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Charging Forward: A Comparative Analysis of Facilitators to Electric Vehicle Adoption in Three U.S. States

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Barriers and Facilitators to Electric Vehicle Adoption: A Comparative Analysis

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Abstract

Electric vehicles (EVs) are a way to reduce greenhouse gas emissions from transportation, but low consumer adoption rates present a challenge. In order to understand what factors may facilitate EV adoption, a comparative analysis of three U.S. states was performed. These states have the highest rates of EV adoption in the country. Thus, studying them provided insights into what may make EV adoption successful. California, Hawaii, and Washington are the states with the highest EV adoption rates. Based on previous research, a list of 12 characteristics that may influence EV adoption was compiled and applied to each state, focusing on what may impact human behavior. Each of these characteristics was applied to the three states. The results revealed that key features related to EVs in these states that could be applied to other states in an effort to increase adoption rates. Key features include high quantity and quality of climate change legislation, high quantity and quality of EV-supportive legislation, urban areas in large cities, highly developed public charging infrastructure, higher-than-average median household income, and positive individual attitudes toward EVs. Many of these may be applied to other states. Considering a new EPA policy that outlines EV sales targets and emissions reductions

targets, motivation exists for states to increase EV adoption. EVs are here to stay, so unlocking the environmental benefits rests on improving states' abilities to facilitate EVs.

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Introduction

Background

The purpose of this study is to explore the behavioral barriers and facilitators to electric vehicle (EV) adoption. EVs are a way to mitigate fossil fuel emissions from vehicles, as they have no tailpipe emissions (U.S. Department of Energy Alternative Fuels Data Center, n.d.-c). Lower emissions also lead to better air quality, and EVs are associated with this benefit to human health (Choma et al., 2020). However, slow public acceptance of EVs may stand in the way of the environmental benefits. Studying the barriers and facilitators to EV adoption may provide insight into how to improve adoption rates, thus providing direction for improving EV sales and charging infrastructure and a more sustainable transportation sector.

This research topic is significant because of its implications for understanding barriers and facilitators to other pro-environmental behaviors. Conclusions regarding factors that affect consumer adoption of EVs may be similar across other climate change mitigation or adaptation efforts. This could provide explanations for behavior and avenues of recourse. Research about barriers and facilitators to EV adoption exists, but much of it focuses on the technological components. Only some of it examines the human perception and behavior aspects. This study aims to consider the impact various characteristics have on EV adoption in terms of human behavior by comparing three successful states, providing insight into how this success may be applied to other states. This analysis has the potential to increase EV adoption and improve sustainability in the transportation sector. Overall, this research will help to understand what is influencing EV adoption rates and what needs to be changed.

An especially important development in the conversation surrounding EVs in the United States is a new policy from the Environmental Protection Agency (EPA). The Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles

policy sets new lower greenhouse gas emissions standards, building on previous standards. Light-duty vehicles refers to the passenger vehicles used in a civilian's everyday life, and medium-duty vehicles are larger-scale vehicles that aren't quite the size of a semi-truck. This rule applies to new vehicles with model years from 2027 to 2032 and emphasizes alternative fuel vehicles such as EVs, and although it has been finalized, it is still in pre-publication (Environmental Protection Agency, 2024b). Within the standards, the EPA has identified multiple pathways for decreasing emissions through the use of alternative fuel vehicles. In these scenarios, by 2032, either 35%, 43%, or 56% of light-duty vehicle sales in the U.S. will be EVs (Environmental Protection Agency, n.d., p. 47). While this is not a requirement, it is a standard that the federal government is seeking to meet. There will be a push for states to improve EV adoption rates. With states looking to improve EV adoption rates, the results of this study will provide insights from states that have already had increased EV adoption rates.

Electric vehicles are unique in that they have zero emissions. EVs run on electric motors and batteries. The electric motor powers the vehicle, whereas an internal combustion engine powers traditional vehicles. The electric motor is powered by a battery that is recharged by a plug-in charger, while traditional vehicles consume gasoline (U.S. Department of Energy Alternative Fuels Data Center, n.d.-e). The use of electricity to power the vehicle avoids the burning of gasoline that releases greenhouse gases into our atmosphere, thus mitigating climate change. EVs are a more sustainable alternative to conventional gasoline vehicles because they receive their power from charging a battery as opposed to consuming fuel and releasing emissions (U.S. Department of Energy Alternative Fuels Data Center, n.d.-e).

EV adoption rates are still low, though. As of September 2023, electric vehicles accounted for 6.7% of vehicle sales in the United States (Dwyer, 2023a). These low rates of EV adoption and ownership mean that climate change mitigation will be less effective. Although this

rate of adoption has been improving, most Americans have poor attitudes toward EVs in general. In a Gallup poll of Americans, 61% said that electric vehicles help address climate change "only a little" or "not at all" (Brenan, 2023). The same poll also found that 4% of respondents owned an EV, and only 12% of respondents were "seriously considering" purchasing an EV (Brenan, 2023). A Pew Research Center poll found that 50% of Americans are "not too" or "not at all" likely to "seriously consider" buying an EV, while 38% said they were "very" or "somewhat" likely to do so (Spencer et al., 2023). From this, it can be concluded that Americans attitudes toward EVs are not generally positive.

The implications of this are significant. If someone has a negative perception of EVs, it can be assumed that they are unlikely to buy an EV. At a large scale, this would stand in the way of the environmental benefits EVs provide. The transportation sector contributes the most to greenhouse gas emissions, and passenger vehicles make up the majority of that sector (Environmental Protection Agency, 2023). There is a large opportunity for intervention here, but that opportunity is lost if negative perceptions keep adoption rates down. The present study aims to explore what factors impact these attitudes and what can be done overall to increase adoption rates and decrease transportation emissions. The specific research questions in this study are as follows:

RQ1: What are facilitators to EV adoption in places where it has been successful?

RQ2: What can be learned from places where EVs have been successfully adopted?

RQ3: Given what is known about human behavior in the context of EV adoption, how can this be applied going forward?

Before these questions can be addressed, however, previous research in this field must be considered.

Literature Review

Beyond the technical and scientific problems of EV adoption and climate change at large lies the matter of social and human behavior. The role of communication is important to consider in this realm because of its ability to impact consumer perceptions and behaviors and because of the strategies that may be applied to EV communication. The role of communication in climate change is discussed, along with barriers to EV adoption related to perceptions and thought processes and examples of EV adoption success, including what contributed to the success and the implications for communication surrounding EV policy and marketing.

The Role of Communication in Climate Change

The ways climate change is communicated about in our society influences and shapes perceptions of the issue, which has implications for whether the issue is confronted or ignored. Many studies have examined the impact on climate change communication on perceptions and beliefs. Sanders and others (2022) found that perceptions of the government's ability to confront climate change can impact citizens' perception of the issue, along with ideology and political affiliation. To effectively communicate about climate change and to increase concern about the issue, communication should consider associated political ideologies and affiliations and the various ways they interact with perceptions (Sanders, 2022). These elements of personality hold significance when considering the impact of climate change communication. Personal values are also important to consider when communicating about climate change, as they can influence how climate change information is received and processed, which then affects attitudes (Z. Yang et al., 2014). Communication that takes this into account may lead to more serious perceptions of climate change. Another important consideration is media communication about climate change. Concerning climate change mitigation policy, it was found that perception of the impact of media communication on others was significant in increasing personal attention on the issue (X. Yang et

al., 2021). Communication can influence how climate change policy messages are received and reflected upon, which is significant in increasing support for climate change mitigation.

