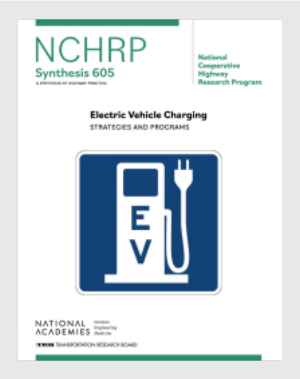

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 605

Electric Vehicle Charging

STRATEGIES AND PROGRAMS

A Synthesis of Highway Practice

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Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-05, "Synthesis of Information Related to Highway Practices," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, Synthesis of Highway Practice.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

FOREWORD

By Trey Joseph Wadsworth
Staff Officer
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The objective of this synthesis is to document current strategies and practices in use by state departments of transportation (DOTs) to facilitate and coordinate the provision and operation of electric vehicle (EV) charging facilities. The synthesis also includes DOTs' current plans to address the future maturity of EV charging, such as preparation for medium- and heavy-duty electrification.

Information for this study was gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs. Six case examples provide additional information on approaches to EV charging facility deployment, procurement and funding, maintenance, and benefits and challenges.

Roy E. Sturgill, Jr., of Blue CyClone, LLC; Christofer Harper, of Black Dog Consultants, LLC; and Daniel Tran of Tran and Associates, LLC collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on page iv. This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

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SUMMARY

Electric Vehicle Charging: Strategies and Programs

With the Federal Highway Administration (FHWA) and other agencies supporting the Presidential Administration's goal of providing 500,000 new electric vehicle (EV) charging stations by 2030, many state departments of transportation (DOTs) are investigating sources of funding and potential revenue to meet this goal and the needs of EV owners (The White House Briefing Room 2021). Additionally, an FHWA memorandum, dated April 27, 2021, provided guidance that alternative fueling facilities, such as EV charging stations, could be accommodated within state DOT rights-of-way (ROW) by considering them as a utility (FHWA 2021b). Several state DOTs have since been planning approaches to provide or accommodate EV charging stations based on this guidance. Most state DOTs also attempted pilot deployments of EV charging infrastructure even before the recent emphasis and guidance. This synthesis report presents the state of the practice to capture these efforts and the immediate plans of state DOTs regarding the growing needs of EV charging infrastructure.

There are more than one million EVs in the United States, with a 20-fold growth of this number expected by 2030. This rapid growth requires effective strategies to develop charging infrastructure and distribution networks. This synthesis assists in moving toward that solution by collecting and documenting current strategies and practices in use by state DOTs to facilitate and coordinate the establishment and operation of EV charging facilities. Additionally, working toward that solution is the National Electric Vehicle Infrastructure (NEVI) Formula Program, as part of the new Infrastructure Investment and Jobs Act (IIJA)/ Bipartisan Infrastructure Law (BIL) passed in the fall of 2021. It is noteworthy to mention this legislation, as the timing of its guidance and implementation began while this synthesis was ongoing. The rapidly changing landscape presented challenges for developing a synthesis, but the data presented capture findings of the current perceptions and past attempts of the state DOTs.

NEVI entails a $5 billion program over 5 years that will strategically deploy EV charging infrastructure. The NEVI Discretionary Program provides an additional $2.5 billion beyond the Formula Program and will be available at a later date. Initial guidance for NEVI was made available in February 2022, with a notice of proposed rulemaking in June 2022. Initial funding under NEVI requires state plans for the deployment of Electric Vehicle Supply Equipment (EVSE, used interchangeably with "Charging Infrastructure") along designated Alternative Fuel Corridors. Guidance suggests that state DOTs may own or lease EVSE or contract with private service providers who will purchase, install, own, and maintain the chargers. To be eligible for the NEVI funding, state DOTs must submit an infrastructure deployment plan by August 2022.

This synthesis used existing literature and previous discussions with DOTs to develop and conduct a survey of state DOTs. The survey was electronically distributed to the voting

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membership of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Planning. The survey was initially distributed on February 22, 2022, with a majority of the responses completed by mid-April 2022. Representatives of 42 state DOTs completed the survey, with the findings of the survey presented in Chapter 3. Respondents were not required to answer every survey question; therefore, the number of respondents is noted for each question within Chapter 3.

