THE CLASS OF 1964 POLICY RESEARCH SHOP

RESPONDING TO INCREASING EV USE IN VERMONT

PRESENTED TO THE VERMONT SENATE COMMITTEE ON TRANSPORTATION

Senator Richard Mazza, Chair

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EXECUTIVE SUMMARY

As electric vehicles (EVs) become more common, and public EV infrastructure more extensive, the State of Vermont will likely need to address three issues: reduced gas tax revenue, public EV charger siting, and expired EV battery processing. EVs do not consume gasoline, so the adoption of EVs will diminish gas tax revenue, which represents a significant share of Vermont's transportation budget. Increasing EV use necessitates the development of public charging stations, which can be placed strategically to maximize utility and minimize strain on the electric grid. Finally, EV batteries eventually expire after use, and Vermont may want to implement strategies for regulating and recycling these expired batteries. We aim to provide the Vermont Senate Committee with information about the scale of these challenges and potential solutions for addressing them.

1 INTRODUCTION

The passage of the Inflation Reduction Act in 2022 significantly bolstered pre-existing federal incentives for the purchase of electric vehicles. State-funded EV incentives in Vermont, combined with federal funding sources, have created an environment that favors the expansion of EV use in the near future. Indeed, major automakers have committed to producing many more EVs in the coming years.[1] The number of EVs (including both plug-in-hybrids and fully electric vehicles) in Vermont increased from 5,174 in June, 2021, to 7,491 in June, 2022.[2] By 2025, Vermont can expect EVs to represent at least 5.4 percent of all new vehicles sold within its borders.[3]

The expansion of EV use in Vermont represents an opportunity to meet the greenhouse gas reduction targets that Vermont has set. Currently, transportation accounts for approximately 40 percent of total greenhouse gas emissions in Vermont, more than any other sector of the state's economy.[4] Because the transportation sector represents such a large fraction of the carbon footprint of Vermont, the Vermont Climate Council 2021 Climate Action Plan considered vehicle electrification a "critical short-term priorit[y]"[5] for the state. The plan also notes that electrification would create substantial economic benefits for Vermont. While most of the money spent on fossil fuel transportation leaves the state, vehicle electrification allows for a higher share of profits to remain in-state;[6] it can also reduce the health impacts of pollution, saving the state as much as $73 million by 2050 in avoided medical costs.[7]

These benefits, however, will not be realized easily; Vermont will likely face numerous challenges as EVs become more common. This report assesses the scale of these challenges and solutions to address them, with a special focus on those solutions that have already been developed and implemented in other states.

2 PROBLEM STATEMENT

Vermont is likely to face three key challenges as EV use and EV infrastructure expand. A thorough understanding of each of these challenges will enable lawmakers to decarbonize the Vermont transportation sector more efficiently and effectively.

The first challenge Vermont will face is how to recoup lost gas tax revenue amid increasing EV use. What methods can Vermont use to assess fees on EVs? Are flat fees or mileage fees more sustainable? Do fees disincentivize EV adoption? What parties might be involved in administering these fees? We address these questions and identify ways that Vermont can recover lost gas tax revenue while continuing to support the electrification of its transportation sector.

Second, as EV use expands and both state and federal funding sources for EV chargers grow, Vermont faces choices about where to place new EV charging stations. The siting of public chargers is especially critical for Vermont because its large rural areas necessitate reliable charging stations, but these stations may strain the rural electric grid and are unlikely to be profitable in the near term. Where can public chargers be placed to maximize their accessibility and efficiency? Are different types of charges most useful in regions with different characteristics? Is the Vermont electric grid equipped to meet the additional load imposed by public chargers? By answering these questions, we will provide insights into how public charging stations can be sited to maximize benefits to the people of Vermont.

The third major challenge Vermont faces due to growing EV use is an increasing number of expired EV batteries. Though EVs are rechargeable, their batteries do not last forever.[8] As EVs become more common, it will be critical to develop regulations for managing unusable batteries. Can expired batteries be recycled? What will it cost to recycle them? Can expired batteries be used for other purposes, even if they are no longer suitable for EVs? If batteries must be discarded, what procedures will need to be followed to ensure that they do not damage the environment or create health risks? Given that many EV batteries are expected to last for 17 years or more, these problems may not be immediately apparent;[9] however, Vermont will be better able to address them in the future if it begins this process now. We aim to provide the tools for Vermont to do so.

3 GAS TAX ALTERNATIVES FOR ELECTRIC VEHICLES

As electric vehicle (EV) and hybrid vehicle adoption rises in Vermont, the state will face increasing losses in gas tax revenue. This section examines possible solutions for replacing this revenue stream while continuing to support the electrification of the transportation sector.

3.1 BACKGROUND

Vermont stands to lose a significant portion of state gas tax revenue. If Climate Action Plan targets are achieved, and there are 658,000 EVs in the state in 2050, the loss in revenue will jump from $300,000 in 2021 to $19 million in 2030 and $81 million in 2050.[10] These losses could diminish road funding as gas tax revenue accounts for nearly a third of the state Transportation Fund, suggesting the need for a sustainable alternative to the gas tax.[11]

The two most common alternatives to the gas tax include an electric vehicle registration fee, which adds an additional charge to annual state registration fees, and the road usage charge (RUC), which charges a fee based on each mile driven, using technological or manual methods of mileage reporting. Over thirty states have enacted additional EV registration fees and three states, Utah, Oregon, and Virginia, have active RUC programs.[12] Both methods aim to replace lost gas tax revenue, holding EV drivers responsible for the same road maintenance costs imposed on the drivers of gas-powered vehicles.

This section will examine the feasibility and effectiveness of the two alternatives to the gas tax, the additional registration fees and road usage charge, by examining how these policies have worked when implemented in other states.

3.2 METHODOLOGY

After interviewing officials in the transportation and energy departments of peer states, we employed a state-by-state comparison to determine the efficacy of gas tax alternative policies. The following outlines the rationale for the states included in our comparison.

3.2.1 COMPARISON STATE RATIONALE

The following three states serve as useful comparisons to Vermont: Colorado, Utah, and California. In 2021, the market share of EVs in Colorado and Utah was roughly equivalent to that of Vermont. EVs accounted for 0.6 percent of all vehicles registered in Vermont and Utah in 2021, and 0.7 percent in Colorado.[13] All four states, including California, exhibited similar growth in market share of EVs between 2020 and 2021, and all offer EV incentives.[14]

3.2.2 COMPARISON STATE ELECTRIC VEHICLE FEES

The EV fees in each of the comparison states are outlined below. Colorado, Utah, and California charge additional registration fees for EVs, which increase annually with inflation. While only Utah has an active RUC program, all three states have completed at least a pilot RUC program.

Colorado: The state currently charges an additional registration fee of $51.88 plus a road usage flat fee of $4 for EVs (2023).[15] Colorado completed a pilot RUC program in 2016, which was tested on

147 vehicles of various fuel efficiencies (gas, hybrid, electric) and offered three mileage reporting options.[16] Despite the pilot, the state is not currently considering a RUC program because the additional registration fees were enacted in 2017 as part of a comprehensive plan to provide an alternative source of revenue for at least 10 years.[17] The state was awarded federal funds to pursue alternative funding mechanisms, such as RUC, but ultimately returned them.[18]

Utah: The state offers EV drivers the option to pay the additional registration fee of $130.25 or enroll in a RUC program where drivers pay one cent per mile up to a cap of $130.25 (2023-2024).[19] The RUC program is only available for EVs and offers one mileage reporting option, a plug-in device, which is managed through one third-party account manager, Emovis.[20]

California: The state currently charges an additional registration fee of $108 (2023-2024).[21] The state completed a RUC pilot program in 2016, which was tested on 5,000 vehicles of various fuel efficiencies (gas, hybrid, electric) and offered six mileage reporting options.[22] The automated reporting options were handled by multiple account managers, including a state-run account manager and private account managers.[23] California is actively pursuing a RUC program, especially given the ambitious state goal to eliminate sales of new gasoline-powered vehicles by 2035 and the anticipated effects on gas tax revenue.[24] A report of the newest pilot program in the state, completed in 2021, had not yet been released at the time of writing.[25]

In summary, Colorado, Utah, and California exemplify three distinct cases of EV fees. Colorado is committed to a basic, flat-rate method of charging EVs. Utah offers a simplified RUC program with one method of mileage reporting and one account manager, while California is considering a more complex RUC program that would offer multiple methods of mileage reporting with multiple account managers. To note, the pilot programs in Colorado and California did not focus on the revenue impacts of RUC, but rather the administrative feasibility of a RUC program, though officials from both states believe that a RUC program could provide a sustainable source of revenue.[26]

3.3 SUMMARY OF FINDINGS

We detail lessons learned from the additional registration fees and RUC programs in the states examined.