Many have also studied the impact of communication on intention to act and on behaviors associated with climate change. Despite the influence attitudes toward climate change can have on the issue, intent to act and behaviors hold even more significance toward the matter. Therefore, studying how communication can influence pro-environmental behavior is necessary. Message framing is a strategy that has been found to play a significant role. It has been found to influence intention to engage in pro-environmental behavior more than it influences climate change engagement, although specific frames were found to be stronger than others (Li & Su, 2018). Framing concerning the economy, the environment, and morality in terms of climate change had the largest impact on intentions to engage in pro-environmental behavior Li & Su, 2018). Other research has found that message frames that personalize climate change influenced pro-environmental intentions (Shih & Lin, 2017). The same study also found that information in the message about the issue was not enough to elicit actions, and that the addition of information that outlined opportunities to act was what spurred intention to act. Liang and others (2017) also studied the impact of specific message strategies on climate change behavior. Intention to conserve water was greater when specific message strategies were applied, meaning that effective climate change communication can increase pro-environmental behavior, but it must take into account concerns and values of consumers. Similar to influencers of attitudes and perceptions, consideration of personal values when communicating about climate change is important in increasing pro-environmental behaviors. Specifically, framing the issue in ways that acknowledge personal values holds potential for increased engagement.

Consumer Perceptions of Electric Vehicles: Barriers That Influence Adoption

Consumer perceptions of electric vehicles play an important role in EV adoption. Positive perceptions may lead to more widespread adoption, while negative perceptions can limit adoption. Thus, in order to improve adoption rates, it is important to consider what perceptions exist and the factors that influence those perceptions.

Many studies have analyzed the barriers to EV adoption. One common barrier is range anxiety. Consumers worry that the range of an EV battery is too short and won't fit into their driving habits (Krishna, 2021). Lack of available charging is another concern, especially since EV infrastructure in the United States is still developing (United States Department of Energy, 2023). Research found that there is not enough attention focused on the planning of charging infrastructure, which can greatly impact the logistics of EV adoption (Kovačić et al., 2022). The amount of time it takes to charge EVs is another concern, along with price (Krishna, 2021). While is important to consider the impact of these technical concerns, it is also necessary to consider the social and behavioral concerns regarding that influence EV adoption. Doing so may inform communication, marketing, and policy decisions.

Many of the barriers detailed in research can be categorized as perception barriers in that the primary issue may not be the concern itself, but consumers' perceptions of that concern. As mentioned above, range anxiety is a barrier. While range is important, Franke and Krems (2013) found that perceived range needs were higher than actual range needs. Skippon (2014) concluded that perceived poor performance compared to conventional vehicles is a barrier. Brase (2018) also found perceived poor performance of EVs to be a notable barrier. The actual performance gap is not the issue here; rather, perception is the main barrier. In fact, EVs have the potential to outperform conventional vehicles (Skippon, 2014; Krishna, 2021). Other barriers include the perception that EVs are not an environmentally beneficial alternative to conventional vehicles because of the mining used to source the lithium for batteries and the fact that energy needed to

power EVs will still create emissions due to the burning of fossil fuels during generation (Krishna, 2022). Along with improving the sourcing and the emissions associated with charging an EV, these negative perceptions need to be addressed if EVs are to become widely adopted. Aesthetic perceptions also pose a barrier. Krishna (2022) found that EVs are perceived to lack "fun" compared to conventional vehicles, and the look of many EVs also has a negative perception. Brase (2018) found that participants were concerned about what ownership of an EV might communicate about their "personal values." The thing that all of these barriers have in common is a negative perception of EVs, which reflects that it is necessary to consider the social and behavioral elements at work.

These perceptions have the potential to impact EV adoption, so the extent to which they can be influenced is important to consider. Druckman and Bolsen (2011) found that when a new technology is introduced to the public, perceptions were not influenced solely based on facts, as was previously assumed. Perceptions were found to lead to biases, which in turn meant that the introduction of factual information did not impact initial perceptions. While this study focuses on perceptions of carbon nanotubes and genetically modified foods, its implications for perception formation are relevant to emerging EV technology. In the context of electric vehicles, negative perceptions and biases will not be influenced simply by providing information about the environmental benefits of EV adoption. Hart and others (2015) also studied factors that influence perceptions, concluding that deeper feelings of media bias intensify existing perceptions. With the large amount of polarization present in today's society, perceived media bias can work to make perceptions even more difficult to influence, which necessitates finding ways to overcome perception barriers.

Overcoming Barriers to EV Adoption

To address barriers to EV adoption and to reinforce facilitators, it is helpful to look at places where EVs have been adopted and the factors that challenged and facilitated success. Many studies have analyzed these factors, providing implications that could impact other locations. Norway has emerged as a leader in the EV transition, with high rates of adoption (64.5% of new car sales), proving to be a mature market (A. Yang et al., 2023). Thus, lessons learned may be provide insight into increasing adoption rates. The authors found that facilitators of EV adoption include urban areas, higher incomes and money-saving incentives, while barriers include concerns about the impact of local temperature on battery health, cost of EVs, and increased elderly population. An interesting takeaway is the importance of charging infrastructure in adoption consideration. In a mature market, concerns about infrastructure became less important as infrastructure grows and becomes more common (A. Yang et al., 2023). The study also found that, despite older populations' lower likelihood of EV adoption, the number of older drivers is on the rise in Norway, creating an opportunity to target education and communication toward older people (A. Yang et al., 2023). Adopters tend to be middle-aged, but rates of young people adopting EVs is also increasing. Based on the case study of Norway, a mature EV market, potential improvements to EV communication, marketing, and policy may lead to increased adoption in other countries.

The case study of Ireland also offers insights into EV adoption, especially focused on early adopters. Similar findings exist concerning barriers and facilitators to adoption. Urban areas had increased rates of adoption, likely associated with higher incomes and higher rates of education that exist in those areas; in turn, higher rates of adoption in urban areas also had the potential to trigger adoption in nearby areas, creating a "spillover effect" (Mukherjee & Ryan, 2020). Higher rates also were found in suburban areas, which may also be associated with higher incomes and longer commutes that would increase cost savings (on gas) over time (Mukherjee &

Ryan, 2020). Another reason for this relationship is the increased availability of off-street parking where a charger could be installed, pointing to suburban areas as facilitators and urban areas with more apartments and fewer dedicated spots as a barrier (Mukherjee & Ryan, 2020). Increased adoption is generally associated with urban areas, so this finding provides insight into how adoption may be increased in suburban areas. The study also found that another important facilitator was incentives that provide money or rebates for EV owners, which acts as an area of policy improvement. The case study of Ireland provides important insight into factors that inhibit and support adoption, again providing applications for improvements.

Finally, New Zealand's experience with EV adoption is another source of information on EV adoption barriers and facilitators. Researchers interviewed New Zealand drivers, including both EV owners and non-EV owners, to better understand consumer behavior related to EVs. New Zealand was considered an appropriate case study because of government policies introduced in 2016 that encouraged EV adoption (Broadbent et al., 2021). The authors found there were a variety of attitudes and views among consumers, which means there is no single way to target consumers. To accommodate this, drivers were grouped into categories related to their likelihood to adopt an EV. "EV Positives" were found to be those most likely to adopt EVs, after the early adopters who already own EVs, meaning they are the most important group to target (Broadbent et al., 2021). Facilitators to EV adoption included government incentives that decreased the price, fuel cost savings, and widespread availability of off-street parking (Broadbent et al., 2021). Barriers included EV range, perceptions of high cost, uncertainties about charging and infrastructure, and the long-term value of EV batteries (Broadbent et al., 2021). To address these barriers, the authors proposed four recommendations: increase implementation of government incentives that will lower the cost of EVs (and increase awareness of these incentives), increase government funding to improve charging infrastructure,

improve consumer perceptions of EVs by reframing them in terms of cost savings and "lifestyle gains," and increase EV access and availability (Broadbent et al., 2021).