From the survey, 22 state DOTs reported that they have installed or contracted to have installed EV charging stations, and 14 state DOTs have a plan or are currently planning to deploy EV charging infrastructure. The survey results show that the top locations of deployment for the Level 1 charging are: (1) at DOT-/state-owned buildings but non-public facing (for government use only) and (2) at parking areas in DOT-/state-owned rights-of-way. The top locations of deployment for the Level 2 – charging are: (1) at DOT-/state-owned buildings but non-public facing (for government use only), (2) at DOT-/state-owned public-facing buildings (i.e., offices, driver's licensing locations, etc.) for public use, (3) at parking areas in DOT-/state-owned rights-of-way, and (4) at public-facing facilities along DOT-/state-owned rights-of-way. The top locations of deployment for the direct-current fast charging (DCFC) are: (1) In local-government or metro-owned rights-of-way, (2) along high-traffic corridors, and (3) at public-facing facilities along DOT-/state-owned rights-of-way.

In regard to policies and guidance on EV charging stations, the survey results indicated that most state DOTs (65% out of 34 state DOTs who responded to the subject question) reported that they have not provided guidance or technical assistance to local governments regarding deployment, or planned deployment of EV charging infrastructure. The survey results also indicated that federal policies and regulations influence state DOT deployment of EV charging infrastructure on the following issues (from 35 responding state DOTs):

- Siting and location (29 DOTs),
- Material used, such as Buy America Act requirements (24 DOTs),
- The EV type and charging levels installed (23 DOTs),
- The number of EV charging stations installed (22 DOTs), and
- Fee structures and cost recovery (19 DOTs).

For the operation and management of EV charging, out of 31 state DOT respondents that deployed or planned to deploy EV charging, 15 DOTs indicated that they collect user fees for all EV charging stations. However, only seven DOTs intend to make use of rules allowing for rate recovery mechanisms or other opportunities for cost savings. Twenty-one DOTs also reported that they include a plan to provide operations and maintenance of the current or planned EV charging infrastructure. Additionally, 31 state DOTs indicated that they include operations and maintenance to be provided by the lessee, grantee, vendor, or service provider for their planned and current EV charging deployment. The survey results also showed that 10 DOTs out of 34 state DOT respondents used a pilot program before implementing a full-scale build-out of their EV charging infrastructure.

For the evaluation of EV charging infrastructure deployment, 20 state DOTs out of 35 respondents have not evaluated the effectiveness or quantified the benefits of their EV charging infrastructure. States were also asked what technologies are used to enhance their EV charging infrastructure; the two technologies that state DOTs noted in the enhancement of their EV charging infrastructure are the use of battery storage to reduce demand charges, and the use of renewable energy sources (e.g., solar). Regarding these technologies, state DOTs were asked if there was an evaluation of how their use increases the value of the investment in EV charging infrastructure (e.g., cost/benefit analysis, feasibility, or approaches for cost recovery). Twenty-four state DOTs reported that they are unsure or do not evaluate their investment in technologies to support their EV charging infrastructure.

Finally, the survey results showed that the top five challenges that state DOTs encountered when deploying EV charging infrastructure included

- Commercialization (fee) restrictions at rest areas,
- Procurement of EV charging infrastructure,
- Instituting fees for charging services,
- Buy America requirements for EV charging infrastructure, and
- Plans for operation and maintenance.

The level of these challenges ranged from moderate to very high impact on the deployment of EV charging infrastructure.

Beyond the survey, the follow-up case examples provided detailed feedback from select state DOTs. Interviewees were largely selected based on survey responses and their applicable AASHTO region to achieve diverse regional feedback. Based on their leading-edge approach to inductive charging, Michigan DOT was added as a case example, though they were only able to provide a partial survey response within the time constraints of the study. The final interviewee list included California, Hawaii, Massachusetts, Michigan, Tennessee, and Vermont.

The case examples presented various effective practices but also pointed out common challenges to the deployment of EV charging infrastructure. Some of the common challenges from the cases include

- Responsibilities for paying for the service lines for the EVSE;
- Supply chain challenges, such as electric companies being able to find transformers;
- Compliance with Buy America;
- Understanding of EV strains on the electric grid; and
- The implementation and unknowns regarding NEVI.

The study overall points to a significant knowledge gap within "Strategies and Programs for Electric Vehicle Charging" (NCHRP Synthesis 20-05/Topic 53-08). The gap noted is the development of summarized, AASHTO–type guidelines that can inform state DOTs regarding

- Electric Vehicle Supply Equipment (EVSE) siting;
- Design, construction, and EVSE selection for sites based on current and future needs; inclusive of criteria such as use cases, trips, and range; and
- Applicable funding and implementation of the NEVI program.

