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Accessing EVs at the Margins: Increasing Electric Vehicle Adoption in Rural Virginia

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ACRONYMS

- ACC – Advanced Clean Cars standards
- BIL – Bipartisan Infrastructure Law
- DMME – Department of Mines, Minerals, and Energy
- DMV – Department of Motor Vehicle
- EVs – Electric Vehicles
- EVSE – Electric Vehicle Supply Equipment [1]
- IRA – Inflation Reduction Act
- NEVI – National Electric Vehicle Infrastructure formula program
- VCC – Virginia Clean Cities
- VDOE – Virginia Department of Energy
- VDOT – Virginia Department of Transportation
- VDEQ – Virginia Department of Environmental Quality
- VDT – Virginia Department of Taxation

[1] EVSE is another way to refer to EV charging stations.

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BATTEN 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 CODE

On my honor as a student, I have neither given nor received unauthorized aid on this assignment.

EXECUTIVE SUMMARY

Transportation by car is an important facet of American life. However, the transportation sector accounted for 27 percent of total GHG emissions in the United States in 2020; of that 27 percent, 57 percent of transportation sector emissions came from light-duty vehicles, such as cars (Environmental Protection Agency, 2022). One viable way to meet transportation needs in a less carbon-intensive way is the electric vehicle (EV). **Currently, too few rural Virginians have adopted EVs. Given rural communities spend a disproportionate share of their income on transportation, increasing EV adoption in rural Virginia will help the environment and decrease the financial burden of transportation on this community (Lowell et al., 2020).**

There are several contributing causes to the lack of EV take-up in rural Virginia, such as the high upfront cost of EVs, limited model availability, lack of education and awareness on EVs range anxiety, and lack of electric vehicle supply equipment (EVSE) infrastructure. The literature highlights three main drivers to promote EV adoption: physical charging infrastructure, financial incentives (tax credits and rebate programs), and educational/awareness campaigns.

Considering the literature, I propose three potential alternatives to increase EV adoption in rural Virginia:

1. Keeping the Status Quo (Including Current State and Federal EV Projects)
2. Funding Virginia's Electric Vehicle Rebate Program
3. Producing an Educational Awareness Campaign

Based on the criteria of cost, effectiveness, political feasibility, administrative feasibility, and equity, I recommend that Virginia Clean Cities (VCC) produce an Educational Awareness Campaign, in coordination with VDOT, that targets the specific needs of rural communities. Though its impact on equity is to be determined, this policy solution is the cheapest and potentially most effective alternative. Though it might encounter some difficulty with political feasibility, it is administratively feasible and could address the equity concerns present in the problem statement.

Regarding implementation, VCC should begin collaborating with the Virginia Department of Transportation (VDOT) and rural communities early in the process to create a productive campaign that addresses the concerns of rural Virginians. In conclusion, VCC should prioritize this practical solution to increase EV adoption and environmental benefits while ensuring rural communities can access this cost-saving technology.

INTRODUCTION

Problem Statement

Transportation by car is an important facet of American life. However, the transportation sector accounted for 27 percent of total GHG emissions in the United States in 2020; of that 27 percent, 57 percent of transportation sector emissions came from light-duty vehicles, such as cars (Environmental Protection Agency, 2022). One viable way to meet transportation needs in a less carbon-intensive way is the electric vehicle (EV). **Currently, too few rural Virginians have adopted EVs. Given rural communities spend a disproportionate share of their income on transportation, increasing EV adoption in rural Virginia will help the environment and decrease the financial burden of transportation on this community (Lowell et al., 2020).** Thus, increasing EV adoption in rural communities across the state will result in many benefits.

Client Overview

As a clean transportation non-profit under the Department of Energy's Clean Cities Coalition, Virginia Clean Cities is working to find sustainable alternatives to our current transportation systems. The organization's goal is to work with government actors, fleets, community partners, non-profits, and other stakeholders to increase EV adoption while reducing reliance on petroleum. VCC participates in relevant EV projects such as Drive Electric VA, Drive Clean Rural USA, and Rural Re-Imagined, which demonstrates their commitment to addressing the transportation and environmental burdens afflicting rural Virginians. Therefore, VCC is uniquely situated to utilize its resources and study the regional impacts of EVs on diverse constituents in the state.

BACKGROUND

Scope of the Problem – The Transportation Sector and Rural Communities

Of the various industrial sectors in the United States, the transportation sector contributes the most to greenhouse gas (GHG) emissions at 27 percent of total GHG emissions in the country; of that 27 percent, 57 percent of transportation sector emissions came from light-duty vehicles, such as cars (Environmental Protection Agency, 2022). The large amount of GHG emissions from the transportation sector represents a prime market for reducing GHG emissions to help address the impacts of climate change.

Further, living in a rural community impacts transportation in many ways, through accessing food, healthcare, job opportunities, and even social connections. In addition to spending up to 20 percent more on fuel costs than their urban counterparts, rural communities typically lack extensive public transportation, making these communities partially reliant on personal cars (Vaidyanathan et al., 2021). Rural folks also spend more time driving than their urban counterparts (US Department of Transportation, 2022). Rural communities, therefore, spend a disproportionate amount of money and time on transportation, forgoing other ways to spend these resources.

Electric vehicles could be helpful for rural folks, as they have a lower total cost of ownership when compared to internal combustion engine vehicles (Harto, 2020). As of the end of 2022, rural counties in Virginia contained 979 registered EVs, or 2 percent of all EVs in Virginia (*EV Dashboard*, 2023). Considering 26 percent of the state's population lives in rural communities, there is a lot of potential for expanding equitable adoption of EVs in the state (Virginia Rural Health Plan, 2022). Thus, expanding the adoption of EVs in rural communities is an important issue because it addresses GHG emissions and the climate crisis while providing equitable opportunities for communities to feel empowered through their transportation.

Causes of the Problem

There are several reasons why rural communities have a low number of EVs, despite their cost savings. For instance, the upfront cost of EVs is too expensive. The average cost of a light-duty EV, reported in July 2022, is over $66,000, compared to $43,942 for a non-luxury vehicle (Kelley Blue Book, 2022). Given that EVs are currently priced around 33 percent higher than passenger cars, this higher upfront cost imposes a high barrier to entry for rural folks, regardless of the lower total cost of ownership of EVs (Harto, 2020). Another secondary cause is the limited model availability, which represents the lack of models of interest to rural communities. Pickup trucks are a popular choice of car for rural communities, but there are not a lot of electric trucks on the market, aside from the relatively recent release of the Ford F-150 Lightning and Rivian's R1T (Tolbert, 2021). Without many electric truck options, rural communities must settle for the few models currently available at a high upfront cost.

