“Driving” Electric Vehicle Adoption in Rhode Island

A Policy Analysis Report to Allow Rhode Island to Meet New Electric Vehicle Regulations

Prepared by Charles Groscup

Second Year Master’s in Public Policy Candidate at the University of Virginia’s Frank Batten School of Leadership and Public Policy

Prepared for Rhode Island’s Office of Management and Budget

University of Virginia
Frank Batten School of Leadership and Public Policy

Table of Contents

Abbreviations

AFC – Alternative Fuel Corridor

CARB – California Air and Resources Board

DCFC – Direct Current Fast Charging

DEM – Department of Energy Management

DRIVE – Driving Rhode Island to Vehicle Electrification

EPA – Environmental Protection Agency

EV – Electric Vehicle

FHA – Federal Highway Administration

GHG – Greenhouse Gas

ICE – Internal Combustion Engine

NEVI – National Electric Vehicle Infrastructure

NPV – Net Present Value

OER – Office of Energy Resources

OMB – Office of Management and Budget

PUC – Public Utilities Commission

RIDOT – Rhode Island Department of Transportation

RFP – Request for Proposal

USDOT – United States Department of Transportation

Executive Summary

This report begins by defining the central problem currently facing Rhode Island's electric vehicle (EV) market. Given new regulations from the California Air and Resources Board (CARB), *too few Rhode Island citizens drive EVs.* This problem was refined from questions posed by Rhode Island's Office of Management and Budget (OMB), which specializes in quantitative analysis of various state policies and works in conjunction with the state's governor.

The background section presents research on the effects that insufficient EV adoption has had on Rhode Island, including evidence that greenhouse gas (GHG) emissions make this particular problem a pivotal issue. An assessment is then conducted of why this problem has persisted, which examines barriers consumers face to EV adoption and supply-side dynamics of EV markets. Rhode Island's current EV policy arena is then examined, specifically focusing on the state's Driving Rhode Island Vehicle Electrification (DRIVE) EV rebate program and a recent proposal for federal funding to expand the state's EV charging infrastructure, both of which were enacted this past summer.

The subsequent section discusses the existing evidence on policies designed to incentivize EV adoption. Researched policies focus primarily on tax incentives, tax rebates, improved EV charging infrastructure, and policies to address information and market failures in the EV arena.

This report then presents four possible policy solutions: 1) The Status Quo; 2) Increasing fast EV charging station presence in the Providence metropolitan area; 3) Expanding the current DRIVE EV rebate program; and 4) Establishing a user-friendly webpage that provides citizens with useful information regarding EVs. These alternatives are assessed according to their budgetary cost, a cost-benefit analysis (CBA), their effectiveness in reaching the new CARB targets, and their administrative feasibility.

Ultimately, I recommend that Rhode Island's OMB bring the second and fourth alternatives to Governor McKee, which together performed the best in progressing the state towards the new EV sale's targets. The implementation section outlines how the OMB can coordinate with other state agencies and the governor's office to ensure that these policies have their intended effect.

Disclaimer

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. 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 Batten School, by the University of Virginia, or by any other agency.

Honor Statement

On my Honor, I have neither given nor received unauthorized aid on this assignment.

Charles Groscup

Acknowledgements

I could not have completed this project on my own and owe thanks to many people. Thank you to Michelle Charochak and her wonderful colleagues in Rhode Island's Office of Management and Budget for their insights and assistance throughout this process. Michelle's knowledge of Rhode Island's electric vehicle policy arena and her expertise in policy analysis helped to shape this project.

I would also like to thank Professor Andrew Pennock for his guidance over the past nine months. His familiarity with Rhode Island and extensive knowledge on both qualitative and quantitative standards in policy analysis were very appreciated and made this project possible. Additional thanks go to Irene Cox, Scott Rykala, and Madison McCaffrey. You all kept me grounded and engaged in this process, and I certainly benefited from your questions and hearing about the incredible work you all have done.

Lastly, I need to thank my loved ones. To Mom, Dad, Jack, and Matthew: Thank you for encouraging me through this process and for keeping me focused on the bigger picture of my educational pursuits. To Molly Gloeckner: Thank you for supporting me throughout this journey and for always believing in me.

I. Introduction

Climate change is one of the most important and urgent policy issues facing our world. Currently, the automotive sector accounts for 15 to 25 percent of polluting emissions, which not only damage the world's climate but create health hazards across many cities (Thomson Reuters, 2017). Within Rhode Island, the state's Department of Environmental Management (DEM) concluded that transportation was the largest contributor to greenhouse gas (GHG) emissions in 2018, accounting for nearly 40 percent that year (Rhode Island Department of Energy Management, 2018). This makes electric vehicles (EVs) one of the most impactful investments for any government looking to make a difference in the environment.

The purpose of this document is to investigate past trends in EV markets, and to advocate for a policy solution that will substantially progress Rhode Island's EV market. The first sections of this paper will orient the reader as to how EV market trends have developed in recent years, along with their driving forces. Evidence on potential solutions to the problem will then be presented, followed by proposals for possible policy solutions and an analysis of their impacts. Lastly, this paper will offer a policy recommendation for Rhode Island's Office of Management and Budget (OMB) and a brief discussion of potential implementation steps.

II. Problem Statement

Under Section 177 of the Federal Clean Air Act, states may elect to regulate their vehicle emission standards to either the Environmental Protection Agency's (EPA) standard or to the California Air and Resources Board's (CARB) standard. As of this past May, 17 states including Rhode Island regulate to the CARB standard (California Air Resources Board, 2022). CARB enacted a new standard this past August that will require 100 percent of new vehicle sales to be EVs by 2035 (California Air Resources Board, 2022). As of September of last year, EVs comprised about 12.12 percent of all vehicle sales in Rhode Island, and the most generous estimate suggests that EVs will represent 52.6 percent of the vehicle market share by 2035 (Alliance for Automitve Innovation, 2022; James Archsmith, 2022;).[1] *Given the new CARB standard and the state's current EV market share, too few Rhode Islanders drive EVs.*

[1] Under the new CARB regulations, only battery-cell electric (BEV) and fuel-cell electric (FCEV) will fully count towards the new standards, while plug-in hybrid electric vehicles (PHEVs) can only account for 20 percent of a given state's CARB credit (California Air Resources Board, 2022). Consequently, any EV market share percentage in this paper that does not explicitly account for this should be treated as such.

III. Client Overview

The Rhode Island OMB works under the governor's office, who currently is Governor McKee. Rhode Island's OMB is responsible for conducting policy analysis of current and potential policies for the state. The analysis includes both quantitative and qualitative analysis, with a central focus on cost-benefit analysis to provide effective and accurate metrics.

While environmental issues and EV policies specifically received some attention during Governor McKee's last term, these areas faced under-investment over the last few years. Given the new CARB standards and an increased national and state-wide focus on EVs over the last few months, it seems likely that the governor's office will require evidence-based EV policy solutions in the near-term. Consequently, the Rhode Island OMB is preparing for an expected increase in demand for EV policy analysis.

Rhode Island has recently enacted a new EV rebate program and has a sizeable federal grant to use for EV charging infrastructure in the coming years. Given these recent developments and the state's increasing focus on EVs, an apt analysis is required to inform Rhode Island's OMB how to utilize future resources in shaping policies.

IV. Background of the Problem

Issues surrounding climate change have certainly received increased attention over the last few decades, a trend that has been prevalent across Rhode Island. In 2016, Rhode Island's Executive Climate Change Coordinating Council put forth a report that outlined the state government's goals for climate change initiatives moving forward. At the time, the state targeted emissions reductions that were 45 percent below 1990 levels by 2035 and 80 percent below 1990 levels by 2050 (The Executive Climate Coordinating Council, 2016). When it came to EVs, the Council theorized that to reach the state's ambitious GHG emissions reductions, 75 percent of the total vehicle miles traveled in the state would need to come from EVs by 2050 (The Executive Climate Coordinating Council, 2016). Furthermore, the Green Energy Consumer Alliance projected that a complete transition to EVs will save the state $178 million in annual healthcare costs (Green Energy Consumers Alliance, 2022).

A total of 427 EVs were sold in Rhode Island this past September, bringing the state's market share to just over 12 percent (Alliance for Automotive Innovation, 2022). The most optimistic of estimates indicates that EVs could reach 52.6 percent of the state's vehicle market share by 2035, as shown below in *Table 1*, which would still put Rhode Island behind the 2035 CARB standard (James Archsmith, Future Paths of Electric Vehicle Adoption in the United States: Predictable Determinants, Obstacles, and Opportunities, 2022). However, EV purchases in Rhode Island have increased by 16 percent between February and June of this year (Burns, 2022). Despite these upward trends in EV sales, Rhode Island still must make significant strides to comply with the new CARB regulations.

Table 1: Projected Electric Vehicle Market Share by 2035

	Intrinsic Demand Growth		
State	High	Medium	Low
District Of Columbia	64.8%	39.9%	29.3%
California	54.8%	26.5%	16.6%
Connecticut	54.1%	26.0%	16.2%
New Jersey	54.3%	25.9%	16.1%
Maryland	53.8%	25.8%	16.1%
Massachusetts	53.5%	25.4%	15.8%
Hawaii	53.2%	25.4%	15.9%
Rhode Island	52.6%	24.3%	14.8%
Illinois	50.7%	23.2%	14.2%
Virginia	50.1%	23.0%	14.1%

Source: (James Archsmith, 2022)

While overall EV purchases are a key facet of this policy problem, a 2018 report from Rhode Island's DEM concluded that transportation was the largest contributor to GHG emissions in 2018, accounting for nearly 40 percent that year (Rhode Island Department of Energy Management, 2018). Consequently, addressing this policy problem will not only allow Rhode Island to comply with CARB's new regulation but will also assist the state in reaching their GHG emission goals.

Causes of the Problem

To fully address EV adoption, sales, and usage in Rhode Island, compliance from consumers, car dealerships, and state government actors is needed. Without the support of any of these key stakeholders, the effectiveness of policies aimed at enhancing EV adoption will be limited.

Consumers' Barriers to Electric Vehicle Adoption

There are several hurdles that stand in the way of increasing EV adoption. Specifically, consumers face barriers in the form of lack of adequate EV charging availability, high costs associated with buying an EV, and information barriers and misconceptions surrounding EVs.

Currently, there are approximately 300 EV charging stations in Rhode Island, according to the Rhode Island Department of Transportation (RIDOT) (Rhode Island Department of Transportation, 2021). However, a recent report outlined past projected charging needs of Rhode Island under both conservative and aggressive EV adoption scenarios. Assuming an annual growth rate of 10 percent for EVs between 2016 and 2023, the state was expected to require an additional 83 EV charging plugs (United States Department of Energy, 2021). Furthermore, assuming that 10 percent of the entire state's light-duty vehicle fleet would be electrified by 2023, the state needed an additional 2,751 EV charging plugs (United States Department of Energy, 2021). Looking forward, if EV market share in the U.S. is to reach 40 percent by 2030, EV chargers will need to increase by more than eight-fold over the next seven years (Lewis, 2023).

