, DC: Federal Highway Administration.
U.S. DOT. (2017). National Household Travel Survey 2017. Retrieved February 28, 2019 from https://nhts.ornl.gov/

[32] Baatar, B., Heckmann, K., Hoang, T., Jarvis, R., & Sakhiya, P. (2019). Preparing Rural America for the Electric Vehicle Revolution. https://epm.ucdavis.edu/. https://epm.ucdavis.edu/sites/g/files/dgvnsk296/files/inline-files/Preparing%20Rural%20America%20for%20the%20Electric%20Vehicle%20Revolution.pdf.

[33] Baldassare , M. (2017, June 12). Special Survey Of The Central Valley: There's No Place Like Home! Public Policy Institute of California. https://www.ppic.org/press-release/special-survey-of-the-central-valley-theres-no-place-like-home/.

will likely have trouble navigating them due to the socioeconomic conditions of rural California. These include existing language barriers, connectivity issues, and technical knowledge gaps. For example, rural California is home to hundreds of thousands of immigrants who speak a native language other than English[34], rural California has less broadband internet[35], and rural California has the lowest education rates in the state[36].

Although guidance is provided for community members once they begin contact with a rebate or grant program like the ones offered by California, without knowledge of these financial supports, many people do not even consider an EV. The process of purchasing an EV and/or an accompanying charger can be complex, therefore education through resources, videos, or scheduled appointments, at various steps in the EV purchasing process is necessary to overcome this education barrier.

IV. Programs Addressing EV Adoption Barriers in Rural California:

There are various programs throughout California that are attempting to address the barriers mentioned in this analysis. These programs provide the following: rebates, grants, demonstration projects, education, outreach, and technological advancement for EVs. In the following section of this analysis, I share about some of these programs that are succeeding in addressing EV adoption barriers.

Rural EV Share Programs:

Green Raiteros, Huron, CA:

Green Raiteros is a shared EV program based in the rural town of Huron, CA. In partnership with EVgo, Green Raiteros has helped establish over 30 public and privately-shared EV chargers (see Figure 9 for a description of the different types of EV chargers), both private and public in this small rural town according to interviews with staff. Mayor of Huron, CA, Rey Leon, has called this town the "greenest" in rural California because of their charging infrastructure. Huron, CA is predominantly Latino, with many residents working in agriculture in the surrounding areas. Since the program's launch, Green Raiteros has been able to serve over 230 trips for mostly low-income immigrant farmworkers. Green Raiteros was started to support local residents who would often rely on "raiteros" (people who give rides with their cars for a fee to community members). Green Raiteros currently has two EVs (a Chevy Volt and a BMW i3) for local volunteer drivers to use in their fleet with plans to purchase more. Barriers this program addresses include:

- Limited Charging Infrastructure - by installing over 30 public and privately shared EV

[34] Johnson, H., Perez, C., & Mejia, M. (2021, March 24). Immigrants in California. Public Policy Institute of California. https://www.ppic.org/publication/immigrants-in-california/.

[35] Gao, N., & Hayes, J. (2021, February 18). California's Digital Divide. Public Policy Institute of California.

[36] Jones, C. (2020, December 2). The long road to college from California's small towns. EdSource. https://edsource.org/2019/the-long-road-to-college-from-californias-small-towns/621428.

chargers.
- Political Apathy - by having local elected officials apply for grants and pressure the state and private partners to support EV infrastructure development and grants for their ride-share EVs.
- Cultural Preference for Gas-Powered Vehicles - by competing directly with local systems of community ride-share that usually uses gas-powered vehicles.
- Lack of EV Education - by seeking local volunteers and providing a low-cost service for local residents.

CA Agricultural Worker Vanpools Pilot Project XL:

The California Vanpool Authority (CalVans) is a state program that provides agricultural workers in rural communities with affordable and reliable vans to drive themselves and others to job sites. The project uses zero emission hybrid vans. Riders pay a modest fee to ride in a CalVans vanpool with most paying around $2 per ride. This fee covers CalVans' cost of maintaining and insuring the vans. The program is volunteer based as workers volunteer to operate a vanpool. The project launched in 2019 with the deployment of 154 General Motors, 15-passenger hybrid vans fitted with hybrid conversion kits. CalVans has also received $4.7 million in funding to support the deployment of 111 hybrid vans by spring of 2020 (for a total of 265 hybrid vans). Approximately 70 percent of the project fleet is deployed in the San Joaquin Valley (a rural heavy region), with remaining deployments in the Coachella Valley, Salinas Valley, Santa Maria, and South Coast. Barriers this program addresses include:

- High Cost of EVs - by providing low-cost access to 15-passenger hybrid vans for local agricultural workers.
- Limited EV Options for Essential Workers & Agriculture in Rural California - by providing a transportation service specifically reserved for essential workers in rural parts of California.
- Cultural Preference for Gas-Powered Vehicles - by competing directly with local systems of community ride-share that usually uses gas-powered vehicles. And by competing directly with other agricultural worker transportation programs that use gas-powered vans and busses.
- Lack of EV Education - by seeking volunteers from rural communities and word-of-mouth outreach from worker to worker.

Ecosystem of Shared Mobility in the San Joaquin Valley:

The San Joaquin Valley Air Pollution Control District (SJV APCD) was awarded $2,250,000 in the 2016-2017 year for EV programs and ride-share in the rural heavy San Joaquin Valley. There are two parts to this program. The first one is Valley Go which is deploying EV ride-share through an app known as Miocar in affordable housing communities located within Tulare and Kern county. At least 24 Battery EVs and 17 Level 2 EV chargers will be installed to support these vehicles. The second part of this program is known as Valley Flex. This program seeks to improve the efficiency of existing transit services within local transit agencies through an app named VAMOS. Ride hailing services have

been integrated into this program to help users travel to fixed bus routes within Stanislaus and San Joaquin counties. This project will ultimately serve over 25 disadvantaged communities census tracts.

The vehicles/equipment funded through this program include the following: 12 Level 2 EV chargers in total deployed throughout the cities of Orosi, CA, Dinuba, CA, Visalia, CA, Lamont, CA, Arvin, CA, and Wasco, CA - all which are situated either in rural Tulare County and Kern County. The program has also purchased for ride-share services 6 EVs (4 BMWs i3s and 2 Chevrolet Bolts), within the above-mentioned cities. Barriers this program addresses include:

- High Cost of EVs - by making 6 EVs available for rent at a low-cost in affordable housing communities within rural California.
- Limited Charging Infrastructure - by installing and making 12 Level 2 EV chargers publicly available to rural communities in the above-mentioned cities.
- Cultural Preference for Gas-Powered Vehicles - by competing directly with local systems of community ride-share that usually uses gas-powered vehicles. And by competing directly with other non-EV centered transportation services such as UBER.
- Lack of EV Education - by outreaching low-cost EV transportation services to affordable housing communities and by providing outreach to surrounding community members.

<u>Valley Air ZEV Mobility Pilot Project:</u>

The San Joaquin Valley Air Pollution Control District, has received $749,800 in funding from the California Air Resources Board to implement advanced clean car sharing and mobility options in census tracts in the San Joaquin Valley that are within the top 19% of disadvantaged communities. The funding is intended to develop EV infrastructure in the San Joaquin Valley, targeting over 1000 residents in disadvantaged communities for EV vanpooling and car-sharing services. This project also enables residents to access EVs without the high cost of ownership. The project has the goal to fund 12 EVs (6 Tesla Model X's and 6 Chevrolet Bolts) and at least 31 publicly available EV chargers (at least 5 DC/Level 3 chargers and Level 2 chargers for the remaining). As of now, the project has funded 8 Level 2 chargers, 2 DC/Level 3 chargers, 5 Chevrolet Bolts, and 3 Tesla Model X's. Barriers this program addresses include:

- High Cost of EVs - by making 12 EVs publicly available through low-cost hourly rates or daily rates for community members in predominantly rural communities (e.g. Cantua Creek, CA).
- Limited Charging Infrastructure - by attempting to install at least 31 publicly available EV chargers within disadvantaged rural communities in the San Joaquin Valley. And by already installing 8 level 2 chargers and 2 DC/level 3 chargers in the San Joaquin Valley.
- Cultural Preference for Gas-Powered Vehicles - by competing directly with local systems of community ride-share that usually uses gas-powered vehicles. And by competing directly with non-EV centered transportation services such as UBER.
- Lack of EV Education - by outreaching low-cost EV transportation services to disadvantaged communities in rural California and by providing outreach to surrounding community

members.