3.3.1 ADDITIONAL REGISTRATION FEES

Additional registration fees do not fully replace gas tax revenue loss: EV registration fees are a popular approach to addressing gas tax revenue loss in part because they rely on existing state registration systems. However, based on analysis of the comparison states, the fees are insufficient. Colorado has pulled more than $1 billion from the general fund in the last five years to support transportation costs, despite the additional registration fees in effect since 2017, which suggests that the registration fees are not adequately recovering lost revenue.[27] In Utah and California, EV registration fees cover only about a third of gas tax revenue. On average, gas-powered sedan drivers in Utah paid $187 in state gas taxes in 2019, and the additional registration fee was $60.[28] A vehicle owner in California pays $300 per year on average in state gas taxes, while the additional registration fee is $108.[29] In California, the additional registration fees combined with the gas tax were estimated to lead to a decrease in infrastructure funding by over $500 million annually by 2030, assuming the state reaches the goal of five million zero-emission vehicles on the road in 2030 (this estimate was based on the registration fee in 2018, which was $100 at the time).[30]

Disincentive effects could arise from increasing registration fees: EV registration fees are expected to continue to increase. For example, Colorado anticipates that the road usage flat fee for battery electric vehicles (included in the additional registration fee) will rise from $4 (2023) to $96 in 2032.[31] These rising fees could disincentivize EV adoption. A report by the Institute of Transportation Studies at UC Davis found that additional registration fees in California would reduce zero-emission vehicle sales by 10 to 20 percent in the short run (long-run effects are more challenging to predict).[32] EV incentives, such as tax credits, as offered in the three comparison states, may compete with rising registration fees.[33]

3.3.2 PILOT ROAD USAGE CHARGE PROGRAMS

Pilot RUC programs show strong participant satisfaction: Participants enrolled in the Colorado and California pilot RUC programs were generally very satisfied, measured using four comparable characteristics: drop-out rate, willingness to participate in a RUC program again, how easy the program was to use, and satisfaction with mileage reporting method, according to the participants. These statistics are likely not reflective of the entire population, but they do indicate state ability to effectively implement a RUC program. The drop-out rate was only five percent in Colorado and four percent in California.[34] In both pilots, over 90 percent of participants said they would be willing to participate in another RUC program and over 85 percent of participants reported that the RUC program was easy to use.[35] In California, 86 percent of participants reported being satisfied with the mileage reporting method and, in Colorado, 99 percent of participants felt that the mileage reported on the invoice was accurate.[36]

Pilot enrollees mostly opted for automated mileage reporting methods: The Colorado pilot offered three mileage reporting options: a plug-in device with GPS tracking (automated), a plug-in device without GPS tracking (automated), and submitting evidence of odometer readings (manual).[37] 87 percent of participants opted for the automated methods.[38] The state found that the devices were highly-accurate and convenient, while the manual odometer was difficult to enforce and had lower overall satisfaction ratings.[39] The California pilot offered six reporting methods: time permit (pre-pay for an unlimited amount of driving in a fixed time), mileage permit (pre-pay for a fixed number of miles), manual odometer (submit evidence of odometer), plug-in device, smartphone app, and in-vehicle telematics.[40] Seventy-nine percent of participants chose one of the automated options (plug-in device, smartphone app, or in-vehicle telematics), and of these participants, 60 percent chose the plug-in device.[41]

3.3.3 CURRENT ROAD USAGE CHARGE AND FUTURE CONSIDERATIONS

RUC could be a long-term solution if many vehicles are enrolled: Utah has identified the RUC program as a potential long-term solution if the state is able to enroll more participants, including non-electric vehicles.[42] If Utah uses a real-time technology-based odometer, as used in their current program, and assesses fees for all vehicles with a qualified mpg rating of 30 or more, expanding eligibility every two years, the state anticipates it can enroll 570,000 vehicles in RUC by 2024 and raise $6.85 billion in transportation funding between 2024 and 2031.[43] If the state opted for a manual odometer method, with the lump-sum due at the time of annual vehicle registration, the state would assess fees for all vehicles with a qualified miles per gallon rating of 20 or more and would expect to enroll two million vehicles by 2024, raising $7.04 billion in transportation funding between 2024 and 2031.[44]

RUC programs present some advantages over EV registration fees: In recent years, RUC programs have grown increasingly popular because they reflect the cost of per-mile travel and could encourage vehicle owners to be more mindful of their driving frequency and distance. RUC programs are also more similar to traditional state gas taxes than EV registration fees as RUC relies on individual driving behavior. Furthermore, a RUC program could potentially replace the gas tax altogether if it enrolled vehicles of all fuel efficiencies.

Privacy concerns are a major obstacle to RUC enrollment: In Utah, only 4,050 vehicles, three percent of eligible vehicles, are currently enrolled in the RUC program.[45] Though the state dropped the per-mile cost from 1.5 cents to one cent in 2023 to incentivize participation, Daryl Ballantyne of the Utah Department of Transportation says that privacy concerns have continued to be a barrier to enrollment.[46] Security was also a focal concern of the California pilot RUC program, especially after the passage of the California Consumer Privacy Act in 2020, the first state-level consumer privacy law to date that gives consumers more control over the personal information that businesses collect.[47] In managing multiple account managers, the pilot program implemented extensive security measures including authentication and authorization for data access, data masking, and encryption.[48] Seventy-eight percent of participants were satisfied in regards to pilot privacy and data security, though due to the voluntary nature of the pilot and the current concerns in Utah, this statistic is not reflective of the larger population, and RUC programs likely demand greater oversight and security.[49]

RUC programs pose high administrative costs: It currently costs the Utah Department of Transportation $100 per month for each vehicle enrolled in RUC.[50] However, if the state switches from the plug-in device to a manual odometer method, the state estimates that it can bring administrative costs down to $5 per month for each enrolled vehicle.[51] In California, while gas tax collection costs represent just 0.54 percent of gas tax revenue, the administrative costs of a RUC program are expected to be five to ten percent of RUC revenue.[52] Lauren Prehoda of the California Department of Transportation (CDOT), however, notes that gas tax collection is abnormally low-cost and that the RUC program would be similar to other state-issued programs.[53]

Out-of-state and private road driving is difficult to account for under RUC: After completing the pilot RUC programs, both Colorado and California identified out-of-state driving and travel on private roads as areas that needed further research before a RUC program could be implemented.[54] A GPS-based mileage reporting method could distinguish between in-state and out-of-state driving and different roads, but would require location tracking, which poses security and privacy concerns. The Utah RUC program currently does not separate out-of-state driving or private roads, so the program charges drivers for both.[55]

Rural drivers save under a RUC program, according to a recent report: As rural drivers typically travel longer distances, one concern regarding a RUC program, particularly one that involves vehicles of all fuel efficiencies, is the impact on equity. Using data from fourteen states involved with RUC initiatives, a study by RUC America in 2022 examined how household payments change if fuel taxes are replaced with a state RUC that collects an equivalent amount of revenue to the current state policy (a "revenue neutral" RUC rate).[56] The report found that, on average, vehicle payments would decrease by 6.4 percent for households in "Rural Independent" areas (less than 50 percent of commuters travel into urban areas and the population is under 10,000), and decrease by roughly 2 percent for "Rural

Commuter" areas (more than 50 percent of commuters travel into urban areas and the population is under 10,000) and "Small Urban" areas (population is greater than 10,000 but smaller than 250,000).[57] In comparison, households in urban areas would experience small increases in payments. For example, payments for households in "Large Urban Dense" areas (where the metro population is greater than 250,000) would increase by 2.8 percent.[58] Though rural drivers would pay more than urban drivers overall because they generally travel longer distances, rural drivers would pay less and urban drivers would pay more than they currently do under fuel taxes.[59] This report relies on the fact that rural drivers typically have less fuel-efficient vehicles than urban drivers, so a RUC program could more evenly balance the burden of road funding.[60]

A free market for RUC account managers may be optimal in the future: California is considering a system in which multiple third-party account managers could compete with each other to attract RUC users to their platforms.[61] Under this system, the state would be impartial to any particular account manager and would instead oversee security measures and other regulations governing the account managers.[62] Lauren Prehoda of CDOT imagines that these account managers could, in the future, include big companies like Verizon, Amazon, and Uber.[63] Multiple account managers would allow drivers to make more individualized choices and also would limit the monopolistic positions held by single-contract account managers. For example, Emovis, the account manager for the Utah RUC program, also manages the RUC program in Oregon and managed the pilot program in Washington with limited competition.[64] A competitive market may spur managers to add additional features to their mileage-reporting services to attract drivers.

3.4 KEY TAKEAWAYS

States must consider the long-term effectiveness of alternatives to the gas tax: EV registration fees are not sustainable alternatives to the gas tax. In all three comparison states, EV registration fees fail to fully recoup lost gas tax revenue. For states with a large number of EVs, like California with the largest share of EVs in the country, the loss of revenue is felt more intensely.[65] This is not as pressing of a problem for states like Colorado and Utah, where electric and hybrid vehicles comprise a small portion of total registrations (6.5 percent in Colorado for EVs and plug-in hybrids and 2.4 percent in Utah for EVs and full hybrids in 2021).[66] However, all three states are working to test alternative fee structures now so they are operational in the future when additional revenue sources are more strongly demanded. Similarly, while EVs account for only five percent of new vehicle sales in Vermont (2022), the state may want to continue considering and testing long-term replacements now as the state exhibits strong EV growth (the number of EVs grew 35 percent between 2022 and 2023).[67]

Automated mileage reporting methods are generally preferred in RUC programs, but may come with higher costs and security challenges: Pilot RUC participants showed a clear preference for automated mileage reporting, with over 75 percent of participants in the Colorado and California pilots opting for automated methods.[68] Multiple methods allow for more user flexibility and convenience, but also pose administrative challenges with handling the many third-party account managers. For a smaller state like Vermont, implementing an extensive security and regulatory system may be administratively feasible. Instead, the state could explore working with a single account manager or using a more manual method (like an odometer) to start. In the future, as an increasing number of new cars have telematics, the technology may become more reliable and easier to administer.[69] In addition, as RUC programs become larger, states may opt to shift administrative responsibilities to different departments. California, for example, is already considering splitting state administration such that the Department of Transportation would handle EV fees while the Department of Tax and Fee Administration would handle commercial vehicles, like trucks (a change that would occur gradually over seven years).[70]

Equity remains a concern under a RUC program: Although the report by RUC America showed that rural drivers save under a RUC program, research in this area is still limited. States with a large number of rural drivers will need to consider the impacts of RUC more closely, and potentially complete research specifically tailored to the rural population in the state, such as Vermont, where nearly two-thirds of residents live in rural areas.[71]

More research is needed to determine how to account for out-of-state drivers under RUC: States with a large number of tourists (or with residents who frequently travel out-of-state) must consider the limitations of RUC. Vermont would likely face this same dilemma as tourism is an important part of the state economy. In the future, states may collaborate to charge for out-of-state miles. Such coalitions are already in development, like RUC America, which aims to organize states researching or implementing RUC programs and is currently composed of mostly western states.[72] However, states surrounding Vermont in New England have also begun to research the possibility of RUC. The New Hampshire Department of Transportation, for example, received a federal grant of $250,000 in 2018 to study a road usage fee.[73]

4 EV CHARGING STATION SITING STRATEGIES

In order to adapt to and support the increasing adoption of EVs, both the Vermont government and the federal government have opted to invest public funds in EV charging infrastructure. This section critically examines the strategies employed by the State of Vermont for selecting public EV charging sites and provides insights for how these strategies might be improved to more efficiently and effectively meet the need for public EV chargers.