Beyond these logistical concerns, consumers have proven to be aware of the insufficiencies of the current EV charging infrastructure. According to a survey from Consumer Reports, 61 percent of survey respondents stated that the lack of EV charging infrastructure was the largest barrier to purchasing an EV, proving to be the largest barrier to adoption (Bartlett, 2022). There is also an equity concern with EV charging availability, as rural and disadvantaged communities do not have the same access to EV chargers than their counterparts in other communities do. For example, while metropolitan areas tend to have anywhere between 500 and 1,000 public charging outlets per 25 square miles, suburban communities have at most 25 outlets over the same distance while rural communities tend to have none (Tolbert, 2021).

Furthermore, multi-unit dwellings, often found in disadvantaged communities, face a substantial barrier to EV charging access, particularly at-home charging availability. For example, a 2021 study of California's EV charging infrastructure found that communities with below-median incomes had limited access to public charging stations compared to other groups. Similar instances were found in communities with majority Black or Hispanic populations. These effects were exacerbated in localities with increased amounts of multi-unit housing units (Chih-WeiHsu, 2021).

Consequently, those in single-family units in urban and suburban communities who can afford at-home charging units do not face the same barriers to EV adoption as those in disadvantaged and rural communities.

Even if consumers have sufficient access to EV chargers, this alone does not guarantee that barriers to charging are mitigated. A 2020 review of EV charging stations found that many charging stations are owned by vastly different entities, and consequently require EV users to adapt to an array of interfaces depending on their location. The review also noted that private homeowners who wish to install fast charging stations must first seek approval from both local utility companies and local governments (H.S. Das, 2020). These difficulties are corroborated by a more recent examination of barriers to EV adoption. A 2021 study found that consumers' concerns regarding EV battery capacity, available charging infrastructure, and lack of technological development all act as inhibitors of EV adoption (Krishna, 2021). Obstacles such as these may then diminish the impact of an expanded EV charging infrastructure.

Another significant barrier to EV adoption is the price tag difference between an internal combustion engine (ICE) vehicle and EVs. As of this past September, EVs were approximately $17,000 more expensive than ICE vehicles, on average (Valdes, 2022). According to a 2023 survey from Deloitte, 52 percent of survey respondents reported that cost was the predominant concern when considering purchasing an EV (Deloitte, 2023). While innovation, new technology, and large-scale developments are continuing to push EV prices downwards, EVs are not expected to reach price parity with ICE vehicles until 2026 (Reuters, 2022). Therefore, price differentials between ICE vehicles and EVs will likely be a continued barrier for EV adoption.

Given the relatively higher costs of new EVs, low-income individuals face additional barriers to entry in the EV market. Households in the lowest income quintiles spend nearly 30 percent of their after-tax income on transportation, compared to just 10.4 percent amongst households in the highest income quintiles. Thus, disadvantaged communities may face restrictions when buying new vehicles that do not affect other communities to the same extent.

Consumers also face barriers to EV adoption in the form of information and market failures. One of the barriers stems from dealerships, where consumers perceive that car dealers purposely provide misinformation of EVs to disincentivize their purchase. Consumers feel that car dealerships face a decrease in profits when selling EVs as opposed to ICE vehicles, and as such attempt to discourage EV purchases. Yet another concern observed amongst consumers is that EVs are unsafe. Specifically, consumers worry of the possibility of battery explosion during an accident or extreme weather condition (Krishna, 2021).

Additional information barriers exist in the form of misconceptions and lack of knowledge about EVs. For example, a survey from Ascend Elements found that over 40 percent of Americans believe that EV batteries cannot be recycled, which is incorrect (Ascend Elements, 2022). Furthermore, the same survey found that only 37 percent of Americans knew that lithium-ion EV batteries can be recycled and re-purposed into new EV batteries (Ascend Elements, 2022). A 2020 survey from Consumer Reports reported that 98 percent of respondents had heard of EVs, yet only 30 percent felt they were knowledgeable about EVs (Consumer Reports, 2020). Additionally, 30 percent of survey respondents cited that their lack of EV knowledge was a deterrent in purchasing an EV (Consumer Reports, 2020).

There are handful of barriers that currently stand in the way of EV adoption for consumers across the country, along with impactful equity concerns. These unnecessary hurdles to EV adoption create a clear and justified path for government action on this issue.

The Supply-Side of Electric Vehicles

CARB's new regulations not only hold implications for consumers but for auto manufacturers as well and are especially impactful for brand-name dealerships. Several dealerships have opted to become EV-certified in the wake of the new standards, which entails training service and sales employees and upgrading existing equipment to support and service EVs, which can cost upwards of $50,000 (Woods, 2021). Steep costs for dealership EV-certification, along with any hesitancies to convert existing equipment to support EVs or advocate for EV sales, may delay EV adoption.

Another roadblock for EV adoption is the availability of EVs for sale. In 2022 there were only 29 fully-electric vehicle models available, compared to over 400 models for fuel-alternative vehicles (Exro, 2022). Furthermore, Rhode Island citizens face pronounced delays in acquiring EVs. Prior to the state releasing their DRIVE (Driving Rhode Island to Vehicle Electrification) EV Rebate Program last summer, the state's Office of Energy Resources (OER) received public comments about the program. Many of the comments cited that Rhode Island citizens face extended wait times for EVs that took anywhere from eight months to over a year (Resources, 2022). Consequently, Rhode Island citizens appear to face severe limitations in EVs immediately available for purchase.

CARB's new policy, however, places the regulatory burden on auto manufacturers as opposed to government agencies or consumers (California Air Resources Board, 2022). Furthermore, most major auto manufacturers have already stated their intention to ramp up EV production in the coming years, such as Ford (EVs will be half of their motor sales by 2030), General Motors (all-electric vehicle lineup by 2035), Hyundai (100 percent zero-emission by 2035), and Nissan (carbon-neutral for all vehicles by 2050) (Jeff S. Bartlett, 2023).

Beyond the stated intentions of auto manufacturers, developments in traditional EV batteries, lithium-ion batteries, are expected to enhance the capabilities of EVs and lower their price tag. Researchers at the University of Houston have recently made strides towards developing commercialized all-solid state sodium batteries (ASSSBs). Current solid-state batteries being tested for EVs are highly susceptible to fires and explosions, while new ASSSB designs operate at both a lower temperature and a lower cost, making them both safer and more feasible (Xiaowei Chi, 2022). As their development continues, ASSSBs could drastically alter how EVs compete against ICE vehicles.

Further innovations in EV batteries have revolved around the temperatures at which they can operate. Existing EV batteries operate optimally at approximately 21.5 degrees Celsius, yet colder temperatures generate excessive demands on EV batteries (e.g. battery heating, cabin heating, vehicle traction, etc.) and can diminish the vehicle's driving range. Additionally, cold weather drastically impacts the effectiveness of fast charging stations (Bayram, 2021). However,

strides have been made in EV battery design to combat this issue. A 2018 study analyzed a lithium-ion battery design that allowed EVs to reach up to 80 percent of full vehicle charge within just 15 minutes of charging, even at temperatures of negative 50 degrees Celsius (Xiao-Guang Yang, 2018).

The continued commitment to EV production and sales from auto manufacturers and dealerships, along with the acceleration of innovation in EV batteries, will continue to drive down EV prices. This trend, in turn, will hopefully reduce the barriers that consumers face in purchasing new EVs. However, the current supply-side dynamics of EV markets continue to hinder EV adoption.

The Current State of EV Policies in Rhode Island

As previously stated, the Rhode Island government has dedicated increasing amounts of attention to EV policies in recent years. For example, the Electric Transportation Act was drafted by Senator DiMario and Representative Cortvriend and introduced in March of 2022 (Green Energy Consumers Alliance, 2022). The legislation was designed to incentivize EV adoption that would enable the state to meet their 2030 GHG emissions reduction target. Despite the bill dying in committee, it would have directed the state's new energy supplier to offer off-peak charging incentives for EV drivers. Doing so would have encouraged drivers to charge their vehicles during times of minimal electric grid demand. However, the state's Public Utilities Commission (PUC) opposed the bill and believed that such a policy would be more appropriate once the state had a smart electric grid that allows for differentiated utility prices across all electric appliances (Skowron, 2022).

The federal government has also devoted more resources towards EV adoption within the last few years. Under President Biden's Infrastructure Investment and Jobs Act the United States Department of Transportation's Federal Highway Administration (FHA) has allocated funds to states specifically for building out the EV charging infrastructure. Rhode Island received $3.8 million this year, and is expected to receive $22 million over the next five years (McCabe, 2022).

The implementation of the Bipartisan Infrastructure bill requires states to submit a plan to detail how charging funds will be allocated. The RIDOT published a document this past July that put forth their current and future plans for the state's EV charging infrastructure. The U.S. FHA requires that states first equip their Alternative Fuel Corridors (AFCs), defined generally as major interstate roadways, with EV chargers before expanding charging infrastructures in other areas of the state. Of the $22 million available for the state over the next five years, RIDOT plans to allocate about $3.8 million for chargers along I-95, the state's main AFC. Aside from satisfying the FHA's requirement, doing so will assist EV adoption in disadvantaged communities by expanding charging access for those in multi-unit dwellings in Providence and Bristol counties. Furthermore, the largest proportion of the grant ($8.25 million) is being allocated to loans that will allow business to invest in EV chargers, with preference being given to businesses in disadvantaged communities (Burns, 2022).

Governor McKee also enacted the state’s new EV rebate program, DRIVE EV, this past summer. The program is on-par with similar programs offered in other states and offers up to $2,500 towards EV purchases. DRIVE EV also offers an additional $2,000 in EV rebates for low-income qualifying individuals (Rhode Island Governor's Office, 2022). According to a report from the RIDOT, DRIVE EV is expected to support the purchase of 600 EVs, adding to the 16 percent EV increase experienced by the state between February and June of last year (Burns, 2022).

While Rhode Island has made substantial progress in policies that encourage EV adoption, these incentives were only adopted recently. Consequently, it is difficult to predict how effective these policies will be in enabling the state to comply with the new CARB standards.

V. Evidence on Potential Solutions to the Problem

As EVs have become increasingly popular over the last decade, policies have continually emerged to adapt to and stimulate additional EV demand. Such policies most often include tax incentives, purchase subsidies, enhanced charging infrastructure, utility rate reductions, and many others. This section aims to evaluate the efficacy of several of these policies where they have been implemented.

Demand-Side Incentives versus Intrinsic Demand Growth

Purchase incentives such as EV tax rebates and tax credits are amongst the most common policies utilized by states to encourage EV adoption. One 2018 study analyzed how demand-side incentives (tax incentives, EV purchase subsidies, etc.) and EV charging infrastructure influenced EV purchases. While the authors found that each of these policies significantly increased EV purchases, they found that tax rebates were generally more effective than tax credits. Results from the study indicated that a 1 percent increase in tax credits and rebates increased EV purchases by 1.8 percent and 2.16 percent, respectively (Easwaran Narassimhan, 2018).