Other contributing causes are education and awareness, range anxiety, and lack of EVSE infrastructure. Education and awareness are relevant because some folks do not know what EVs are, what models are available, how they work, and what potential funding opportunities there are to reduce the costs of EVs. Increasing opportunities for rural communities to use or ride in an EV will help increase familiarity and encourage folks in these communities to be open to purchasing one of these vehicles (King, 2022). Range anxiety, which refers to fears surrounding an EVs ability to go longer distances, is a common concern for rural communities (Krishna, 2021). Even with farther distances to drive, the average trip distance in rural areas is between 11 and 14 miles, which is well within the range of current EVs (Electrification Coalition, 2022). Range anxiety can therefore be tied to education and awareness to assuage fears surrounding EV myths. Lastly, the lack of EVSE infrastructure and the inability to charge EVs showcases the need to expand the EV charging network, especially in rural areas (Tolbert, 2021). The Bipartisan Infrastructure Law's (BIL) National Electric Vehicle Infrastructure (NEVI) formula program is currently providing State Department of Transportations with electric vehicle charging infrastructure funding; since this is an ongoing project, the impact of increasing the number of EV charging stations has yet to be realized (US Department of Transportation, 2022). It is my hope that addressing these various causes with creative policy solutions will increase EV adoption among rural Virginians.

A Recent History of EVs

The first electric car dates back to the mid-1800s (Suh & Cho, 2017). During the early 1900s, EVs grew in popularity, but the mass production of Henry Ford's Model T meant that gas-engine cars were significantly cheaper than EVs (Matulka, 2014). It was not until the early 1970s when foreign oil prices rose that the United States government began to investigate alternative fuel and electric vehicles. Then, through the 1980 and 1990s, the environmental movement spurred interest in alternative fuel vehicles. Two other important developments in the rise of EVs are Toyota's Prius, which became the first mass-produced hybrid electric vehicle in 1997, and Tesla's entry and domination of the EV market, which started with Tesla's first fully electric model in 2006.

Since these 21st-century developments, other legacy automakers, such as Ford and GM, have entered the market with their own EV models. In July 2022, EVs made up over 5 percent of new car sales for the first time, reaching a critical threshold where other countries saw an exponential increase in new EV sales (Randall, 2022). Another representation of the recent focus on EVs can be measured through Super Bowl ads; there were 10 commercials for EVs in last two Super Bowls, which is equivalent to the number of EV ads in the prior six years (2015-2021) combined (Mandel, 2023). Therefore, though EVs have been around for a long time, recent developments in the market and their potential to help reduce GHG emissions have vastly increased their adoption potential.

Potential Solutions

In the literature, three main drivers emerge to promote EV adoption: physical charging infrastructure, financial incentives (tax credits and rebate programs), and educational/awareness campaigns.

According to the literature, increasing the amount of EV charging stations could boost EV adoption. It is important to note that the 2021 BIL established the NEVI formula program to develop an EV charging network across the United States through State Departments of Transportation, which is an active project (US Department of Transportation, 2022). From an equity standpoint, rural communities have often been overlooked for this infrastructure, and they could stand to benefit from increased low-cost charging infrastructure (Hardman et al., 2021). In a paper that reviewed studies on EVs, all of the 28 studies on charging infrastructure and EV adoption found a relationship between EV chargers and EV adoption (Hardman, 2019). Though the author acknowledges that it is hard to determine the causality between these variables, their studies and surveys suggested that increasing charging infrastructure could grow EV adoption (Hardman, 2019).

Other studies also found a relationship between EVSE and EV adoption. A 2017 study of 58 California counties found a 1.9 percent increase in the probability of purchasing an EV per additional charging station per 10,000 capita (Javid & Nejat, 2017). Across multiple regression models, such as logit and probit models, each of the study's models produced statistically significant coefficients for charging stations, emphasizing the strength of this finding. Another important aspect of this study is its inclusion of various control variables, such as age, employment, and income. It is important to note that this study had an average annual household income ranging from $75,000 to $99,999, so these results might not be entirely generalizable. It should also be noted that California is geographically different from Virginia, so the outcomes might be less reflective of rural communities. Therefore, the literature suggests that the current status quo, increasing charging infrastructure, could aid in the adoption of EVs.

Overall, financial incentives, such as tax credits and rebate programs, boost adoption (Clinton & Steinberg, 2019; DeShazo et al., 2017; Wee et al., 2018). An analysis of state-level policies for EVs from 2010 to 2015 that utilized a difference-in-difference model with fixed effects found that a $1,000 increase in state-level EV subsidies results in a 7.5 percent increase in EV registrations in that state (Wee et al., 2018). Comparably, when scaled to the average level of subsidies at the state level, $2,305, states can expect a 17.3 percent increase in EV registrations (Wee et al., 2018). This finding was statistically significant at the 1 percent level and held up to sensitivity testing (Wee et al., 2018). Similarly, a 2019 study on the impact of state-level financial incentives on EV adoption, using panel data and a fixed effects regression model, found that for every $1,000 direct purchase rebate incentive, EV adoption increased by around 8 percent (Clinton & Steinberg, 2019). Interestingly, this study also found that EV tax credits are not effective for increasing EV adoption, compared to direct rebates, though this could be a result of a small sample size since the authors acknowledged the lack of state-level tax credits during the study period (Clinton & Steinberg, 2019).

Another study on the impacts of financial incentives on EV adoption spoke to the equity implications of these incentives. Specifically, using an innovative choice model with data from a statewide survey of over a thousand potential new car buyers in California, the authors found that the status quo policy, a rebate of $2,500, results in an EV adoption increase of 7 percent (DeShazo et al., 2017). Further, they found that a progressive rebate structure that benefits low-income

households has a similar effect on EV adoption, while also reducing costs to the state by around 26 percent, making it a more cost-effective option while achieving more equitable outcomes (DeShazo et al., 2017).[2] Thus, the literature suggests that financial incentives, specifically rebates, are effective at increasing EV adoption equitably.

Lastly, educational awareness campaigns are another potential solution to increasing access to EVs. This solution is particularly relevant for rural communities because there could be a knowledge gap, in which these communities are unaware of potential models of interest or potential cost-saving measures that are associated with EVs. In fact, the literature shows there are misconceptions about EVs. In a 2011 survey of 2302 individuals across 21 of the largest urban areas, over 66 percent of respondents answered questions about EVs incorrectly, nearly 75 percent undervalued EV advantages, and almost 95 percent did not know about state or local EV incentives (Carley et al., 2013; Coffman et al., 2017). All that said, this survey might be old at this point, and it is hard to say how generalizable these results are to our population of interest, given that all respondents were from urban areas. Further studies show the impact of this knowledge gap on EV adoption. While general findings of a 2018 study found a 2.6 percent increase in EV adoption per $1,000 of incentives, the inclusion of a variable for consumer awareness resulted in variation in the effectiveness of incentives across states, ranging from a 62 percent increase in California to a 0 percent in Montana or the Dakotas (Jenn et al., 2018).[3] This robust study utilized data from over 83 million car registrations between 2010 and 2015, and the authors created a method for cataloging knowledge to then run a two-stage least squares regression, accounting for endogeneity (Jenn et al., 2018).[4] Overall, this study, and the studied gap in EV knowledge, suggests that educational or awareness campaigns could have a significant impact on EV adoption.

Limitations

Since the EV industry is in an opportunity window, even recent literature is a bit behind on what is currently unfolding in this space. For instance, with the passage of the Inflation Reduction Act (IRA) in August 2022, there are new federal-level tax credits in 2023 that change each year with increasingly specific requirements (*Inflation Reduction Act Benefits*, 2022). Since these tax credits just started, the effect of these federal-level financial incentives will need to be evaluated over time to gather a sense of its impact. Thus, the active nature of the EV industry poses a limitation in evaluating the literature.

