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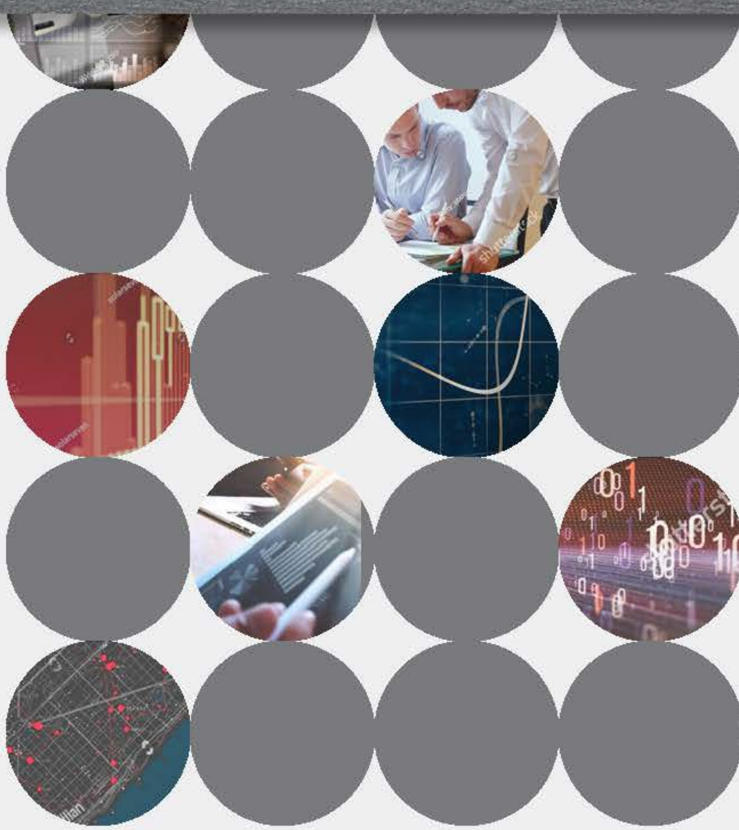

Electric Vehicle Infrastructure

2023

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Turning Information into Insight

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Introduction

There are numerous catalysts behind the current trend favoring electric vehicles (EVs), and environmental concerns are prominent among them. The transportation industry is the largest source of GHG emissions produced in the United States. The average gas vehicle emits 11,435 pounds of CO_2 every year, compared to an electric vehicle's 3,922 pounds of CO_2 produced per year.[1] Reducing GHG emissions is not only crucial in the fight against climate change, but also crucial to keeping the air free of pollutants. The pollutants from internal combustion engines have been linked to heart disease, stroke, and cancer. Research has also found that lower-income communities are typically exposed to a relatively large proportion of environmental hazards from GHG emissions. In addition to the environmental benefits and combatting inequalities, EV owners, on average, save $9,000 in fuel costs and $4,600 in repair costs over a 200,000-mile lifetime compared to individuals with cars running on internal combustion engines.

There are challenges associated with the trend toward EVs, such as determining how to integrate them into standard power systems, deploy recharging infrastructure, manufacture more sustainable EV batteries, source EV building materials and dispose of waste sustainably, and increase the sustainability of electricity generation. In the latter area, electricity generation sources have trended towards cleaner methods, including renewables, in recent years. Published data has shown that the share of electricity generated from renewables has grown from 9 percent in 2000 to 17 percent in 2019. Meanwhile, the share generated from coal decreased from 52 percent to 23 percent.[2] Overcoming these obstacles can facilitate significant progress in efforts to combat climate change while meeting the country's energy and transportation needs.

This report will provide an overview of EV infrastructure, including the types of electric chargers and stations and the costs associated with developing EV infrastructure. It will also explore policies and detail the economic impact of EVs at the national and state levels while addressing the overall concerns of consumers and corporations surrounding the possibility of EV adoption.

Industry Outlook

Several goals have been set for individual states and the nation to further the adoption of electric vehicles and the construction of more EV infrastructure. On the national level, as part of the 2021 Infrastructure Investment and Jobs Act (also known as the Bipartisan Infrastructure Law), expectations for the year 2030 include the following:

- EVs will comprise half of all vehicles sold in the U.S.
- A convenient network of half a million chargers will have been built across the country.
- Vehicles will be required to maintain at least 80 percent of electric range for 10 years or 150,000 miles.[3]

By 2050, 15 states (including Pennsylvania) and the District of Columbia have targeted all new commercial HDVs (Heavy-Duty Vehicles) to become ZEVs (Zero Emission Vehicles), with an interim goal of 30 percent of all HDVs being ZEVs by 2030.