Through a review of relevant literature, it was found that communication can impact attitudes and behavior toward climate change, especially when framing is employed. Another finding is that a significant barrier to EV adoption concerns negative perceptions held by consumers, regardless of the fact in question. This human behavior barrier may benefit from strategic communication, as indicated by the case studies of Norway, Ireland, and New Zealand. Thus, the need for a comprehensive review of the barriers and facilitators to EV adoption is warranted.

Methods

This study follows a case study research design and utilizes a comparative analysis to understand barriers and facilitators to EV adoption. A case study research design provides an in-depth look into a situation which can then be explored in the context of the real world (Crowe et al., 2011). This study examines three U.S. states that have had the most experience with EV adoption—one case study for each city. The value of a case study design in this study is evident. EVs have not had widespread adoption success. There are fewer locations to analyze, which is where a case study is useful. Case studies were utilized in the literature review, as they provide specialized information that may be applied to other situations and locations. Those case studies focused largely on countries, so this study focuses on places within the United States in order to provide more specific and relevant insights.

The first step in completing this analysis was to identify the states that were to be compared. To do this, states with adoption rates above the national average were selected. EVs accounted for 6.7% of new vehicle sales in 2023, but this same data was not available on a state-by-state basis. Instead, data describing EVs as a percent of total vehicle registrations in the state

were used. The most recent year data was available is 2022. Since the market share of EVs based on total vehicles in the country, the percent of EVs is smaller than the percent EVs make up as new sales. However, total market share of EVs still provides an adequate way to identify places where EV adoption is higher than the national average because it is proportionate to each state, and it has shown change over the past years.

The three states with the highest market share of EVs, California, Hawaii, and Washington, were selected for comparison. The number of states chosen (three) was decided on in order to provide an in-depth analysis while still considering the timeline of this research. Since these states have the highest market shares, it can be assumed that they have been more successful in adopting EVs than other states. To explore the factors that may have impacted this adoption rate, many characteristics were considered. Guidance for factors to consider was taken from articles in the literature review that detailed case studies of other countries (Broadbent et al., 2021; Mukherjee & Ryan, 2020; A. Yang et al., 2023). Characteristics used in this research were narrowed down to include those present in previous studies that analyzed successful adoption in Ireland, Norway, and New Zealand. These studies had a similar aim to the present research studies, so they provided insight into which characteristics to focus on when considering what impacts EV adoption.

To identify the data, an online search engine was used. Search terms included the words used for each category, such as “electric vehicle state legislation” or “state climate policy.” Credible sources were then determined. While collecting data for the three different states, sources were determined based on their credibility, and data was collected from the same source for the different states, when possible, to ensure uniformity of data. Data was also narrowed down to only include information about fully electric vehicles (as opposed to hybrids or other forms of alternative fuel vehicles) to comply with the scope of this analysis. A source was

determined credible if it was a part of a government website (e.g., a .gov site) or if it was associated with a recognized organization, such as a university, or official publication, such as a newspaper.

EV adoption characteristics analyzed from each state include:

- State EV incentives, regulations, and legislation
- State climate change mitigation/adaptation efforts
- Average price of gas
- Climate and average temperature
- Number of public EV charging stations
- EV incentives from electric utilities
- Population
- Number of metropolitan statistical areas (MSAs) and urban vs. rural populations
- Concentration of registered EVs
- Median household income
- Median household income of EV owners
- Attitudes toward EVs

To compare and frame this information in a useful way, the social ecological model was applied to the analysis. The social ecological model is a framework used to address socioecological issues and human behavior (Lee et al., 2017). Below, Figure 1 shows a version of the social ecological model from the Centers for Disease Control and Prevention (2022).

Figure 1

The Social Ecological Model

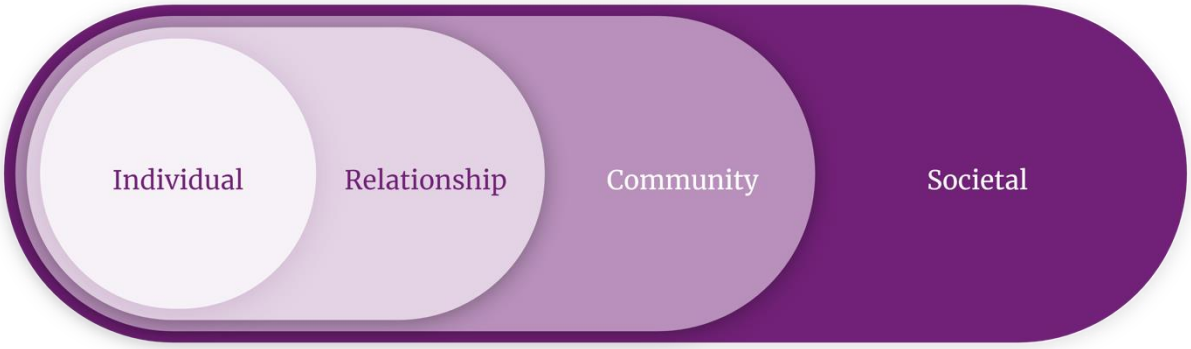

Figure 1. Chart describing the social ecological model. From *The social ecological model*, by Centers for Disease Control and Prevention, 2022, https://www.cdc.gov/violenceprevention/about/social-ecologicalmodel.html.

The social ecological model consists of multiple interacting spheres. The model is set up with overlapping categories to reflect the interconnected factors that influence individual behavior (Centers for Disease Control and Prevention, 2022-a). The value of this framework is that it provides a way to consider how human behavior is influenced. It recognizes that there are multiple levels of influence, that these influences are intertwined, and that a system-level approach across these spheres may be more effective at influencing individual behavior (Lee et al., 2017). Since EV adoption is a human behavior, the multiple spheres of influence can be considered in order to understand how it may be influenced and increased.

According to the CDC, the broadest category, societal factors, are the broadest influences on individuals, which may include social norms and attitudes, public policies, and other regulations (2022). The CDC describes the next category, community, as places and groups where people socially interact with others and the associated characteristics. This could include schools, workplaces, or other organizations. The third category is relationships, which covers interpersonal relationships that influence behavior, such as family and friends, and the individual sphere refers to individual factors that may influence behavior (Centers for Disease Control and

Prevention, 2022). These individual factors include experience, attitudes, and knowledge. The data from this research was sorted into one of the four categories of the social ecological model based on the associated description. This provided the structure for the comparative analysis of the factors of EV adoption in California, Hawaii, and Washington.

Results

Eight states had EV market shares higher than the national average market share. States were sorted according to the market share of EVs in 2022 as a percentage, which was rounded to the nearest tenth by the data source. According to data from the U.S. Department of Energy's Alternative Fuels Data Center, the average market share of EVs in the U.S. in 2022 was 0.9% (n.d.-f). Any state with a higher market share percentage was separated from the list, for a total of eight states.

- California (2.5%)
- Hawaii (1.8%)
- Washington (1.5%)
- Nevada (1.3%)
- New Jersey (1.2%)
- Oregon (1.2%)
- Colorado (1.1%)
- Arizona (1%)

(U.S. Department of Energy's Alternative Fuels Data Center, n.d.-f)

California, Hawaii, and Washington were selected as the states to be compared. A table containing the results below can be found in the appendix. Each state was compared according to the EV adoption characteristics previously determined and sorted based on the categories of the Social Ecological Model. Societal-level characteristics include state EV incentives, regulations,

and incentives and state climate change mitigation/adaptation efforts. These are all factors that may affect human behavior at a broad level. The next sphere of influence is the community-level factors, which include the price of gas, climate of the state, charging stations, population, cost of living, concentration of urban vs. rural population and number of MSAs, and EV incentives from electric utilities. All of these factors still affect human behavior at a larger scale, but it is more specific to the community or city in the state. The next sphere of human behavior influence is the relationship level. Characteristics that would fit into this category were not uncovered in this research. The purpose of this research was not to analyze interpersonal interactions regarding EV adoption, so this does not necessarily negatively impact this research. The final sphere of influence includes individual characteristics. In this research, average resident income and attitude toward EVs make up this category. These are existing characteristics that are unique to an individual which also impact human behavior. The three states were all found to be conducive to EV adoption based on all of these characteristics and how they impact human behavior at different levels.