Despite these results, the efficacy of demand-side policies relative to other incentives and barrier reductions has been limited. For example, a recent study examined how intrinsic EV demand growth, net-of-subsidy EV cost declines, and government subsidies will affect projected EV growth through 2035. The study found that the first $500 billion in nationwide EV subsidies will increase projected EV market share by 7 to 10 percent by 2035. However, the authors also concluded that this effect diminishes for subsidies beyond this amount. They also found that intrinsic demand growth (i.e., charging infrastructure, product quality, and cultural acceptance) can have much larger impacts on EV growth than demand-side incentives and falling EV costs (James Archsmith, 2022). Yet another study indicated that EV rebates had statistically significant effects on increasing EV adoption, while quintupling EV battery size increased adoption by only 0.5 percent (Adedamola Adeptu, 2015).

Electric Vehicle Charging Infrastructure Investments

Another common EV policy is EV charging structure investment. While not mutually exclusive from tax credits and rebates, increasing charging infrastructure has been found to be more effective than the aforementioned policies. For example, a 1 percent increase in EV charging stations was associated with a statistically significant 7.2 percent increase in EV purchases (Easwaran Narassimhan, 2018). Similar conclusions have been reached by other researchers in the field, including in a 2017 white paper from Hall and Lutsey (2017). The authors assessed how various EV charging infrastructures and purchase incentives affected EV market share across several major global cities in 2016. Results indicated that Level 2 and Direct

Current Fast Charging (DCFC) infrastructures significantly increased EV market share (Dale Hall, 2017).[2]

These conclusions are supported by other studies, including a 2020 U.S. survey of consumers' willingness to purchase EVs. Survey results showed that willingness to purchase EVs significantly increased as both EV driving range and charging infrastructure improved (Tianqi Zou, 2020). Results such as these demonstrate that charging infrastructure policies can address the informational and market failures that act as burdens for consumers looking to enter the EV market.

When examining EV charging infrastructure in Rhode Island specifically, the state's trends closely resemble those of the nation. A 2018 forecast of the state's existing charging infrastructure compared to EV usage showed that placement of EV chargers, rather than their prevalence, poses concern for future EV development. The author notes that EVs in Rhode Island are parked 90 percent of the time in their lifespan, thus presenting a critical charging opportunity. However, similar to the findings of H.S. Das, the study highlights that the variance in charging processes across chargers acts as a disincentive for EV adoption. The report goes on to note that future investments and placements of EV chargers should be focused on addressing varying peak charging demand (e.g., during morning commutes) and various locational needs (e.g., workplaces, residential areas, and social locations) (Macht, 2018).

Addressing Informational and Market Failures

There are also feasible and low-cost policies that can be undertaken to alleviate some of the informational and market failures surrounding EV markets. A 2022 survey studied how three norms (lower range anxiety, lower perceived mobility restriction, and more positive pro-BEV subjective norms) explained how improved public charging infrastructure tends to increase EV adoption rates. The researchers found that the pro-BEV subjective norm played the largest role in increasing EV presence (Lee V. White, 2022). Essentially, these results indicate that once citizens observe the government investing in EVs (through charging infrastructure), they will invest in EVs in turn.

[2] Level 2 charging stations are typically used for commercial and public EV charging stations, while DCFC stations provide accelerated charging times. More specifically, Level 2 charging stations can charge an EV to a 150-mile driving range in in four to eight hours, while DCFC stations can reach the same driving range in 15 to 30 minutes of charging (Stone, 2022).

VI. Alternatives and Criteria

Alternatives

The following section outlines the proposed alternatives that will empower Rhode Island to make significant progress towards complying with the new CARB regulations. These policy proposals were examined in accordance with the previously cited research, which indicates that EV charging investments, tax rebates for EV purchases, and other policies that work to eradicate information and market barriers to EVs are among the most popular and effective policies for increasing EV adoption. Furthermore, these alternatives largely expand upon policies previously enacted in Rhode Island, and consequently would require incremental action from the state.

Alternative 1: The Status Quo

This policy alternative allows current EV market trends to progress, including the DRIVE EV rebate program and expanding EV charging infrastructure. Aside from these recent policy actions, this alternative assumes that there will be no additional policy interventions that may alter the existing trends.

Currently, there are approximately 300 EV charging stations in Rhode Island, according to the RIDOT (Rhode Island Department of Transportation, 2021). Under President Biden's Infrastructure and Jobs Act, Rhode Island will be receiving approximately $23 million over the next five years from the United States Department of Transportation (U.S. DOT). Rhode Island's DOT plans to enhance EV charging capability along I-95, construct fast-charging facilities within one mile of National Highway System Roadways, and to allocate $8.25 million towards constructing 7 to 14 new EV charging stations in low-income communities (Burns, 2022).

This past July, the Rhode Island Office of Energy Resources (OER) launched the state's DRIVE EV Rebate Program, which totals $1.25 million. The program offers rebates of $2,500 for most EVs, with an additional $2,000 in rebates for low-income individuals (Rhode Island Governor's Office, 2022). The program is expected to add an additional 600 EVs to the state (Burns, 2022).

As stated, this alternative will assume that these policies exclusively dictate the future trends in Rhode Island's EV sales.

Alternative 2: Improving Rhode Island's Charging Infrastructure

In addition to the planned EV charging investments, this alternative will expand fast-charging availability for the vast majority Rhode Island citizens. To this end, Rhode Island will utilize competitive federal grants to expand the access of DCFC stations primarily in the Providence metropolitan area.

The existing plan for Rhode Island's EV charging infrastructure outlines $8.25 million to be spent supporting 7-14 new EV charging stations across Providence, RI, with priority towards disadvantaged and low-income communities defined as Justice40 communities (Burns, 2022). This alternative expands on the existing EV charging policy by adding an equivalent amount of DCFC stations.

The U.S. DOT is allocating $2.5 billion through their Discretionary Grant Program for Charging and Fueling Infrastructure as part of the Infrastructure Investment and Jobs Act (United States Department of Transportation, 2022). One condition of this grant program is that 50 percent of the funding must be used for disadvantaged communities, particularly in low-income neighborhoods and communities with limited private parking spaces (United States Department of Transportation, 2022). Given that the Providence metropolitan area, to a certain extent, meets this criterion, this alternative is eligible for funding from this competitive grant program. Any excess of funds will be used towards constructing DCFC charging stations in Justice40 or similarly disadvantaged communities outside of Providence, RI.

Similar to the state's existing program, this policy will utilize Requests for Proposals (RFPs) to partner with public and private contractors in establishing these new DCFC stations. Furthermore, the allocated funds will cover maintenance costs for these stations over the course of five years.

Alternative 3: Extending the Office of Energy Resources' Electric Vehicle Rebate Program

As previously stated, OER's current $1.25 million DRIVE EV rebate program is projected to add 600 EVs to the state. Under this alternative, OER will extend the program by allocating an additional $5 million in funding. Doing so will assist in alleviating pricing concerns amongst EV consumers and will ideally shorten the timeline for EVs to reach price parity with their ICE vehicle counterparts.

The program will still operate under its existing terms, with applicants filing their driver's license and registration information, tax information, EV sales contract, and other relevant documentation. Individuals who believe they may qualify for the low-income rebate amount must provide documentation that they participate in a state or federal income-qualified program or provide proof of income.

Alternative 4: Create a User-Friendly, Interactive Information Center for Electric Vehicles

Under this policy alternative, the OER will work with public and private partners to develop an interactive government database that allows consumers to track relevant data that may impact decisions regarding EV purchases and usage. Currently, Rhode Island has allocated $1.25 million to increasing consumer awareness and information regarding EVs, including smartphone apps, websites, surveys, and other informational campaigns (Burns, 2022). This alternative, however, differs in that it will aggregate nearly all relevant EV information into a single, user-friendly database and provides a specified directive.

The OER currently has a webpage that contains an EV charger locator and existing financial incentive programs for EV adoption (Rhode Island Office of Energy Resources, 2022). This policy will modify the existing locator tool to incorporate comprehensive and real-time information regarding charging prices, type of charging available, and driving distance to a given EV charger.

In addition to the above information, the database will include information regarding EV prices. The webpage will allow consumers to search for prices across EV models, relying on publicly reported information from sources such as Kelly Blue Book. This section will also allow consumers to enter information regarding their taxes and income to estimate the federal and/or state EV rebate that they may be eligible for, allowing for an EV price estimation across any given model. Lastly, the webpage will utilize data from public sources to allow consumers to compare ICE vehicle and EV estimated maintenance and fuel costs side-by-side.

Given that Rhode Island has already apportioned $1.25 million for information awareness over the next five years, a portion of these funds can be utilized for this specific initiative. The

OER, in combination with Rhode Island’s DOT, will release RFPs for public and/or private web designers and data collection sources for constructing the webpage.

Criteria

Budgetary Costs

The cost criterion is designed to assess the administrative, bureaucratic, and maintenance costs that a given policy proposal will impose on the Rhode Island state government. Given that the new CARB standard must be reached by 2035, maintenance or similar costs borne by the state government beyond this date will not be considered under this criterion. This criterion allows the Rhode Island Office OMB to assess the extent to which a given policy imposes costs upon state agencies.

Operationalizing the Cost Criterion

Fortunately, many of the administrative costs of the proposed alternatives are publicly available. For example, Rhode Island's NEVI program development plan, along with other publicly available sources, have published cost estimations for installing and maintaining EV chargers. The costs related to the existing EV rebate program are publicly available from the OER.

Cost-Benefit Analysis

A cost-benefit analysis (CBA) is an important criterion for the Rhode Island OMB and many other state agencies across Rhode Island. This criterion not only includes the administrative costs borne by the state government in each policy, but also costs to consumers and other actors incurred by engaging in the policy and adopting EVs. As is standard practice in CBAs, costs are assessed only to the extent to which they exceed what a given actor would have done in the counterfactual of a policy's implementation.

Benefits of a given policy stem primarily from two sources. Firstly, benefits realized by consumers in the form of any estimated savings count towards this analysis. Secondly, Rhode Island citizens will incur localized environmental benefits in the form of cleaner air stemming from a reduction in the number of ICE vehicles sold and driven.

Operationalizing Cost-Benefit Analysis

Annual historical data on EV sales and EV market share in Rhode Island was compiled using publicly available data from Alliance for Automotive Innovation (Alliance for Automotive Innovation, 2022). With this data EV sales and EV market share in the state were projected through 2035, the estimates of which were used in the CBA.