[2] The specific structure of this policy is as follows: "1) less than $25,000, a rebate of $7500, 2) $25,000–$50,000, a rebate of $5,000, 3) $50,000–$75,000, a rebate of $2000, and 4) over $75,000, no rebate" (DeShazo et al., 2017, p. 41).
[3] Based on their figure, Virginia saw an increase in the range of 7.65 to 62 percent when accounting for consumer awareness (Jenn et al., 2018).
[4] Endogeneity in this model would be from those who purchase EVs being more likely to read about EVs, which was a part of how they indexed consumer awareness (Jenn et al., 2018).

Conclusion

Electric vehicles can provide many benefits, both to the environment and to their users. Rural communities are uniquely situated to benefit from EVs, considering the cost burden of transportation. After highlighting the problem, potential causes, and a recent history of EVs, this paper reviewed existing literature on potential solutions to increase the adoption of EVs. The existing literature highlighted three solutions with relatively similar impacts: though it is hard to prove causality, the literature suggests increasing physical charging infrastructure could increase EV adoption. Financial incentives, specifically direct purchase rebates, boost EV adoption equitability. Lastly, educational awareness campaigns also help address the knowledge gap and increase EV adoption. This section analyzed the existing literature to the best of its ability while acknowledging its limitations, especially regarding the active nature of the EV space. Further research to inform this work should analyze the impacts of current policy implementations at the federal and state level, such as the federal tax credits, on EV adoption.

CRITERIA

Cost

The cost criterion quantifies the cost of each alternative. Understandably, an alternative's cost could be a barrier if the cost is too high. To evaluate alternatives for this criterion, I will analyze government documents to gather the current cost of existing programs. For alternatives that would establish new programs, I will utilize fiscal impact statements, salary estimates, and other government documents to gather an estimate of potential costs. Cost estimates will be reported as the net present value of the program over the next five years.

Effectiveness

The effectiveness criterion measures how well each alternative does at increasing EV adoption. To calculate this metric, I will gather information on how different interventions increase adoption through the literature, and I will use that rate times the number of EVs registered in Virginia in 2022 to estimate the increase in EV registrations over five years (EV Dashboard, 2023). To account for the non-linear nature of EV adoption, I will utilize a 0.2 percent increase in adoption rate per year, as suggested in the literature when calculating this criterion (Chakraborty et al., 2021). EV registrations for 2022 will be listed to accurately forecast subsequent years, but they will not be included in the five-year total. Also, for alternative #3, I will perform a sensitivity analysis on the growth rate to provide a potential range of EV registrations, since there is a range of growth rates provided in the literature (Jenn et al., 2018).

Cost-Effectiveness

The cost-effectiveness criterion reflects how much money it costs for each additional EV registration in rural Virginia. To calculate this ratio, I will divide the cost criterion by the effectiveness criterion to provide a scale of the different amounts of investment needed across alternatives.

Administrative Feasibility

The administrative feasibility criterion captures the ease of implementation. In other words, do actors have the administrative capacity to implement the alternative? To measure this, I will collect data on how many agencies will be involved in implementing the alternatives. The more agencies involved in the implementation process, the more complicated implementation will be. For that reason, a higher number of agencies involved reflects a lower administrative feasibility. A second impact category under this criterion is expertise: does the agency currently have the necessary skills to implement the policy? The impact categories under this criterion will be evaluated as either low, medium, or high, with high being the most optimal outcome.

Political Feasibility

Like administrative feasibility, political feasibility analyzes political support for each alternative. Specifically, I will measure political feasibility by evaluating potential veto points. To assess the current political climate at the state level, I will estimate whether each alternative is likely to make it through the committee, the House, the Senate, and the Governor to be implemented. This criterion will be ranked as either low, medium, or high, with high being the most optimal outcome. High political feasibility will represent passing most of the veto points while low feasibility represents failing most of the veto points.

Equity

The equity criterion is central to the problem at the heart of this project: how do we increase EV adoption in rural communities in Virginia? To measure this criterion, I will evaluate the geographic distribution of the alternatives. This will involve analyzing whether the program is distributed equitably across regions in the state. I will analyze this by looking at maps that compare rural localities to EV charger maps and median household income maps to project the potential impact of these interventions on rural counties in the state (Income Map for Virginia Counties | HDPulse Data Portal, 2019; Virginia Department of Transportation, 2022; Virginia Rural Health Plan, 2022). This criterion will be ranked on a low, medium, and high scale, where high equity is preferred. This criterion is given the highest priority, as equity is central to the problem statement.

ALTERNATIVES

Alternative #1: Keeping the Status Quo (Including Current State and Federal EV Projects)

In this alternative, there would be no policy changes. Although there is nothing added, this alternative would include active state-level and federal-level electric vehicle projects over the next five years. One of these programs is the NEVI formula program. Allocated in the BIL, VDOT will receive an estimated $100 million in funding to carry out its approved plan for building out a network of EV chargers; VDOT projects the initial build-out of chargers to begin in 2023 or 2024, but the funding will continue through 2026 (Virginia Department of Transportation, 2022). Implementation of these chargers will involve public-private partnerships where the NEVI funding will subsidize up to 80 percent of the costs of the EVSE.

In addition to NEVI, the IRA, which was signed into law in August 2022, includes robust EV tax credits that help reduce the upfront cost of an EV (*Inflation Reduction Act Benefits*, 2022). Passenger vehicles manufactured in the United States qualify for a tax credit of up to $7,500 and used EVs qualify for a tax credit of up to $4,000 (*Inflation Reduction Act Benefits*, 2022). Lastly, it is important to note the Virginia Code § 10.1-1307 established the Advanced Clean Cars (ACC) standards for new car sales which would require increasingly strict standards on low-emissions vehicles and targets for increasing sales of zero-emissions vehicles; state legislators tried to repeal these standards during this year's session, with HB 1378 passing the House in January 2023 (Virginia Department of Transportation, 2022; Wilt, 2023). However, the bill died in the Senate Committee on Agriculture, Conservation, and Natural Resources in February 2023.

- *Cost*: The three existing EV-related programs are NEVI, federal tax credits, and ACC standards. While there are clear cost estimates for both federal programs, the fiscal impact statement for ACC legislation did not provide a cost estimate; it did suggest, however, that any costs would be within the Virginia Department of Environmental Quality's (VDEQ) existing budget (Department of Planning and Budget, 2021b). Therefore, the cost of the two existing federal programs is roughly **$419 million** (Bipartisan Infrastructure Law - 5-Year National Electric Vehicle Infrastructure Funding by State, 2022; Shepardson & White, 2022).
- *Effectiveness*: The average growth rate in registrations over the last five years of data, 2017-2021, was 42 percent. In addition to accounting for non-linear growth at .2 percent, tax benefits lead to an increased growth rate of 1.781 percent (Xue et al., 2021). Therefore, with a projected growth rate of 44 percent over five years, the number of EV registrations is **16,634** between 2023-2027 in rural Virginia.
- *Cost-Effectiveness:* This alternative will cost **$25,206** for each additional EV registration in rural Virginia.
- *Administrative Feasibility*
    - *Agencies*: There are many agencies involved in these existing programs. For instance, the federal Department of Transportation and VDOT coordinate to run NEVI, the federal tax credits are evaluated by the Internal Revenue Service, and VDEQ