California

Societal-Level Characteristics

The first factor considered that facilitates EV adoption at the societal level considered was legislation put in place at the state level regarding electric vehicles that may encourage EV adoption. A list of laws and incentives from every state was obtained from the U.S. Department of Energy's Alternative Fuels Data Center, which provides a list of laws and incentives regarding EVs for any given state. California currently has 57 state laws and regulations and 32 state incentives regulations as of March 4, 2024 (U.S. Department of Energy Alternative Fuels Data Center, n.d.-b). These incentives and regulations address multiple aspects of EV adoption. Almost half of the state laws and regulations are a part of the state's Zero-Emission Vehicle

(ZEV) program. The ZEV program, first implemented in 1990, regulates vehicles sold in California based on set emissions standards, and it is currently on track to require all vehicles sold in California to have zero emissions by 2035 (California Air Resources Board, n.d.). One of the two types of zero-emission vehicles is the EV. California laws and regulations pertaining to the ZEV program cover sales requirements, support and promotional plans, infrastructure requirements, deployment plans, production requirements, and opportunity for stakeholder engagement (U.S. Department of Energy Alternative Fuels Data Center, n.d.-b). The other laws and regulations cover fleet electrification requirements, charging infrastructure and access, guidelines, signage and awareness of chargers, and regulations for incentives. The laws and regulations in California regarding EVs are comprehensive and extensive.

State incentives are also numerous. California has a total of 32 incentives sponsored by the state, and about 1/3 of incentives provide money for fleet and commercial electrification, 1/4 of incentives provide money for commercial and public charging infrastructure, and the rest provide financial manufacturing and maintenance support, other privileges such as parking and commuter lane exceptions, and money to support overall EV implementation (U.S. Department of Energy Alternative Fuels Data Center, n.d.-b). Most of the incentives are financial incentives that encourage charging infrastructure and commercial adoption.

The other societal-level characteristic is the efforts each state has undertaken in response to climate change, which may provide a sense of whether the state is committed to addressing climate change. California finalized a state-led climate plan in 2009, which has been reevaluated and updated every 3 years since 2014, and it currently has 35 pieces of state law and policy, 41 state agency plans, and 27 other resources (Georgetown Climate Center, 2018). The total number of resources regarding climate change mitigation and adaptation in California is 103. The state laws and policies that have been implemented generally cover ways to make the state more

resilient to climate change. The legislation includes funding for climate action and associated preparedness and protection projects that concern coastal and ocean health, wildfires, ecosystem and wildlife health, environmental justice, water management, emissions targets, sea-level rise, and community health (Georgetown Climate Center, 2018). The state agency plans include policies and programs that assist with the implementation of state legislation, 14 of which cover the transportation sector, and the 27 other resources are additional resources that may aid in implementation, such as planning guides, program funding, assessments, progress reports, etc. (Georgetown Climate Center, 2018). Overall, these numerous and comprehensive resources reflect the commitment to climate change adaptation and mitigation in California.

Community-Level Characteristics

At the community level, California has multiple factors that facilitate EV adoption. This is also the level that happens to include factors that are not easily changed by human action: price of gas, climate of the state, population, and concentration of urban vs. rural population. In California, the average price of gas per gallon on March 18, 2024, was $4.91 (Smith, n.d.). EVs do not use gas to operate, thus making them attractive in terms of gas savings. Gas prices fluctuate daily, so the average gas price for regular gas on the day the data was collected was used. This was the state with the highest price per gallon gas on the day of data collection, and past data affirms California as the state with the highest gas prices (Smith, n.d.). Climate may impact EV battery health and performance and therefore influence a person's decision to adopt an EV. Cold weather can drain an EV's battery faster, leading to a lower driving range and lower energy efficiency, but constant high temperatures may prematurely degrade a battery if the vehicle is left without cover (like a garage) (Yuksel & Michalek, 2015). California's general climate is moderate. The average annual temperature in California is in the mid 60s, although temperatures may exceed 100°F in the summer (Encyclopedia Britannica, n.d.-a). Thus, charging

and range is not (regularly) affected by the temperatures, and battery degradation is not a frequent concern.

Population and its concentration may affect EV adoption in terms of ease of charging and range concerns. Urban areas facilitate adoption because of the shorter distances to charge and stronger charging infrastructure. The population of California is approximately 38,965,193, making it the most populous state (U.S. Census Bureau, n.d.). This population is largely concentrated in metropolitan statistical areas (MSAs), places with at least one urban area with a population of 50,000 or more with close social and economic ties among the surrounding area (U.S. Office of Management and Budget, 2023). 94.2% of California's population lives in urban areas, while 5.8% live in rural areas (Johnson & Cuellar Mejia, 2024). California has a total of 29 MSAs (U.S. Office of Management and Budget, 2023). These larger areas appear to be facilitators of EV adoption. The 20 zip codes in the state with the highest EV registrations are either in the Bay Area (San Francisco MSA) or Los Angeles/Orange counties (Los Angeles MSA) (Lopez & Yee, 2023).

California also has community-level influences that can be affected by human action. Charging infrastructure is one of those influences. Stronger infrastructure facilitates EV adoption. California has 43,898 individual public charging ports among 15,753 public charging stations (U.S. Department of Energy Alternative Fuels Data Center, n.d.-a). Incentives from community electric utilities can also promote EV adoption. There are 48 utility and/or private incentives in California (U.S. Department of Energy Alternative Fuels Data Center, n.d.-b). Half of these incentives promote charging installation (split mostly evenly between the residential and commercial level), nine concern financial incentives for residential EV purchases, 5 concern financial incentives for commercial/fleet EV purchases, 11 provide financial savings on electricity rates for customers, and one provides money for charging infrastructure support in

general (U.S. Department of Energy Alternative Fuels Data Center, n.d.-b). Both residential and community EV support can be beneficial to EV owners (i.e., commercial charging infrastructure for individuals). Finally, local and regional climate change adaptation and mitigation plans can also support EV adoption, since EVs are a form of climate change mitigation. California has 44 local and regional plans that address climate change based on the characteristics of the community. 25 different communities have at least one plan to address climate change.

Individual-Level Characteristics

Income and attitudes toward EVs are both individual characteristics that can affect EV adoption. Higher incomes facilitate higher adoption rates, since EVs are, on average, more expensive than traditional gasoline vehicles even though EV fuel costs are lower (U.S. Department of Energy Alternative Fuels Data Center, n.d.-c). The median household income in California in 2024 is $84,907 (World Population Review, n.d.), but the median household income in the 20 zip codes with highest EV registrations ranges from $109,704 to over $250,000 (Lopez & Yee, 2023). Positive attitudes toward EVs also facilitate adoption. In California, 75% of respondents have a “very positive” or “somewhat positive” opinion of EVs, 15% have a “somewhat negative” or “very negative” opinion, and 10% aren’t sure (Climate Nexus, 2021-a).

Hawaii

Societal-Level Characteristics

Hawaii has 15 state laws and regulations and 3 state incentives regarding electric vehicles (U.S. Department of Energy Alternative Fuels Data Center, n.d.-d). State legislation is focused on supporting the transition to EVs at multiple levels. About a third of the laws and regulations mandate the development and implementation of public charging infrastructure and incentives. Another couple concern the Zero-Emission Vehicle Task Force, which is a multi-state agreement, which Hawaii is a part of, to transition government medium- and heavy-duty vehicles to fully

electric (U.S. Department of Energy Alternative Fuels Data Center, n.d.-d). Another few regulations oversee plans for promoting clean energy, specifically in transportation, to meet state emissions goals. There are three regulations that mandate a $50 fee for EV owners to pay when they register their vehicles, which supports highway maintenance. The state incentives all provide funds for government fleet electrification and public charging infrastructure. Hawaii laws and incentives do primarily focus on commercial vehicle transition and infrastructure, so there is room for improvement in things that may facilitate residential adoption. It appears that the state is on the right track though, and EV support is a priority based on the existing legislation and incentives.