In calculating the costs of a given policy, previously calculated administrative costs were included as a baseline. Secondly, the extent to which consumers are paying for EVs beyond what they would have paid for an average ICE vehicle across each year was assessed. Maintenance and fuel costs that follow EV purchases were estimated, although it is worth noting that both EV maintenance costs and fuel costs appear to be cheaper than those for ICE vehicles (Duke Energy, 2022; Gorzelany, 2022).[3] Consequently, these metrics were calculated as a benefit under this

[3] Researched figures used to quantify the impacts of a given alternative can be found in Appendix B.

analysis. Any continuous maintenance costs imposed on the state government or any other entity from a given policy was also included in this CBA. Lastly, fuel savings to Rhode Island citizens were calculated only to the extent to which these savings exceeded the gas tax revenue collected by the state government. Any declines in gas tax revenue collected by the Rhode Island government were included as a cost under each CBA.

Beyond these metrics of the CBA, an estimation of monetary benefits realized through society in the form of cleaner local air was also included. For the simplification of this analysis, it was assumed that each EV sale represents a foregone ICE vehicle, thereby constituting a lifetime of abated emissions from that given vehicle. The localized environmental benefit generated by each EV sale up until 2035 was estimated using a researched impact of abated emissions on local air.

It should be noted that the costs and benefits borne by consumers and society were evaluated across each EV's lifetime. Maintenance costs and savings, fuel costs and savings, and environmental benefits for each EV purchased were forecasted across that vehicle's lifetime, which research indicates is approximately 15 years (Brennan Borlaug, 2022). Consequently, while direct policy effects were only measured to the extent to which they influence outcomes through 2035, the costs and benefits of EVs purchased in 2035 were assessed through 2050.

As is standard practice in CBAs, a social discount rate provided by the Rhode Island OMB to estimate the present-day value of costs and benefits for each policy in terms of today's dollars.

Within any given CBA it is useful to know how a benefit-cost ratio might vary if any of the underlying costs and benefits should differ from their expected value. To this end, a Monte Carlo Simulation is employed to assess the sensitivity of the final CBA estimates and their various inputs. The specifications of how this simulation was constructed and run are available in Appendix B.

Effectiveness

This criterion assesses how well a given policy empowers the state of Rhode Island to reach CARB's outlined goals of 35 percent new vehicle sales in 2026 coming from zero emission vehicles, 68 percent in 2030, and 100 percent by 2035 (California Air Resources Board, 2022). This criterion also allows for an evaluation of how quickly or slowly EV sales grow in Rhode Island.

For the effectiveness criterion, a basic forecast function in Excel was used to predict how much EV market share in Rhode Island will increase in the coming years. These projections were then compared to the CARB standards from 2026, 2030, and 2035. Each alternative was then assessed on the cumulative percentage difference between the projected EV market share and

CARB's new standards. Further details on the calculations involved in the effectiveness criterion are available in Appendix B.

Operationalizing Effectiveness

As previously mentioned, publicly available data on EV sales and EV market share in Rhode Island were used to project the state's EV market share. Utilizing empirical estimates on the effects of EV charging presence, price reductions, and informational campaigns, estimates were developed regarding how each of the proposed policy alternatives affected Rhode Island's EV sales and EV market share up until 2035.

Administrative Feasibility

This criterion assessed the potential support or opposition a given alternative may face from the Rhode Island state government, accompanied by the reasoning involved in each assessment. Each alternative was subsequently ranked on how receptive the state's government would be to its adoption.

VII. Findings and Evaluation

Alternative 1: The Status Quo

Cost

Given that this alternative does not impose any additional cost to the Rhode Island government beyond what has already been budgeted and appropriated, there are no costs to this alternative.

Cost-Benefit Analysis

Should the Rhode Island government elect to pursue this alternative, the costs and benefits are expected to begin accruing this summer, as the effects of each alternative are assessed based on the decisions the state government makes following this report. Rhode Island's National Electric Vehicle Infrastructure (NEVI) Program proposal outlines federal funds as being both acquired and used through fiscal years (FY) 2023 through 2026 (Burns, State Plan for Electric Vehicle Infrastructure Deployment, 2022). As such, a timeline for both costs and benefits to begin accruing this summer is aligned with the state's DOT's expectations.

Using the net present value (NPV) calculations and methodologies discussed in the Appendix, the NPV of the costs of this alternative is expected to be $382,794,745, while the NPV of the benefits is expected to be $1,423,689,597. Consequently, the benefit-cost ratio is projected to be 3.72. It is also worth noting that for the costs of this alternative to outweigh the benefits, the costs would need to increase by $1,040,894,852, or by nearly 271 percent.

The next step of this this project's CBA was to assess the potential variance of the benefit-cost ratio presented above. **Figure 1 in Appendix A** represents a Monte Carlo Simulation, using 5,000 runs to project expected NPV costs, benefits, and a benefit-cost ratio. The benefit-cost ratio of 3.72 does not appear to deviate from its expected value.

Effectiveness

While this alternative is an improvement from a counterfactual where Rhode Island did not enact landmark EV policies in the summer of 2022, this alternative still leads Rhode Island to fall short of the standards set by CARB. As shown in **Figure 2 in Appendix A**, under this alternative Rhode Island is expected to fall short of their 2026 goal by 24.63 percentage points, the 2030 goal by 55.5 percentage points, and the 2035 goal by 84.3 percentage points.

Administrative Feasibility

Given that the policies under this alternative have already been enacted, this alternative ranks the highest amongst the proposed alternatives in administrative feasibility.

Alternative 2: Improving Rhode Island's Charging Infrastructure

Cost

Under Rhode Island's current EV charging infrastructure development plan, the state's DOT has allocated $8.25 million over the coming years to build out level 2 chargers in the Providence, RI area (Burns, 2022). According to an assessment Future Energy, DCFC stations cost on average 13 percent more than their Level 2 counterparts (Future Energy, 2021). Based on this assessment, it can be expected that this alternative would cost the Rhode Island government just over $9 million to install 7 to 14 DCFC stations. However, the pre-existing Level 2 charging structures could lead to a downward shift in the predicted costs of this alternative, as the existing structures could be adjusted to incorporate DCFC stations.

Regardless, Rhode Island can still apply for the $2.5 billion grant from the Discretionary Grant Program for Charging and Fueling Infrastructure (United States Department of Transportation, 2022). If the state receives the same proportion of this grant that they received under the original disbursement, Rhode Island should expect to receive around $11 million from this grant, which would cover the costs of this alternative. Consequently, for the purposes of this project, it is assumed the costs borne by the Rhode Island state government under this alternative are expected to be zero.

Cost-Benefit Analysis

Given that this alternative requires construction and possibly adaptations of Providence's electric grid, the costs and benefits of this policy are not expected to accrue until the beginning of 2024. However, as standard level 2 charging stations can be installed in a few hours, this estimate likely overestimates the time that it would take to install DCFC stations to account for construction, traffic, and other potential barriers (Ultralec, 2022).

Forecasting towards 2050, the NPV of the costs of this alternative is expected to be $62,607,835, while the NPV of the benefits is expected to be $235,129,286. Consequently, the benefit-cost ratio is projected to be 3.75. It is also worth noting that for the costs of this alternative to outweigh the benefits, the costs would need to increase by $172,521,451, or by nearly 276 percent.

The Monte Carlo simulation used to assess how the expected benefit-cost ratio might alter under different conditions is displayed in **Figure 3 in Appendix A**. Allowing for reasonable variation, it does not appear that the benefit-cost ratio of 3.75 deviates from its expected value. Subsequently, the benefits of this alternative clearly outweigh the costs.

Effectiveness

Given that the effects of EV charging infrastructure will last as long as the chargers themselves, this alternative is highly effective in relation to the other proposed alternatives, as shown in **Figure 4 in Appendix A**. Despite its effectiveness, Rhode Island is projected to miss their 2026 goals by 16.83 percentage points, their 2030 goal by 47.4 percentage points, and their 2035 goal by 76.1 percentage points.

Administrative Feasibility

In an informational interview with Kevin Simpson of Rhode Island's OMB, he shared that the state's DOT was particularly interested in vehicle policies that attracted federal dollars to the state to improve the state's infrastructure. Rhode Island's DOT produced the NEVI Program proposal, and as such they were likely supportive of the increased charging infrastructure investment. Given that this alternative would attract additional federal dollars to Rhode Island but may incur additional costs, support from RIDOT is difficult to predict. For example, the NEVI Program proposal noted that a barrier to installing to DCFC stations in Providence was costs borne by citizens, businesses, and their respective concerns (Burns, Rhode Island Electric Vehicle Infrastructure Deployment State Plan, 2022). However, the large amount of federal dollars that could be brought into the state, along with the extensive benefits of this alternative, should enhance the feasibility of this policy.

Furthermore, given the state's recent increased focus on EV charging infrastructure, other state agencies, including OER and DEM will likely be in support of this alternative. It should also be noted that while this policy will require a processing and distribution of funds, along with allocation of project work through an RFP, the majority of the construction burden will be borne private construction companies. Consequently, this policy ranks the second highest in terms of administrative feasibility.

Alternative 3: Extending the Office of Energy Resources' Electric Vehicle Rebate Program

Costs

As previously noted, this alternative will inject an additional $5 million into Rhode Island's DRIVE EV Rebate program. Consequently, if adopted, this alternative would impose a cost of $5 million on the Rhode Island state government.

Cost-Benefit Analysis

Given that this alternative expands upon Rhode Island's existing DRIVE EV rebate program, the costs and benefits of this alternative are expected to begin towards the end of the year. Through 2050, the NPV of this alternative's costs is expected to be $27,114,830, while this alternative's NPV benefits is projected to be $34,749,319. Therefore, the benefit-cost ratio of this alternative was calculated to be 1.28. As with the other alternatives, it is important to note that for the costs of this policy to outweigh the benefits, costs would need to increase by $7,634,489, or just under 29 percent.

The Monte Carlo simulation that was conducted for this alternative, which displays the variances of expected benefit-cost ratios, is shown in **Figure 5 in Appendix A**. If projected inputs of this CBA did alter, it does not appear that the calculated benefit-cost ratio would deviate from its expected value.

Effectiveness

This alternative is not quite as effective as the Fast Charging alternative, largely due to the fact that the policy only has an effect on the years before the $5 million rebate expansion reaches zero, which was expected to extend into 2025 for the purposes of this project.

As shown in **Figure 6 in Appendix A**, if adopted, this alternative will lead to Rhode Island missing the 2026 CARB standard by 25.38 percentage points, the 2030 goal by 55.68 percentage points, and the 2035 goal by 84.56 percentage points.

Administrative Feasibility

This alternative will impose the highest cost of any of the alternatives on the Rhode Island government. Furthermore, this alternative will likely include an administrative burden of process applications and distributing program funds through the OER and other state agencies. Given the extensive burden imposed on the state's OER, along with the significant costs of this alternative, this policy ranks the lowest on administrative feasibility amongst the proposed alternatives.