4.1 BACKGROUND

This section provides an overview of the existing landscape of EV charging in Vermont, technological considerations relevant to EVs and EV chargers, and both state and federal funding sources for public EV charging infrastructure.

4.1.1 CURRENT LANDSCAPE OF EV CHARGING IN VERMONT

With 144 charging stations for every 100,000 residents, Vermont currently has more EV chargers per capita than any other state in the nation.[74] There are 253 public charging stations in the state, including 28 Level Three DC Fast chargers and 225 slower Level One and Two stations.[75] The Vermont public charging network is likely to expand in the near future; the state has provided grants to install 262 additional charging stations, including 42 Level Three DC Fast chargers, 89 Level Two chargers, and 131 dual Level Two and Three charging stations.[76] Though most Level Three chargers and many Level Two chargers were installed in densely populated areas,[77] these grants will broaden public charging networks to rural areas such as Grand Isle and Essex county.[78] As discussed below, Vermont will soon see even more EV charging stations constructed with newly available federal funds from the National Electric Vehicle Infrastructure (NEVI) Program.

4.1.2 TECHNOLOGICAL CONSIDERATIONS

Range anxiety—the fear of not having adequate battery range or accessible charging to make a trip—is a common concern limiting EV adoption. Studies indicate that EV batteries are less efficient at cold temperatures, meaning that the maximum range of travel in an EV is especially limited in cold weather.[79] This has the potential to heighten range anxiety in states like Vermont that experience cold temperatures.[80] The figure below illustrates the number of miles that many common EV models can travel on one charge, and how these ranges vary in warm and cold weather. While all models included in the graphic have a range above 100 miles, even in freezing temperatures, there remains significant range loss in cold weather, and notable variability in range between models.[81] Given this variability by model and temperature, it is all the more important that the Vermont EV charging infrastructure be designed to minimize the distance between charging stations.

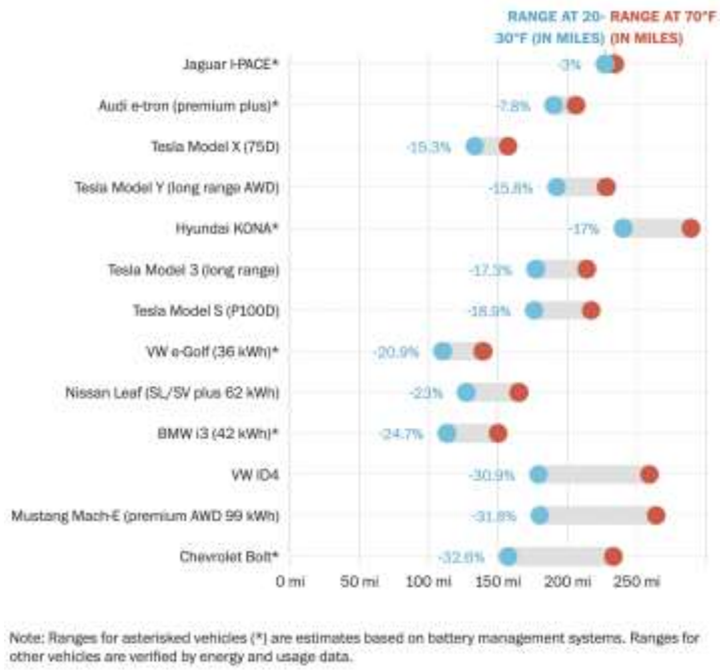

Figure 4.1.2.1: Comparison of electric vehicle ranges at freezing and warm temperatures.[82]

As with EVs, not all EV charger models are created equal. There are three main tiers of EV charging models: Level One, Level Two, and Level Three. Level One offers the slowest charging, at a rate of three to five miles of range per hour, but is easily plugged into a 120-volt home outlet. This type of charger is most useful for charging low-capacity plug-in hybrid vehicles. Level Two systems charge at a rate of twelve to eighty miles of range per hour, enabling quick top-offs. These chargers can also be installed in homes, albeit at a higher cost. Level Three systems, also known as Direct Current Fast Chargers (DCFCs), charge vehicles at a rate of three to twenty miles of range per minute. DCFCs cannot be installed in homes because they require high voltages and high capital costs. For this reason, Level Three chargers are generally used only at public or commercial charging stations.[83]

4.1.3 STATE EV AND EV CHARGER FUNDING SOURCES

There is no shortage of EV incentive programs in Vermont. Vermont's Incentive Program for New Plug-In Electric Vehicles, which was established by the 2019 Transportation Bill, provides financial incentives for Vermont residents, especially those in lower income brackets, to purchase EVs.[84] Incentives are indexed to adjusted gross income (AGI) and are as high as $3,000 for plug-in hybrid vehicles and $4,000 for all-electric vehicles.[85] The Vermont MileageSmart program provides up to $5,000 for low-to-moderate-income Vermonters to cover the upfront cost of purchasing a used high-efficiency vehicle such as an EV or hybrid.[86] The 2021 Transportation Bill established Replace Your Ride, an incentive program that offers up to $3,000 for Vermonters looking to retire an old vehicle and replace it with an EV.[87]

According to the Vermont Agency of Commerce and Community Development, "The State will continue investments in public charging stations as well as investments in home and workplace charging to ensure EV drivers have a reliable place to charge their vehicles."[88] That same agency also reports that the 362 percent increase in registered EVs in the state between 2015 and 2021 demonstrates a growing need for EV infrastructure investments.[89]

The Electric Vehicle Supply Equipment (EVSE) grant program was established in 2014 by the Vermont Department of Housing and Community Development to meet the need for EV infrastructure. ESVE grants have been supported by the $2.8 million settlement amount the state received from Volkswagen in 2017 for its violation of the Clean Air Act. $1.7 million of this funding was used to develop Level Two and Level Three stations to close gaps in Vermont's network of public charging stations. These gaps were also addressed by the $750,000 appropriated by the state legislature in 2021. In 2022, the state legislature appropriated $10 million to continue funding charging stations in the state.[90]

At-home charging stations are also an important piece of the EV charging infrastructure puzzle. The state legislature set aside $1 million in 2021 to fund a pilot program to incentivize installing chargers at multi-unit affordable housing locations. At a minimum, around $3 million of the 2022 EV charging appropriation will be used to expand this program. The 2022 appropriation will be also be used to incentivize installing chargers at workplaces, in communities, and at tourist destinations.[91]

4.1.4 FEDERAL EV CHARGER FUNDING SOURCES

Funding from the National Electric Vehicle Infrastructure (NEVI) Formula Program, allocated under the 2021 Infrastructure Investment and Jobs Act (IIJA), makes up a large portion of the funding available for states to construct EV charging stations. This program will provide approximately $21 million to Vermont over fiscal years 2022 to 2026. In fiscal year 2022, Vermont received $3.1 million through this grant program.[92] These funds come with a 20 percent match requirement which Vermont can meet through state funding or private investments.[93]

The NEVI Formula Program allocates funding to each state based on a formula, and these funds must be used to place stations of four 150-kW chargers at 50-mile intervals, no more than one mile from Federal Highway Administration-designated Alternative Fuel Corridors (AFCs). After these requirements are met, the funding may be used to build chargers at different intervals or further from the AFCs. NEVI discretionary funding is also available for states that wish to apply for federal dollars to use on additional EV infrastructure projects.[94]

Other IIJA programs that underserved and rural Vermont localities can apply for are the $2.5 billion Discretionary Grant Program for Charging and Fueling Infrastructure and the $15 billion Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program, from which Vermont received $34.6 million in funding in fiscal year 2022.[95]

The Inflation Reduction Act also allocated funds for electric vehicle infrastructure. It reinstated the Alternative Fuel Infrastructure Tax Credit, which can be used to cover 30 percent of electric vehicle charging projects in rural and disadvantaged areas, up to $100,000. For projects that comply with certain requirements for worker wages and apprenticeships, the $100,000 cap is waived.[96]

4.2 METHODOLOGY

In order to determine the optimal layout, placement, and type of charging stations for Vermont, we conducted a multi-state policy analysis. We reviewed the electric vehicle infrastructure plans submitted to the Federal Highway Administration in 2022 by Vermont and three states with similar characteristics: Maine, Utah, and Colorado. We also contacted individuals involved in the creation and implementation of these plans. We conducted personal interviews with individuals from each of these states, excluding Utah, whose Department of Transportation opted to send us a list of relevant documents in lieu of an interview.

To complete our understanding of EV charger siting in Vermont, we also contacted representatives of the companies that have received grants from the Vermont state ESVE program to install public charging stations, focusing on those companies that operated in rural regions of the state. By interviewing these entities, we sought to examine three critical aspects of the installation process: finding site hosts, accounting for grid infrastructure, and assessing economic viability.

Unfortunately, only Norwich Technologies, the 2021 grant recipient, was available to be interviewed. However, we are confident that this company's experiences are relatively generalizable because they were contracted to install chargers in several rural communities throughout the state. The relevance and accuracy of these challenges were also supported by our interview with the Vermont Department of Housing and Community Development, which administers many EV charging grant programs.

After reviewing state EV charger siting plans and speaking with state officials and local charging companies, we conducted a comparative analysis to determine how siting strategies differ state-by-state. We focused on the differences in how each state defined its goals for EV charging infrastructure and how the states went about identifying and addressing challenges related to six key areas: climate, rurality, equity, grid capacity, tourism, and supply chain delays. We then identified key findings based on this comparative analysis.