TransPort Transit Program, Porterville, CA:

On April 13, 2020, the City of Porterville started an on-demand or microtransit-type service similar to private companies UBER and LYFT. The program also uses EV vans that have their own chargers provided by the city. Unlike other transit services provided by local governments that rely on fixed-routes, the "TransPort" program allows residents to request travel as-needed from Porterville Transit. The program uses technology like the TransLoc app to allow residents to view available rides similar to UBER. TransPort is the first of its kind transportation service in rural California that also services local towns like Strathmore, CA. Rides through the service are also low cost, costing only $3.00 one way and offered seven days a week from Monday to Friday: 6:00 am to 9:00 pm on weekdays, and 8:00 am to 8:00 pm on weekends.

The TransLoc app allows users to schedule and pay for their trip through their phone or cash in-person when being picked up. According to an interview with city council member Daniel Penaloza, the service had over 800 clients in the last month alone, and has seen an upwards demand since its launch. Barriers this program addresses include:

- High Cost of EVs - by making EV transportation accessible through low-cost fees for community members in rural Tulare County. .
- Political Apathy - by directly involving local government and elected officials in the implementation of an EV rideshare program managed directly by the city. And by sharing the success of the program with neighboring local governments and encouraging them to start their own EV city transit service.
- Cultural Preference for Gas-Powered Vehicles - by competing directly with local systems of community ride-share that usually uses gas-powered vehicles. And by competing directly with non-EV centered transportation services such as UBER. And also by competing directly with the need to purchase a vehicle to travel locally.
- Lack of EV Education - by outreaching low-cost EV transportation services to communities in rural California and by providing outreach to surrounding community members. And by normalizing EV transit services rather than other transportation services.

EV Ownership Incentive Programs:

California Rebate Program:

The Clean Vehicle Rebate Project (CVRP) is a program started by the California Air Resources board to support Californians purchasing EVs by providing up to $7,000 in rebates for qualifying customers. Funding is available mostly for BEVs, PHEVs, and FCEVs. According to a report by the program, "Over the first five years of the program, roughly three-quarters (>74%) of eligible purchases and leases were rebated. Over two-thirds (>67%) of plug-in hybrid electric vehicle (PHEV) consumers, and over

four-fifths (>81%) of all-battery electric vehicle (BEV) consumers, participated"[37]. By the end of March 2015, at least 74% of eligible vehicles applied for and received a rebate. A table of these participation rates by county can be found in Figure G of the appendix of this analysis. Since its inception in 2010, the CVRP has helped put 350,000 EVs on the road. It has also given up to 409,609 in rebates mostly to EVs, totaling $935,002,923 in funding[38]. Although there is insufficient data for some rural counties, those with adequate data are showing high participation rates for rural community members. A map of these data is shown in Figure H. Barriers this program addresses include:

- High Cost of EVs - by providing rebates that can total up to $7,000 for individual ownership of EVs.
- Cultural Preference for Gas-Powered Vehicles - by competing directly with gas-powered vehicle purchases and helping increase the total number of EV individual owners.
- Lack of EV Education - by outreaching to dealerships throughout California, including those located in rural communities. And by partnering with local governments and businesses working in rural communities to inform people of the state EV rebate incentives.

Clean Vehicle Assistance Program:

The Clean Vehicle Assistance Program (CVA) provides grants and loans to low income and moderate income individuals who want to purchase a new or used EV. The program gives up to $5,000 in grants for both PHEVs and BEVs, and up to $2,500 for hybrid vehicles. The program also has charging grants available for level 2 chargers to be installed in a grantee's home or prepaid charge credit to use for pay to charge, publicly accessible chargers.The program's goal is to make EVs accessible to Californian's of all economic brackets, but especially low-income Californians. As of now, the program has given 3,157 grants for EV purchases, as well as 966 EV charger grants[39]. It is important to note that in an interview with staff, staff mentioned that it is likely the majority of grantees are from urban areas even though their funds are available to all Californians. From available data, 277 of grants have gone to rural Californians[40]. Barriers this program addresses include:

- High Cost of EVs - by providing grants that can total up to $5,000 for individual ownership of EVs. And also by providing low-interest loans for qualifying individuals wanting to own an EV.
- Limited Charging Infrastructure - by providing grants and prepaid credit for individuals wanting to purchase an in-home level 2 charger, or who want to use a publicly accessible EV

[37] Center for Sustainable Energy. (2015, October). Clean Vehicle Rebate Project Participation Rates: The First Five Years (March 2010 – March 2015).

[38] Center for Sustainable Energy. (2021, April 16). CVRP Rebate Statistics. Clean Vehicle Rebate Project. https://cleanvehiclerebate.org/eng/rebate-statistics.

[39] Clean Vehicle Assistance Program. (2021, April 29). Program Data. Clean Vehicle Assistance Program. https://cleanvehiclegrants.org/program-data/.

[40] Clean Vehicle Assistance Program. (2021, April 29). Program Data. Clean Vehicle Assistance Program. https://cleanvehiclegrants.org/program-data/.

charger.

- Cultural Preference for Gas-Powered Vehicles - by competing directly with gas-powered vehicle purchases and helping increase the total number of EV individual owners in rural California.
- Lack of EV Education - by outreaching to dealerships throughout California, including those located in rural communities. And by partnering with local governments and businesses working in rural communities to inform people of these grant and loan incentives.

Clean Cars for All:

The Clean Cars for All program helps lower-income Californians access EVs by retiring older, higher-polluting vehicles. The program includes up to $9,500 in incentives for the replacement of older gas-powered vehicles[41]. Residents also have the option to replace their older vehicle for up to $7,500 in funding for alternative transportation options such as public, private, and shared mobility options. The program is limited to vehicle owners living within the participating air districts, income thresholds, and replacement vehicle requirements. The participating air districts in California are South Coast Area Air District (includes Los Angeles), San Joaquin Valley Air District, Bay Area Air District, and the Sacramento Area Air District. Of the participants, 89 percent have household incomes that are within the program's low-income category. These funds can also be combined with incentives from other programs such as the Clean Vehicle Rebate Project. This means some low-income participants can get up to $14,000 for a new EV purchase. As of December 2020, the program has replaced older vehicles with 7,166 EVs throughout the 4 participating air districts[42]. Barriers this program addresses include:

- High Cost of EVs - by providing funding that can total up to $9,500 for individual ownership of EVs in rural California.
- Political Apathy - by directly involving local government and elected officials in the implementation of EV incentive programs (via air districts boards e.g. San Joaquin Valley Air District). And by having locals outreach and encourage their local communities to utilize the EV funding.
- Cultural Preference for Gas-Powered Vehicles - by competing directly with gas-powered vehicle purchases and helping increase the total number of EV individual owners in rural California.
- Lack of EV Education - by outreaching to air districts, including those representing rural communities. And by partnering with local governments and businesses working in rural communities to inform people of these EV funding incentives.

[41] California, S. of. (2016). Clean Cars 4 All. https://ww3.arb.ca.gov/msprog/lct/vehiclescrap.htm.