California officials have made significant strides in the electrification of their vehicle economy. The state has an active ZEV mandate which requires all auto manufactures to offer a specific number of electric vehicles for sale annually. In fact, state leadership has been working toward electrification since the 2009 launch of the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), which plays a role in the deployment of more ZEVs. There is also legislation compelling large utilities to submit proposals for electric transportation, in addition to exemptions on weight for freights that are powered on alternative fuels.[4]

As for the best, most effective EV deployment methods, there is no one-size-fits-all solution. Special consideration of underserved and historically marginalized communities, which have been disproportionately impacted by GHG emissions, is warranted. For example, there should be further acknowledgement of costs associated not only with electric vehicles but with charging at public charging stations. Doing so will help ensure equitable circumstances for an enhanced and accelerated EV adoption process. Part of ensuring equitable access to charging stations is positioning a variety of chargers in each area, with level one, level two, and direct-current fast chargers (DCFC) to accommodate all sorts of electric vehicles. Electrification of major fleets and the advancement of fast charging technology should also be among these solutions.[5]

Rapid technological advancements will likely continue to shape the EV landscape in the U.S. and throughout the world. For instance, improved range of newer EVs with more powerful batteries, in tandem with more readily available EV infrastructure, will give drivers less range anxiety and quell other worries about long-range trips in electric vehicles. Extreme Fast Chargers (XFCs), which can provide 350kw and higher, are on the horizon, as more and more are being deployed to eventually electrify entire HDV fleets for companies. The possibility of inductive charging, using electromagnetic fields to transfer electricity cordlessly, is another feature that has not yet made big strides in the market but may become prominent in the future.

Electric Vehicle Infrastructure

Types of EV Chargers

In the United States, the top five electric vehicles include the Tesla Model Y, the Tesla Model 3, the Ford Mustang Mach-E, the Tesla Model S, and the Chevy Volt EV/EUV.[6] Appropriate chargers may be used and installed in settings including but not limited to household properties, residential areas, workplaces, gas stations, and public areas.[7] There are three different levels of charging, each with different numbers of charging ports.

Level 1 charging is the lowest power charge, using only the power from a common 120-volt AC plug most typically used in residential homes. This sort of charger can provide a range of five miles per hour of charging.[8] Level 1 charging uses a J1772 connector pictured below.

J1772 connector

Image by: US Department of Energy

Level 2 charging is the second fastest charging option, with two types of connectors. These types of chargers use a 240-volt outlet in residential settings, or more commonly, 208-volt outlets that are found in commercial settings. These chargers provide 25 miles of range per hour of charging. There were 93,312 Level 2 chargers throughout the United States as of October 2022. As shown below, the two types of connectors for Level 2 charging are the basic J1772 connector, and the Tesla connector. The Tesla connector is a unique connector that works for all Tesla charging options. Each Tesla also comes with a charging adapter so that Tesla vehicles can also be charged using the conventional J1772 plug in any sort of setting.[9]

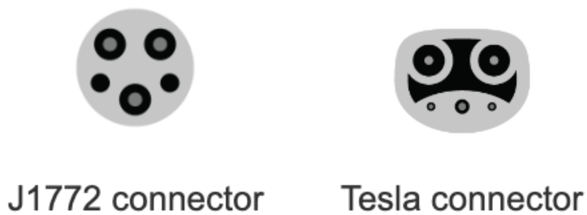

Image by: US Department of Energy

The third level of charging is known as DC Fast Charging (DCFC). These chargers are more powerful than their counterparts, giving the user around 200 miles of range per hour of charging with 50kW of power. There are currently 23,506 DCFC ports throughout the United States and they can be used with any of three connectors. The CCS connector, also known as an SAE J1772 Combo, can use the same type of port for charging with all three levels of power, meaning this one connector can charge using Level 1, Level 2, or DCFC ports. The CHAdeMO connector is another common DCFC, and the unique Tesla charger works at all these charging stations – including the fast option known as a *Supercharger*. It is important to consider the type of connectors different vehicles use depending on the demographic and electric vehicle market share of a given area.