Alternative 4: Create a User-Friendly, Interactive Information Center for Electric Vehicles

Cost

As previously stated, Rhode Island's DOT has already allocated $1.25 million over the next five years for increasing EV charging station awareness (Burns, Rhode Island Electric Vehicle Infrastructure Deployment State Plan, 2022). Research indicates that the cost of this alternative would be approximately 4% of the pre-existing funds from the NEVI Program proposal (Yoko, 2020). Since this would require such a small percentage of the pre-designated federal funds, it is expected that the entirety of the costs of this alternative will be covered by the federal money outlined in the NEVI Program proposal.

Cost-Benefit Analysis

Similar to the other alternatives, the costs and benefits for this alternative were calculated through 2050. The NPV of the costs is expected to be $19,404,561, while the NPV of the benefits was calculated as $73,054,561. Subsequently, the benefit-cost ratio of this alternative is expected to be 3.76. For the costs of this alternative to outweigh the benefits, the costs would need to increase by $53,649,486, or 276 percent.

As demonstrated in **Figure 7 in Appendix A**, the benefit-cost ratio of this alternative does not vary from 3.76. This, along with the metrics reported above, indicated that the benefits of this alternative certainly outweigh the costs.

Effectiveness

While not quite as effective as the Fast Charging alternative, the fact that this alternative increases EV market share through 2035 makes this alternative particularly effective. As shown in **Figure 8 in Appendix A**, this alternative falls short of the 2026 CARB goal by 22.27 percentage points, the 2030 goal by 52.91 percentage points, and the 2035 goal by 81.56 percentage points.

Administrative Feasibility

Policies such as the ones proposed in this alternative have already been adopted by the state's DOT as recently as this past summer (Burns, Rhode Island Electric Vehicle Infrastructure Deployment State Plan, 2022). However, this alternative would place a rather extensive administrative burden on the state's OER, whose website will contain the EV informational webpage. As such, this policy ranks third in administrative feasibility.

Outcomes Matrix

For comparing each of the above alternatives, each alternative was compared across the employed criteria. In the context of this project, a favorable policy would be one that is relatively low in cost, has a high benefit-cost ratio, is effective in reaching the new CARB standards, and ranks high in feasibility. The Outcomes Matrix below ranks how each alternative compares to the others across these criteria, with a score of four indicating that a given alternative is the best performer for a given criterion. It should be noted that the criteria were weighted, as shown in the table below. Effectiveness was awarded the most substantial weighting, as the primary concern of this project is enabling the state to reach the new CARB standards. The cost-benefit criterion was weighted highly as well, as the benefits accrued to citizens and EV consumers are a vital and often an underweighted consideration. The remaining weights were subsequently evenly distributed to the administrative feasibility and cost criteria. In Table 1 below, the first figure in each cell denotes the numerical evaluation of each alternative across each of the criterion. Here, cost is measured in dollars, cost-benefit is represented by the cost-benefit ratio, and effectiveness is measured as the cumulative percentage point amount by which Rhode Island misses the new CARB standards across the three target years. The second row represents a given alternative's strength for a given criterion, while the figure in parenthesis denotes the alternative's weighted score.

Table 2: Outcomes Matrix

Criteria	**Alternative 1: Status Quo**	**Alternative 2: Fast Charging**	**Alternative 3: Rebate Program**	**Alternative 4: Informational Center**
Cost (15%)	$0 4* (0.6)	$0 4* (0.6)	$5 million 1 (0.15)	$0 4* (0.6)
Cost-Benefit (30%)	3.72 2 (0.6)	3.75 3 (0.9)	1.28 4 (1.2)	3.76 1 (0.3)
Effectiveness (40%)	163 1* (0.4)	140.33 4 (1.6)	164 1* (0.4)	156.74 3 (1.2)
Administrative Feasibility (15%)	- 4 (0.6)	- 3 (0.45)	- 1 (0.15)	- 2 (0.3)
Total Score	2.2	**3.55**	1.9	2.4

Note: * Denotes that an alternative received the same score as another alternative for a given criterion. Also, cost is measured in dollars, cost-benefit is represented by the cost-benefit ratio. Effectiveness is measured as the cumulative percentage point amount by which Rhode Island misses the new CARB standards across the three target years

VIII. Recommendation

As shown in the table above, the Fast Charging alternative ranks the highest amongst the proposed alternatives. However, based on this project and the current needs of the state, I recommend that Rhode Island's OMB recommends that the state government adopt both the Fast Charging alternative and the Information Center alternative. Together, these alternatives will attract additional federal dollars to the state and will bring the state closer to meeting the new CARB standards, displayed in **Figure 9 in Appendix A**. The performance of this alternative across CARB's three target years is also presented in Table 2 below.

Table 3: Effectiveness Performance of the Recommended Policy

Year	2026	2030	2035
CARB Market Share	19.98%	23.07%	26.37%

None of the proposed alternatives allow the state to fully comply with the new standards, but adopting these two alternatives now will ensure that the state is making sufficient progress towards these goals. Regardless of the policies adopted and implemented, Rhode Island will likely need additional policies in the years ahead to incentivize EV adoption and meet CARB's new regulations.

IX. Implementation

Using similar methods as those utilized in this project, Rhode Island's OMB should construct a proposal for the governor that outlines the recommended alternatives, along with the rationale for their recommendation. Given the governor's favorable sentiment towards EVs in the past, Governor McKee will likely endorse and adopt these policies statewide (Rhode Island Governor's Office, 2022). Rhode Island's OMB should bring these recommendations to the governor's office as soon as possible to ensure prudent progress towards CARB's new standards.

Similar to the existing NEVI Program proposal, Rhode Island's DOT will need to release and process RFPs from groups willing to construct DCFC stations in the Providence region. Furthermore, the state's DOT will need to assess whether the new DCFC stations will build on or add to the existing plans for Level 2 chargers in the Providence metropolitan area.

Given that the proposals for receiving federal funds are compiled by the state's DOT but likely implemented by a number of state agencies, coordination across these actors will be necessary. For example, while OER will be responsible for constructing the new informational webpage, they will need to coordinate with DOT regarding the amount of funds available and any standardization of the RFP process.

Across each of the recommended alternatives, the state's DOT, OER, DEM, and PUC will likely be involved in different facets of the implementation process. Examples of roles taken on in the recommended alternatives include the DOT, who will likely be involved in the general planning and oversight of EV charging stations, and the PUC, who will be tasked with overseeing the construction of EV charging stations and any necessary electric grid adaptations.

With the vast areas of interest, expertise, and goals across each of these state agencies, enhanced coordination efforts will likely be needed. To this end, an EV policy task force should be established across these agencies, which will meet periodically to discuss the implementation progress and barriers of the recommended alternatives. Other state agencies who may hold relevance to various implementation stages, including the state's OMB, should be encouraged to participate in these task force meetings.

Informal discussions with Rhode Island's OMB have revealed that groups representing the interests of bikers and pedestrians are strongly opposed to EV policies. This particular interest group is averse to any policies that promote vehicles, regardless of their emissions, and prefer policies that promote travel by foot and bicycle. In addressing this particular interest group, Rhode Island's OMB should stress the economic case for EVs, namely that the benefits of the proposed policies significantly outweigh the costs. Furthermore, the OMB should stress that the counterfactual of such policies is an increased number of ICE vehicles on Rhode Island's roads, which would be a direct threat to the interests of this group.

X. Conclusion

The transportation sector is the largest contributor to GHG emissions in the state, and increased federal attention towards EVs has left Rhode Island with extensive resources to utilize for EV-related policies. These conditions, along with pressure from CARB on auto manufacturers and dealerships to boost EV sales, places Rhode Island in an ideal position to act to incentivize EV adoption. As previously noted, the recommended policies still leave Rhode Island behind the new CARB targets, likely requiring the state to take additional action to increase EV sales. Furthermore, the analysis conducted in this report is preliminary and rudimentary, and the importance of this issue necessitates further analysis and research into this problem.