This synthesis presents an opportunity to use the state of the practice as captured and promote additional research to address the guidance gap noted.

CHAPTER 1

Introduction

The current presidential administration set a goal of providing 500,000 new electric vehicle (EV) charging stations by 2030. With the support of the Federal Highway Administration (FHWA) and other agencies, many state departments of transportation (DOTs) are investigating various sources of funding to meet the needs of EV owners (The White House Briefing Room 2021). Beyond the funding for such infrastructure, there was also concern about the use of state DOT rights-of-way (ROW) for EV charging infrastructure. An FHWA memorandum, dated April 27, 2021, provided guidance that alternative fueling facilities, such as EV charging stations, could be accommodated within public ROW by considering them as a utility (FHWA 2021b). While many state DOTs had already attempted pilot deployments of EV charging infrastructure, the national emphasis on EV charging infrastructure has resulted in substantial interest in the topic. This synthesis report presents the state of the practice to capture these efforts and the immediate plans of state DOTs regarding the growing needs of EV charging infrastructure.

There are more than one million EVs in the United States, with a 20-fold growth of this number expected by 2030. This rapid growth requires effective strategies to develop charging infrastructure and distribution networks. The expected growth and the potential new growth from segments such as driverless vehicles and EV freight fleets present a clear need for a charging station network that would include stations at home, en route, and at destinations. State DOTs have employed various pilot attempts to deploy and operate charging stations, either through the electrification of their fleets or varying deployments of public-facing EV charging infrastructure. However, stemming from the growing demand, there is a rapidly advancing need for a more programmatic and sustainable approach to providing an EV charging solution. This synthesis will assist in moving toward that solution by collecting and documenting current strategies and practices in use by state DOTs to facilitate and coordinate the establishment and operation of EV charging facilities. Additionally, working toward that solution is the National Electric Vehicle Infrastructure (NEVI) Formula Program, as part of the new Infrastructure Investment and Jobs Act (IIJA) passed in the fall of 2021. It is noteworthy to mention this legislation, as the timing of its guidance and implementation began while this synthesis was ongoing. The rapidly changing landscape presented challenges for developing a synthesis but the data presented capture findings of the current perceptions and past attempts of the state DOTs.

1.1 Background

First, it is necessary to provide a frame of reference regarding the vehicles of interest within this synthesis. Alternatively fueled vehicles are sometimes categorized within a singular group if vehicles powered in some aspect by electricity are not categorized as EVs. According to Sanguesa et al. (2021), there exists a taxonomy of EVs. The following excerpt explains this taxonomy.

- Battery Electric Vehicles (BEVs): vehicles are 100% propelled by electric power. BEVs do not have an internal combustion engine and they do not use any kind of liquid fuel. BEVs normally use large packs of batteries to give the vehicle acceptable autonomy. A typical BEV will reach from 160 to 250 km (100 to 155 miles), although some of them can travel as far as 500 km (310 miles) with just one charge.
- Plug-In Hybrid Electric Vehicles (PHEVs): hybrid vehicles are propelled by a conventional combustible engine and an electric engine charged by a pluggable external electric source. PHEVs can store enough electricity from the grid to significantly reduce their fuel consumption in regular driving conditions.
- Hybrid Electric Vehicles (HEVs): hybrid vehicles are propelled by a combination of a conventional internal combustion engine and an electric engine. The difference regarding PHEVs is that HEVs cannot be plugged into the grid. The battery that provides energy to the electric engine is charged thanks to the power generated by the vehicle's combustion engine. In modern models, the batteries can also be charged from the energy generated during braking, turning the kinetic energy into electric energy.
- Fuel Cell Electric Vehicles: these vehicles are provided with an electric engine that uses a mix of compressed hydrogen and oxygen obtained from the air, having water as the only waste resulting from this process. Although these kinds of vehicles are considered to present "zero emissions", it is worth highlighting that, although there is green hydrogen, most of the hydrogen used is extracted from natural gas.
- Extended-range EVs (ER-EVs): these vehicles are very similar to those in the BEV category. However, the ER-EVs are also provided with a supplementary combustion engine, which charges the batteries of the vehicle if needed. This type of engine, unlike those provided by PHEVs and HEVs, is only used for charging, so it is not connected to the wheels of the vehicle. (Sanguesa et al. 2021)