Hawaii also is supportive of statewide adaptation and mitigation of climate change. Although Hawaii does not have a finalized state-led adaptation plan, it has 7 state laws and policies, 2 state agency plans, 3 local and regional plans, and 9 other resources, for a total of 21 climate change resources (Georgetown Climate Center, 2021). Legislation created the Hawaii Climate Change Mitigation and Adaptation Commission, which emphasizes low emission goals to reduce greenhouse gas emissions (Georgetown Climate Center, 2021). The two state agency plans provide community resources to work toward this goal, as well as resources for ocean and coastal health, sea-level rise, pollution, ecosystem health, and public health. One of the two state agency plans covers transportation. There are nine other resources that outline support resources for communities. Addressing climate change is a priority for Hawaiian lawmakers, especially the mitigation of greenhouse gas emissions. This emphasis on decreasing emissions aligns with the promotion of EVs.

Community-Level Characteristics

Hawaii has the current second-most expensive gas, on average. On March 18, 2024, gas cost $4.70 per gallon in Hawaii (Smith, n.d.). The average temperature in Hawaii is in the low

70s, and extreme temperatures can range from the upper 50s and the low 90s (Encyclopedia Britannica, n.d.-b). This bodes well for EV battery range and health. The population of Hawaii is approximately 1,435,138 (U.S. Census Bureau, n.d.), and 96% of Hawaii's population lives in urban areas, while 4% live in rural areas (U.S. Health Resources and Services Administration, 2020). Hawaii has two MSAs (U.S. Office of Management and Budget, 2023), which is where most of the population is concentrated. Hawaii is also a small state made up of islands, which means transportation around the small land area where population is concentrated and range is limited may facilitate EV adoption better than large and rural areas. In Hawaii, 76% of EVs are registered in Honolulu County on Oahu Island, which is where most of the population is concentrated (Hawaii EV Association, n.d.; U.S. Census Bureau, n.d.). Places with higher populations are more likely to facilitate EV adoption.

Characteristics that are affected by human actions also facilitate EV adoption at the community level in Hawaii. There are 797 public charging ports among 359 public charging stations (U.S. Department of Energy Alternative Fuels Data Center, n.d.-a). There is only one private/utility incentive regarding EVs, and it provides a rebate for commercial charging station installation (U.S. Department of Energy Alternative Fuels Data Center, n.d.-d). Finally, there are three different local and regional climate change mitigation and adaptation plans that for three different communities in Hawaii that encourage sustainable behaviors and attitudes (Georgetown Climate Center, 2021).

Individual-Level Characteristics

The median household income in Hawaii is $84,857 (World Population Review, n.d.), but zip codes with incomes $10,000 higher than the median household income also have, on average, 8-30% more EV registrations (Wee et al., 2020). Again, higher median incomes tend to facilitate EV adoption in this state. Hawaii also tends to have more positive attitudes toward EVs. During

a 2021 survey, 76% of people respondents had a “very positive” or “somewhat positive” opinion of EVs, 14% had a “somewhat negative” or “very negative” opinion, and 10% weren’t sure (Climate Nexus, 2021-b).

Washington

Societal-Level Characteristics

Washington has 29 state laws and regulations and 12 state incentives regarding EVs (U.S. Department of Energy Alternative Fuels Data Center, n.d.-g). Charging infrastructure is a priority, since ten of them concern public and commercial charging infrastructure. There are also five laws and regulations that cover fleet and commercial transition to EVs. Washington is also a part of the multi-state Zero-Emission Vehicle task force that pledges to transition government fleets to fully electric, so there are 4 pieces of legislation that address that. Washington has also set a goal for all vehicles sold after 2030 to be EVs. The other laws and regulations cover EV fees and mandate EV planning and infrastructure support. The 12 state incentives follow a similar pattern (U.S. Department of Energy Alternative Fuels Data Center, n.d.-g). Over half of the incentives provide money for general EV support and transition and public charging. As for the rest, there are two that provide money for commercial EV purchases, two that provide money for residential/light-duty EV purchases, and one that provides money to implement the ZEV agreement. Washington has actually chosen to adopt California’s stricter vehicle emissions standards (Motor Vehicle Emissions Standards, 2020). This further promotes EV adoption.

Washington has also made progress in legislating for climate change in general. Washington implemented a state-led climate change policy in 2012, and it currently has 8 pieces of state law and policy, 6 state agency plans, and 9 other resources (Georgetown Climate Center, 2020). Washington has a total of 23 resources for addressing climate change. The state-led climate change plan, known as Preparing for Climate Change: Washington State’s Integrated

Climate Response Strategy, covers multiple sectors and works toward methods of addressing climate change with an emphasis on reducing emissions (Georgetown Climate Center, 2020). The state legislation, state agency plans, and other resources function to support the implementation of this Strategy. Three of the six state agency plans cover transportation. Reduction of emissions is a priority in Washington, which is beneficial when promoting EV adoption.

Community-Level Characteristics

Gas in Washington is currently the third-most expensive in the country. Gas cost $4.31 per gallon on March 18, 2024 (Smith, n.d.). Temperatures in Washington average in the 50s, ranging from the low 40s in winter to the 70s in the summer, although temperatures have been known to reach above 100° (Encyclopedia Britannica, n.d.-c). Washington has an ideal climate for EVs. The population of Washington is approximately 7,812,880 (U.S. Census Bureau, n.d.), and 80.7% of the population is urban and 19.3% is rural (Washington State Hospital Association, 2017). There are 16 MSAs (U.S. Office of Management and Budget, 2023). About half of registered EVs are found in King County, which is where Seattle is located (Zhou, 2023). King County is also the most populated county (U.S. Census Bureau, n.d.) The counties with the next highest EV registrations are Snohomish and Pierce counties, which are third and second in population behind King County (Zhou, 2023; U.S. Census Bureau, n.d.). Again, places with higher populations appear to better facilitate EV adoption.

Public charging infrastructure is also robust. Washington has 5,590 charging ports among 2,133 charging stations (U.S. Department of Energy Alternative Fuels Data Center, n.d.-a). This is conducive to EV ownership. Of the eight utility/private incentives offered regarding EV adoption, most offer rebates for the installation of residential chargers and the others provide money for fleet electrification and public charging infrastructure development (U.S. Department

of Energy Alternative Fuels Data Center, n.d.-g). Washington also has 14 plans that address climate change mitigation adaptation at the local and regional level (Georgetown Climate Center, 2020). These community-level characteristics provide superior conditions for EV adoption.

Individual-Level Characteristics

The median household income in Washington is $84,247 (World Population Review, n.d.). Higher median household incomes facilitate EV adoption more, though, since EV owners in Washington had a median household income of $136,100 (Balk, 2023). Attitudes toward EVs in Washington do facilitate adoption. In Washington, 72% of people have a "very positive" or "somewhat positive" opinion of EVs, 21% have a "somewhat negative" or "very negative" opinion, and 6% aren't sure (Climate Nexus, 2021-c). Washington residents are largely in support of EVs, which is positive for adoption.

Discussion

Lessons From Three State Where EV Adoption Bas Been Successful

Through analysis of relevant EV adoption characteristics, multiple facilitators to EV adoption were found, aligning with previous research. California, Hawaii, and Washington all facilitate EV adoption at multiple levels of influence according to the Social Ecological Model. Behavior change is most effective when addressing all spheres of influence in the Social Ecological Model—societal, community, interpersonal, and individual. This is important when addressing the behavior of EV adoption. All states address EV adoption through characteristics at multiple levels that make EV adoption more attractive.