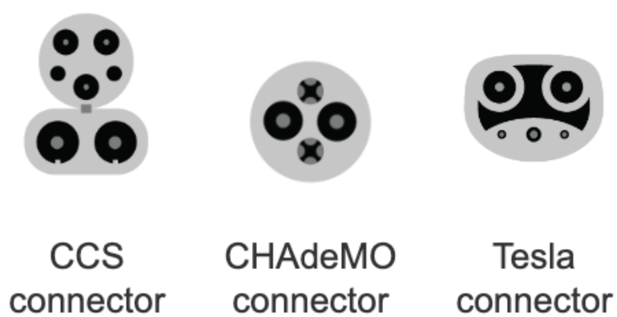

Image by: US Department of Energy

Charging Networks

There are barriers to the adoption of electric vehicles in the nationwide market. One major issue is 'range anxiety,' which describes the average person's worry about running out of range on the charge, perhaps because there is not an electric charging station or proper EV infrastructure readily available in their area or along the routes they usually drive.[10] This anxiety tends to dissuade people from purchasing electric vehicles, especially in places lacking the proper infrastructure. Determining where EV infrastructure should be installed and what type of infrastructure to install requires a thorough evaluation of various components and their costs.

The equipment costs vary based on factors such as location and charging level. Level 1 Chargers in residential settings typically cost between $700 and $900, and in a public or workplace setting the costs vary from roughly $593 to $813. A Level 2 charger in a residential setting cost between $1,400 and

$4,100, and in a public setting the cost ranges from $938 to $3,127. It is important to note that these ranges are rough estimates, but that charging equipment for public and workplace settings are generally much less expensive than the equipment for residential use. There are also higher costs associated with installing residential equipment in apartment settings across major cities and more densely populated metropolitan areas. DC Fast Chargers (DCFC) are not available for residential use, though in workplace or public settings they cost between $28,400 and $140,000 based on the type of equipment and whether the installation is a networked station.[11] The costs are outlined in the table below.

Level	Type	Chargers per pedestal	Per-charger cost
Level 1	Non-networked	One	$813
Level 1	Non-networked	Two	$596
Level 2	Non-networked	One	$1,182
Level 2	Non-networked	Two	$938
Level 2	Networked	One	$3,127
Level 2	Networked	Two	$2,793
DC fast	Networked 50 kW	One	$28,401
DC fast	Networked 150 kW	One	$75,000
DC fast	Networked 350 kW	One	$140,000

Source: The International Council of Clean Transportation

The installation costs for EV charging infrastructure vary as well, depending on the particular infrastructure, geographic location, specific site location, and required trenching and electrical upgrades needed. Residential installation costs for Level 1 charging are between $400 and $600, while Level 2 charging installation costs between $680 and $3,300 for residential areas. Again, higher costs are associated with installation for an apartment complex. Public and workplace installation costs are priced at $3,000 for Level 2 charging, and between $18,000 and $66,000 for DCFC. Labor is the greatest expense when it comes to installation. Installing numerous chargers per project is most economically efficient because per-charger costs drop significantly with larger-scale installations of EV infrastructure.

When considering adoption of EV infrastructure, it is beneficial to include community members who understand the needs of a given area in the decision-making process. They will help identify the expected charging needs of the community, the community's travel patterns, the level of EV ownership in said community, the amount of time it would take to charge the various types of vehicles in each area, and the actual number of EV's expected to be served. There may be great variance among these factors, depending on regional characteristics, so it is crucial to understand community dynamics. Doing so will ensure provision of optimal EV infrastructure to both support and incentivize EV adoption.

Other major costs associated with EV infrastructure involve connection of EV charging stations to the internet and joint networks. A networked system allows for data collection when the machine is connected to internet it, so the user can better understand usage patterns and needs such as frequency of charging, average charge times, and the types of EV chargers in demand in each area. To install a networked station, the site must have some sort of internet connection, wired or wireless, or any type of cellular service. Non-networked sites do not have the benefits of data collection and higher level of technology; however, the costs of non-networked charging stations' hardware have been falling. They can still provide basic charging capabilities without advanced utilization monitoring or payment capabilities available with networked chargers. Additionally, compliance, permitting, and inspections are required to ensure that equipment and installation follows ADA and other guidelines. Other minor expenses involve operations and maintenance costs over time. [12]