[42] California Air Resources Board. (2020). EFMP Retire and Replace Program Statistics. CARB. Retrieved from https://ww2.arb.ca.gov/sites/default/files/2021-03/2020_q4_%20EFMP%20Website%20Statistics%20Tables%20Cumulative.pdf

Heavy Duty and Agricultural EV Options for Essential Workers:

FARMER Program:

The Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program is intended to reduce agricultural sector emissions by providing grants to replace high emission agricultural equipment including utility terrain vehicles (UTVs), tractors/harvesters, agricultural trucks, and other vehicles. Since 2017, the California Legislature has appropriated $323 million for the FARMERS program with 65% of the funds benefiting disadvantaged and low-income communities[43]. The program includes funding for demonstration projects for zero-emission agricultural utility terrain vehicles (UTV), heavy-duty agricultural trucks, and off-road mobile agricultural equipment trade-up pilot projects. Some lower emissions agricultural vehicles and equipment need field demonstrations to test the vehicle or equipment viability in performing the same work as the vehicle/equipment it would replace. As of now, the FARMER program has implemented 1,916 UTVS, 2487 Tractors/Harvesters, and 254 agricultural trucks; with the majority of funding going to the San Joaquin Valley due to its emissions concentration[44]. Barriers this program addresses include:

- High Cost of EVs - by providing grants and funding to the agricultural sector to purchase electric UTVs.
- Limited EV Options for Essential Workers & Agriculture in Rural California - by funding technological advancements for heavy duty vehicles and the eventual replacement of gas-powered agricultural vehicles and equipment with EV options.
- Political Apathy - by directly involving local government and elected officials in the implementation of FARMER incentive funding (via air districts boards e.g. San Joaquin Valley Air District). And by having locals outreach and encourage their local communities to utilize the FARMER funding.
- Lack of EV Education - by outreaching to air districts, including those representing rural communities. And by partnering with local governments and businesses working in rural communities to inform people of these EV funding incentives.

Volvo LIGHTS Project:

Volvo LIGHTS (Low Impact Green Heavy Transport Solutions) is part of California Climate Investments, a program that is trying to reduce greenhouse gas emissions, and that is trying to improve public health and environmental conditions in California. The total project cost is $90 million. Volvo LIGHTS project aims to get cleaner trucks on the road to transport goods from ports to the Inland Empire. The project includes 23 zero-emission battery electric trucks, 29 off-road battery electric

[43] California Air Resources Board. (2020). EFMP Retire and Replace Program Statistics. CARB. Retrieved from https://ww2.arb.ca.gov/sites/default/files/2021-03/2020_q4_%20EFMP%20Website%20Statistics%20Tables%20Cumulative.pdf

[44] CARB. (2020). Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program. California Air Resources Board. Retrieved from https://ww2.arb.ca.gov/sites/default/files/classic/ag/agincentives/outreach/farmerinfographic.pdf

tractors, and 58 Level 2 and DC/Level 3 EV chargers[45]. The EV freight trucks have a range of about 300 miles. Over a three-year project period, Volvo LIGHTS will seek to demonstrate the capacity for heavy-duty EV trucks and equipment to reliably move freight between two major Southern California ports and warehouses throughout the region. Barriers this program addresses include:

- Limited EV Options for Essential Workers & Agriculture in Rural California - by funding technological advancements for heavy duty vehicles and the eventual replacement of gas-powered agricultural vehicles and equipment with EV options.
- Political Apathy - by directly involving local government and elected officials in the implementation of the EV project (via partnerships with air districts boards, private companies, universities, etc.).

Electric Pickup and Electric Bus Concepts:

Many of the world's largest auto companies are making the commitment to produce 100 percent electric pickup trucks. For example, the Ford F-150 electric pickup has been heavily anticipated, and is set to launch in 2022, with a promising range of over 300 miles[46]. There are currently five other major electric pickup trucks set to be released in the U.S. market. These are Tesla's Cybertruck, Bollinger's B2, Lordstown Motor's Endurance, GMC's Hummer EV and Rivian's R1T. These trucks also measure closely with the capacity of conventional trucks. For example, Tesla's Cybertruck has the highest reported speed of 130mph. It will also boast the highest towing capacity on the market, at 14,000 pounds[47]. For horsepower and torque, the GMC Hummer EV is expected to have the strongest capacity, rated at an estimated 1,000 horsepower, with 11,500 pound feet of torque[48].

Electric buses are also becoming popular throughout California. For example, the California Energy Commission has delivered 68 electric school buses while replacing some of California's oldest diesel buses, and updating supporting charging infrastructure[49]. The commission is projected to replace up to 167 buses this year. For a spatial map of these data see appendix Figure I. These include buses in rural California. Currently, the U.S. electric bus market is expected to grow from a market size of $469.3 million in 2019 to $2.6 billion by 2024[50]. Bloomberg predicts that electric Buses will represent

[45] California Climate Investments. (2020, February 12). A Collaboration to Commercialize Battery Electric Freight Trucks. Volvo LIGHTS. https://www.lightsproject.com/.

[46] Lambert, F. (2020, March 5). Ford F150 Electric 2022 rendered based on inside info. Electrek. https://electrek.co/2020/03/05/ford-f150-electric-render-inside-info/.

[47] Plungis, J. (2019, November 22). Electric Tesla Cybertruck Unveiled With Edgy, Futuristic Design. Consumer Reports. https://www.consumerreports.org/hybrids-evs/electric-tesla-cybertruck-unveiled-with-edgy-futuristic-design/.

[48] Ewing, S. (2020, October 21). GMC Hummer EV's 11,500 lb-ft torque figure is misleading, here's why. Roadshow.

[49] California Energy Commission. (2021). Zero Emission Vehicle and Infrastructure Statistics. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics.

[50] Prescient & strategic intelligence. (2020, December). *U.S. Electric Bus Market Size, Trend, Revenue & Forecast - 2024.* Prescient & Strategic Intelligence Private Limited.

80 percent of the global bus fleet by 2040[51]. Barriers these market dynamics could address in the future include:

- Limited EV Options for Essential Workers & Agriculture in Rural California - by funding technological advancements for heavy duty vehicles and introducing the masses with heavy duty EV options.
- Cultural Preference for Gas-Powered Vehicles - by presenting heavy duty EVs as viable alternatives to the masses.

V. Objectives Addressing Rural EV Adoption Barriers:

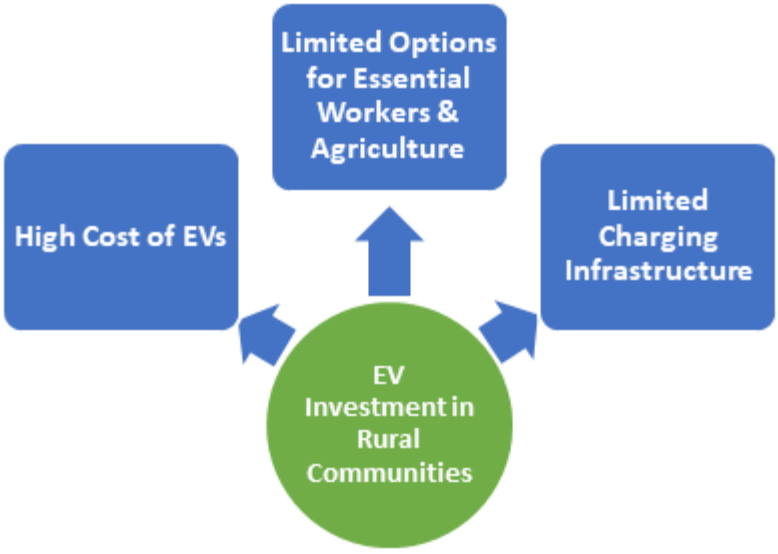
The above programs provide current models that are addressing EV adoption barriers. Although data shows that rural California is still far from complying to the EO as a whole; these programs are succeeding in supporting rural Californians in EV adoption. As shown in the last section of this analysis; these programs are uniquely addressing rural EV adoption barriers through EV rideshare programs and EV ownership incentives; with hopes to eventually scale the adoption of heavy duty EVs in the coming future. Taking inspiration from the success of these programs, I compiled the rural EV adoption barriers into separate categories that can be addressed by 3 separate objectives in this analysis. These objectives include the following:

1. Increase EV Investment in Rural Communities

A central issue in this analysis has been the incapacity that rural communities as a whole have to purchase EVs at the rate that urban California has been able to. Although there are some programs that support rural community members in accessing EVs such as the incentive programs and the ride-share programs; for the most part, rural Californians will need continued investment in order to adopt EVs at a capacity that can fulfill the EO. Namely, EV needs to reach price parity with new and used gas-powered vehicles, publicly charging needs to be widely accessible in rural counties for those that cannot afford in-home chargers, and essential/agriculture workers will need viable EV options for their heavy duty vehicles. By continuing to invest in programs that will support rural EV adoption, California will continue to actively address rural EV adoption barriers of the high cost of EVs, the limited EV options for essential workers & agriculture, and limited charging infrastructure. Figure 13 represents this dynamic:

Figure 13

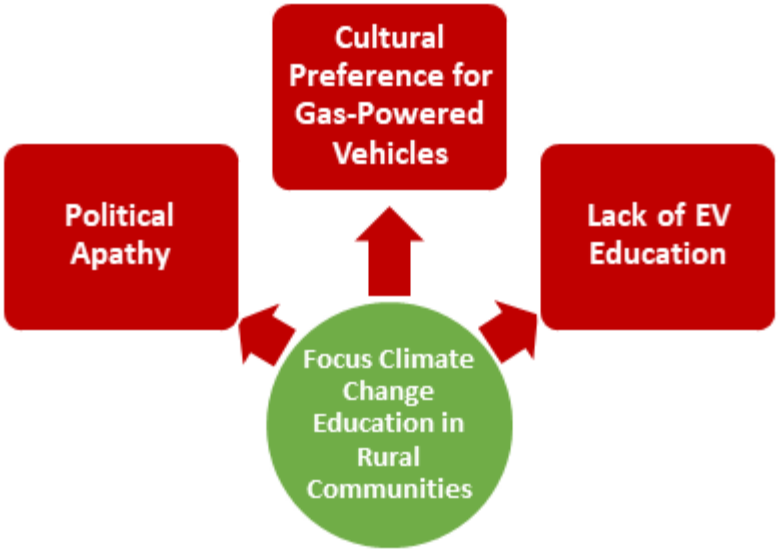
[51] Bloomberg NEF. (2018, July 12). Bloomberg.com. https://www.bloomberg.com/professional/blog/e-buses-surge-even-faster-evs-conventional-vehicles-fade/.



2. Focus Climate Change Education in Rural California

Another central issue in this analysis has been the lack of EV education in rural communities. Ultimately, this lack of EV education is likely a product of the broader rural issue of lower education attainment rates than the rest of California. As data in this analysis has shown, there is a correlation between the communities that have the highest rates of EVs, their overall educational attainment, and the overall household income of those same communities. This makes sense because higher educated communities tend to have higher incomes, and higher educated communities prioritize abstract ideas like climate change mitigation. And these tend to be more urban. Meanwhile, less educated communities tend to be working-class, and working-class communities prioritize fulfilling basic needs like having clean drinking water rather than abstract concerns. And these tend to be more rural. For this reason, the second objective of this analysis is focusing and expanding climate change education overall in rural California so that these communities also have access to abstract ideas like the environmental and public health impact of climate change; and build a sense of urgency which the EO exudes. By focusing climate change education in rural California, California will actively address the rural EV adoption barriers of political apathy, the cultural preference for gas-powered vehicles, and the lack of EV education. Figure 14 represents this dynamic:

Figure 14

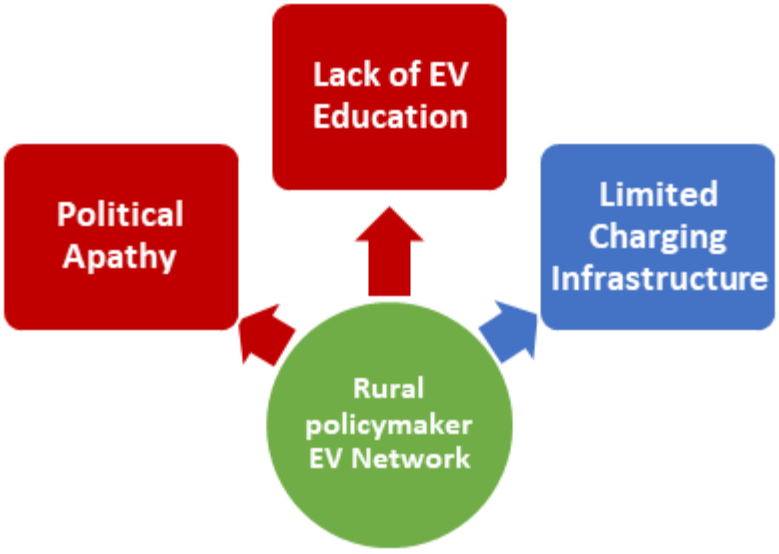


3. Build a Rural Policymaker EV Adoption Network

A third central issue in this analysis has been the lack of political and local economic mobilization in rural communities for EV adoption. Although other communities have implemented and invested in a plethora of EV adoption programs (e.g. Bay Area & Los Angeles); rural California has just a handful of examples of local policymakers taking initiative to support EV adoption in their communities. Although the few rural policymakers that are mobilizing resources for EV adoption are succeeding; these handful of models need to be scaled and multiplied so that all rural cities are put in a trajectory where they have the capacity to support their residents to comply with the EO by 2035.

By identifying rural policymakers that have the political will to support EV adoption, and bringing them together with policymakers already supporting EV adoption in their cities; California can expand the capacity of rural governments to support EV adoption. A rural policymaker EV adoption network can yield an exchange of ideas, share best EV adoption practices, form partnerships, and ultimately compound and synergize resources. For this reason, the third objective of this analysis is building a rural policymaker EV adoption network. Through this coalition, California will address the rural EV adoption barriers of political apathy, lack of EV education, and limited charging infrastructure. Figure 15 represents this dynamic:

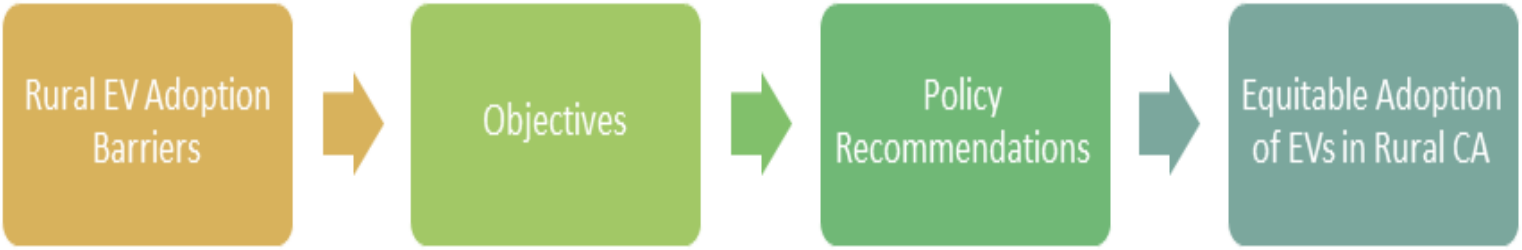
Figure 15



These 3 objectives in conjunction address all the rural EV adoption barriers presented in this analysis. It is also important to note that the relationships in these objective systems are ultimately subjective since some barriers can be addressed by more than one objective, and some objectives may address even more barriers than attributed in the systems exemplified; however these have proven to be useful guides for determining the policy recommendations in this analysis.

VI. Policy Recommendations that Fulfill the Objectives:

The following policy recommendations are designed to meet the objectives as described above, objectives that in turn will address the barriers of rural EV adoption. If the following policy recommendations are implemented, California will be better prepared to equitably expand EV adoption in rural California to accomplish the goal of the EO. This logical sequence is described below:



Policy Recommendations:

Through analysis of spatial data, interviews, EV programs, and review of the literature, I have

identified policies that the state of California can use to overcome rural EV adoption barriers in the short-term and long-term.