At the *societal* level, all three states have implemented policies regarding climate change at large and laws and incentives that specifically address EV adoption. The states' commitment to addressing climate change is evident through the legislation and plans that support state adaptation and mitigation policies. These policies function to foster a culture that values

sustainable behaviors and supports societal-level norms of climate-friendly behaviors. Legislation that supports EVs and EV infrastructure also leads to norms of EV support, as well as providing legal protections and incentives for EV owners. California and Washington even have set targets of selling only EVs in the state within the next decade. It should be noted that Washington has adopted California's ZEV standards. Other states could also choose to hold themselves to this higher standard and show more support for EVs. These norms can promote behavior change and therefore facilitate EV adoption at the societal level of influence.

California, Hawaii, and Washington had the most differences at the *community* level. Despite these differences, the characteristics related to EV adoption were still facilitating conditions based on the Social Ecological Model. The three states with the highest EV adoption rates also had the top three highest gas prices in the country on the day of data collection, with California having the most expensive gas in the country, followed by Hawaii and Washington, respectively. While the everyday data may fluctuate, these states are consistently in the list of states with the most expensive gas. Gas prices are not the sole factor that influence EV adoption, but it's reasonable that this may play a role. With rising gas prices, people may be looking for an alternative to save money on fuel, meaning that high gas prices in a community may facilitate EV adoption. California, Hawaii, and Washington also have climate conditions that accommodate EVs, since temperatures don't get too high (and risk battery damage) or too low (decrease battery range and increase charging time). High state populations don't seem to be a facilitating condition of EV adoption, but large urban areas do. Most EV owners in the states analyzed were concentrated in the most populous cities in the states. These larger areas don't require long driving distances that are more common in rural areas, which avoids range anxiety. Hawaii is especially primed to accommodate EVs, since the islands have a smaller land area, making it easy to get around with less range anxiety. These facilitating conditions make these

three states good locations for EVs without human intervention—these states seem to already have facilitating conditions that other states may not. The changes these states have made can further facilitate EV adoption. Another reason urban areas better facilitate EVs is charging infrastructure. California, Hawaii, and Washington have robust public charging infrastructure and numerous legislation and incentives that provide more infrastructure support. With more public charging comes less range anxiety. Incentives offered by the states' utilities and other private entities also provide money for both residential and commercial charging. California, Hawaii, and Washington have added to the community characteristics that make the states conducive to EVs through community-level actions such as incentives and infrastructure.

California, Hawaii, and Washington also had commonalities in the *individual* sphere of influence. While the median household incomes were all similar, the median household income of EV owners was higher than the state median income. Higher incomes facilitate EV adoption in these states. The majority of residents of the states also had generally positive views toward EVs. Negative perceptions pose an obvious barrier to EV adoption, so positive individual attitudes are a good thing for improving EV adoption.

These takeaways align with previous research into barriers and facilitators to EV adoption. Previous literature has found that higher-than-average income, larger cities, vast public charging infrastructure, positive perceptions of EVs, moderate climates, and support in the form of incentives and policies (A. Yang et al., 2023; Mukherjee & Ryan, 2020; Broadbent et al., 2021). All of these were found to be present in the states studied in this research. Analyzing these factors through the Social Ecological Model provides an explanation for why these factors facilitate EV adoption in these states. They address multiple spheres of influence, which work together to create behavior change.

Potential Applications for Other States

Other states looking to improve EV adoption rates can apply some of the same characteristics that California, Hawaii, and Washington have. At the societal level, increasing climate change policy and EV policy can support norms that are more conducive to EV adoption. There are multiple community-level characteristics that facilitate EV adoption that some states just can't change, such as climate, urban vs. rural areas, or gas prices. This means that other ways of facilitating EV adoption in communities become more important. Creating a strong charging network among communities would be very important, since that is something that successful states all have in common. Providing reliable fuel sources is an important community-level facilitator. California, Hawaii, and Washington also have extensive plans to transition government fleets to electric. While this is not directly related to individual EV adoption, seeing EV commitment within the community appears to be helpful. Finally, individual-level facilitators could be addressed. Since people with higher incomes are more likely to purchase EVs, implementation and awareness of incentives and other programs that may make EV purchases more cost-effective could address this aspect of adoption. To foster positive perceptions of EVs, states could implement information campaigns that highlight the benefits of EVs. Positive examples of EVs could also be helpful, such as government fleet electrification that decreases emissions or leads to better performance. While these behavior interventions address various levels of human behavior influence, addressing all spheres of the Social Ecological Model will be the most effective in improving EV adoption rates across the country.

The Future of EVs in the United States

Not all states may be enthusiastic about improving EV adoption, but the reality is that EVs are not going away. Adoption rates have been increasing, and projections show that EVs will make up between 13% and 29% of new vehicle sales by 2050 (Dwyer, 2023b). Other projections predict 40% to 50% of cars sold will be EVs by 2030 (U.S. Bureau of Labor

Statistics, 2023). All available data combines these statistics to include fully electric vehicles and plug-in hybrid electric vehicles (PHEVs) in these projections. (PHEVs still consume gasoline.) Regardless, EV adoption rates will continue to rise, so creating facilitating conditions will be not only more convenient in the long run but also increase the environmental benefits of EVs. Investing in the support and infrastructure now may avoid having to catch up in the future, and transportation emissions will decrease. While EVs draw criticism for the greenhouse gas emissions that are created during the production process as a result of the mining for the battery metals, this technology is constantly improving (Environmental Protection Agency, 2024a). Finding better ways to produce these batteries is a top priority. Another common criticism is that the electricity generated for EV charging creates more emissions, making EVs worse for the planet. This is not true. Renewable energy sources are more common than people realize, meaning that emissions from electricity generation are not as high as people tend to believe. In fact, the greenhouse gas emissions that come from fueling EVs are lower than those from gasoline cars, even taking into account charging electricity (Environmental Protection Agency, 2024a). Including the emissions from battery procurement and electricity for charging, the lifetime emissions from an EV are less than half that of gasoline cars (Environmental Protection Agency, 2024a). Improving EV adoption by addressing facilitating conditions will make it easier to achieve these environmental benefits,

The new EPA policy that sets EV sales targets and emissions limits is even more of a reason to pay attention to facilitators and barriers to EV adoption in all states. This policy is only in effect for vehicle model years 2027 to 2032, which means it will be updated in the coming years and standards will be even higher in the future (Environmental Protection Agency, 2024b). California and Washington even have their own state standards that will require all vehicles sold in the state to be EVs by a certain year. These types of policies and emissions standards are

becoming increasingly numerous, providing even more reason why these facilitating conditions to EV adoption are necessary to understand and implement.

Summary and Conclusions

This study was performed to identify relevant characteristics that facilitate EV adoption in the U.S. states that have had the most success with EV adoption and evaluate them in terms of human behavior. This study addressed the questions of what facilitates EV adoptions in states that have higher rates of adoption and what can be learned from these places. California, Hawaii, and Washington have the highest rates of EV adoption in the United States. Based on characteristics from previous research, multiple facilitators of EV adoption were found and evaluated in each state, revealing interventions at multiple levels of human behavior, including social, community, and individual. These facilitators include state-level EV laws, regulations, and incentives, state climate change mitigation and adaptation plans, high gas prices, moderate temperatures, large urban MSAs, well-developed charging infrastructure, local climate change adaptation and mitigation plans, private incentives, higher-than-average median incomes, and positive attitudes toward EVs. Some of these facilitators are innate to individual states and may not be influenced by humans, but most facilitators can be applied to other states also looking to improve EV adoption rates. Improvements to adoption rates can lead to lower greenhouse gas emissions from the transportation sector and meet standards set in new policies such as the EPA rule that sets emissions standards and EV adoption targets.