Federal and State Funding for Charging Infrastructure

It is possible to incentivize the use of elective vehicles by lowering the costs of EVs and expanding the needed infrastructure. Federal infrastructure funds are currently available through the Infrastructure Investment and Jobs Act (IIJA). Specifically, the bill includes $7.5 billion for investment in electric vehicle charging, with a goal of 500,000 EV chargers, in addition to adoption of electric buses for schools and public transit. That $7.5 billion includes $5 billion for National Electric Vehicle Infrastructure (NEVI) and $2.5 billion for the Discretionary Grant Program for Charging and Fueling Infrastructure (CFI).

In addition to IIJA funds, the Inflation Reduction Act (IRA) provided further tax credits for purchase of electric vehicles. As a result, the demand for charging infrastructure is likely to grow as consumers continue to take advantage of these incentives. The IRA also reinstated the Section 30C Tax Credit, which can provide tax credits on new EV charging stations of 30 percent of the cost of the charging station (including installation) to a maximum of $100,000.[13]

Alternative Fuel Corridors

In 2015, the federal government began the process of designating alternative fuel corridors (AFCs) in all 50 states, the District of Columbia, and Puerto Rico. Subsequent federal programs have prioritized funds for EV infrastructure, as well as other alternative fuels such as CNG, LNG, propane, and hydrogen, along these corridors. Six rounds of designations have occurred as of early 2023. Each interstate in Northeastern Pennsylvania (with the exceptions of Interstate 180 near Williamsport and Interstate 380 in the Poconos) has been designated as an AFC. Among them, only one (Interstate 476 between Wilkes-Barre and Philadelphia) has been identified as “corridor-ready,” meaning that it currently has a sufficient number of fueling/charging facilities. The remaining designated Interstates in the region (80, 81, and 84) are “corridor-pending,” meaning that needed infrastructure to complete the corridor has not yet been built.

NEVI Program

The National Electric Vehicle Infrastructure (NEVI) Formula Program under the Infrastructure Investment and Jobs Act allocates funding to states to acquire, install, network, operate, maintain, and share data from EV charging stations. A federal rebate up to $7,500 is available to those who purchase a new, qualified plug-in electric vehicle.[14]

Pennsylvania’s NEVI State Plan was approved in September 2022. The priorities are to build out the Alternative Fuel Corridor (AFC) Network, expand charging to non-interstate routes that can serve disadvantaged communities, provide mobile charging to support emergency response motorists, offer charging at key public destinations and mobility hubs, and develop infrastructure to support heavy and medium-duty freight movement. According to the plan, full build-out would require an EV charging station installed every 50 miles along the AFC system, infrastructure containing at least four 150kW DCFCs with Combined Charging System ports, and a minimum power station capability of 600kW to support 150kW per port.

The most current version of the plan is available on the PennDOT website. It details the state’s activities over the five years since the bill was passed. It covers Outreach and Education, PennDOT Fleet Transition, and EVSE deployment.[15]

CFI Program

In addition to the $5 billion allocated for the NEVI program, $2.5 billion is included in the Charging and Fueling Infrastructure (CFI) Discretionary Grant Program to build upon and fill gaps left by the larger funding source. While NEVI allocates funds to states, the CFI program is aimed at a wider range of applicants to further build out the charging network. Half the funds are intended to support AFCs and the other half is intended for community enhancement. In this case, infrastructure may be available on any public road or any other publicly accessible location, such as parking facilities at public buildings, public schools, public parks, and in parking facilities open the public but owned or managed by private parties.[16]

Other Programs

In Pennsylvania, there are 31 policies or programs connected to the adoption of EVs (14 state incentives, six utility/private incentives, and 11 laws and regulations).[17] The state incentives are detailed here:

- NEVI Planning: PennDOT submits an EV infrastructure deployment plan describing how the state intends to use its NEVI funds.
- Medium- and Heavy-Duty Vehicle Rebates: Rebates are offered for the replacement or repower of Class 4-8 local freight trucks, school buses, transit buses, etc.
- EV Charging Station and Hydrogen Fuel Cell Infrastructure Grants: Competitive grants are awarded by the Pennsylvania Department of Environmental Protection for the acquisition, installation, operation, and maintenance of DCFC stations and hydrogen fueling infrastructure. The reimbursements are described in the table below.