oversees the implementation of the ACC standards. Therefore, since there are several agencies on the state and federal levels, which requires complex cross-agency collaboration, this alternative ranks as **medium** for administrative feasibility.
    - *Expertise:* Though there are several agencies involved in this process, the existence of these programs attests to the current administrative capacity to conduct these programs. Further, work products, such as VDOT's NEVI plan, depict the current expertise present in these agencies (Virginia Department of Transportation, 2022). Therefore, this alternative ranks as **high** for administrative feasibility.
- *Political Feasibility*: For this alternative, political feasibility revolves around the potential overturning of these programs. These programs face two potential political constraints. The federal tax credits contain a stipulation that a growing amount of the materials in the car must be domestically manufactured to be eligible for the credit, which could make the credits inaccessible if the domestic supply chain does not grow to meet the requirements (Yarmuth, 2022). Also, state politicians tried to repeal the ACC standards during the 2023 session, with HB 1378 passing the House in January 2023 (Virginia Department of Transportation, 2022; Wilt, 2023). Though the bill died in the Senate Committee on Agriculture, Conservation, and Natural Resources in February 2023, this displays that numerous political actors are trying to repeal the standards. Therefore, the political feasibility for the status quo ranks as **medium**.
- *Equity*: Of the fifty three rural counties outlined by the Virginia Rural Health Plan, eight counties contain or might potentially gain an EV charging station through the first round of NEVI funding (Virginia Department of Transportation, 2022; Virginia Rural Health Plan, 2022). Therefore, this alternative ranks **low** on this criterion.

Alternative #2: Funding Virginia's Electric Vehicle Rebate Program

In 2021, the Virginia General Assembly established an electric vehicle rebate program, which allows for a rebate of $2,500 for Commonwealth residents and up to $4,500 for qualified Commonwealth residents (Code of Virginia, 2021).[5] However, this program never received funding, and neither the House of Delegates nor the Senate included funding for the program in 2022's biennial budget (Vogelsong, 2022). While there is a structure in place for state-level EV incentives, no one has used this program due to a lack of funding. The literature has shown that financial incentives increase EV adoption, so finding a way to fund this program and allow Virginians to access this financial incentive has the potential to help increase accessibility (Clinton & Steinberg, 2019; DeShazo et al., 2017; Wee et al., 2018). The Virginia General Assembly could allocate money in the budget to fund the rebate program. This would involve a representative introducing a budget amendment to the General Assembly, and the legislation would need to move through the subcommittee, committee, House, and Senate before receiving the Governor's approval and being enacted into law (State Budget, 2021).

[5] A "qualified Commonwealth resident" is a Commonwealth resident whose "annual household income does not exceed 300 percent of the current poverty guidelines" (Code of Virginia, 2021).

- *Cost:* The estimated cost contains cost projects for the rebate and the need for an additional Department of Mines, Minerals, and Energy (DMME) employee to help with the implementation. Thus, the cost of the rebates and administrative needs for this program is roughly **$236 million** (Department of Planning and Budget, 2021a; GovSalaries, 2023a).
- *Effectiveness*: In addition to accounting for historical average growth rate and non-linear growth, the average projected growth rate for EV adoptions across three studies, when scaled to the level of subsidy listed in the legislation ($2,500) is 15.27 percent (Clinton & Steinberg, 2019; DeShazo et al., 2017; Wee et al., 2018). When considering additional access to federal tax credits, which increases the growth rate by 1.781 percent, the projected annual growth rate for this alternative is 59 percent (Xue et al., 2021). Therefore, the number of EV registrations is **24,173** between 2023-2027 in rural Virginia.
- *Cost-Effectiveness:* This alternative will cost roughly **$9,758** for each additional EV registration in rural Virginia.
- *Administrative Feasibility*
    - *Agencies*: The three main agencies are involved with this program: DMME, a subdivision of Virginia's Department of Energy (VDOE), Department of Taxation (VDT), and the Department of Motor Vehicles (DMV) (Department of Planning and Budget, 2021a). DMME will implement the program and report yearly on its status, VDT will administer the rebates, and DMV could play a role in documenting and verifying the rebates. Therefore, since there are three state agencies involved, this alternative ranks **high** in this impact category.
    - *Expertise*: Though the rebate program currently exists, it has never been implemented due to a lack of funding. Further, while the fiscal impact statement included an employee to help implement this program, there is currently little information about EVs on VDOE's website, even under its clean energy section (Virginia Department of Energy, 2021). Thus, this alternative ranks **low** for expertise.
- *Political Feasibility*: This alternative would encounter trouble along most veto points. Delegate Reid introduced a budget amendment to get funding for the program during the state's most recent session, but it failed to move beyond committee (Reid, 2023a). Additionally, the program failed to get funding when Democrats controlled both the House and the Senate, and some representatives, such as Delegate Bloxom and Delegate Hudson, have expressed concern over funding the program (Farah, 2023). Lastly, while the Governor has not spoken directly about the EV rebate program, he has expressed anti-EV sentiments in the past that might signal his hesitance toward funding a program like this. Therefore, this alternative ranks **low** on political feasibility.
- *Equity*: Evidence suggests that a progressive rebate structure, such as the one found in Virginia's EV rebate program, stands to both increase adoption and cut state costs at an equitable rate by targeting lower-income households (DeShazo et al., 2017). Since there appears to be some overlap between lower-income and rural counties, this alternative ranks **medium** on this criterion.

Alternative #3: Producing an Educational Awareness Campaign

Inspired by public awareness campaigns in the United Kingdom and Canada and other educational materials produced at the state level in the United States, this alternative would involve VCC partnering with VDOT to promote information about EVs to the public (Jin & Slowik, 2017; *Propelling Québec Forward with Electricity: Transportation Electrification Action Plan 2015-2020*, 2015; Rosenblum, 2022). One of the central work products of the campaign would be a VDOT website that acts as an EV toolkit for Virginians. Some of the information on this website would include information on where to buy an EV, EV model availability, EV cost savings, environmental benefits, eligibility for financial incentives, and EV charger locations. Another main output from this campaign would be a social media campaign, where VDOT and VCC promote information on the benefits of EVs on their social media and partner with influential Virginians to expand the campaign's reach. Beyond these main outputs, other potential aspects of the campaign could be internet and/or radio advertisements and partnering with nonprofits on community events such as a ride-and-drive.[6] The focus of the campaign would be on reaching rural communities around the state, so the work products should be tailored to that audience. Lastly, funding for this campaign could come from a variety of sources, such as VDOT or the federal Department of Energy.