4.3 CURRENT VERMONT SITING STRATEGIES

This section details how public EV charging sites are currently selected in Vermont. Specifically, the key goals guiding the Vermont EV siting strategy are outlined, as well as six categories of significant challenges Vermont has attempted to address as they build charging stations across the state.

Guiding Goals: In August of 2022, the Vermont Agency of Transportation (VTrans) submitted the State of Vermont National Electric Vehicle Infrastructure (NEVI) Plan to the Federal Highway Administration. This document, approved by the FHWA in late 2022, outlines how Vermont will use NEVI funds to expand its electric vehicle charging network throughout the next five years.[97]

Per the rules of the NEVI Formula Funding Program, Vermont must use its $21,215,761 in NEVI funding[98] to fill out its federally designated Alternative Fuel Corridors (AFCs) in line with the stringent NEVI siting requirements before those funds can be allocated for any other purpose.[99] The plan sets out a goal of achieving "fully built-out" status for each of its AFCs, and investing the entirety of the available NEVI funding toward this end in FY22 and FY23.[100] 'Fully built-out' status entails having charging stations at 50-mile intervals along AFCs, no more than 1 mile off from the AFC, each with a charging capacity of four 150-kW DCFCs that can charge four vehicles at the same time.[101] The plan also acknowledges that the 2022 Vermont state transportation bill set an even more stringent goal of placing DCFCs at *twenty-five-mile* increments along every state highway.[102]

Route	Designation
I-89 from NH border to Quebec border	Corridor-ready
I-91 from MA border to Quebec border	Portions corridor-ready and pending
I-93 from St Johnsbury to NH border	Portions corridor-ready and pending
US 2 from Montpelier to the NH border	Portions corridor-ready and pending
US 7 from MA border to S Burlington	Portions corridor-ready and pending
VT 9 from NH border to NY border	Corridor-ready

Table 4.3.1: Vermont Alternative Fuel Corridors.[103]

The above table from the Vermont NEVI Plan lists the stretches of AFC-designated road on which there are already EV chargers located at appropriate distances under the NEVI requirements ("corridor-ready") and the stretches on which further construction of or upgrades to charging stations are needed in order to meet these requirements ("corridor-pending").

The report finds that ten new charging stations must be added, and five must be upgraded, in order for Vermont to attain a status of "fully built-out."[104] The sites are listed in the following table:

State EV Charging Location Map ID	Route(s)	Location	Anticipated EV Network	Utility Territory	Status
1	I-89	St Albans	TBD	Green Mountain Power	To be constructed
2	I-89 / US 7	S Burlington	TBD	Green Mountain Power	To be constructed
3	I-89 / US 2	Berlin	TBD	Green Mountain Power	To be constructed
4	I-89	Randolph	Blink	Green Mountain Power	Potential exception for contracted installation
5	I-89 / I-91	White River Jct	TBD	Green Mountain Power	To be constructed
6	I-91	Derby	Blink	VT Electric Coop	Potential upgrade of current installation
7	I-91 / US 2	St Johnsbury	Blink	Green Mountain Power	Potential upgrade of current installation
8	I-91	Bradford	TBD	Green Mountain Power	To be constructed
9	I-91	Springfield	Blink	Green Mountain Power	Potential upgrade of current installation
10	I-91 / VT 9	Brattleboro	TBD	Green Mountain Power	To be constructed
11	US 7	Middlebury	TBD	Green Mountain Power	To be constructed
12	US 7	Rutland	Blink	Green Mountain Power	Potential upgrade of current installation
13	US 7	Manchester	TBD	Green Mountain Power	To be constructed
14	US 7 / VT 9	Bennington	TBD	Green Mountain Power	To be constructed
15	VT 9	Wilmington	TBD	Green Mountain Power	To be constructed

Table 4.3.2: Intended FY23 NEVI-Funded Charging Locations.[105]

All sites listed above in Table 4.3.2 and shown in bright green on Figure 4.3.3 below fall within the location requirements for NEVI-funded charging sites along AFCs, with the exception of the Randolph location. The Randolph charger (location number four) would be located three miles from the designated AFC on I-89. VTrans has requested a discretionary exception to supplement this already contracted two-charger station with another two 150-kW chargers a mile from the highway, and count the whole as one NEVI-compliant charging location.[106]

Figure 4.3.3: Intended FY23 NEVI-Funded Charging Locations Map.[107]

Patrick Murphy, Sustainability and Innovations Project Manager at VTrans, noted that if the FHWA does not grant the discretionary exception that Vermont requested for the Randolph charging location, one to two additional charging stations may have to be built. As of this writing, the FHWA has yet to provide a clear response to the exception request that VTrans made.[108]

Climate Considerations: As a state that experiences very cold temperatures in the winter time, Vermont must be cognizant of the decreased range that EVs experience in cold weather.[109] Chargers themselves can also be negatively impacted by ice formation and cold temperatures, so the Vermont NEVI Plan recommends use of charging equipment that is specially rated by the National Electrical Manufacturer Association (NEMA) to shield electrical components from adverse conditions.[110] Climate change presents a challenge as well, and the NEVI Plan accordingly includes language about siting EV chargers away from areas prone to flooding.[111]

Rurality Considerations: Another challenge Vermont faces when planning EV charging sites is the extreme rural nature of many areas in the state. Not all parts of Vermont have the grid infrastructure needed to run DCFCs, and lower traffic concentrations in these areas mean that chargers placed there would likely be used much less frequently than chargers placed in more urbanized areas.[112] Such realities make chargers in rural locations more costly to operate and potentially a less efficient use of public funds.

In many rural areas of Vermont, identifying site hosts for new charging stations presents a significant difficulty for installers. Towns in these areas are hesitant to establish charging stations for several reasons. First, they face constraints on the number of parking spaces that are available to be converted into charging stations.[113] Second, EV penetration into these areas is relatively low, and residents who own EVs usually have a Level Two charger at home.[114] As a result, residents of rural towns often do not see the need to install a public charger. Level Three chargers are primarily used by long-distance travelers,[115] so rural communities also do not tend to see the tradeoff between parking spaces and charging stations as beneficial. This source of hesitancy is further complicated by the fact that potential hosts often have an incomplete understanding of the rules governing the purposes for which grant money can be spent by installers.[116]

This hesitancy also reduces the overall efficiency of public chargers. To meet grant requirements, a charger needs to service at least four parking spots, but the hardware needed to meet this requirement can accommodate 6 cars altogether.[117] Because some towns are unwilling to devote more parking spots than necessary to these projects, the charging station's hardware is relatively underutilized.

To resolve these difficulties, Norwich Technologies has occasionally offered to establish lease agreements with site hosts for their parking spaces. This solution, however, is not perfect because the revenue generated by the use of a charger is usually low (we will return to this issue in Section 3.1.3).[118] Norwich Technologies has also attempted to inform potential hosts about the ability of new charging stations to increase the number of long-distance travelers who pass through a community (thereby increasing commerce). This effort has yielded only mixed results because even towns that see the potential long-term benefits of a charger are still hesitant to sacrifice their limited parking spaces.[119] As a result of these issues, installers have had minimal success convincing towns that are strongly opposed to giving up their parking spaces. In towns that are more inclined to host public chargers, siting chargers in less desirable parking spaces or in highly visible areas has proven to be an effective way of overcoming hesitancy.[120]

Hesitancy to host a charger can also stem from a lack of access to information on charger usage. As it stands, there is little publicly available data about electric vehicle charger use in the United States.[121] This lack of data creates a significant challenge for charging station installers because it prevents them from reliably modeling the revenues that a charger would generate. Though some forecasting services are available (for example, Stable Auto), these services are usually expensive and are not covered by the state's existing system of installation grants.[122]

These difficulties in predicting revenue are compounded by the high electrical costs associated with operating a charger. These costs are primarily driven by demand charges. High-power, rapid chargers have very high demand charges—by definition, they draw a large amount of energy in a short amount of time.[123] If charging stations are not used frequently, their operators are unable to spread out this demand charge, causing some stations to bring in a net loss for installers.[124] Some utilities have been willing to assist installers with this issue, while others have not done so,[125] creating regional differences in the feasibility of maintaining charging stations long-term.

Equity Considerations: The FHWA directs states to explain in their NEVI plans how they will ensure that at least forty percent of the benefits from the charging stations accrue to "disadvantaged communities" (DACs).[126] Based on this requirement, laid out by President Biden as the Justice40 Initiative, the U.S. Department of Transportation (DOT) and Department of Energy (DOE) identified areas in each state that qualify as DACs. Vermont faces a challenge in meeting this requirement, given the existing landscape of inequality in infrastructure and the already stringent constraints on where chargers can be placed. In our interview, Patrick Murphy of VTrans noted an inherent contradiction in the law because states are asked to address environmental justice concerns, yet the program builds on an existing unjust infrastructure.[127] The figure below shows a map of federally identified DACs (shown in green) overlaid on Figure 4.3.3, to demonstrate the proximity of NEVI priority locations to DACs in Vermont. Based on this comparison, it is evident that seven of the fifteen priority charging locations—St. Albans, South Burlington, Derby, St. Johnsbury, Springfield, Brattleboro, and Rutland—fall within or very near to a DAC). Consequently, it appears that more than forty percent of NEVI-funded charging stations VTrans plans to construct by the end of FY2023 will be geographically accessible to DACs.