While the analysis of three states led to an abundance of valuable information, results from three states may not be generalizable. Continued research on these characteristics in other states, both successful and unsuccessful in EV adoption, may provide further insights. Future research may also consider the interpersonal level of human behavior. The other three levels, societal, community, and individual were all present, but behavior change efforts are most

successful when it addresses all four levels. Data from this research did not reveal characteristics related to EV adoption at the interpersonal level. Further study on interpersonal communication about EVs, for example, would provide a more well-rounded approach to improving EV adoption. Finally, additional characteristics that facilitate EV adoption may be considered. The characteristics considered in this research were generated based on previous research into barriers and facilitators to EV adoption, but it is by no means an exhaustive list. Other facilitators exist, and future research may take these into account when addressing EV adoption improvement.

The experience of conducting this research has been a learning process that was both challenging and rewarding. I grew a lot from this experience. I practiced critical thinking, creative application, communication, and flexibility. I also learned about myself—how I work best, when to ask for help, and that I can accomplish challenging tasks. This type of project was out of my comfort zone, but the skills I've gained throughout the process are invaluable. One of these skills is thinking though problems with sustainability in mind. When confronting a complex, wicked problem such as climate change, strategic and creative thinking is necessary. Electric vehicles are by no means perfect, but no approach to sustainability is. That's why it's important to fully analyze the technology and how it may be applied in a productive way. The multi-level systems thinking practiced in this study is what will drive us toward a sustainable way of living.

References

Balk, G. (2023, October 5). *As Seattle gas prices soar, so does interest in electric vehicles.* The Seattle Times. https://www.seattletimes.com/seattle-news/data/as-seattle-gas-prices-soar-so-does-interest-in-electric-vehicles/#:~:text=The%20data%20shows%206.1%25%20of,June%202022%20to%20May%202023.

Brase, G. L. (2018). What would it take to get you into an electric car? Consumer perceptions and decision making about electric vehicles. *The Journal of Psychology: Interdisciplinary and Applied, 153*(2), 214–236. https://doi.org/10.1080/00223980.2018.1511515

Brenan, M. (2023, April 12). *Most Americans are not completely sold on electric vehicles.* Gallup. https://news.gallup.com/poll/474095/americans-not-completely-sold-electric-vehicles.aspx

Broadbent, G. H., Metternicht, G. I., & Wiedmann, T. O. (2021). Increasing electric vehicle uptake by updating public policies to shift attitudes and perceptions: Case study of New Zealand. *Energies, 14*(10), 2910. https://doi.org/10.3390/en14102920

California Air Resources Board. (n.d.). *Zero-Emission Vehicle Program*. https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program/about

Centers for Disease Control and Prevention. (2022). *The social-ecological model*. https://www.cdc.gov/violenceprevention/about/social-ecologicalmodel.html

Centers for Disease Control and Prevention. (2022). *The social-ecological model* [Chart]. https://www.cdc.gov/violenceprevention/about/social-ecologicalmodel.html

Choma, E. F., Evans, J. S., Hammitt, J. K., Gómez-Ibáñez, J. A., & Spengler, J. D. (2020). Assessing the health impacts of electric vehicles through air pollution in the United

States. *Environment International, 144*, 106015. https://doi.org/10.1016/j.envint.2020.106015

Climate Nexus. (2021). *California Poll Toplines* [Report]. https://coltura.org/wp-content/uploads/2023/01/CaliforniaPollToplines1111.pdf

Climate Nexus. (2021). *Hawaii Poll Toplines* [Report]. https://coltura.org/wp-content/uploads/2023/01/HawaiiPollToplines1111.pdf

Climate Nexus. (2021). *Washington Poll Toplines* [Report]. https://coltura.org/wp-content/uploads/2023/01/WashingtonPollToplines1111.pdf

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology, 11*(1), 100-100. fhttps://doi.org/10.1186/1471-2288-11-100

Druckman, J. N. & Bolsen, T. (2011). Framing, motivated reasoning, and opinions about emergent technologies. *Journal of Communication, 61(4),* 659-688. https://doi.org/10.1111/j.1460-2466.2011.01562.x

Dwyer, M. (2023, September 7). *Electric vehicle sales make up 16% of U.S. light-duty vehicle sales*. U.S. Energy Information Administration. https://www.eia.gov/todayinenergy/detail.php?id=60321#

Dwyer, M. (2023, May 15). *Incentives and lower costs drive electric vehicle adoption in our annual energy outlook.* U.S. Energy Information Administration. https://www.eia.gov/todayinenergy/detail.php?id=56480#:~:text=According%20to%20our%20Annual%20Energy,%25%20and%2026%25%20of%20on%2D

Encyclopedia Britannica. (n.d.) *California.* https://www.britannica.com/place/California-state/Climate

Encyclopedia Britannica. (n.d.) *Hawaii.* https://www.britannica.com/place/Hawaii-state/Climate

Encyclopedia Britannica. (n.d.) *Washington.* https://www.britannica.com/place/Washington-state#ref79325

Environmental Protection Agency. (n.d.). *Multi-pollutant emissions standards for model years 2027 and later light-duty and medium-duty vehicles* [Regulation]. Retrieved April 15, 2024, from https://www.epa.gov/system/files/documents/2024-03/lmdv-veh-standrds-ghg-emission-frm-2024-03.pdf

Environmental Protection Agency. (2023, October 31). *Fast facts on transportation greenhouse gas emissions*. https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions

Environmental Protection Agency. (2024, April 9). *Electric vehicle myths.* https://www.epa.gov/greenvehicles/electric-vehicle-myths

Environmental Protection Agency. (2024, April 1). *Final rule: Multi-pollutant emissions standards for model years 2027 and later light-duty and medium-duty vehicles.* Retrieved April 15, 2024, from https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-multi-pollutant-emissions-standards-model

Franke, T. & Krems, J. F. (2013). What drives range preference in electric vehicle users? *Transport Policy, 30,* 56-62. https://doi.org/10.1016/j.tranpol.2013.07.005

Georgetown Climate Center (2018, August 1). *Preparing for climate change in California*. https://www.georgetownclimate.org/adaptation/state-information/california/overview.html

Georgetown Climate Center (2020, July 28). *Preparing for climate change in Washington.* *https://www.georgetownclimate.org/adaptation/state-information/washington/overview.html*

Georgetown Climate Center (2021, August 27). *Preparing for climate change in Hawaii.* *https://www.georgetownclimate.org/adaptation/state-information/hawaii/overview.html*

Hart, P. S., Feldman, L., Leiserowitz, A., & Maibach, E. (2015). Extending the impacts of hostile media perceptions: Influences on discussion and opinion polarization in the context of climate change. *Science Communication*, *37*(4), 506–532. https://doi.org/10.1177/1075547015592067

Hawaii EV Association. (n.d.). *EV adoption in Hawaii – Now over 30,000!* https://hawaiiev.org/

Johnson, H., & Cuellar Mejia, M. (2024, March). *Rural California* [Fact Sheet]. Public Policy Institute of California. https://www.ppic.org/wp-content/uploads/rural-california.pdf

Kovačić, M., Mutavdžija, M., & Buntak, K. (2022). New paradigm of sustainable urban mobility: Electric and autonomous vehicles—A review and bibliometric analysis. *Sustainability (Basel, Switzerland)*, *14*(15), 9525. https://doi.org/10.3390/su14159525

Krishna, G. (2021). Understanding and identifying barriers to electric vehicle adoption through thematic analysis. *Transportation Research Interdisciplinary Perspectives*, *10*, 100364. https://doi.org/10.1016/j.trip.2021.100364

Lee, B. C., Bendixsen, C., Liebman, A. K., & Gallagher, S. S. (2017). Using the socio-ecological model to frame agricultural safety and health interventions. *Journal of Agromedicine, 22*(4), 298-303. https://doi.org/10.1080/1059924X.2017.1356780

Li, N., & Su, L. Y.-F. (2018). Message framing and climate change communication: A meta-analytical review. *Journal of Applied Communications*, *102*(3), 1–16. https://doi.org/10.4148/1051-0834.2189

Liang, Y., Henderson, L. K., & Fee, K. K. (2017). Running out of water! Developing a message typology and evaluating message effects on attitude toward water conservation.