- *Cost*: The costs for this campaign, modeled after Québec's public awareness campaign, includes a budget for creating a governmental communication strategy and another pocket of funding allocated for working with community partners or influencers to disseminate the campaign's information (*Propelling Québec Forward with Electricity: Transportation Electrification Action Plan 2015-2020*, 2015). Additionally, the budget will include hiring an additional VDOT employee to help run the campaign and outreach needed for implementation. Therefore, the cost of the campaign and administrative needs are roughly **$7.8 million** (*Canadian Dollar to US Dollar Spot Exchange Rates for 2015*, n.d.; Consumer Price Index, 1913-, 2023; Consumer Price Index Summary - 2023 M02 Results, 2023; GovSalaries, 2023b; *Propelling Québec Forward with Electricity: Transportation Electrification Action Plan 2015-2020*, 2015).
- *Effectiveness*: In addition to accounting for both historical average growth rate and non-linear growth, the average projected growth rate for EV adoptions that involve both financial incentives, like the federal tax credit, and consumer awareness is 34.83 percent (Jenn et al., 2018). Since that average growth rate is based on the 7.65 to 62 percent range in the literature, the projected annual growth rates based on these three percentages are 50, 77, and 104 percent. Thus, the number of potential EV registrations ranges from **19,366-65,927** between 2023-2027 in rural Virginia.
- *Cost-Effectiveness:* This alternative will cost somewhere between **$119.10-405.45** for each additional EV registration in rural Virginia.

[6] A ride-and-drive is a public event that allows the public the chance to test drive and/or sit in an EV (Jin & Slowik, 2017).

- *Administrative Feasibility*
    - *Agencies*: This alternative would involve VCC, as a non-profit, and VDOT, as a government entity working together to create and run the education campaign. Since there is only one state agency involved in implementation, this alternative ranks as **high** in this impact category.
    - *Expertise*: Additionally, there are several employees at VDOT working on and planning for the expanding EV market, which is evidenced in the work being done for the NEVI program. Therefore, this alternative ranks as **high** in this impact category.
- *Political Feasibility:* Like the alternative above, there is currently resistance along the state's veto points to getting funding for EV programs. However, it is possible that this program could encounter less resistance, given its lower price point. Also, given that the state ended FY 2022 with a budget surplus of $1.94 billion, this project's $7.8 million projected cost could be one of many projects funded with the surplus funds (Porter, 2022). Therefore, the potential resistance yet the lower cost of this program leads to a **medium** ranking for political feasibility.
- *Equity*: The campaign should be tailored and designed to target rural communities and their specific travel needs. Since this alternative has yet to be designed, it ranks as **to be determined (TBD)** on this criterion.

OUTCOMES MATRIX

Criteria and Impact Categories	Alternatives		
	Status Quo	**Funding EV Rebate Program**	**Educational Campaign**
Cost	$419,269,257.53	$235,882,685.44	$7,851,987.68
Effectiveness	16,634	24,173	19,366-65,927
Cost-Effectiveness	$25,205.56 per EV registration	$9,758.11 per EV registration	$119.10-405.45 per EV registration
Administrative Feasibility 1. *Agencies* 2. *Expertise*	1. Medium 2. High	1. High 2. Low	1. High 2. High
Political Feasibility	Medium	Low	Medium
Equity	Low	Medium	TBD

RECOMMENDATION

Ultimately, I recommend that VCC produce an educational awareness campaign, in coordination with VDOT, that targets the specific needs of rural communities. It is both the cheapest alternative, and it has the potential to be the most effective alternative. Together, this alternative might cost as a little as $119 per EV registration, compared to thousands of dollars per EV registration for the other alternatives. It is important to acknowledge that this alternative might encounter some difficulty with political feasibility, as the current administration and make-up of the VA General Assembly might make it difficult to get funding for an EV project. That said, it is administratively feasible for VCC and VDOT to carry out this program, as they would only be working with each other to coordinate the campaign. Also, they have expertise on the current state of EVs, and there is money budgeted in the costs to hire a contract worker for 5 years to help with the campaign.

Lastly, this alternative has the highest potential for addressing the equity concern present in the problem statement. The equity implications are harder to calculate for this alternative than the other two, as this campaign would need to be designed to understand the precisely what the impacts might be. That said, given the ability to tailor the campaign to the direct needs of rural Virginians, VCC should prioritize this practical solution to increase EV adoption and environmental benefits while ensuring rural communities can access this cost-saving technology.

IMPLEMENTATION

In recommending the educational awareness campaign, it is helpful to anticipate challenges in its implementation. This section outlines steps and a timeline for the campaign, spotlights relevant stakeholders, and summarizes potential obstacles to implementation, such as organizational expertise, political feasibility, and coordination with rural communities. The guidance on implementation below serves to help VCC prevent implementation failures across all stages of this process.

Implementation Steps

There are three main phases of implementation for this project: planning, production, and follow-up. In the planning phase, which should take around a year, the following steps should occur:

- Coordinate with VDOT to brainstorm ideas and define roles in the project. In the initial meeting, VCC and VDOT should work to identify funding source(s) and discuss potential directions for the campaign.
- Contact local officials in rural communities to identify influential community members who are interested in advocating for EVs. In working with these community leaders, VCC should collaborate with community leaders to conduct focus groups in rural communities, which serves to identify what information is most needed.

Once brainstorming and planning are completed, VCC should move toward producing the agreed-upon and budgeted content, working with rural communities to disseminate important information on adopting EVs. Over the next four years, the following steps exemplify potential action items for VCC:

- Work with VDOT to create an EV toolkit section on their website, based on feedback from focus groups. This might involve hiring a new staff member to research incentives, EV chargers, and other information as well as to build this section of the VDOT website. Another task this employee should perform is updating the website with up-to-date information; their updates should occur on the back end in the code to ensure the website is functioning properly and on the user interface to ensure the website is accessible and easy to navigate.
- Create social media accounts on big platforms (i.e. Facebook, Instagram, Twitter). An employee at VCC could undertake this task, and brainstorm content that spotlights the information found on the VDOT website in creative ways. They should post regularly to keep followers up to date on EV news and relevant information, and they should include a link to the VDOT website in the biography section of each account.

Lastly, the final phase of implementation is the follow-up, in which VCC checks to ensure this program has an equitable impact on EV adoption in rural counties in Virginia. Because VCC keeps track of the annual EV registration data by county, they can check on the effectiveness of this alternative annually by analyzing the increase in EV registration in rural counties over time.

Relevant Stakeholders

Relevant stakeholders include VCC, VDOT, Delegate Reid, and rural communities. VCC, my client, will need to work on coordinating with VDOT to brainstorm potential ideas for the campaign and discuss potential funding plans. While VDOT will need to create and maintain the website, VCC can help build that website or provide data for it. Similarly, VCC has experience running EV projects and might take lead on creating social media accounts and organizing potential rural community members, though VDOT could help in providing leads or tips on marketing. Lastly, Delegate Reid has a history of introducing EV legislation in the House and even served as a patron on the bill that ultimately created the EV rebate program; he even introduced a budget amendment, which passed through committee, that would fund a Rural EV-Tourism Network in the state (Reid, 2023a; Reid, 2023b; Vogelsong, 2022). Thus, as a proponent of EV policies, Delegate Reid could be an important ally to engage, if VCC and VDOT seek funding through the state's General Fund. Lastly, this campaign will be designed to meet the needs of rural communities. To make this program work effectively, VCC and VDOT will need to partner with and consult local community members to ensure community voices are engaged throughout the process.