Project Type	Maximum Reimbursement	Maximum per Award
DCFC Stations	Up to 60% reimbursement	$250,000
DCFC Stations Corridor Expansion Projects	Up to 65% reimbursement	$250,000
Hydrogen Fueling - at least 250 kg/day	Up to 33% reimbursement	$500,000
Hydrogen Fueling - at least 100 kg/day	Up to 25% reimbursement	$500,000

Source: Alternative Fuels Data Center

- EV Charging Station Rebate: The Pennsylvania Department of Environmental Protection (DEP) offers rebates for the creation of Level 2 EV charging stations. Those reimbursements are described in the table below, based on the location of the charger.

Project Type	Maximum Reimbursement
Public Access, Government Owned Property	$4,000 per port or up to 70% of total project costs
Public Access, Non-Government Property	$3,500 per port or up to 60% of total project costs
Multi-Unit Dwelling	$3,000 per port or up to 50% of total project costs
Other Eligible Projects	$2,500 per port or up to 40% of total project costs

Source: Alternative Fuels Data Center

- Alternative Fuel Vehicle (AFV) Rebate: DEP offers rebates to assist residents with costs associated with buying an EV. Applicants must meet income requirements and the eligible AFV purchase price must not exceed $50,000. The rebate is $2,000 for purchase of a new or pre-owned EV, $1,500 for purchase of a new or pre-owned plug-in hybrid vehicle (PHEV), and $500 for compressed natural gas (CNG) vehicles, propane, and electric motorcycles that are new or pre-owned. An additional $1,000 is available for applicants who meet low-income requirements.
- Medium and Heavy Duty Zero Emission Vehicle Grant: Offers funding for the replacement of Class 4-8 local freight trucks. Eligible applicants and their grants are listed below.

Applicant Type	Maximum Grant Funding Amount
Non-government entity	Up to 75% of project costs
Government entity	Up to 90% of project costs
Financially distressed municipality	Up to 100% of project costs

Source: Alternative Fuels Data Center

These remaining incentives are smaller or more specialized in nature:

- Diesel Emission Reduction Grants
- Off-Road Electric Equipment Grants
- Hydrogen and Natural Gas Tax Credit
- Heavy-Duty Emission Reduction Grants
- Alternative Fuels Incentive Grant Program
- Alternative Fuel and Idle Reduction Grants
- Alternative Fuel Infrastructure and Energy Production Grant Program
- Idle Reduction, Natural Gas Vehicle, and Electric Vehicle Weight Exemption

Utility and Private Incentives

Utility and private incentives offered by electric utilities or private organizations can also play a role in EV adoption. Examples are offered by the Duquesne Light Company (DLC) and PECO Energy Company. DLC offers advisory services to analyze fleet electrification opportunities for its customers, a $50 gift card or direct deposit to residential customers who purchase an EV, and time-of-use rates to small and medium-sized businesses with EV charging stations at their locations. PECO Energy Company offers a $50 rebate to customers who purchase an electric vehicle and rebates up to $2,000 for the purchase and installation of Level 2 EV charging stations.

Economic Impact

There are short-term and long-term impacts of developing more EV infrastructure at both local and national levels. The short-term personal income effects have been noted, with the average EV owner saving $9,000 in fuel costs and around $4,600 on maintenance in a 200,000-mile lifetime. Although EV's have high upfront costs, owners save significantly throughout the lives of their vehicles.[18] They leave more disposable income to be spent in local economies. States that do not produce much oil many enjoy huge economic benefits, once there is a greater shift from oil to EV, because there will be less reason to import as much oil from other states and less reason for outflow of capital from the state's economy.

Pennsylvania spent $13.8 billion and consumed over 107 million barrels of motor gasoline in the year 2021.[19] However, Pennsylvania is only second to Texas as the largest net supplier of total energy in the country, largely due to the Marcellus Shale natural gas industry adjacent to Northeastern Pennsylvania. Reduced demand for fossil fuels for transportation could represent a risk to the regional and state economies. Nonetheless, the issue is complex because these fuels are also used for electricity generation.