1. **Tailor Incentive EV Programs to Rural California.**

California has a multitude of EV adoption incentive programs that are available to rural Californians such as the CVRP, CAVP, and financial incentives through air districts. Although these programs have been able to distribute all their available funding to support EV ownership, data in this analysis shows that rural Californians are less likely to utilize these programs. Either because of lack of awareness about these programs, complexity of the application process, or because there are less people interested in EVs in rural California. However, data from the CVRP program shows that out of eligible EV clients, there is at least a 60 percent rebate utilization rate in all rural Counties, many above 70 percent, and some closing in on 80 percent. These data are shown in figures G and H in the appendix. Although the utilization rate of eligible clients is more than half in the rebate program in particular, the total number of EV clients from rural California is still less than non-rural counties. Therefore, in the short-term it is recommended that **the CVRP, CAVP, and the Clean Cars for All air district programs set aside incentive funding specifically for rural counties so that California can ensure a certain percentage of incentive funding goes to these less electrified areas.**

The data explored in this analysis is consistent with the dynamic that the incentive programs have more demand than supply, even as the majority of funding goes to non-rural counties. In order to mitigate this discrepancy in funding, and ensure rural utilization of EV funding, and therefore EV adoption, incentive programs need to limit the amount of funding that goes to non-rural clients. Although the exact percentage of funding that should go to rural counties is an area for future research, one method EV incentive programs can use to distribute incentive funding is to distribute at a rate that is consistent with the populations of rural and non-rural counties. For example, rural California as defined in this analysis represents about 11.2 percent of the California population[52]. Therefore, **the incentive programs should set aside 11.2 percent of their funding to go directly to rural EV clients to ensure they are not pushed out from funding by the demand of non-rural Californians.**

In the long-term, it is recommended to the California Air Resources Board (CARB - the administrator of these EV programs), to establish a separate rural EV incentive program. An incentive program that can either be a rebate program, grant program, loan program, or a combination of all these. The important dynamic is that rural California has a separate funding source to increase EV adoption. Ultimately, to ensure rural compliance with the EO by 2035, the already under-resourced rural counties need to have the opportunity to apply to and be informed about EV incentives without

[52] US Census Bureau. (2020, May). California Counties by Population. California Outline. https://www.california-demographics.com/counties_by_population.

having to compete with already over-resourced non-rural counties. The projected outcome is that this policy recommendation will result directly in increasing the number of rural Californian's adopting EVs, fulfilling the first objective of this analysis: (A) Increase EV Investment in Rural California.

2. Encourage and Invest in Local Modes of EV Rideshare in Rural Cities and their EV Infrastructure.

There are a few examples of established EV infrastructure in rural California cities. One example shared in this analysis is Huron, CA in Central Valley which has had over 30 EV chargers installed throughout the city. These charging stations ranging from level 2 chargers to level 3 DC chargers are strategically located in places such as the local city hall and near other centers of town. A lot of this is due to the many years of advocacy from the local EV rideshare program (Green Raiteros) and the initiative taken by the local government to electrify its city. As of now, the rideshare program is credited with having given several hundred trips to disadvantaged rural community members that either do not own vehicles or need a low-cost mode of transportation.

Another example shared in this analysis is rural city Porterville, CA in the Central Valley. The city of Porterville has invested in its own electric buses, EV vans, and city chargers partially with the help of funding from the California Air Resources Board[53]. The city is also credited with being North America's first 100 percent electric municipal bus system[54]. Additionally, the city of Porterville also uses its EV vans to provide what it calls a microtransit service similar to UBER called "Porterville TransPort". According to a Porterville city representative, the microtransit services already reached close to 1,000 users just last month in April.

Although California has already mandated all municipal buses to be electric by 2029, in the short-term, it is recommended that the California Air Resources Board also expand locally owned EV rideshare programs throughout more rural cities. Data from this analysis shows that EV rideshare programs have been successful in supporting rural California's electrification and in helping prepare rural California for an EV future consistent with the EO. However, it is important to note that an area for future research is finding if there is a correlation between the presence of these EV rideshare programs and an increase in EV individual ownership in their cities of implementation. For example, new EV sales in Porterville, CA increased from 14 for the year of 2015, to 97 for the year of 2020[55]. For Huron, CA, new EV sales increased from 0 in 2015, to 6 for the year of 2020. Nonetheless, EV ownership is not expected to increase significantly in rural cities unless EVs reach price parity with gas-

[53] The Recorder. (2019, September 10). Last electric bus in Transit fleet makes its way to Porterville. Porterville Recorder. https://www.recorderonline.com/news/last-electric-bus-in-transit-fleet-makes-its-way-to-porterville/article_9b9495ba-d3d9-11e9-9b7b-13d532c1dab5.html.

[54] Hales, R. L. (2016, December 9). North America's First Percent Electric Municipal Bus System. CleanTechnica. https://cleantechnica.com/2016/12/09/north-americas-first-100-percent-electric-municipal-bus-system/.

[55] California Energy Commission. (2021). Zero Emission Vehicle and Infrastructure Statistics. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics.

powered vehicles and unless EV incentives reach the rural masses. Regardless, EV rideshare programs still serve as supportive appendages to EV education and normalization.

Importantly, EV rideshare services are also significantly cheaper than the purchase of both an EV or a conventional vehicle. Rideshare programs could actually help further the climate change mitigation goals of the EO by reducing the number of vehicles on the road overall. This is because public transportation services like EV rideshares can compete directly with the high costs of vehicle ownership which place a significant financial burden on rural communities. For example, the average household income for Huron, CA is $25,060 and for Porterville, CA it is $43,823 and for East Porterville, CA it is $27,974. Therefore, EV rideshare services help make EVs that much more accessible to rural community members.

Lastly, these EV rideshare programs also inevitably result in public-private partnerships with rural policymakers that expand EV infrastructure in rural California. For example, the stakeholders involved in the implementation of these private-public partnerships include the city of Huron, the city of Porterville, local nonprofit Valley LEAP, EV company EVgo, the Fresno County Rural Transit Authority, the Shared-Use Mobility Center[56], and the California Air Resources Board[57]. Public EV infrastructure will be essential to ensuring rural EV adoption because low-income EV owners are already known to depend more on public EV chargers rather than being able to afford in-home chargers according to a report by the CVRP[58]. Therefore, a long-term recommendation is for **California to invest in publicly-shared and privately-shared EV charging stations in every rural city in California.** In the meantime, the state can continue to expand EV infrastructure with EV rideshare programs that partner with local governments, nonprofits, and private companies that mutually benefit from EV infrastructure expansion. This dynamic will ultimately build a network of rural policy makers which are necessary to passing local EV public programs. The projected outcome is that this policy recommendation will result directly in increasing the number of rural Californian's accessing EVs, it will result in increasing rural EV infrastructure, and it will help build partnerships with local governments. This fulfills the first and third objectives of this analysis: (A) Increase EV Investment in Rural California and (C) Build a Rural Policymaker EV Adoption Network.

3. Conduct a Climate Change Educational Campaign in Rural California.

Rural California suffers from a multitude of economic, environmental, and social disadvantages.

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[56] Shared-Use Mobility Center. (2021, March 31). The Story of Green Raiteros: A Shared & Electric Lifeline for California Farmworkers, 2020. MOD Learning Center. https://learn.sharedusemobilitycenter.org/casestudy/the-story-of-green-raiteros-a-shared-electric-lifeline-for-california-farmworkers-2020/.

[57] The Recorder. (2019, September 10). Last electric bus in Transit fleet makes its way to Porterville. Porterville Recorder. https://www.recorderonline.com/news/last-electric-bus-in-transit-fleet-makes-its-way-to-porterville/article_9b9495ba-d3d9-11e9-9b7b-13d532c1dab5.html.