Potential Barriers

One potential barrier to confront is expertise. Running a successful educational campaign is hard. To address this in implementation, VCC should work with VDOT to either identify a current employee with experience on educational campaigns or they should work to hire someone who can spearhead this initiative. Additionally, this project might encounter resistance from state representatives and rural communities. State representatives hold mixed opinions on EV policies: while both Republicans and Democrats showed hesitancy to fund the EV rebate program, Democrats were successful in preventing a repeal of ACC standards (Farah, 2023; Virginia Department of Transportation, 2022; Wilt, 2023). Therefore, depending on the amount of funding requested and the political makeup of the General Assembly when asking for funding, this program might or might not face pushback from state legislators. Also, rural communities tend to feel unheard and unseen by decision-makers in government, so they might feel resistant to this campaign (Cramer, 2016). That is why it is crucial and necessary to engage with local community members and leaders early in the process to hear about their concerns and needs from this program: what information are they missing about EVs? How can this program reduce burdens in their community? While VCC and VDOT might act with formal authority to reach out to rural communities, they should approach rural communities with the goal of listening to and learning from communities, which will ultimately inform how the campaign is designed and run.

Conclusion

In conclusion, engaging with allies and walking through the steps listed above gives VCC the best chance to successfully implement an educational awareness campaign. Their collaboration with VDOT and rural communities will help ensure an effective campaign that expands EV adoption in rural Virginia.

APPENDIX A – COST CALCULATIONS

Alternative 1: Status Quo

- Time: 5 years
- Discount: 7%
- Formula: $NPV = \sum \frac{FV}{(1+R)^T}$

	Fiscal Year				
Costs	**2022**	**2023**	**2024**	**2025**	**2026**
NEVI	$15,745,244.00	$22,657,583.00	$22,657,740.00	$22,657,759.00	$22,657,806.00
Tax Credits		$ 85,000,000.00	$ 87,550,000.00	$ 90,176,500.00	$ 92,881,795.00
Totals	$15,745,244.00	$107,657,583.00	$110,207,740.00	$112,834,259.00	$115,539,601.00

**Federal tax credits in the IRA started in 2023; To account for the expected exponential rate of EV adoption, the cost projection for the tax credits increases by 3 percent per year to keep up with projected increase in EV sales.*

Source: Bipartisan Infrastructure Law - 5-Year National Electric Vehicle Infrastructure Funding by State, 2022; Shepardson & White, 2022.

	NPV of Costs
2022	$15,745,244.00
2023	$107,657,583.00
2024	$102,997,887.85
2025	$98,553,811.69
2026	$94,314,730.99
Total	$419,269,257.53

Alternative 2: Funding the EV Rebate Program

- Time: 5 years
- Discount: 7%
- Formula: $NPV = \sum \frac{FV}{(1+R)^T}$

$$\frac{29,460,343}{(1.07)^0} + \frac{41,661,851.58}{(1.07)^1} + \frac{57,063,397.86}{(1.07)^2} + \frac{69,664,982.81}{(1.07)^3} + \frac{79,666,607.38}{(1.07)^4} = \$235,882,685.44$$

	Fiscal Year				
Costs	**2023**	**2024**	**2025**	**2026**	**2027**
Rebates	$29,400,000.00	$41,600,000.00	$57,000,000.00	$69,600,000.00	$79,600,000.00
Salary *	$60,343	$61,852	$63,398	$64,983	$66,607
Total	$29,460,343.00	$41,661,851.58	$57,063,397.86	$69,664,982.81	$79,666,607.38

**Salary increases by 2.5 percent annually to mimick annual raises*

Source: Department of Planning and Budget, 2021a; GovSalaries, 2023a.

	NPV of Costs
2023	$29,460,343.00
2024	$38,936,309.88
2025	$49,841,381.66
2026	$56,867,377.56
2027	$60,777,273.33
Total	$235,882,685.44

Alternative 3: Educational Campaign

- Average exchange rate in 2016: $1 CAD = $0.7832 USD (*Canadian Dollar to US Dollar Spot Exchange Rates for 2015*, n.d.)
- Formula: $PRICE_X = PRICE_Y \left(\frac{CPI_X}{CPI_Y}\right)$
- CPI 2016: 237.0 (Consumer Price Index, 1913-, 2023)
- CPI 2018: 251.1 (Consumer Price Index, 1913-, 2023)
- CPI 2023: 300.840 (Consumer Price Index Summary - 2023 M02 Results, 2023)

	2015 US Dollars	
Costs	CAD ($)*	USD ($)
Government Communication Plan	1,200,000	939,840
Funding Partner Projects	520,000	407,264
Salary		

**Initial #s are posted as annual funding, since the funds are reported for a 5 year period in the original document.*

Source: Canadian Dollar to US Dollar Spot Exchange Rates for 2015, n.d.; Propelling Québec Forward with Electricity: Transportation Electrification Action Plan 2015-2020, 2015.

	CPI Adjustment	
Costs	2015 USD	2023 USD
Government Communication Plan	939,840	1,193,002
Funding Partner Projects	407,264	516,968
Salary*	63,550	76,138.52

**Salary is in 2018 USD, but is converted to 2023 USD.*

Source: Consumer Price Index, 1913-, 2023; Consumer Price Index Summary - 2023 M02 Results, 2023; GovSalaries, 2023.

	Fiscal Year				
Costs	**2023**	**2024**	**2025**	**2026**	**2027**
Government Communication Plan	$1,193,002	$1,193,002	$1,193,002	$1,193,002	$1,193,002
Funding Partner Projects	$516,968	$516,968	$516,968	$516,968	$516,968
Salary	$76,139	$78,041.98	$79,993.03	$81,992.86	$84,042.68
Yearly Totals	$1,786,108	$1,788,011	$1,789,963	$1,791,962	$1,794,012

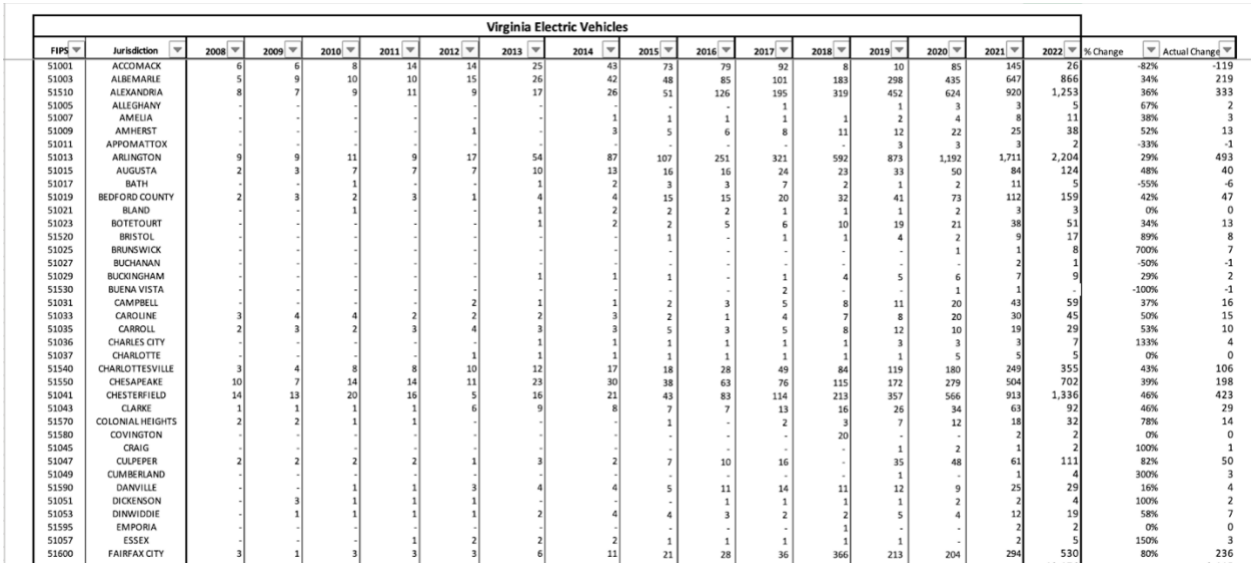
**Salary increases by 2.5 percent annually to mimick annual raises; the campaign costs remain roughly the same over the time period, based on the assumption that this money will provide for operating costs and other potential expenses of the program.*