Figure 4.3.4: NEVI Priority Locations and Disadvantaged Communities.[128]

However, simply placing a public charger in a DAC does not solve the problem of unequal access to EV charging. VTrans finds that Vermonters without access to at-home charging have to pay about five times more to charge their EV than someone with access to at-home charging because public chargers tend to be much more expensive.[129] Thus, low-income Vermonters with a public charging station in their community still may not accrue the benefits of that charger, and it is therefore not clear that forty percent of the benefits of NEVI-funded charging stations in Vermont will go to DACs. VTrans proposes meeting challenges that DACs face in accessing affordable EV charging by building chargers near low-income multifamily housing. These projects would be funded through the Vermont Agency of Commerce and Community Development (ACCD), not through NEVI.[130]

Infrastructural Considerations: The most significant infrastructural challenge for installers is the fact that the visibility and accessibility of a site do not necessarily correlate with its capacity to sustain a charger.[131] For this reason, installers often need to install new electrical infrastructure at rural charging stations.[132] Some of the most commonly upgraded components include local transformers, switchgear, and circuit breakers.[133] At times, installers even need to replace entire power lines to sustain the electrical demands of a new load.[134] Though certain power providers have been willing to defray some of the costs of these upgrades, these improvements usually drive project costs up significantly.[135] The need to improve local electrical equipment can also substantially increase the time taken to complete a project due to the high lead times associated with certain components. For example, the 500KVa transformers that can be used to support several high-power charging stations often have lead times of a year or more due to a combination of supply chain issues and simple manufacturing times; even previously common components like circuit breakers sometimes have high lead times due to these supply chain problems.[136] According to Norwich Technologies, these upgrades will also support Vermont's ongoing electrification efforts and improve the general electrical services available to rural residents.[137]

A difficulty facing installers that we did not expect was the significant degree of disparity in the available information about grid quality. Vermont's utilities companies are not equal in their willingness to share information about grid conditions at prospective sites.[138] Some companies, like Green Mountain Power, provide three-phase power maps and grid use data that allow installers to easily identify suitable sites long before a project begins while other companies, like Hardwick Electric Department, do not publicly release information before they conduct site visits and develop interconnection quote estimates.[139] As a result, it is difficult for installers to predict project costs and feasibility, delaying the installation process.

Vermont's cellular infrastructure also presents challenges for its charger network. Currently, public EV chargers are meant to be able to connect to the Internet.[140] To do so, they can either connect through a cellular network or through a hardwired connection.[141] Because some pieces of equipment cannot be hardwired without substantial modifications, cellular connections are generally preferred.[142] Unfortunately, cellular connectivity is extremely variable throughout the state; there are some rural regions that have extremely poor cellular infrastructure.[143] Thus, the state's charging network faces two major infrastructural obstacles.

A further challenge is the inefficiency of installing Level Two and Level Three chargers in the same location. Under current grant rules, these different types of chargers are required to be installed in close physical proximity.[144] This requirement creates difficulties for installers because the infrastructural needs of these different types of charger are very different; Level 3 chargers require 480V and 3-phase power while Level Two chargers require only 240V and single-phase power.[145] Because of these differences, installing L2 and L3 chargers together requires the installation of additional systems to step down voltage.[146] This need for additional equipment exacerbates space constraints. Some sites barely have enough physical space for the equipment needed to sustain one type of charger, let alone both.[147]

Tourism Considerations: The Vermont NEVI Plan does not mention collaboration with the Vermont Department of Tourism and Marketing, but it does acknowledge that tourism impacts EV charger use. For instance, stations with typically lower levels of utilization may see drastic increases in usage during holidays or weekends, when tourists are traveling, causing heightened demand costs for charging station operators.[148]

Supply Chain Considerations: While these sites were intended to be completed by the end of calendar year 2023, wait times for Federal Highway Administration (FHWA) approval, combined with supply chain issues and inflation, have delayed the deployment process.[149] Supply chain delays are compounded by the Buy America provisions of the IIJA, which require federally funded infrastructure projects, including those related to public transportation, to use only domestically manufactured steel, iron, construction materials, and other manufactured materials.[150] The FHWA recently released a notice that, beginning March 3, 2023, some of these Buy America provisions have been waived for EV charging projects.[151] This exception will end with a staged phase-out period that starts on July 1, 2024.[152] This waiver may be of some help to VTrans, which is currently seeing up to a forty-week backlog for some of the materials it needs to construct charging stations,[153] but Patrick Murphy anticipates that VTrans will still face a significant backlog for materials.[154]

4.4 PEER STATE SITING STRATEGIES

In this section, we detail the EV charger siting strategies used in each of the three peer states we analyzed, so that those strategies may be compared and contrasted with siting strategies used in Vermont.

4.4.1 MAINE

Though ranked twelfth in the nation for number of EV chargers per 100,000 people (Vermont ranks first), the state of Maine provides an apt comparison to Vermont because it also leveraged funds from the 2017 Volkswagen settlement to install EV charging stations across the state.[155] Furthermore, Maine is an overwhelmingly rural state (98.8 percent rural by area) with a climate similar to Vermont's and an economy reliant on outdoor recreation (3.3 percent of GDP).[156] For comparison, Vermont is 98.3 percent rural and derives 3.7 percent of its GDP from outdoor recreation.[157]

Guiding Goals: Maine, which has over 8,000 more miles of state, county, and town roads than Vermont, nevertheless receives a similar amount of NEVI Formula Program funding to Vermont.[158] Because Maine must spread its NEVI dollars over a much larger area, the Maine Plan for Electric Vehicle Infrastructure Deployment (Maine PEVID) proposes a multi-phased approach for developing EV charging stations across the state.[159] The Maine PEVID was authored by the Maine Department of Transportation (MaineDOT) and the Efficiency Maine Trust (Efficiency Maine), a quasi-state agency that works closely with MaineDOT to award funding for EV infrastructure projects. It identifies a goal of developing charging stations along its interstates at 50-mile intervals by 2024, in line with the initial stage of the phased approach.[160]

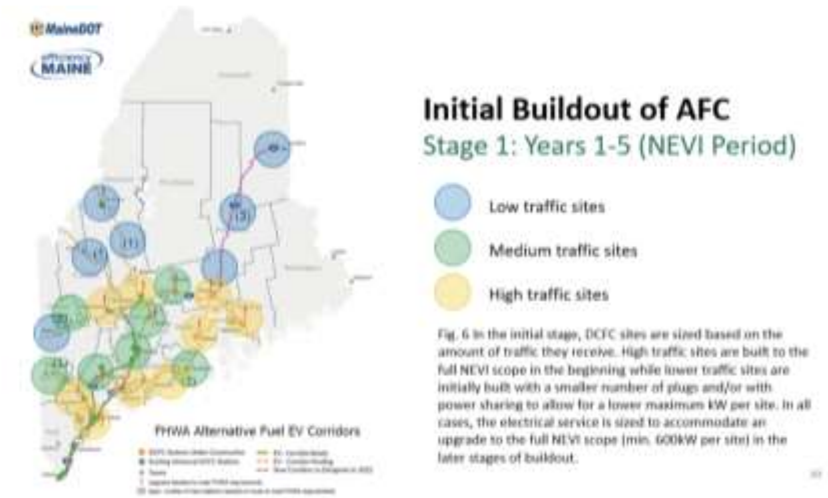

Figure 4.4.1.1: First Stage of Maine Staggered Siting Approach.[161]

According to Amalia Siegel, Program Manager for EV charging programs at Efficiency Maine, the primary factor in EV charger siting decisions is the 50-mile NEVI spacing requirement.[162] After designating a general area where they hope to install a NEVI-funded charging station, Efficiency Maine evaluates proposals for specific sites based on four criteria: "(1) cost to the program (i.e., amount of funding requested from Efficiency Maine for capital costs per kilowatt of capacity); (2) quality of the proposed site, equipment, and systems; (3) capacity, readiness and commitment of the bid team (including the host site property owner), and (4) overall quality and responsiveness of the proposal."[163]

Climate Considerations: One challenge Maine faces in developing its EV charging network stems from its cold climate. Maine, like Vermont, must contend with the decreased efficiency of EV batteries in cold temperatures. Decreasing the distance between charging stations through the development of new stations will help address this problem and encourage EV use during the colder months.[164]

Rurality Considerations: Like Vermont, Maine must build a significant number of chargers in rural areas. This comes at a steep cost. Analysis by Cadmus in the 2021 Maine Clean Transportation Roadmap indicates that the profitability of a charging station is heavily dependent on how frequently that station is used by consumers.[165] Absent subsidies and changes to electricity demand charges, even high-use DCFC stations built in 2020 are unlikely to turn a profit by 2030. Low-use stations, often found in rural areas, are projected to report much greater losses than high-use stations.[166] This finding informs the phased approach Maine is taking, which involves initially installing fewer plugs at low-traffic charging locations. Under this approach, low-traffic sites will not be built out to the NEVI standard of four 150-kW plugs.[167]

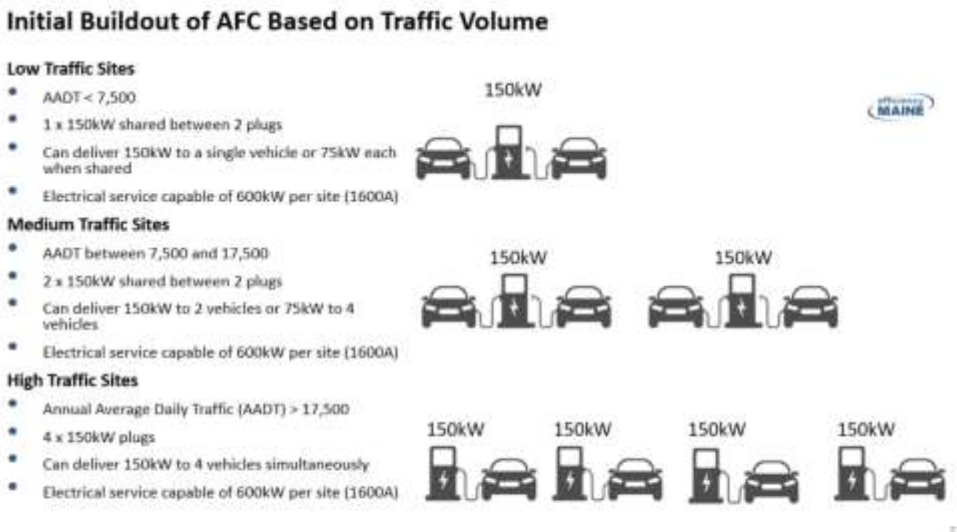

Figure 4.4.1.2: Site Buildout by Traffic Volume in Maine.[168]

In addition to employing this phased approach, Efficiency Maine and MaineDOT plan to invest additional funding and resources in order to encourage private operators to operate sites in rural, low-traffic locations.[169]

Equity Considerations: Equity is another factor that Maine must account for when siting EV chargers. The Maine PEVID reports that over forty percent of the DCFCs that Maine plans to construct on AFCs fall inside federally designated DACs.[170] However, geographic proximity to a charging station does not guarantee *affordable* charging for DACs. The plan cites point-of-sale EV purchase rebates provided by Efficiency Maine as a mechanism for reducing inequity in EV use, but no mechanism is proposed to reduce the cost of charging for low-income EV users at NEVI-funded stations.[171] Instead, Efficiency Maine and MaineDOT plan to allocate other funding sources for the development of charging stations near multi-unit dwellings (MUDs) and affordable housing.[172] Similar to Vermont, Maine plans to resort to alternative funding programs in order to address inequities in its EV charging network.