Appendices

Appendix A: Additional Figures

Figure 1

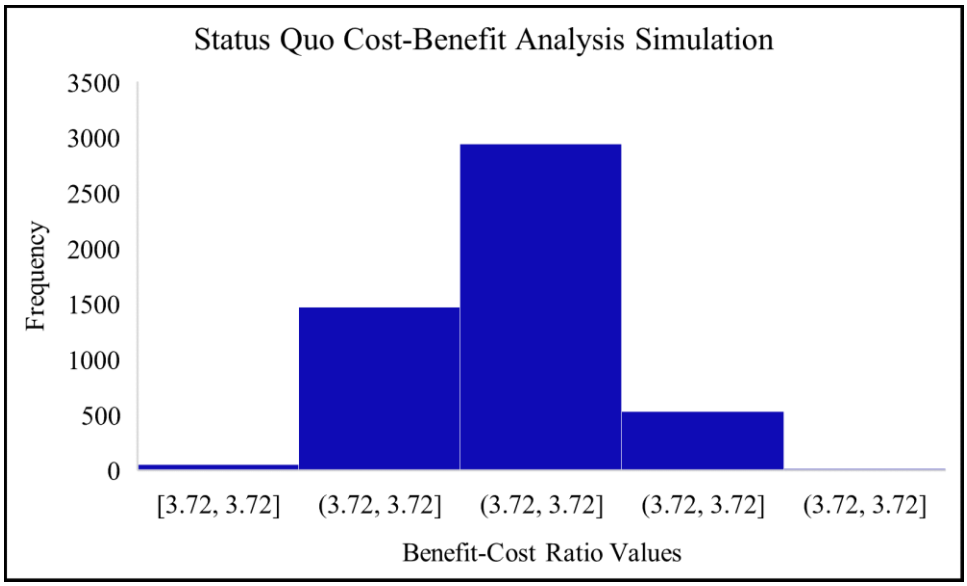


Figure 2

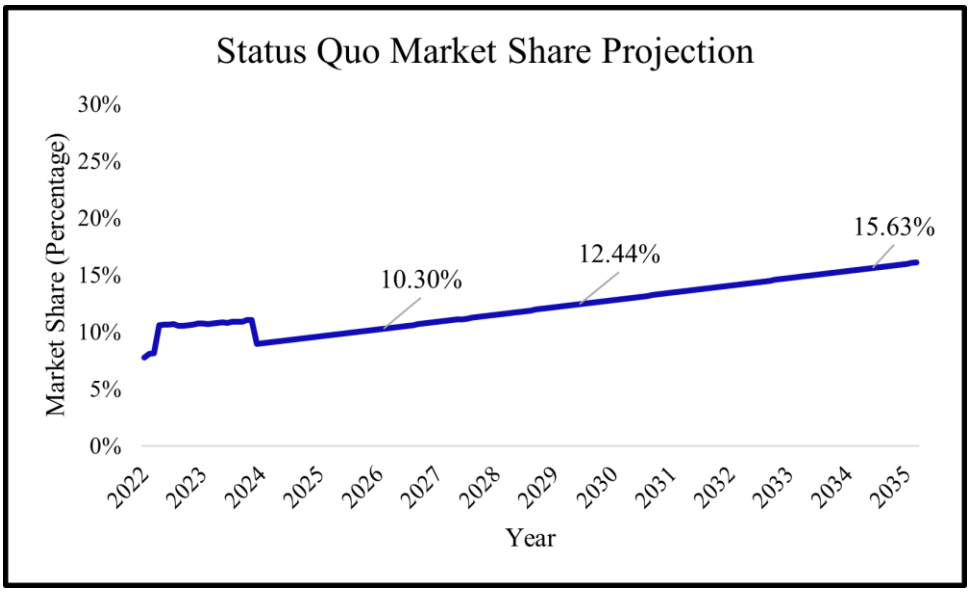


Figure 3

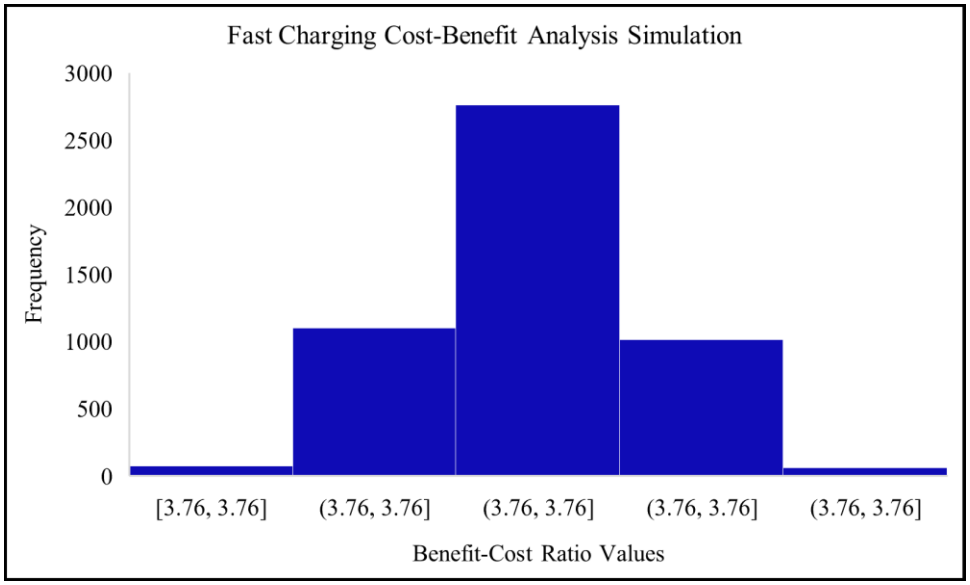


Figure 4

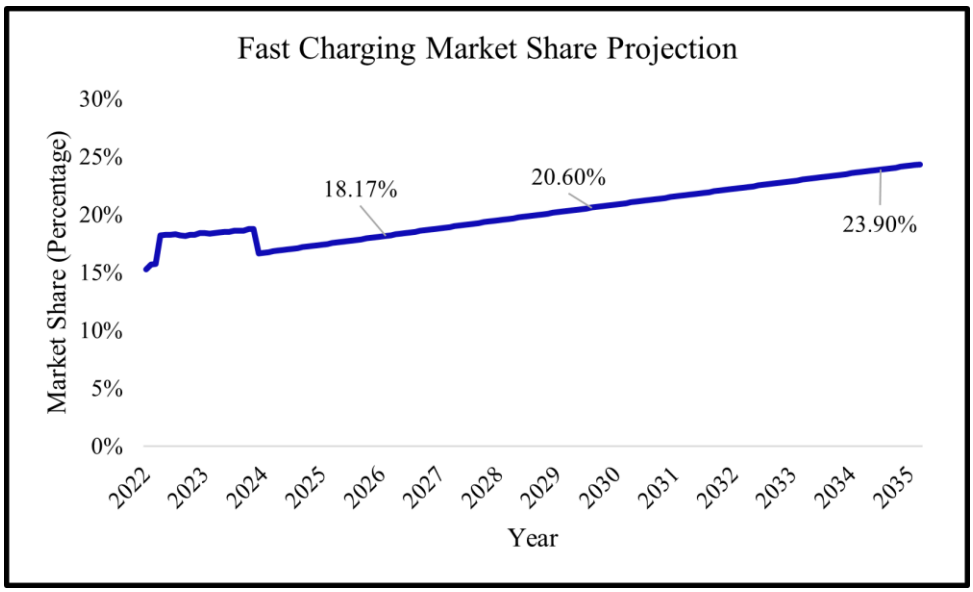


Figure 5

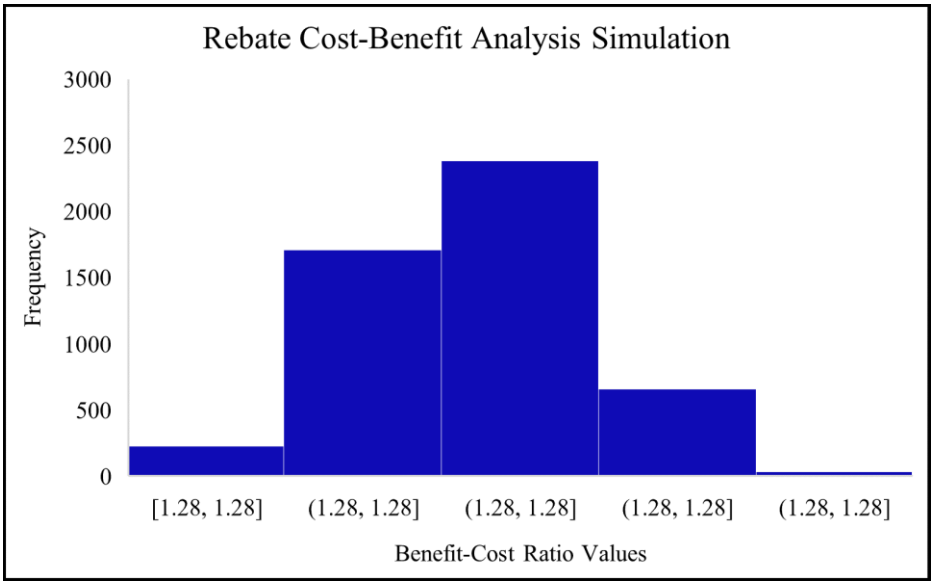


Figure 6

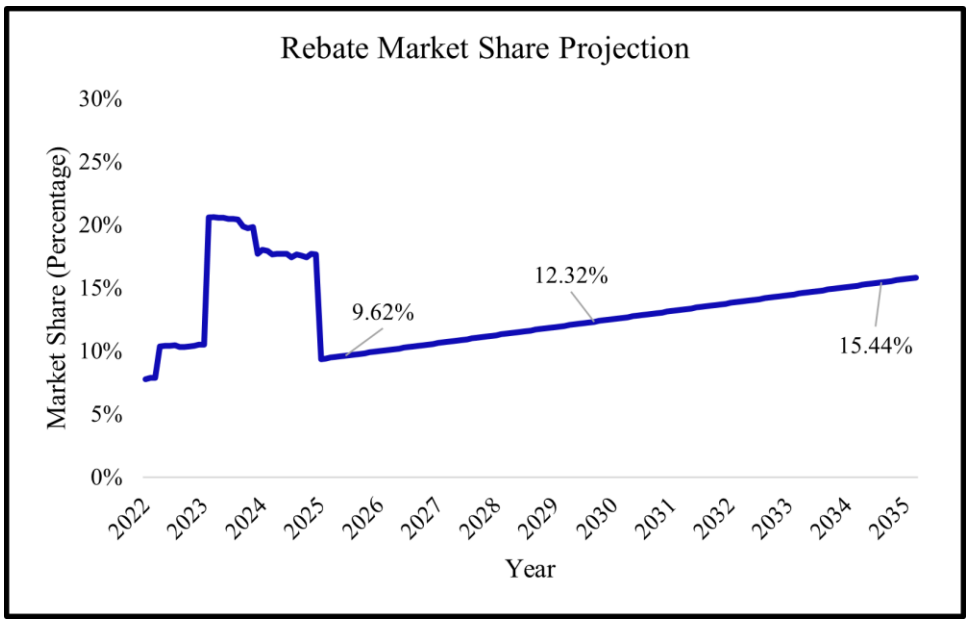


Figure 7

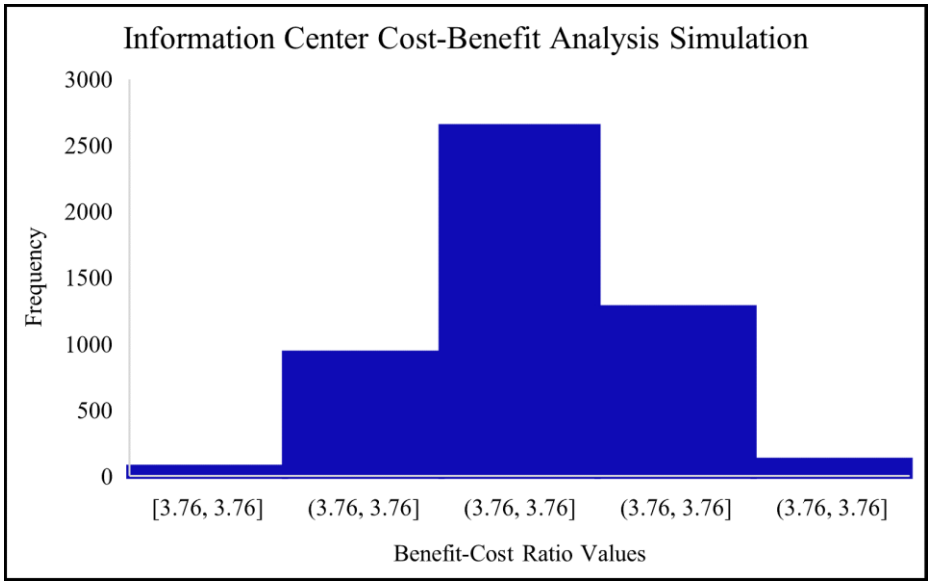


Figure 8

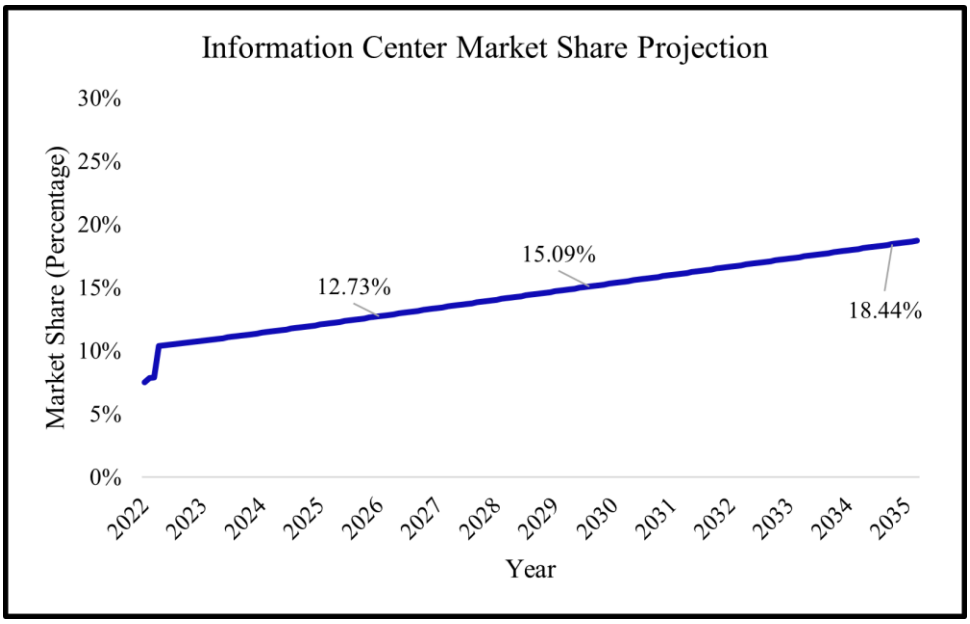
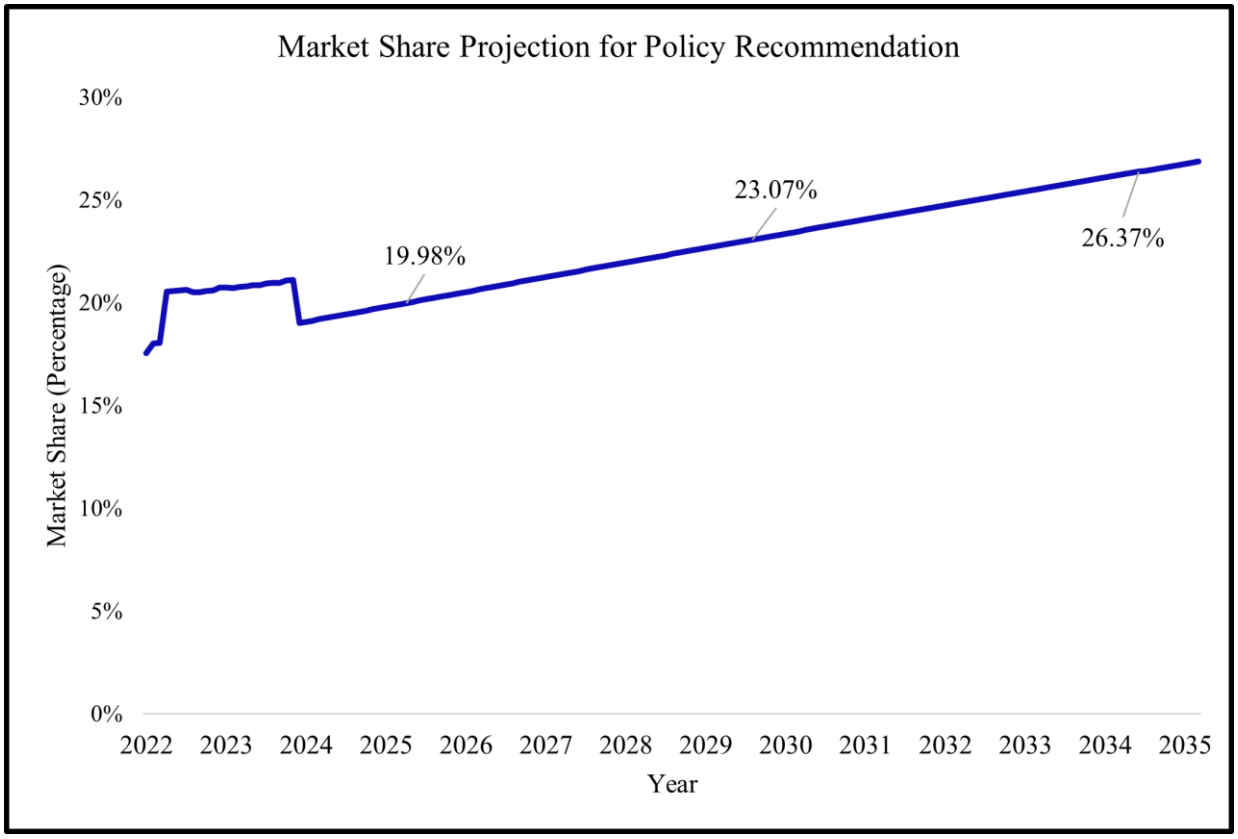


Figure 9


Market Share Projection for Policy Recommendation
30%
25%
20%
15%
10%
5%
0%
Market Share (Percentage)
19.98%
23.07%
26.37%
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
Year

Appendix B: Methodology and Assumptions

The following section discusses the methods that were used in calculating, forecasting, and simulating the effects of each of the proposed alternatives.

To project how many EVs would be purchased in Rhode Island in the coming years, historical data from the Alliance for Automotive Innovation was used as a baseline trend (Alliance for Automotive Innovation, 2022). A generic Excel forecast function was then used to model how many EVs would be purchased in the state in subsequent years.

The following sub-sections discuss the calculations of the effect sizes utilized in the forecasting across each of the various alternatives. Within the Excel forecasting function, the standard deviation for the EV market share that counts towards the new CARB standards was approximately 1.73 percent in the last years of the CARB target standards and about 2.3 percent in the first years of the new regulations. This difference occurred because Excel's forecast variance narrowed as the model was able to base its prediction on an increasing amount of years' data points. Given the calculations used in this project, these variations are captured both in the effectiveness and cost-benefit criteria.

Status Quo Forecasting

The first step in forecasting how many EVs would be added to Rhode Island's EV fleet was to determine the effect of the policies already enacted, namely the Drive EV Rebate program and the federally-funded infrastructure development. As was stated in Rhode Island's National Vehicle Infrastructure (NEVI) Program proposal, the state government anticipated that the Drive EV Rebate program would add an additional 600 EVs to the state's existing fleet (Burns, Rhode Island Electric Vehicle Infrastructure Deployment State Plan, 2022).

In regards to the effect of added charging infrastructure, a 2020 study from Zou, Khaloei, and MacKenzie found that for every minute walking time to the nearest slow charging station was reduced, the likelihood of buying an EV increased by about 4.31% (Tianqi Zou, Effects of Charging Infrastructure Characteristics on Electric Vehicle Preferences of New and Used Car Buyers in the United States, 2020). Furthermore, the authors found that every additional fast charging station available per 100 miles of highway increased the likelihood of purchasing an EV by about 4.87% (Tianqi Zou, Effects of Charging Infrastructure Characteristics on Electric Vehicle Preferences of New and Used Car Buyers in the United States, 2020). The total effect of the Status Quo alternative on EV market share in Rhode Island was subsequently determined based on these figures, which are presented in the table below.

Status Quo Effect Sizes		
Charging Infrastructure Effects	**Total Effect Size**	**Calculation**
Walking time to charging station	12.63%	2.929 (average walking distance to new charging stations in Providence, RI based on 20.5 square mileage) * 4.31% (Effect of reduced walking time on likelihood of buying an EV)
Fast charging availability on I-95	9.7502%	4.76% (Effect of fast charging station per 100 miles of highway) * 2 (Estimated number of fast charging stations available per 100 miles of highway (Burns, Rhode Island Electric Vehicle Infrastructure Deployment State Plan, 2022)).
Total Effects of Charging Infrastructure	22.3802%	