Environmental Communication, 12(4), 541-557. https://doi.org/10.1080/17524032.2017.1288648

Lopez, N. & Yee, E. (2023, March 22). *Who buys electric cars in California—and who doesn't?* CalMatters. https://calmatters.org/environment/2023/03/california-electric-cars-demographics/

Motor Vehicle Emissions Standards—Zero Emission Vehicles, 70A WRC § 30.010 (2020). https://app.leg.wa.gov/RCW/default.aspx?cite=70A.30.010

Mukherjee, S. C., & Ryan, L. (2020). Factors influencing early battery electric vehicle adoption in Ireland. *Renewable & Sustainable Energy Reviews*, *118*, 109504. https://doi.org/10.1016/j.rser.2019.109504

Sanders, C. E., Gibson, K., & Lamm, A. J. (2022). Perceived government control and its influence on climate change knowledge and perceptions: Applications for effective communication. *Journal of Applied Communications*, *106*(3), 1–25. https://doi.org/10.4148/1051-0834.2441

Shih, T.-J., & Lin, C.-Y. (2017). Developing communication strategies for mitigating actions against global warming: Linking framing and a dual processing model. *Environmental Communication*, *11*(6), 840–858. https://doi.org/10.1080/17524032.2016.1154886

Skippon, S. M. (2014). How consumer drivers construe vehicle performance: Implications for electric vehicles. *Transportation Research. Part F, Traffic Psychology and Behavior, 23*, 15-31. https://doi.org/10.1016/j.trf.2013.12.008

Smith, K. A. (n.d.). *Today's gas prices by state*. Forbes Advisor. Retrieved March 18, 2024, from https://www.forbes.com/advisor/personal-finance/gas-prices-by-state/

Spencer, A., Ross, S., & Tyson, A. (2023, July 13). *How Americans view electric vehicles*. Pew Research Center. https://www.pewresearch.org/short-reads/2023/07/13/how-americans-view-electric-vehicles/

U.S. Bureau of Labor Statistics. (2023, February). *Charging into the future: The transition to electric vehicles* (BLS Volume 12 Publication No. 4). United States Department of Labor. https://www.bls.gov/opub/btn/volume-12/charging-into-the-future-the-transition-to-electric-vehicles.htm#:~:text=S%26P%20Global%20Mobility%20forecasts%20electric,surpassing%2050%20percent%20by%202030.

U.S. Census Bureau. (n.d.) *QuickFacts*. Retrieved March 18, 2024, from https://www.census.gov/quickfacts/fact/table/CA,WA,HI,US/PST045223

U.S. Department of Energy Alternative Fuels Data Center. (n.d.). *Alternative fueling station counts by state*. Retrieved March 18, 2024, from https://afdc.energy.gov/stations/states

U.S. Department of Energy Alternative Fuels Data Center. (n.d.). California laws and incentives. https://afdc.energy.gov/laws/state_summary?state=CA&technologies=ELEC

U.S. Department of Energy Alternative Fuels Data Center. (n.d.). *Electric vehicle benefits and considerations*. https://afdc.energy.gov/fuels/electricity-benefits

U.S. Department of Energy Alternative Fuels Data Center. (n.d.). *Hawaii laws and incentives*. https://afdc.energy.gov/laws/state_summary?state=HI&technologies=ELEC

U.S. Department of Energy Alternative Fuels Data Center. (n.d.). *How do all-electric cars work?* https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work

U.S. Department of Energy Alternative Fuels Data Center. (n.d.). *TransAtlas*. https://afdc.energy.gov/transatlas#/

U.S. Department of Energy Alternative Fuels Data Center. (n.d.). *Washington laws and incentives.* https://afdc.energy.gov/laws/state_summary?state=WA&technologies=ELEC

U.S. Department of Energy Alternative Fuels Data Center. (2023). *Electric vehicle charging infrastructure* trends. https://afdc.energy.gov/fuels/electricity_infrastructure_trends.html

U.S. Health Resources and Services Administration. (2020). *III.B. Overview of the state – Hawaii – 2020*. https://mchb.tvisdata.hrsa.gov/Narratives/Overview/1ee04f05-2727-49ff-91af-80c7e9cad3aa

U.S. Office of Management and Budget. (2023, July 31). *OMB Bulletin No. 23-01* [Report]. https://www.whitehouse.gov/wp-content/uploads/2023/07/OMB-Bulletin-23-01.pdf

Washington State Hospital Association. (2017, March 16). *Health inequities in rural communities*. https://www.wsha.org/articles/health-inequities-rural-communities/#:~:text=Rural%20communities%20comprise%2019.3%20percent,unlike%20those%20in%20urban%20areas

Wee, S., Coffman, M., & Allen, S. (2020). EV driver characteristics: Evidence from Hawaii. *Transport Policy, 87,* 33-40. https://doi.org/10.1016/j.tranpol.2019.12.006

World Population Review. (n.d.) *Median household income by state 2024*. https://worldpopulationreview.com/state-rankings/median-household-income-by-state

Yang, A., Liu, C., Yang, D., & Lu, C. (2023). Electric vehicle adoption in a mature market: A case study of Norway. *Journal of Transport Geography, 106,* 103489. https://doi.org/10.1016/j.jtrangeo.2022.103489

Yang, X. (2021). If others care, I will fight climate change: An examination of media effects in addressing the public goods dilemma of climate change mitigation. *International Journal of Communication.*, *15*, 3315–3335.

Yang, Z. J., Rickard, L. N., Harrison, T. M., & Seo, M. (2014). Applying the risk information seeking and processing model to examine support for climate change mitigation policy. *Science Communication, 36(3),* 296-324. https://doi.org/10.1177/1075547014525350

Yuksel, T., & Michalek, J. J. (2015). Effects of regional temperature on electric vehicle efficiency, range, and emissions in the United States. *Environmental Science & Technology*, *49*(6), 3974–3980. https://doi.org/10.1021/es505621s

Zhou, A. (2023, October 16). *EV sales have soared in WA; our map shows where they're registered.* The Seattle Times. https://www.seattletimes.com/seattle-news/environment/ev-sales-have-soared-in-wa-our-map-shows-where-theyre-registered/#:~:text=EV%20ownership%20in%20Washington%20is,the%20Washington%20Department%20of%20Licensing

Appendix

EV Adoption Characteristics by State

Characteristic	**California**	**Hawaii**	**Washington**
Pieces of state legislation	57	15	28
Number of state incentives	32	3	12
Number of climate change efforts—state policies and programs	89	18	41
Average price per gallon of regular gas	$4.91	$4.70	$4.31
Average temperature in Fahrenheit	Mid 60s	Low 70s	Mid 50s
Population	38,965,193	1,435,138	7,812,880
Number of MSAs	29	2	16
Public charging stations	15,753	359	2,133
Percent of population in urban areas	94.2%	96%	80.7%
Percent of population in rural areas	5.8%	4%	19.3%
Number of utility/private incentives	48	1	8
Number of local and regional climate change adaptation and mitigation plans	44	3	14
Concentration of EVs	Zip codes with highest EV registrations are in large cities	76% of EVs registered in largest city	3 counties with highest EV registrations are the 3 most populated counties
Median household income	$84,907	$84,857	$84,247

Median household income of EV owners	$109,704 to $250,000+	$10,000 increase in household income associated with 8-30% more EV registrations	$136,100
Percent of population with positive or somewhat positive view of EVs	75%	76%	72%