[58] Bodanyi, R. (2019). (rep.). EV Charging and the Vehicle Purchase Process: Lessons Learned from Rebated Consumers (pp. 1–42). San Diego, CA: Clean Vehicle Rebate Project. Retrieved from https://cleanvehiclerebate.org/sites/default/files/attachments/EUEC_2019_EV_Charging_0.pdf

These disadvantages combine so that rural Californians lack education about EVs and abstract ideas in general. These underlying socioeconomic forces need to be addressed to mobilize the rural masses of people, ideas, resources, and connections needed to fulfill the EO. Ultimately, policy that will impact rural communities, must also take into account a rural mindset to overcome educational barriers preventing people and local leaders from considering EVs. For example, the underlying reason for the California Governor's EO is the urgency in having to mitigate climate change to reduce the intensity of natural disasters, improve public health, and sustain society for the future generations. However, rural California is home to millions of people that still lack basic services like clean drinking water and broadband internet. Therefore, priorities for large swaths of these populations are not in dealing with abstract ideas like climate change, but rather immediate basic needs of food, shelter, water, working, and health care. Ultimately, to mobilize rural community members in support of the EO, rural Californians need to understand why the EO is basic to their immediate needs. Without exposure to the abstract reasoning behind the EO, climate change, the role of renewables, and EVs; education will continue to be a barrier towards EV adoption in rural California.

Therefore, in the short-term, it is recommended that California conduct a climate change education campaign in rural California. Similar to the second recommendation in this analysis, California can use their network of rural policymakers to help in the messaging and strategic outreach of such a campaign. There are a number of rural cities throughout California with policymakers that could be receptive to supporting such work. These include cities with all people of color policymakers, with young elected officials, and with folks eager to deal with abstract issues such as Delano, CA, Lindsay, CA, Farmersville, CA, Arvin, CA, Madera, CA, among others. By working with these types of policymakers, California can create strong messaging for a climate change education campaign targeting rural communities. The participation of rural policymakers is paramount to the success of educational campaigns because as community leaders, they have deep knowledge about their communities and they must lead in their own educational transformation.

In many small, rural communities, local governments are also strong assets to spread word to families and individuals. Local governments include not just cities themselves, but school districts. These are just two of the modes that rural community members are educated about local and broader issues and programs. It is also important to note that a high percentage of rural residents are not college educated[59], and therefore less likely to have been exposed to scientific and exhaustive evidence of climate change. However, a significant percentage of rural residents are at least K-12 educated. For example, Tulare County only has a 14.6 percent bachelor degree attainment rate, but its high school graduation rate is 70 percent[60]. From this data, I conclude that the proper channel to introduce rural residents to climate change mitigation ideas is during the K-12 educational experience. Therefore, in the long-term, it is recommended that California include climate change as an important component of a K-12 curriculum in rural California. The data from this analysis shows that this is where the

[59] Jones, C. (2020, December 2). The long road to college from California's small towns. EdSource. https://edsource.org/2019/the-long-road-to-college-from-californias-small-towns/621428.

[60] US Census Bureau. (2019, July 1). https://www.census.gov/quickfacts/tularecountycalifornia.

government can intervene so that future rural vehicle buyers develop a sense of urgency in regards to climate change and eventually prefer an EV to a gas-powered option. Ultimately, to get the majority of rural residents to care about climate change and adopt EVs to fulfill the EO, California needs to address the underlying educational issues impacting rural mindsets.

The projected outcome of this policy recommendation is that it will directly result in increasing the number of rural residents that will become educated on the abstract issue of climate change and who will advocate for EVs. It will also help rural policymakers get directly involved in taking initiative in climate change mitigation and rural EV adoption. Lastly, this policy recommendation fulfills the second and third objectives of this analysis: (B) Focus Climate Change Education in Rural California and (C) Build a Rural Policymaker EV Adoption Network.

VII. Areas for Future Research:

There are a few areas for future research that can be explored to provide more insight about the findings in this report:

- For this analysis, I was only able to interview rural residents that did not yet own an EV. Although these interviews were fruitful qualitatively, I also wanted to interview rural residents that did own an EV to get a better idea of what drove these community members to purchase an EV. Was it concerns about climate change? Was it savings on gas? Or were there other underlying reasons for an EV purchase? These questions would provide valuable insight into the rural mindset of folks already purchasing EVs despite lack of infrastructure and educational support in rural California.

- Due to my limited data science capacity, I was not able to conduct a data analysis of EVs in California based on zip codes. I instead focused on data analysis based on rural vs urban counties. Zip codes provide more concentrated and localized insight of statistical patterns of EVs in California. For example, the top 20 zip codes with the most battery electric vehicles are all concentrated in the Silicon Valley area of California, with some of the highest educated and highest income zip codes in the state. A table demonstrating these data is shown in Figure A in the appendix B. Figure B in appendix B also shows a spatial map of these zip codes. It is important to note the relative close proximity these zip codes have to each other. Figure C in appendix B is a close up of the same map in Figure B. There also appears to be a linear relationship between the number of Battery Electric Vehicles (BEVs) and Plug-in Hybrid Vehicles (PHEVs) by zip code as shown in Figure D. It would be interesting and insightful for policymaking to see how the average household income, educational attainment rate, geographic location, among other factors contribute or limit EV purchases based on zip codes.

- Although one of the long-term policy recommendations of this analysis is to implement climate change education into K-12 curriculums in rural California, I am limited in my

capacity to detail the process by which this can happen. This would probably be a task better suited for an education policy expert who can conduct an analysis and recommendation for building a strong K-12 climate change curriculum.

Conclusion:

Rural California lacks the needed education, political support, financial resources, and EV infrastructure to comply with the EO at the rate that non-rural California is adopting EVs. Unintended consequences of well-intentioned policies such as the EO is that they can negatively impact the lives of already disadvantaged communities like rural California. To prevent historial inequalities from reproducing themselves through the EO, it is crucial to invest directly in the resources rural communities need to equitably adopt EVs and EV technology. This analysis provides a description of the barriers rural residents are facing for EV adoption, objectives for overcoming these barriers, and policy recommendations that fulfill these objectives; to ultimately ensure equitable implementation of the EO for rural California. With some of the solutions suggested in this analysis California will continue to be on its way to being a climate justice paragon and will continue to be on its way to leading the renewable future without leaving behind our most vulnerable communities.

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APPENDIX B: Figures and Data

Figure A

Zip Code	Total BEVs	Total FCEVs	Total PHEVs	City/Cities
95014	35	5	34	Cupertino, CA, West Santa Clara, CA, Permanente, CA
94611	34	3	40	Oakland, CA, Piedmont, CA
95125	34	3	39	San Jose, CA, Campbell, CA
94538	34	3	29	Fremont, CA
95123	33	4	39	San Jose, CA, Alamitos, CA
94087	33	7	37	Sunnyvale, CA, Cupertino, CA
94025	33	4	31	Menlo Park, CA, West Menlo Park, CA, North Fair Oaks, CA
94303	33	3	26	Palo Alto, CA, East Palo Alto, CA, Mountain View, CA
95120	32	4	41	San Jose, CA, New Almaden, CA, English Town, CA, Twin Creeks, CA
94536	32	4	37	Fremont, CA, Union City, CA, Dresser, CA
95035	32	5	35	Milpitas, CA, San Jose, CA
95051	32	3	32	Santa Clara, CA
94043	32	3	30	Mountain View, CA, Sunnyvale, CA
94539	31	5	33	Fremont, CA
95070	31	8	33	Saratoga, CA
95032	31	4	28	Los Gatos, CA, Campbell, CA, Vasona Junction, CA, Shannon, CA, Rinconada, CA
94070	31	1	25	San Carlos, CA, Redwood City, CA
95124	30	5	37	San Jose, CA, Cambrian Park, CA
94010	30	4	30	Burlingame, CA, Hillsborough, CA, San Mateo, CA
94582	30	5	30	San Ramon, CA