In reference to PHEVs, the United States Department of Energy Alternative Fuels Data Center notes that these vehicles typically have an electric range of 15- to 60-plus miles and operate on electric power until they have nearly depleted their batteries (Office of Energy Efficiency and Renewable Energy 2022). The same sources note that PHEVs are found in two main configurations; parallel and series. In the parallel configuration, the PHEV's gasoline engine and electric motor both have a connection to the drive wheels. In the series configuration, the PHEV's drive wheels are only powered by the electric motor and the gasoline engine provides power to the electric motor via a generator. In these cases, an ER-EV as previously described is considered a type of PHEV.

There are additional references to EVs that capture some portion of their power from the electric grid or charging infrastructure as plug-in electric vehicles (PEVs). Wood et al. (2017) clarify that PEVs include BEVs and PHEVs as previously described. For the context of this report, references to EVs refer to PEVs. PEVs are not considered a new technology. As noted by the National Research Council (2015), as many as 28% of the passenger vehicles sold in the United States in 1900 were EVs, as were two-thirds of the vehicles in several major cities at the time. The advent of mass production of inexpensive gas vehicles, electric starters, affordable gasoline, and an expanding highway system allowing for longer trips, all contributed to the previous decline in PEVs (National Research Council 2015). The 1970s saw some revival of PEV interest because of oil embargoes and energy and environmental awareness, and interest was further revived by California's zero-emission-vehicle policies of the 1990s. This latest round of interest now continues to grow thanks to improving battery, charging, and vehicle technologies. Varying incentives and grants by Federal legislation and philanthropists support the growth in popularity of PEVs (National Research Council 2015). Nonetheless, barriers to EVs in the United States include cost, battery range, general uncertainty, battery safety, charging infrastructure availability, and electric grid impacts among others (Frades 2014). One of the more noted concerns or barriers is "Range

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CHARGE LEVEL	VOLTAGE	CURRENT	POWER	POWER SIMILAR TO…	TIME TO FULLY CHARGE AN AEV †
Level 1 AC	120 V	8-12 amps	1.0-1.4 kW	Toaster	8–24 hours
Level 2 AC	240 V	15–100 amps	3.6–19.2 kW	Clothes dryer	4–8 hours
DC Fast-Charger	480–600 V	80–120 amps	20–72 kW	5–10 Central air conditioners	30 minutes

† AEV refers to a vehicle with a usable battery capacity of approximately 24 kWh.

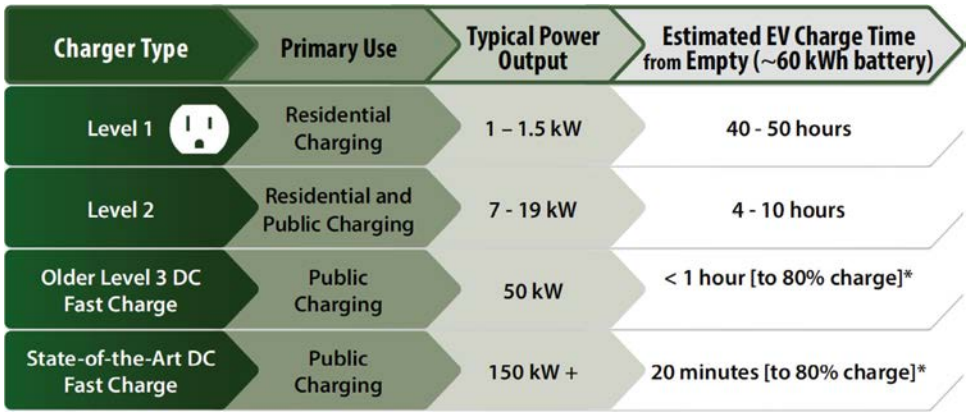
Figure 1.1. Comparison of PEV charging levels (Source: Frades 2014).

Anxiety." The International Energy Agency Policy Brief on Public Charging Infrastructure (IEA 2022b) notes that "Range Anxiety" is the fear of an EV running out of power before reaching its destination. While battery technology is improving and contributing to the easing of this fear, the other aspect of change to reducing range concerns is advancement in charging infrastructure and deployment (Jones et al. 2018). Additionally, some state DOTs, such as Massachusetts, are using more positive terminology like "range confidence" to indicate the battery limits.