Pricing Effects		
Price difference compared to ICE vehicle	600 vehicles	

Fast Charging Forecasting

Each alternative, including the Fast Charging alternative, forecasted EVs that would be added to Rhode Island's EV fleet in addition to what is projected to be purchased under the Status Quo alternative. Consequently, the total effect sizes for each of the alternatives build upon those calculated under the Status Quo alternative.

For the effect that the Fast Charging alternative will have on EV purchases in Rhode Island, an empirical effect was again used from Zou et al.. The authors found that having a DCFC station within a 15 minute drive increased the likelihood of purchasing an EV by approximately 100% (Tianqi Zou, Effects of Charging Infrastructure Characteristics on Electric Vehicle Preferences of New and Used Car Buyers in the U.S., 2020). This effect size was subsequently applied to the percentage of Rhode Island citizens that live within the Providence metropolitan area, as the DCFC stations would be constructed in this region. The total effect size calculation is displayed in the table below.

Fast Charging Effect Sizes		
Effect Category	**Effect Size**	**Calculation**
Effect of Fast Charging alternative	17.509%	100% (Effect of having a fast charging station within a 15 minute drive) * 17.34% (Percentage of Rhode Islanders that live in Providence)
Total Effect	39.89%	Combination of Status Quo effect and Fast Charging effect

Rebate Forecasting

As previously mentioned, Rhode Island's DOT expects that the Drive EV Rebate program, whose budget was $1.15 million dollars, will add 600 vehicles to the state's vehicle (Burns, Rhode Island Electric Vehicle Infrastructure Deployment State Plan, 2022). The modeling for this alternative operates under the assumption that the rebate's expansion will add a proportional number of EVs given the 300% increase in the program's budget. Consequently, the forecast predicts that this alternative will add 2,400 EVs to Rhode Island's fleet.

Information Center Forecasting

Under the Information alternative, the effect of the alternative stems from both the effect of EV informational campaigns and the percentage of individuals who lack what may be interpreted as common knowledge of EVs. A 2015 report from Bailey, Miele, and Axsen found that increased EV charger awareness increased the likelihood of buying an EV by 8 percentage points (Joseph Bailey, 2015). Additionally, a 2020 report produced by Consumer Reports noted that 68% of survey respondents reported knowing very little about EVs (Consumer Reports, 2020). Given these figures, the table below presents the calculation of the effect that this alternative is expected to have on projected EV market share in Rhode Island.

Effect of an Informational Center		
Type of Effect	**Effect Size**	**Calculation**
Effect of Informational Center	5.44%	8 percentage points (Increase in likelihood of buy an EV as awareness increases) * 68% (Percent of people who reported lacking EV knowledge)
Total Effect	27.82%	Combination of Status Quo Effect and Informational Center effect

The effect sizes for each respective alternative were then used to determine the extent to which EV market share in Rhode Island would increase, and how many EVs would be added to the state that did not exist under the Status Quo alternative. It should be noted that under the new CARB regulations, only battery-electric vehicles (BEVs), plug-in hybrid electric (PHEV), and hydrogen fuel cell vehicles will count towards a state's CARBs credits. Furthermore, PHEVs can only account for 20% of a given state's credit (California Air and Resources Board, 2022). As such, the above figures were calculated according to this constraint.

Using the projected figures from these calculations, the costs and benefits borne by the Rhode Island state government, consumers, Rhode Island citizens, and other parties. The monetary value of each of these costs and benefits is presented in the table below.