Infrastructural Considerations: The Maine PEVID also identifies that as EV use increases, electric grid capacity may be exceeded in certain parts of the state. These challenges will be met on a case-by-case basis, in coordination with the Maine Public Utilities Commission (PUC).[173] Efficiency Maine has yet to encounter a direct problem with grid capacity while implementing their EV charger programs.[174]

Tourism Considerations: Maine also plans to use separate funding sources to subsidize charging stations at significant tourist destinations across the state.[175] This is critical because Maine experiences a significant amount of out-of-state traffic as tourists come from Canada and the Northeast United States to visit remote destinations such as Acadia National Park.[176]

Supply Chain Considerations: Lastly, the Maine PEVID makes no mention of challenges associated with acquiring the necessary parts for EV chargers. Amalia Siegel acknowledged that supply chain delays pose a challenge to the development of EV charging stations in Maine, but was confident that these delays would not significantly derail the plans outlined in the Maine PEVID.[177]

4.4.2 UTAH

Utah is an apt state for this comparison because it also has a high concentration of EV chargers, with the sixth most charging stations per 100,000 people of any state in the nation.[178] As in Colorado, outdoor recreation accounts for 2.5 percent of GDP in Utah.[178] Utah is also 98.9 percent rural, making it only slightly more rural than Vermont.[180]

Guiding Goals: The Utah Plan for Electric Vehicle Infrastructure Deployment, developed by The Utah Department of Transportation (UDOT) and the Utah Office of Energy Development (UOED), was approved by the FHWA in 2022.[181] The Plan identifies three strategies for achieving widespread accessibility of EV charging across the state. The "first priorities" of the plan are "equitable access and connectivity."[182] These goals will be achieved by "meeting NEVI program criteria and providing EVSE every 50 miles."[183] The other two strategies identified are ensuring a quick transition to private sector ownership of charging stations and planning chargers such that they "enhance the quality of life and strengthen local economies, especially in rural and underserved areas."[184] The above-mentioned strategies and goals emphasize an overall aim of meeting the requirements of the NEVI program in a way that is both equitable and economically sustainable. UDOT and UOED are pursuing a comprehensive public engagement program in order to better account for the concerns of local communities, DACs, and to educate the public about the need for more EV charging in the state.[185]

Rurality Considerations: Like Vermont, Utah set an intention of achieving "built out status" on its AFCs during the first year of its NEVI plan.[186] For the two following years, the Plan outlines a strategy of siting EV chargers in important tourist destinations. In years four and five of this strategy, Utah aims to direct investments to rural communities and other underserved areas across the state.[187] This strategy of developing chargers in rural and underserved communities beyond AFCs only as the last phase of the project reflects an understanding that investments in EVSE in these areas may be quite onerous and risky in the short-term. UDOT foresees difficulty in finding private investors willing to host EV chargers at sites in rural, low-traffic areas.[188] State residents are highly concentrated in certain parts of the state, leaving large stretches of road that serve very few residents or travelers.[189] UDOT and UOED recognize that installing the required set of four 150-kW chargers does not make much sense for rural sites where charger utilization is likely to be low and adequate power may not be available to charge four vehicles at once.[190] Thus, they requested several discretionary exceptions to reduce the number of plugs installed in low-use or otherwise impractical locations.[191] They also propose keeping some rural sites in public ownership when private site hosts cannot be found.[192]

Equity Concerns: The Utah NEVI Plan notes that UDOT will use NEVI funds to build more chargers in rural areas, where fewer investments in EV charging have historically been made. UDOT plans to promote equitable practices by including DACs in the decision-making process and to meet the Justice40 requirements by placing over forty percent of its NEVI-funded charging stations in DACs. The Plan discusses many benefits accrued by DACs when EV chargers are placed in their communities, such as air pollution reduction and increased commerce for local businesses. However, UDOT makes no mention of the disparity in cost between at-home charging and public charging that puts low-income EV owners at a further disadvantage, even when they live in close proximity to a public charging station.[193]

Climate Considerations: Utah faces numerous climate and geography-related challenges that impact their ability to develop EV charging infrastructure. Temperatures are highly variable across the state, but numerous portions of the state do experience extreme cold.[194] This cold can reduce the efficiency of EV batteries, decreasing the distance that EVs can travel on a charge.[195]

Infrastructural Considerations: Utah has encountered grid capacity issues in some more rural parts of the state, where more efficient three-phase power is unavailable. Upgrading the power supply in these areas can present extraordinary costs. For one proposed project, the cost of upgrading to three-phase power would have cost twice the project budget.[196]

Tourism Considerations: Tourism makes up a significant and growing portion of the Utah state economy. National and state parks have historically drawn large numbers of tourists, and these numbers have skyrocketed since 2020, driving large increases in traffic.[197] Acknowledging the importance of tourism to the Utah economy and hoping to facilitate tourism by EV, UDOT and UOED sought input from the Utah State Office of Tourism when developing their NEVI plan.[198] The desire to boost tourism informs the emphasis on using funding to site EV chargers near tourist sites after the AFCs have been fully built-out.[199] The REV West, an ongoing partnership between Colorado, Arizona, Idaho, Montana, Nevada, New Mexico, and Wyoming, also facilitates EV accessibility for tourists by building a network of EV charging stations along major roads that cross through multiple of these western states.[200]

Supply Chain Considerations: Supply chain concerns are listed in the Utah NEVI plan as a known challenge associated with EV charger construction because they may delay wait times and increase prices of charging equipment.[201]

4.4.3 COLORADO

Though a much larger and more urbanized state than Vermont, Colorado also provides a useful comparison because it is 98.5 percent rural by area, ranks fourth in the nation for EV chargers per 100,000 people, and derives 2.5 percent of its GDP from outdoor recreation.[202]

Guiding Goals: The Colorado National Electric Vehicle Infrastructure (NEVI) Plan, submitted to the FHWA by the Colorado Department of Transportation (CDOT) and the Colorado Energy Office (CEO) and approved in 2022, outlines three main goals for developing EV infrastructure in the state. The first goal identified is to fill in the gaps along AFCs in Colorado, with an emphasis on siting charging stations in DACs. Colorado also intends to update the stations along its AFCs to meet the NEVI requirements of four 150-kW chargers per station, but doing so comes second to meeting the geographic requirements. After fully building out the AFCs, CDOT and CEO plan to focus on placing chargers in other areas across the state that are important for improving equity and mobility.[203] Colorado may choose to nominate additional stretches of road as AFCs in the future.[204]

Climate Considerations: Colorado is characterized by extreme terrain and rapidly changing weather, which, CDOT believes, may make travelers more hesitant to rely on EV transportation. CDOT resolves, according to the Colorado NEVI Plan, to address this issue by distributing more EV charging stations across the state. Additionally, though the Plan does not note any specific strategies for coping with these challenges, CDOT does identify increased flooding, temperatures, and risk of wildfires as effects of climate change that must be considered when siting EV chargers.[205]

Rurality Considerations: The high percentage of rural land area in Colorado necessitates additional funding and support for EV charging in these areas. CDOT and CEO, in partnership with the Colorado Tourism Office (CTO), run the Electrified Byways and Tourism Program, which brings DCFC and Level Two chargers to rural areas, enhancing local commerce and EV access in these places. All three state agencies also partner with Colorado Parks and Wildlife (CPW) to build Level Two chargers at all of the 43 state parks in Colorado. CDOT and CEO aim to use NEVI funds to build chargers in areas that the private sector has little incentive to serve, due to low utilization rates in these locations.[206] Recognizing that it may be difficult to find willing hosts for rural chargers due to the challenge of low utilization, CDOT and CEO propose utilizing state funding to keep unprofitable stations up and running.[207]

Equity Considerations: Especially in the Front Range of Colorado, where the majority of its population resides, Colorado faces the challenge of equitable access to charging among low-income residents. Low-income Coloradans, especially those in multi-unit dwellings, are less likely to have access to at-home charging, or to be able to afford an EV.[208] CDOT and CEO acknowledge that, beyond access, there are many other factors that reduce EV use in disproportionately impacted communities. The Colorado NEVI Plan outlines a number of key disadvantaged communities and groups that CDOT and CEO will reach out to in order to best identify and address these factors.[209]

Infrastructural Considerations: CDOT and CEO anticipate that grid capacity may constrain their ability to develop charging stations in certain parts of the state, especially rural ones. In response to this challenge, they are considering investing NEVI Program funds in battery storage systems that would allow charging to function even in areas that lack adequate grid capacity for traditional charging systems.[210] In addition, many Colorado electric utility companies are working to enhance EV charging in the state, and CDOT plans to continue working with these utilities to create a more robust and resilient electric grid.[211]

Tourism Considerations: Recognizing that tourism is a vital part of the Colorado economy, CDOT aims to make travel across the state highly accessible to visitors using multiple modes of transportation, including EVs. To this end, Colorado is working to place chargers along all of its Scenic and Historic Byways, as well as at tourist destinations such as ski mountains and hotels, through the Electrified Byways and Tourism Program.[212] Positive national media coverage of the program bolsters the effort to market Colorado as an attractive destination for sustainability-conscious travelers.[213]

Though not discussed in the Colorado NEVI Plan, Colorado is a member, along with Utah, of the REV West Partnership, an effort between eight western states to facilitate cross-state EV travel.[214]

Supply Chain Considerations: Extended wait times for products essential to EV charger construction, such as transformers, are a challenge noted by CDOT and CEO in the NEVI Plan.[215]

4.5 KEY TAKEAWAYS FROM PEER STATE POLICY COMPARISON

We synthesized findings from documents and interviews in order to distill key takeaways for the Vermont Senate Transportation Committee to consider when evaluating the EV charger siting practices used by the state of Vermont.