- Time: 5 years
- Discount: 7%
- Formula: $NPV = \sum \frac{FV}{(1+R)^T}$

	NPV of Costs
2023	$1,786,108.00
2024	$1,671,038.75
2025	$1,563,422.58
2026	$1,462,775.05
2027	$1,368,643.29
Total	$7,851,987.68

APPENDIX B – EFFECTIVENESS CALCULATIONS

Screenshot of Excel File with Registration Data – Full Files Available Upon Request



Virginia Electric Vehicles

FIPS	Jurisdiction	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	% Change	Actual Change
51001	ACCOMACK	6	6	8	14	14	25	43	73	79	92	8	10	85	145	26	-82%	-119
51003	ALBEMARLE	5	9	10	10	15	26	42	48	85	101	183	298	435	647	866	34%	219
51510	ALEXANDRIA	8	7	9	11	9	17	26	51	126	195	319	452	624	920	1,253	36%	333
51005	ALLEGHANY	-	-	-	-	-	-	-	-	-	1		1	3	3	5	67%	2
51007	AMELIA	-	-	-	-	-	-	1	1	1	1	1	2	4	8	11	38%	3
51009	AMHERST	-	-	-	-	1	-	3	5	6	8	11	12	22	25	38	52%	13
51011	APPOMATTOX	-	-	-	-	-	-	-	-	-	-	-	3	3	3	2	-33%	-1
51013	ARLINGTON	9	9	11	9	17	54	87	107	251	321	592	873	1,192	1,711	2,204	29%	493
51015	AUGUSTA	2	3	7	7	7	10	13	16	16	24	23	33	50	84	124	48%	40
51017	BATH	-	-	1	-	-	1	2	3	3	7	2	1	2	11	5	-55%	-6
51019	BEDFORD COUNTY	2	3	2	3	1	4	4	15	15	20	32	41	73	112	159	42%	47
51021	BLAND	-	-	1	-	-	1	2	2	2	1	1	1	2	3	3	0%	0
51023	BOTETOURT	-	-	-	-	-	1	2	2	5	6	10	19	21	38	51	34%	13
51520	BRISTOL	-	-	-	-	-	-	-	1	-	1	1	4	2	9	17	89%	8
51025	BRUNSWICK	-	-	-	-	-	-	-	-	-	-	-	-	1	1	8	700%	7
51027	BUCHANAN	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-50%	-1
51029	BUCKINGHAM	-	-	-	-	-	1	1	1	-	1	4	5	6	7	9	29%	2
51530	BUENA VISTA	-	-	-	-	-	-	-	-	-	2	-	-	1	1	-	-100%	-1
51031	CAMPBELL	-	-	-	-	2	1	1	2	3	5	8	11	20	43	59	37%	16
51033	CAROLINE	3	4	4	2	2	2	3	2	1	4	7	8	20	30	45	50%	15
51035	CARROLL	2	3	2	3	4	3	3	5	3	5	8	12	10	19	29	53%	10
51036	CHARLES CITY	-	-	-	-	-	1	1	1	1	1	1	3	3	3	7	133%	4
51037	CHARLOTTE	-	-	-	-	1	1	1	1	1	1	1	1	5	5	5	0%	0
51540	CHARLOTTESVILLE	3	4	8	8	10	12	17	18	28	49	84	119	180	249	355	43%	106
51550	CHESAPEAKE	10	7	14	14	11	23	30	38	63	76	115	172	279	504	702	39%	198
51041	CHESTERFIELD	14	13	20	16	5	16	21	43	83	114	213	357	566	913	1,336	46%	423
51043	CLARKE	1	1	1	1	6	9	8	7	7	13	16	26	34	63	92	46%	29
51570	COLONIAL HEIGHTS	2	2	1	1	-	-	-	1	-	2	3	7	12	18	32	78%	14
51580	COVINGTON	-	-	-	-	-	-	-	-	-	-	20	-	-	2	2	0%	0
51045	CRAIG	-	-	-	-	-	-	-	-	-	-	-	1	2	1	2	100%	1
51047	CULPEPER	2	2	2	2	1	3	2	7	10	16	-	35	48	61	111	82%	50
51049	CUMBERLAND	-	-	-	-	-	-	-	-	-	-	-	1	-	1	4	300%	3
51590	DANVILLE	-	-	1	1	3	4	4	5	11	14	11	12	9	25	29	16%	4
51051	DICKENSON	-	3	1	1	1	-	-	-	1	1	1	1	2	2	4	100%	2
51053	DINWIDDIE	-	1	1	1	1	2	4	4	3	2	2	5	4	12	19	58%	7
51595	EMPORIA	-	-	-	-	-	-	-	-	-	-	1	-	-	2	2	0%	0
51057	ESSEX	-	-	-	1	2	2	2	1	1	1	1	1	-	2	5	150%	3
51600	FAIRFAX CITY	3	1	3	3	3	6	11	21	28	36	366	213	204	294	530	80%	236

Annual Growth Rates

	Rates			
Alternatives	**Average Growth in past 5 Years of Data (2017-2021)**	**Non-linear Growth Rate Effect Per Year**	**Additional Growth Rate from Interventions**	**Total Growth Rate Per Year**
Status Quo	42%	0.2%	1.78%	44%
Funding Rebate Program			17.05%	59%
Educational Campaign (Low)			7.65%	50%
Educational Campaign (Medium)			34.83%	77%
Educational Campaign (High)			62.00%	104%
	Source: EV Dashboard, 2023.	*Source: Chakraborty et al., 2021.*	*Source: Clinton & Steinberg, 2019; DeShazo et al., 2017; Jenn et al., 2018; Wee et al., 2018; Xue et al., 2021.*	

Alternative 1: Status Quo

Status Quo	Number of EVs
2022	*979*
2023	1,410
2024	2,030
2025	2,923
2026	4,210
2027	6,062
Total	16,634

Source: Chakraborty et al., 2021; EV Dashboard, 2023; Xue et al., 2021.

Alternative 2: Funding EV Rebate Program

Funding EV Rebate Program	Number of EVs
2022	*979*
2023	1,557
2024	2,475
2025	3,935
2026	6,257
2027	9,949
Total	24,173

Source: Chakraborty et al., 2021; Clinton & Steinberg, 2019; DeShazo et al., 2017; EV Dashboard, 2023; Wee et al., 2018; Xue et al., 2021.