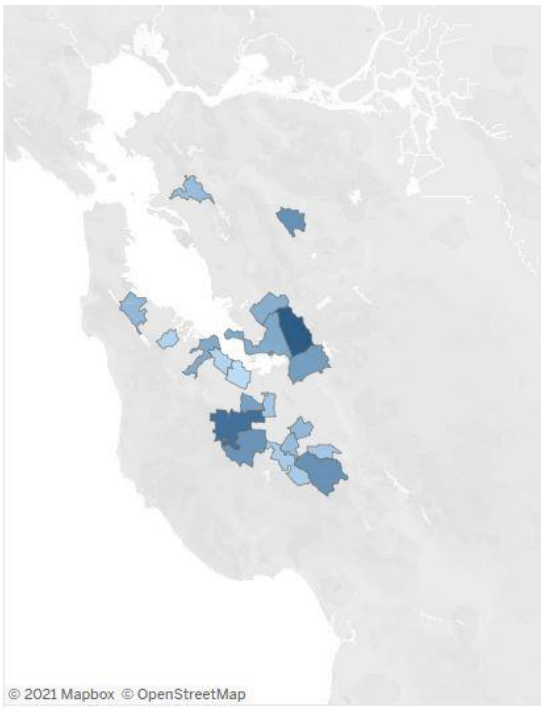
Data Source: California Department of Motor Vehicles. The table shows the top 20 zip codes with the most BEVs in descending order and their location. All are in zip codes/cities in Silicon Valley. It is

important to note that there already appears to be a correlation with the number of BEVs in these zip codes and the number of PHEVs. This correlation between different EVs in zip codes is shown in Figure D.

Figure B

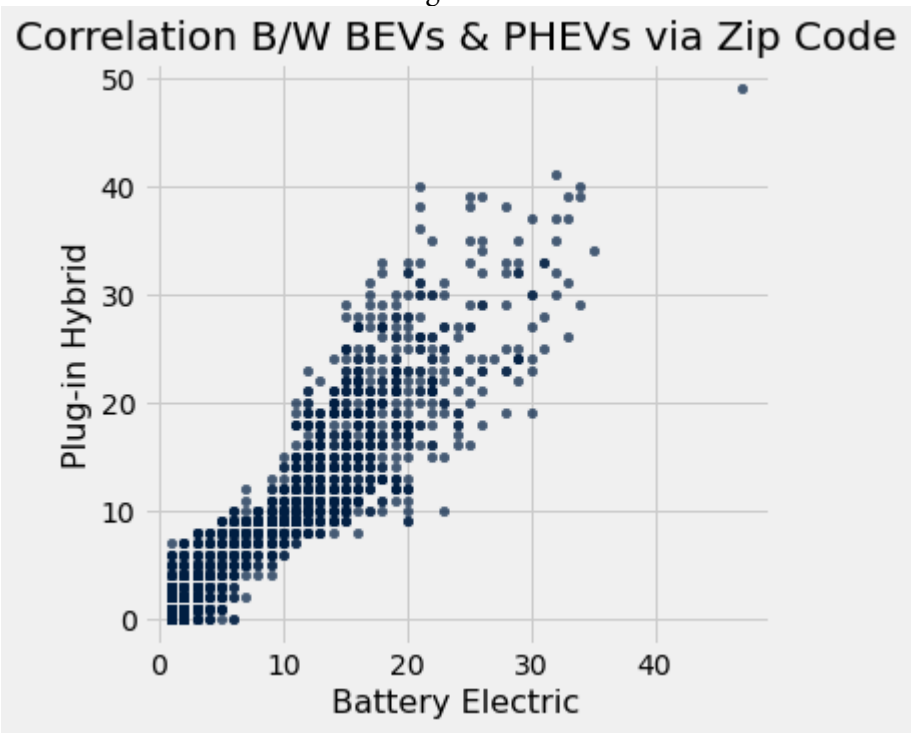
Data Source: California Energy Commission. The blue marks are the zip code spatial maps of the table in Figure A above. The relative close proximity of all the top 20 zip codes with BEVs is important to note, as well as their location in Silicon Valley.

Figure C



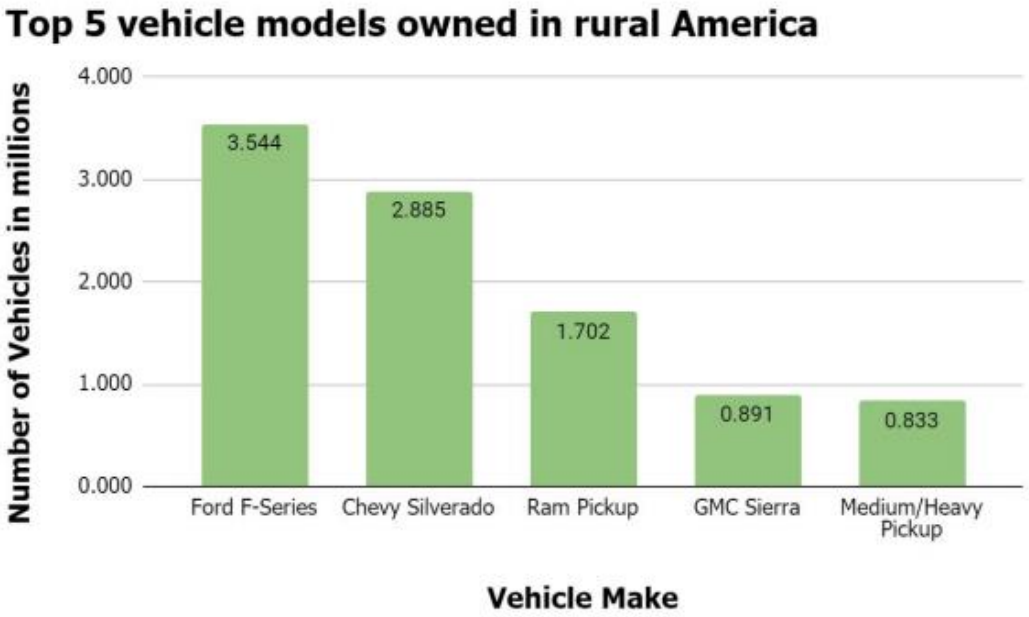
Data Source: California Energy Commission. Close up of Figure B above.

Figure D



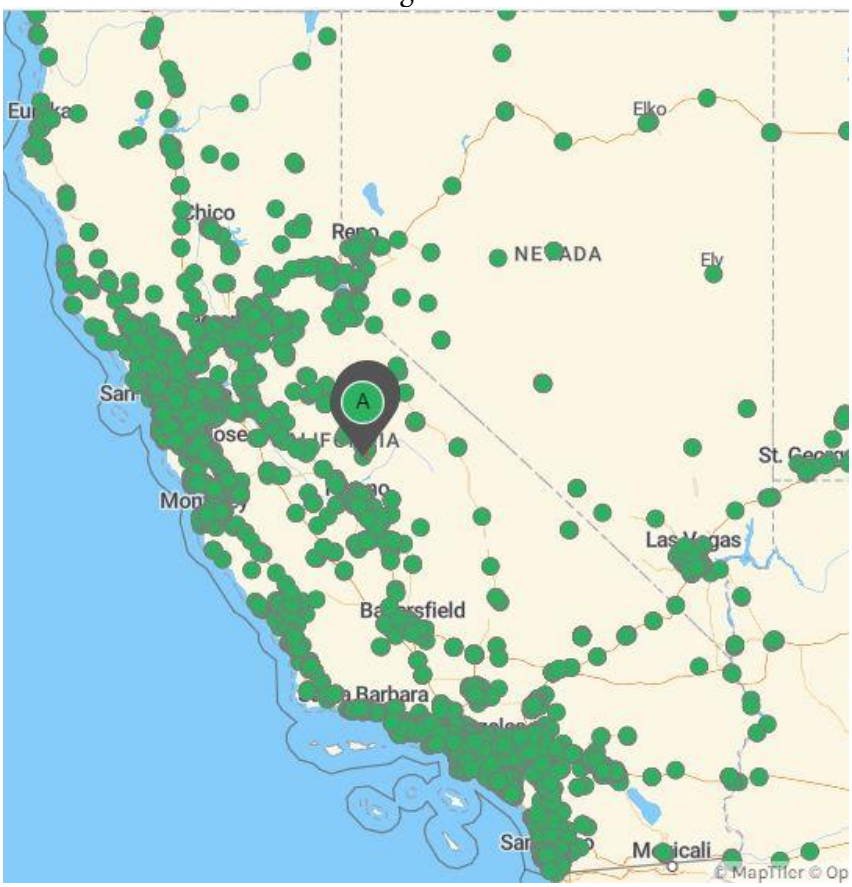
Data Source: California Department of Motor Vehicles.