The effects on employment could be simulated using a JOBS EVSE model. This online tool estimates economic impacts associated with the development and construction of EV infrastructure in each geographic area. The model analyzes the operations and costs of maintenance for different charging stations for up to ten years. For example, officials in Virginia proposed the installation of 148,000 Level 2 home units, 16,881 Level 2 workplace units, and 10,733 Level 2 and 1,201 DCFC public units over a span of 10 years.[20] The model predicted that this would create 274,000 to 291,000 jobs over the set period, and that in 2030 alone, the project would create 40,000 jobs. The same model can be applied to different states with different goals over different time spans. The ripple effects of wages from increased employment and disposable income from the savings produced by EV's can then be reinvested into local communities.[21]

Summary, Conclusions, and Recommendations

Electric vehicles (EVs) represent a monumental shift in energy systems for transportation. To combat climate change via reduction of greenhouse gas emissions, some state and federal policymakers are encouraging adoption of EVs. Vehicle manufacturers and freight companies are also preparing for this change. The economic impacts of the trend favoring electric vehicles are complex, as fossil fuel extraction is an important part of Pennsylvania's economy, but modelling has shown the potential for economic benefits due to consumer savings in the long term being reinvested in local economies.

Pennsylvania is one of 15 states targeting all new commercial heavy-duty vehicles to be designated zero emission vehicles by 2050, with an interim goal of 30 percent by 2030. On the national level, as part of the 2021 Infrastructure Investment and Jobs Act (also known as the Bipartisan Infrastructure Law), expectations for the year 2030 include the following:

- EVs will comprise half of all vehicles sold in the U.S.
- A convenient network of half a million chargers will have been built across the country.
- Vehicles will be required to maintain at least 80 percent of electric range for 10 years or 150,000 miles.[22]

In 2021, $7.5 billion in federal funds were allocated for EV charging infrastructure under the Infrastructure Investment and Jobs Act. A large share of this funding is intended for alternative fuel corridors (AFCs), which offer charging infrastructure at least every 50 miles. In Northeastern Pennsylvania, Interstates 80, 81, and 84 are designated as AFCs but do not yet meet this standard. The region's other AFC-designated highway, the Pennsylvania Turnpike Northeast Extension, already meets the standard for EV charging.

Since its creation, the defined parameters of the AFC designation have been revisited six times. Additional highways received designations in each case. Should the Federal Highway Administration revisit these parameters again in the future, state or regional officials could consider nomination of additional highways for designation. U.S. Route 6 is a promising option because it serves numerous employment and population centers in the Lackawanna Valley and Wayne County and connects many communities across the Northern Tier. Other potential corridors not yet designated as AFCs are Interstate 380 in the Pocono region, Interstate 180 near Williamsport, and U.S. Route 11 through the Wyoming Valley.

Local planners, public administrators, policymakers, and advocates for disadvantaged communities should also be engaged in the process of planning for the use of these funds. In places where these dialogues have not yet begun, local and regional working groups (ideally including PennDOT officials) can be formed to ensure that allocation of EV infrastructure funds is consistent with county and municipal comprehensive plans, adequately serves disadvantaged communities, is conducive to sustainable economic development, and connectedness to other communities and regions in Pennsylvania. Several funding sources for EV charging infrastructure, particular section 30C tax credits offered under the Inflation Reduction Act, prioritize rural census tracts and those with lower incomes. Lower income communities and those who have been subject to disproportionate environmental and health burdens in the past stand to gain most from removing a significant portion of vehicle emissions.

Beyond AFCs, $1.25 billion nationwide has been allocated for other areas of implementation under the Discretionary Grant Program for Charging and Fueling Infrastructure (CFI)'s Community Program funding category. Regional entities should consider the CFI federal funding program and state funding sources through the PA Department of Environmental Protection to support charging infrastructure in proximity to multi-family residential settings, public schools, colleges and universities, health care facilities, and parks.

In some parts of the state, private entities (particularly utilities) also incentivize electric vehicles. Expansion of these programs could help consumers transition to EVs. Other private entities such as foundations, environmental organizations, and landowners/developers may also wish to explore ways they can encourage EV use or support charging infrastructure projects.

Finally, it is important to consider that a large-scale shift toward vehicle electrification will have significant ramifications on funding for transportation infrastructure. Gasoline taxes provide the largest share of these funds, so a decline in gasoline tax revenue will require policymakers to reconsider the methods revenue is generated for road and bridge construction and maintenance. Although extensive study of this issue was beyond the scope of this research, further exploration is recommended.

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