Alternative 3: Educational Campaign

Low	
Education Campaign	**Number of EVs**
2022	*979*
2023	1,469
2024	2,203
2025	3,304
2026	4,956
2027	7,434
Total	19,366

Source: Chakraborty et al., 2021; EV Dashboard, 2023; Jenn et al., 2018.

Medium	
Education Campaign	**Number of EVs**
2022	*979*
2023	1,733
2024	3,067
2025	5,429
2026	9,609
2027	17,008
Total	36,846

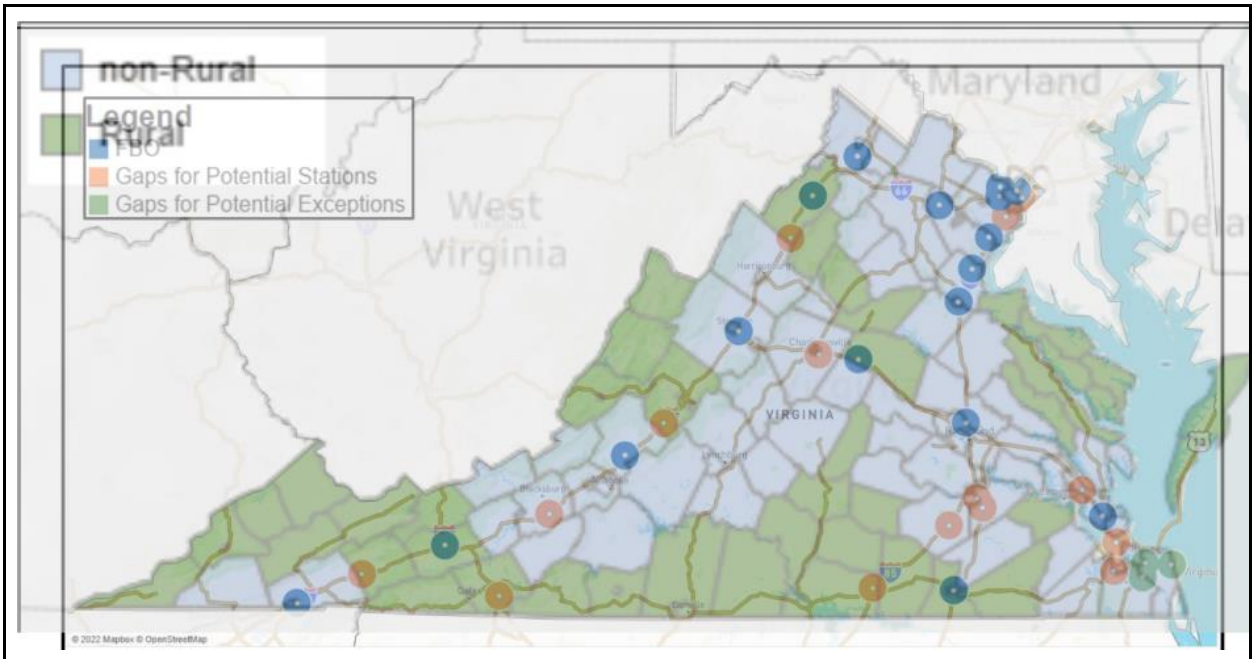
Source: Chakraborty et al., 2021; EV Dashboard, 2023; Jenn et al., 2018.

High	
Education Campaign	**Number of EVs**
2022	*979*
2023	1,997
2024	4,074
2025	8,311
2026	16,955
2027	34,589
Total	65,927

Source: Chakraborty et al., 2021; EV Dashboard, 2023; Jenn et al., 2018.

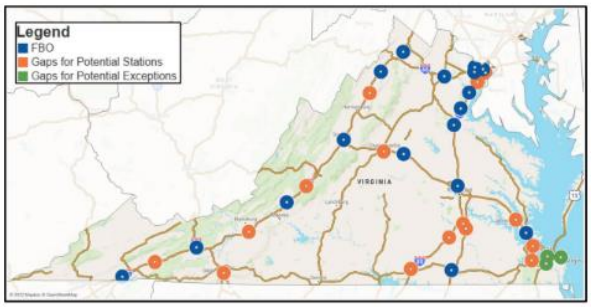
APPENDIX C – EQUITY MAPS

Alternative 1: Status Quo

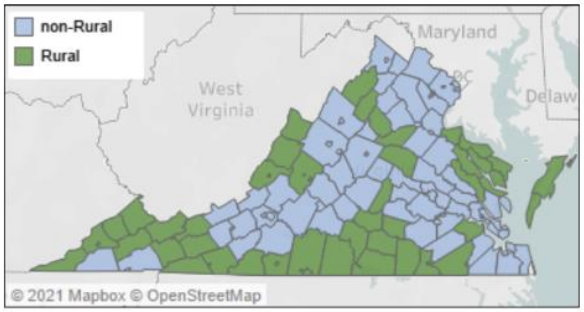


NEVI Plan Legend	Rurality Map Legend
• Blue Dots: FBO • Orange Dots: Gaps for Potential Stations • Green Dots: Gaps for Potential Exceptions *FBO means "fully built out" EV chargers, which are currently accessible EV charging stations	• Non-Rural: Blue Counties • Rural: Green Counties

Figure 1: A Map of Current and Proposed EV Chargers, Based on 2022 NEVI Plan, overlaid on Map of Rural (versus Non-Rural) Counties in Virginia (Virginia Department of Transportation, 2022; Virginia Rural Health Plan, 2022).

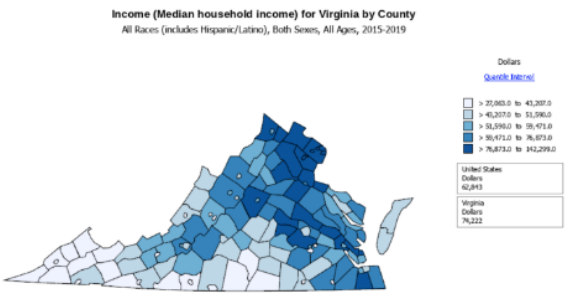


Map of Current and Proposed EV Chargers, Based on 2022 NEVI Plan (Virginia Department of Transportation, 2022). Notes: FBO means "fully built out" EV chargers, which are currently accessible EV chargers stations

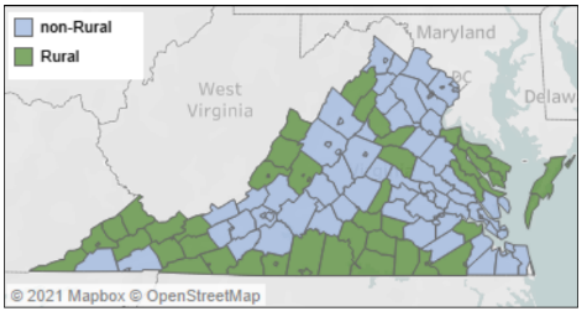


Map of Rural Counties in Virginia, Based on OMB classifications (Virginia Rural Health Plan, 2022).

Alternative 2: Funding the EV Rebate Program



Map of Median Household Income in Virginia by County (Income Map for Virginia Counties | HDPulse Data Portal, 2019).



Map of Rural Counties in Virginia, Based on OMB classifications (Virginia Rural Health Plan, 2022).

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