Strong Influence of NEVI Requirements: First, our analysis makes clear that in Vermont, as well as in peer states, NEVI Formula Funding guidelines are the primary factor currently determining public EV charger siting decisions. Each state examined in our state-by-state comparison listed the completion of the Alternative Fuel Corridors designated under the IIJA as a top priority. The NEVI requirements have a strong influence on the siting decisions made in these states and these requirements are quite stringent, greatly restricting the agency of states in deciding where to place chargers. The NEVI requirements simplify the siting process and allow for more reliable EV charging across the country, but their one-size-fits-all nature presents challenges for states like Vermont that contain extremely rural areas. While each state examined has requested or plans to request discretionary exceptions to these requirements in order to account for extraordinary circumstances in certain sites, it remains unclear how many of these exceptions the FHWA will grant. VTrans, for example, is still waiting to learn if the FHWA will grant its request for discretionary exceptions on two sites.

Benefits to Staggered Development of Rural Sites: Each state examined has a significant proportion of rural land, and all noted concerns about the viability of EV charging stations in remote areas due to low charger utilization and limited grid capacity. Vermont, which has not communicated a concrete plan for addressing such concerns, could learn from the strategies of Maine and Colorado. The plans these states have submitted to the FHWA emphasize meeting the 50-mile NEVI requirement first, and 'fully building out' each location by adding more plugs only when extra plugs are needed and can be supported by the grid. The Utah plan to keep remote charging stations under public ownership when willing site hosts cannot be found may also be instructive for Vermont.

Necessity of Developing At-Home Charging: As the Department of Housing and Community Development pointed out in our interview, Vermont charging stations may end up in different locations than existing gas stations.[216] Though public Level 3 chargers will play an important role, most charging will probably occur in places where cars are parked for long periods of time, such as homes and workplaces.[217] Because of the significant cost differential between at-home charging and charging at public stations, EV users without access to at-home charging are at a clear disadvantage. Low-income Vermonters are more likely to face this challenge, and to struggle to afford EVs in the first place. Therefore, even though a significant portion of the NEVI-funded EV charging stations Vermont plans to build will fall in or near DACs, the placement of charging stations in these areas will not solve the problem of unequal access to EVs and EV charging. To ensure that EV charging is affordable and equitable on the whole, policy should be careful to balance investments in roadside and at-home chargers.[218] Since NEVI Formula Funds are so restrictive in their use, striking this balance will require Vermont to rely on in-state funds and additional federal funding such as NEVI Discretionary Funding Program to support home charging, especially in low-income communities.

Areas for State Action on EV Charger Installation: Though some of the difficulties facing charging station installers probably are not actionable by the state—for example, the state probably cannot single-handedly resolve the supply chain issues that are creating long lead times for transformers—there are some critical areas where it could act. These include reviewing the requirements structuring the existing grant system to ensure that they make the most efficient use of space and hardware possible, working with Vermont's power companies to establish a more uniform system of infrastructure reporting and electrical fees for EV chargers, and working with local governments and businesses to address their parking-space concerns. Policy in these three areas will likely make the installation process much smoother as the state works to expand its EV infrastructure.

5 REGULATING EXPIRED EV BATTERIES

The state of Vermont currently has high EV adoption rates relative to the nation, a trend that is projected to increase in the coming years[219]. As such, once these EVs reach their end of life, Vermont will see an increase in demand for disposing of complex and potentially hazardous spent EV batteries.[220] This section will examine the policies that states other than Vermont have pursued to manage EV battery waste, with a particular focus on how these states have designated parties responsible for processing the EV battery waste. Additionally, this section will outline the legislation and programs for EV battery waste enacted by the federal government, along with relevant legislation in Vermont.

5.1 BACKGROUND

This section provides an overview of terminology and information needed to understand how EV battery waste is being processed. This includes information covering key corporate actors in the industry, the different methods used to process EV battery waste, the value and key components of EV batteries, and a predicted timeline for when EV battery waste will enter the waste system in significant numbers.

5.1.1 EV BATTERY RANGE AND LIFESPAN

Lithium-ion batteries (LIBs) are the most common type of batteries used in EVs.[221] LIBs are favored for their high energy density, stability at high temperatures, lower passive discharge rates, and rechargeability. The LIBs used in EVs lose, on average, two percent of their maximum range in a year, which may lead to a noticeably lower mileage per full charge in the long-term.[222] However, EV battery life spans are rated for about 200,000 miles.[223] The average Vermont citizen drives roughly 12,000 miles in a year; thus a 200,000-mile battery is expected to last a Vermonter 17 years.[224] Should an EV driver need to replace a battery pack, costs range from $5,000 to $15,000, comparable to the price of a transmission or engine replacement in a gas-powered car.[225]

5.1.2 EV BATTERY WASTE PROCESSING STREAMS

EV battery waste is generally disposed of in one of three ways: re-use, repurposing, and recycling. Re-use takes the form of taking slightly damaged EV batteries, repairing or refurbishing them, and reinserting them into an EV. Repurposing involves using the EV battery for a non-EV purpose, such as in a home power supply. Finally, recycling involves breaking apart the EV battery into its constituent materials, which can be used in the manufacturing of new EV batteries.[226]

5.1.3 CORPORATE EV BATTERY WASTE PROCESSING PROGRAMS

Currently, several companies are operating in the U.S. with a goal of recycling EV batteries. These include Redwood Materials, Inc. (Nevada), Ascend Elements (Massachusetts), and Li-Cycle (New York).[227] In addition to these dedicated EV battery recycling companies, major manufacturers of electric vehicles such as Tesla are developing their own recycling chains, though they have relied on the three aforementioned dedicated recycling companies in the interim.[228] In addition to recycling-oriented processes, some companies and utilities offer repurposing programs where batteries are repurposed for alternative energy storage (e.g. for solar farms, or electricity storage in homes).[229]

5.1.4 RECYCLING PROCESS OVERVIEW

While every company has different proprietary processes for recycling EV batteries, the general process can be summarized in five steps. First, applicable waste is collected at participating sites. Second, the waste products are transported to a central sorting facility. Third, the facility separates the waste products into distinct classes, such as plastics and metals. Fourth, the metal recycling products are crushed or chemically processed. Fifth, and finally, the purified metals are sorted and distributed to battery makers to be made into new batteries.[230]

Figure 5.1.4.1: Example of the Redwood Materials Recycling Process.[231]

5.1.5 MONETARY VALUE OF EV BATTERIES

EV batteries contain a wide variety of valuable metals, key among them being lithium, cobalt, manganese, and nickel.[232] As these metals are resource-intensive to mine and have limited domestic production capacity, the demand for and thus price of these metals tends to be high.[233] As a result, used EV batteries, whether directly repurposed or broken down, tend to be highly valuable, depending on weight and capacity. [234]

5.1.6 ISSUE TIMELINE

Currently, EV battery recyclers are reporting low supplies of consumer-generated EV battery waste.[235] This is likely due to the long lifespans of EV batteries—ranging up to 15 years—in combination with lower rates of adoption 15 years ago. EV battery waste is therefore unlikely to be a significant near-term issue, but will become increasingly important over the coming decade.[236]

5.2 METHODOLOGY

In order to gain a better understanding of the policy actions Vermont can take to address the reuse and disposal of EV batteries, we conducted a literature review of existing and planned programs to address these issues at both the federal and state levels. Relevant findings related to federal policies and state policies—both in Vermont and beyond—are summarized in the sections that follow.