Cost and Benefit Figures	
Costs	
Rhode Island's Lost Gas Tax Revenue	$15.06 per month per vehicle (Givens, 2022)
Expected Price Difference Between EVs and ICEs	$17,191 initially, decreases to $0 by 2026 (Reuters, 2022; Valdes, 2022)
Maintenance of EV Charging Stations (only Status Quo Alternative and Fast Charging alternative)	$350 per month (EV Connect, 2022)
Benefits	
Fuel Savings	$22.44 per month per vehicle (Brennan Borlaug S. S., 2020)
Maintenance Savings	$44.44 per month per vehicle (U.S. Department of Energy, 2022)
Environmental Benefit	$28.75 per month per vehicle (London School of Economics, 2017)

Given that EV sales data from the Alliance for Automotive Innovation were reported on a monthly basis, EV sales, costs, and benefits are all measured on a monthly basis. It is also worth noting that fuel savings incurred by EV consumers are only measured to the extent to which those savings outpace the gas tax revenue that the Rhode Island state government loses. Furthermore, given that EVs and ICE vehicles are expected to reach price parity by 2026, costs borne by consumers for paying higher prices for EVs are only considered up until 2026 (Reuters, 2022). Additionally, maintenance costs for EV chargers are only considered for 2027 and beyond, since that is when the federal funds from the Bipartisan Infrastructure Bill are expected to dimmish to zero (Burns, Rhode Island Electric Vehicle Infrastructure Deployment State Plan, 2022).

Cost-Benefit Analysis

The costs and benefits of each alternative were calculated for each month using the figures above, and subsequently used in a present-value calculation, the formula for which is shown below:

$$NPV = \sum_{t=1}^{t=n} \frac{FV}{(1+r)^t}$$

where NPV denotes the net present value, FV denotes the future value, r denotes the discount rate, and t denotes the time period, or month, for which a given cost or benefit was incurred. For the purposes of this project, a discount rate of 3% was used, as is standard practice for Rhode Island's OMB. The present values of both costs and benefits were then aggregated, with 1 being the first month that costs and benefits were calculated for, and n representing the last month for which they were calculated. This resulted in a benefit-cost ratio for each of the alternatives considered.

It should be noted that since the lifespan of most EVs is estimated to be 15 years, the costs and benefits that stem from new EVs, specifically in the form of lost gas tax revenue,

charging station maintenance costs, EV maintenance savings, fuel savings, and local environmental benefits are calculated for the duration of each EVs 15-year lifespan (Hawley, 2022). For example, the costs and benefits of EVs purchased in 2035 are accounted for until 2050.

Monte Carlo Simulation

This project uses a Monte Carlo simulation to display how the variances of the empirical effects used in the CBA might lead to a range of expected benefit-cost ratios across each of the proposed alternatives. The simulation works as a probability distributor, where Excel "draws" a random number for the net present value of costs and benefits based on their expected values, or the values that were originally calculated in the CBA. Across 5,000 simulations, Excel "drew" random values for the costs and benefits based on their expected values and calculated variances.

It is worth noting that the variances were calculated under the assumption that each empirical effect employed was statistically independent from one another. For example, it was assumed that the effect of informational campaigns and walking distance to the nearest EV charger were independent of one another, even though this is likely not the case. However, the lack of publicly available data from each of the studies employed prevented a calculation of the correlation between each of these effects. Due to this restriction, calculating the variances under the assumption of statistical independence appeared as the only feasible option for this project.

Each of the respective simulations resulted in a distribution of expected benefit-cost ratios, which were then displayed in the histograms presented.

References

Adedamola Adeptu, S. K. (2015). *The relative importance of price and driving range on electric vehicle adoption: Los Angeles case study.* Springer Science.

Alliance for Automotive Innovation. (2022, September). *Electric Vehicle Sales Dashboard*. Retrieved from https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard

Ascend Elements. (2022). *New Research: Americans Warming Up to Electric Vehicles, but Many Misconceptions Remain.* Ascend Elements.

Bartlett, J. S. (2022). *More Americans Would Buy an Electric Vehicle, and Some Consumers Would Use Low-Carbon Fuels, Survey Shows.* Consumer Reports.

Bayram, S. (2021). *Impacts of Electric Vehicle Charging under Cold Weather on Power Networks.* Institute of Electrical and Electronic Engineers.

Brennan Borlaug, S. S. (2020). *Levelized Cost of Charging Electric Vehicles in the United States.* Joule.

Burns, C. (2022). *Rhode Island Electric Vehicle Infrastructure Deployment State Plan.* Providence, RI: Rhode Island Department of Transportation.

California Air Resources Board. (2022). *California moves to accelerate to 100% new zero-emission vehicle sales by 2035.* Sacramento, CA: California Air Resources Board.

California Air Resources Board. (2022). *States that have Adopted California's Vehicle Standards Under Section 177 of the Federal Clean Air Act.* California Air Resources Board.

Chih-WeiHsu, K. (2021). Public electric vehicle charger access disparities across race and income in California. *Transport Policy*, 59-67.

Consumer Reports. (2020). *Consumer Interest and Knowledge of Electric Vehicles: 2020 Survey Results.* Consumer Reports.

Dale Hall, N. L. (2017). *Emerging Best Practices for Electric Vehicle Charging Infrastructure.* International Council on Clean Transportation.

Deloitte. (2023). *2023 Global Automotive Consumer Study; Key Findings: Global Focus Countries.* Deloitte.

Easwaran Narassimhan, C. J. (2018). *The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: analysis of US States.* Environmental Research Letters.

EV Connect. (2022). *Estimated Cost Guide to Operating and Maintaining EV Charging Stations.* EV Connect.

Exro. (2022). *Barriers to Electric Vehicle Adoption in 2022.* Exro.

Filippa Egner, L. T. (2018). Electric vehicle adoption in Sweden and the impact of local policy instruments. *Energy Policy*, 584-596.

Future Energy. (2021). *How Much Do EV Charging Stations Cost?* Future Energy.

Givens, A. (2022). *10 states with the highest gas consumption.* Rate Genius.

Green Energy Consumers Alliance. (2022). *Rhode Island Bill Creates Roadmap to Advance Future of Electric Transportation.* PR Newswire.

H.S. Das, M. R. (2020). Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review. *Renewable and Sustainable Energy Reviews*.

Hawley, D. (2022). *How Long Do Electric Car Batteries Last?* J.D. Power.

James Archsmith, E. M. (2022). Future Paths of Electric Vehicle Adoption in the United States: Predictable Determinants, Obstacles, and Opportunities. *Environmental and Energy Policy and the Economy*, 71-110.

Jeff S. Bartlett, B. P. (2023). *Automakers Are Adding Electric Vehicles to Their Lineups. Here's What's Coming.* Consumer Reports.

Joseph Bailey, A. M. (2015). Is awareness of public charging associated with consumer interest in plug-in electric vehicles? *Transportation Research Part D: Transport and Environment*, 1-9.

Karnowski, S. (2022, September 3). 17 States Weigh Adopting California's Electric Car Mandate. *Associated Press*.

Krishna, G. (2021). Understanding and identifying barriers to electric vehicle adoption through thematic analysis. *Transportation Research Interdisciplinary Perspectives*.

Kuffner, A. (2022, March 14). RI will once again offer rebates on electric cars. Here's how it will work. *The Providence Journal*.

Lee V. White, A. L. (2022). Why are charging stations associated with electric vehicle adoption? Untangling effects in three United States metropolitan areas. *Energy Research and Social Science*.

Lewis, M. (2023). *Here's how many EV chargers the US has – and how many it needs.* Electrek.

London School of Economics. (2017). *Economic co-benefits of reducing CO2 emissions outweigh the cost of mitigation for most big emitters.* London School of Economics.

Macht, G. A. (2018). *Electric Vehicle Charging Behavior in Existing Infrastructures: A Rhode Island Case Study.* University of Rhode Island.

Mangement, R. I. (2022). *Rhode Island's Low-Emission Vehicle Program.* Providence, Rhode Island.

McCabe, M. (2022). *RI Delegation Delivers $3.38 Million to Boost RI'S Electric Vehicle Charging Infrastructure.* Washington, D.C.

Motavalli, J. (2021). *Every Automaker's EV Plans Through 2035 And Beyond.* Forbes.

Partridge, J. (2021). *Electric cars 'will be cheaper to produce than fossil fuel vehicles by 2027'.* The Guardian.

Resources, R. I. (2022). *Public Comments: Drive EV Rebate Program.* Rhode Island Office Energy Resources.

Reuters. (2022). *Envision sees cost of electric cars at parity by 2025-2026.* London: Reuters.

Rhode Island Department of Energy Management. (2018). *Greenhouse Gas Emissions Inventory.* Rhode Island Department of Energy Management.

Rhode Island Department of Transportation. (2021). *EV Charging: Statewide EV Charging Stations.* Rhode Island Department of Transportation.

Rhode Island Governor's Office. (2022). *Governor McKee Kicks Off #RIMomentum Tour with Launch of Electric Vehicle Rebate Program.* Rhode Island Governor's Office.

Rhode Island Office of Energy Resources. (2022). *Electric Vehicles*. Retrieved from Rhode Island Office of Energy Resources : https://energy.ri.gov/transportation/electric-vehicles

Skowron, M. (2022, July 20). A Murky Future for RI's Electric Vehicle Programs. *Green Energy Consumer Alliance*.

Stone, N. (2022). *Public EV Charging for Retail: Level 2 vs. DC Fast Chargers.* EV Go.

The Executive Climate Coordinating Council. (2016). *Rhode Island Greenhouse Gas Emissions Reductions Plan.* The Executive Climate Coordinating Council.

Thomson Reuters. (2017). *Will electric vehicles really create a cleaner planet?* Thomson Reuters.

Tianqi Zou, M. K. (2020). Effects of Charging Infrastructure Characteristics on Electric Vehicle Preferences of New and Used Car Buyers in the U.S. *Transportation Research Record*, 165-175.

Tolbert, J. (2021). *Beyond Cities: Breaking Through Barriers to Rural Electric Vehicle Adoption.* Environmental and Energy Study Institute.

U.S. Department of Energy. (2022). *Charging Infrastructure Operation and Maintenance.* U.S. Department of Energy.

Ultralec. (2022). *How Long Does It Take To Install An Electric Car Charger?* Ultralec.

United States Department of Energy. (2021). *Planning Considerations for Electric Vehicles in Rhode Island.* United States Department of Energy.

United States Department of Transportation. (2022, February 2). *Federal Funding Programs*. Retrieved from United States Department of Transportation: https://www.transportation.gov/rural/ev/toolkit/ev-infrastructure-funding-and-financing/federal-funding-programs

Valdes, R. (2022). *Electric Car FAQ: Your Questions Answered.* Kelly Blue Book.

Woods, B. (2021). *GM, Ford are all-in on EVs. Here's how their dealers feel about it.* Consumer News and Business Channel.

Xiao-Guang Yang, G. Z.-Y. (2018). Fast charging of lithium-ion batteries at all temperatures . *Proceedings of the National Academy of Science*, 7266-7271.

Xiaowei Chi, Y. Z. (2022). An electrochemically stable homogeneous glassy electrolyte formed at room temperature for all-solid-state sodium batteries. *Nature Communications*.

Yoko, C. (2020). *How Much Does a Government Contractor Website Cost?*