Figure E



Data Source: NHTS and the Center for American Progress. Top 5 vehicle models owned in rural America. It can be seen from the graph above that the preference for vehicles in rural America are medium and heavy duty pickup trucks.

Figure F



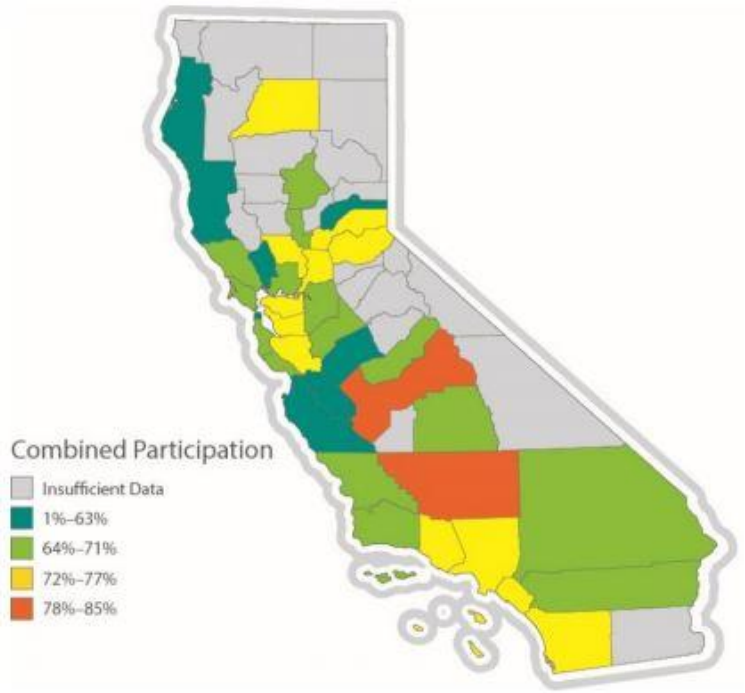
Data Source: the Alternative Fuels Data Center. The charging stations (green dots) are spread throughout California in mostly highly populated regions. While charging stations situated in rural parts of California are strategically placed around interstate highways that are serving urban travelers such as highway 5 and the 99.

Figure G

County*	PHEV	BEV	PHEV, BEV and FCEV
Alameda	70%	83%	78%
Butte	Insufficient Data	Insufficient Data	68%
Contra Costa	66%	83%	74%
El Dorado	67%	86%	76%
Fresno	59%	95%	85%
Humboldt	55%	Insufficient Data	60%
Kern	73%	89%	82%
Los Angeles	70%	80%	74%
Madera	Insufficient Data	Insufficient Data	69%
Marin	57%	77%	69%
Mendocino	40%	Insufficient Data	56%
Merced	Insufficient Data	Insufficient Data	63%
Monterey	55%	71%	63%
Napa	48%	71%	60%
Nevada	Insufficient Data	Insufficient Data	63%
Orange	68%	83%	74%
Placer	68%	87%	78%
Riverside	61%	79%	67%
Sacramento	64%	79%	73%
San Benito	Insufficient Data	Insufficient Data	63%
San Bernardino	61%	82%	68%
San Diego	66%	83%	77%
San Francisco	55%	70%	64%
San Joaquin	62%	80%	72%
San Luis Obispo	59%	78%	70%
San Mateo	63%	76%	72%
Santa Barbara	60%	81%	72%
Santa Clara	68%	79%	74%
Santa Cruz	55%	87%	72%
Shasta	Insufficient Data	Insufficient Data	77%
Solano	55%	89%	66%
Sonoma	59%	87%	72%
Stanislaus	55%	86%	71%
Tulare	Insufficient Data	Insufficient Data	70%
Ventura	68%	83%	75%
Yolo	65%	88%	77%

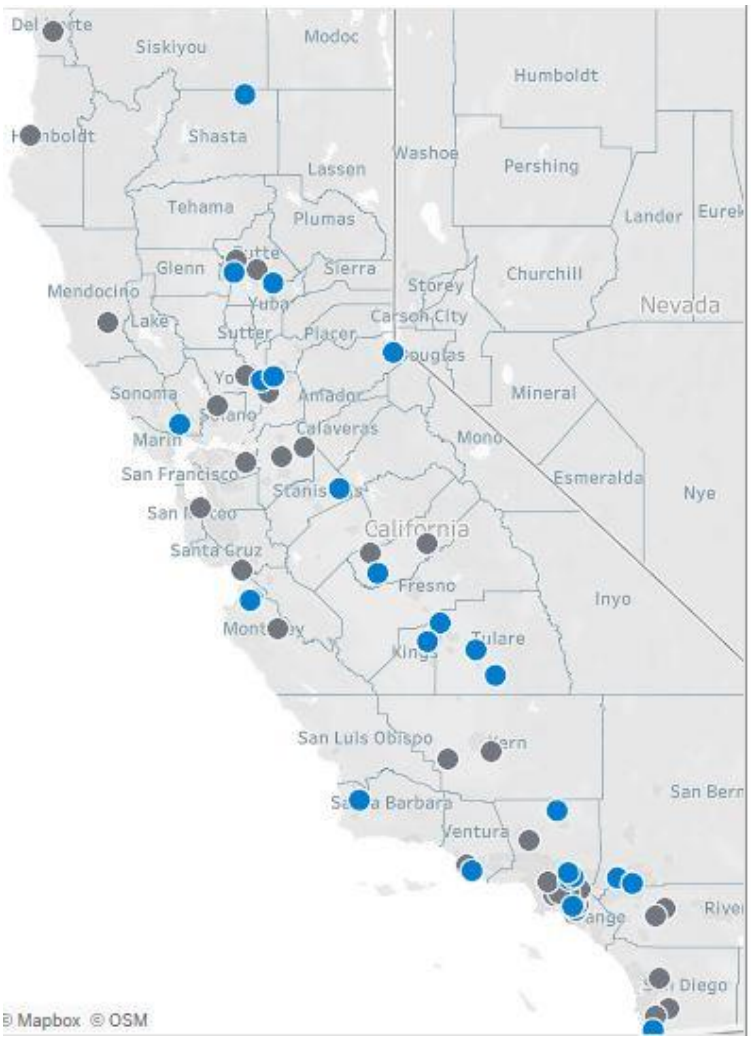
Data Source: The Clean Vehicle Rebate Project. Data gives the percentage of eligible clients using rebate funding to purchase their qualifying EV. It is important to note the high percentage rate seen throughout the counties in California, even rural ones.

Figure H



Data Source: The Clean Vehicle Rebate Project. Data gives the percentage of eligible clients using rebate funding to purchase their qualifying EV by county . It is important to note the high percentage rate seen even in rural counties like Tulare and Madera.

Figure I



Data Source: California Energy Commission. Map shows school buses replaced by the CEC. Blue dots are buses already replaced and the gray dots are the buses projected to be replaced. Buses being replaced are also in rural counties like Tulare, Madera, Butte, Mendocino, etc.