5.3 STATE BATTERY DISPOSAL POLICIES

As of March of 2023, no state has implemented laws that specifically govern the disposal of EV batteries.[237] However, several states (California, Virginia, Missouri, and Texas) have convened task forces with a goal of recommending policies to legislators.[238] These task forces have included automobile, waste management, recycling, and environmental stakeholders in both the public and private sectors.[239]

One state, California, ordered the creation of a EV battery recycling task force through California Assembly Bill 2832 in 2018.[240] This task force was composed of "representatives from the automotive and battery industries (6 members), waste industry (5 members), public interest organizations (3 members), and government agencies (5 members)."[241] In March of 2022, this task force released their findings in a 148-page report, summarizing key challenges associated with recycling EV batteries, in addition to draft policy solutions that were voted on by task force members. Two policy proposals gained significant support, with a focus on clearly defining the party responsible for handling (i.e. organizing collection, paying for transportation and processing) end of life EV batteries through extended producer liability.[242]

The first proposal, under section 6.1.1 of the report, titled "Core Exchange and Vehicle Backstop Policy" has three different pathways with different parties responsible for handling the EV battery (refer to Figure 5.3.1).[243] The first pathway is triggered when an EV that is still in service has its battery replaced. In this case, the party that removes the battery is responsible for processing it. The second pathway is triggered when the EV (as opposed to the battery) reaches its end of life. In this case, the entity dismantling the vehicle as a whole is responsible for processing the battery. Finally, in cases where the EV is under warranty, or if the EV at its end of life is not acquired by a dismantler (as in pathway two), the vehicle manufacturer is responsible for the processing of the battery.[244] The second, under section 6.1.2 of the report, titled "Producer Take-Back" is similar to the "Core Exchange and Vehicle Backstop Policy," but specifies that the auto manufacturer (e.g. Tesla, Nissan) is responsible for the processing of batteries that reach their end of life.[245]

Figure 5.3.1: Lithium-Ion Car Battery Responsibility Timeline.[246]

In addition to the proposed methods of specifying the parties responsible for EV batteries at their end of life, the report also notes that reducing the regulatory burden of transporting EV batteries would be key in making it economical to dispose of them.[247] Studies have noted that 40-60 percent of costs associated with processing used EV batteries involve the transportation phase.[248] In particular, state environmental laws do not clearly regulate EV grade LIBs (which are substantially larger than consumer grade LIBs), and may fall under stricter standards which result in the need for expensive custom made packaging in the transportation process.[249] Thus, the report suggests that California may focus on clarifying environmental regulations for processing and transporting EV LIBs, or providing waivers and incentives for recycling purposes.[250] Additionally, establishing battery processing facilities near collection points would allow the dangerous batteries to be broken down into safer materials such as black mass that could be transported to a refining facility with less extensive safety packaging.[251]

5.4 FEDERAL BATTERY DISPOSAL POLICIES

Federal policymakers have given EV battery recycling significant attention. Federal policies regarding EV battery recycling have been motivated by concerns of supply chain integrity for valuable metals and minerals that are procured from outside of the United States.[252] Relevant pieces of legislation that provide funding for EV battery recycling include the Infrastructure Investment and Jobs Act of 2021 and the Inflation Reduction Act of 2022.

5.4.1 INFRASTRUCTURE INVESTMENT AND JOBS ACT

The Infrastructure Investment and Jobs Act, through Section 40207(c), provides the Department of Energy with three billion dollars of funding over five years to provide grants that help develop domestic advanced battery recycling, such as for boosting corporations that are developing or expanding battery recycling capacity domestically. Of particular relevance to a Vermont EV battery processing program is Section 40207(f)(3), which allocates $50 million in funds for "competitive grants to State and local governments to establish or enhance battery collection, recycling, and reprocessing programs." Section 40207 also authorizes the creation of a "Battery Producer Responsibilities Task Force" which will develop an extended producer responsibility framework that could be adopted by Congress.[253]

5.4.2 INFLATION REDUCTION ACT

The Inflation Reduction Act, through Section 13401, outlines a $3,750 'clean vehicle credit' for vehicles with batteries that use a set amount of 'critical' minerals (e.g. cobalt, lithium) that were extracted or processed domestically.[254] This percentage of required domestically sourced critical minerals in a battery starts at 40 percent in 2023, eventually rising 10 percent a year until 2027 and beyond, where the requirement caps at 80 percent.[255] Because the U.S. lacks the capacity to source at scale these 'critical' minerals, this requirement will likely need to be met using domestically recycled minerals and metals.[256] This will serve as an incentive for car manufacturers to manufacture their cars using domestically recycled minerals, and for EV battery recycling companies to increase capacity to meet this demand.[257] The Inflation Reduction Act also contains a 30 percent tax credit for investments in battery manufacturing capacity (including recycling), which could help companies scale up to meet the demand for domestically sourced minerals created by the clean vehicle credit sourcing requirements.[258]

5.4.3 ACTIONS BY EXECUTIVE AGENCIES

The most relevant federal actor for encouraging EV battery recycling is the Department of Energy (DOE). DOE-led programs include authorizing national laboratories to research methods of reducing the amount of rare metals used in EV batteries, bringing down battery manufacturing costs, finding new methods for recycling batteries, and establishing methods of standardizing production of batteries to make them easier to recycle.[259] The ReCell Center, led by Argonne National Laboratory, has been leading these EV battery recycling research initiatives.[260] Additionally, the DOE is offering a "Lithium-Ion Battery Recycling Prize" to incentivize academia and industry to develop scalable EV battery recycling processes.[261] Both the Infrastructure Investment and Jobs Act and the Inflation Reduction Act mention the DOE as a major distributor of appropriated funds for EV battery policies, making them an important point of contact for states wishing to secure funding for state EV policies.[262]

In addition to the DOE, the Department of Transportation (DOT) plays a significant role in regulating the transportation of EV batteries that have reached their end-of-life. Under the Hazardous Materials Transportation Act, the DOT is authorized to regulate the transportation of hazardous materials, such as LIBs, and may require special packaging and permitting for materials such as damaged EV batteries.[263]

5.5 LESSONS FROM RELATED VERMONT POLICIES

While Vermont currently has no legislation or policies targeting EV batteries, Vermont is a national leader in establishing and carrying out extended producer liability programs for primary (single use, less than two kilograms) batteries. Signed in 2014 as the first of its kind in the country, the Primary Battery Stewardship Law requires any seller of primary batteries to provide to the state a list of batteries they plan to sell, and also provide collection at no cost for consumers. After collecting primary batteries, sellers are responsible for processing the batteries in compliance with state laws. An individual seller or a group of sellers must submit a plan to the Vermont Agency of Natural Resources outlining how these requirements will be met.[264]

5.6 KEY TAKEAWAYS

In summary, we identify three main findings regarding battery disposal. These include the importance of defining responsible parties for disposal, the lack of EV battery waste processing infrastructure in-state, and the relevant scope of federal programs.

Identifying Responsible Parties: In the cases examined, identifying responsible parties for EV battery disposal was a key component of establishing an EV battery recycling system. One method of delineating EV battery processing responsibilities is through a policy of 'extended producer liability,' whereby a producer of a product is required to collect and pay costs associated with processing that product at its end of life. Generally, clear identification of the parties responsible for collecting and processing goods at their end of life helps ensure that funds are available or preallocated for disposal costs, in addition to lessening the burden on consumers. State-commissioned task forces have identified a risk for EV batteries to be unclaimed or improperly disposed of without a clear party responsible for their disposal.[265] Vermont has experience implementing extended producer responsibility programs through its Primary Battery Stewardship Law, which could be drawn upon if a similar program were implemented for EV batteries.[266]

Lack of EV Battery Waste Processing In-State: Vermont currently has no in-state capacity for EV battery processing. The closest processing facilities are located in Worcester, Massachusetts and Rochester, New York.[267] As transportation costs make up 40-60 percent of EV battery processing costs, this could pose a challenge for the economic viability of recycling EV batteries.[268] Federal funds are available through the Infrastructure Investment and Jobs Act to support expansions of in-state EV battery processing capacity, should Vermont pursue that avenue.[269]

Relevant Scope of Federal Programs: Currently, the federal government has focused significant attention towards securing access to key metals and minerals such as lithium and cobalt.[270] As a result, the federal government has offered billions of dollars of research funding and infrastructure development programming through the DOE to increase the recycling rates or LIBs, including EV batteries.[271] Additionally, the federal government has started to explore extended producer liability policies through a congressionally mandated taskforce.[272] As a result, the state of Vermont may choose to await federal guidance, as opposed to being a first adopter of EV battery processing policies.

6 CONCLUSION

Based on an analysis of federal and state policies and interviewing relevant authorities, we distilled key takeaways for the Vermont Senate Transportation Committee to consider as it contemplates responses to rising EV use in Vermont.

As EV adoption continues to grow, states, including Vermont, are facing increased pressure to develop and test EV-friendly alternatives to the gas tax. Additional registration fees for EVs, though a temporary aid, are not sustainable as they do not fully recoup lost revenue, and these shortages are likely to grow in the future. Instead, RUC appears to be more promising, but such a program may require great administrative changes and costs. Key obstacles, such as concerns over privacy and equity, also remain barriers to RUC participation. States may need to experiment with multiple mileage-reporting methods before settling on one (or multiple) to include in official RUC programs, and this research should likely begin early before lost revenue becomes more of a strain on the state.

When it comes to EV charger siting, NEVI Formula Funding Program guidelines play a major role in dictating the placement of charging stations constructed with public funds in Vermont and its peer states. However, the one-size-fits-all approach to charger siting imposed by the NEVI Formula Funding Program presents challenges for rural areas like Vermont. Variation in rurality and socioeconomic status across Vermont and its peer states necessitates an equity-centered approach to charger siting; the restrictiveness of NEVI Formula Funding means that many of the equity concerns associated with EV charging must be addressed through investments from other state and federal programs. There are further concerns regarding charging station layout and installation practices that this committee or other legislative bodies may address through new lawmaking. Namely, there is a need to reduce inefficiencies in the state grant system for EV charging projects, create a more uniform system for reporting on and charging electrical fees for EV chargers, and help communities balance competing needs for EV charging and adequate parking.

To address the coming rise in EV battery disposal in Vermont, the key obstacle is to clearly define the parties that are responsible for battery collection and disposal in the state. One method of delineating EV battery processing responsibilities is through a policy of 'extended producer liability,' whereby a producer of a product is required to collect and pay costs associated with processing the product at its end of life. This policy has already been applied to the sale of other types of batteries in Vermont, and can thus serve as a potential template for EV battery regulations. Additionally, Vermont lacks in-state EV battery processing capacity and may need to rely on capacity in nearby New York state and Massachusetts, which could increase transportation costs associated with processing batteries. To this end, the federal government has created funding opportunities for the state to develop in-state EV battery recycling programs, and may pass legislation to address issues of end-of-life battery responsibility.

Gas tax alternatives, EV charger siting strategies, and EV battery disposal practices all represent largely uncharted policy territory. Much is left to be learned and tried, but by staying up-to-date on technological advancements and policy decisions at the federal level and in peer states, Vermont can make informed policy decisions in each of these areas.

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