Frades (2014), along with many other resources, notes that there are general levels of charging infrastructure including Level 1 alternating current (AC) being the cheapest and slowest approach using standard outlets, Level 2 AC charging running at higher voltage and drawing more current to facilitate faster charges but necessitating specialized equipment, and direct current (DC) fast chargers which are the most expensive equipment but allow for the fastest vehicle charging. Figure 1.1 captures the power comparisons for the different levels of charging.

The FHWA, within its "Federal Funding is Available for Electric Vehicle Charging Infrastructure on the National Highway System," notes the continued advancements in charging infrastructure, with DC fast chargers becoming more efficient (FHWA 2021a). Figure 1.2 outlines the types of chargers noted by the United States DOT (U.S. DOT) in 2021, and highlights the power output increase from the Frades (2014) report. Other notable differences between Figure 1.1 and Figure 1.2 are that the batteries used for estimated charge times are different sizes. Frades (2014) notes a 24-kWh battery, while FHWA (2021a) notes a 60-kWh battery. The FHWA report also notes that DC fast charges underwent an evolution from older technologies to state-of-the-art charging technologies.

Beyond the classification of EVs and their charging infrastructure, it is also important to provide background regarding the context of the current policy environment. NEVI was established



** Note: To prolong battery life, charging slows after an 80% charge level is reached.*

Figure 1.2. Comparison of PEV charging levels (Source: FHWA 2021a).

as part of the Bipartisan Infrastructure Law (BIL), or the IIJA, and signed into law on Nov. 15, 2021. The Joint Office of Energy and Transportation was also established by this legislation in December 2021 (Joint Office of Energy and Transportation). The NEVI Formula Program entails $5 billion over 5 years that will strategically deploy EV charging infrastructure. The additional Discretionary Grant Program for Charging and Fueling Infrastructure entails $2.5 billion to be detailed at a later date. Initial guidance for NEVI was made available in February 2022 with a notice of proposed rulemaking (NPRM) in June 2022. Initial funding under NEVI requires state plans for the deployment of Electric Vehicle Supply Equipment (EVSE) along designated Alternative Fuel Corridors. Guidance suggests that state DOTs may own or lease EVSE or contract with private service providers who will purchase, install, own, and maintain the chargers. To be eligible for the NEVI funding, state DOTs must submit an infrastructure deployment plan by August 2022.

1.2 Synthesis Objective

The objective of this synthesis was to document current strategies and practices in use by state DOTs to facilitate and coordinate the provision and operation of EV charging facilities. The synthesis includes current plans to address the future maturity of EV charging, such as preparation for medium and heavy-duty electrification, and investigates how EV charging has been deployed by DOTs, and what strategies and programs have been adopted or adapted. The scope of the synthesis concerns the deployment of EV charging approaches by state DOTs inclusive of public-private partnerships and working with other stakeholders where relevant. The following areas were considered for data gathering:

- Practices (e.g., those encouraged for or performed by state DOTs) for EV charging infrastructure deployment, delineation of operating and maintenance responsibilities, public/private partnerships, procurement and contracting, and pricing strategies.
- Practices prioritizing the deployment of EV charging (e.g., passenger travel and/or freight, and corridor-based or site-specific opportunities such as multi-dwelling housing or community destinations).
- Practices on planning for EV charging, including expanding pilot programs into full-scale build-outs (e.g., passenger and/or freight vehicles and in urban and rural contexts).
- Practices in working with utilities (e.g., negotiating demand charges or infrastructure upgrades) or other partnering agencies as applicable for EV charging programs.
- Practices for funding—not a list of eligible funding sources, but rather any strategies on navigating the complexities of funding available to pay for EV charging stations and where success has been achieved (e.g., funding regulations, Buy America requirements, or commercialization of rest area regulations, including grandfathered commercial service areas).
- Practices in evaluating the effectiveness of programs, quantification of benefits, cost recapture, and experiences in overcoming barriers to implementation.
- Practices on providing guidance or technical assistance to local governments from DOTs (e.g., rezoning needs for home-based charging facilities or charging for public and private parking lots and garages).
- Policies for EV charging stations along curbs of state-owned roadways or in public rights-of-way.

1.3 Study Approach

The synthesis began with a literature review to develop the initial understanding of the current state of research and practice regarding EV charging infrastructure deployment by state DOTs. The findings of the literature review can be seen in Chapter 2. The existing literature and previous discussions with DOTs assisted with the development of the survey questionnaire.

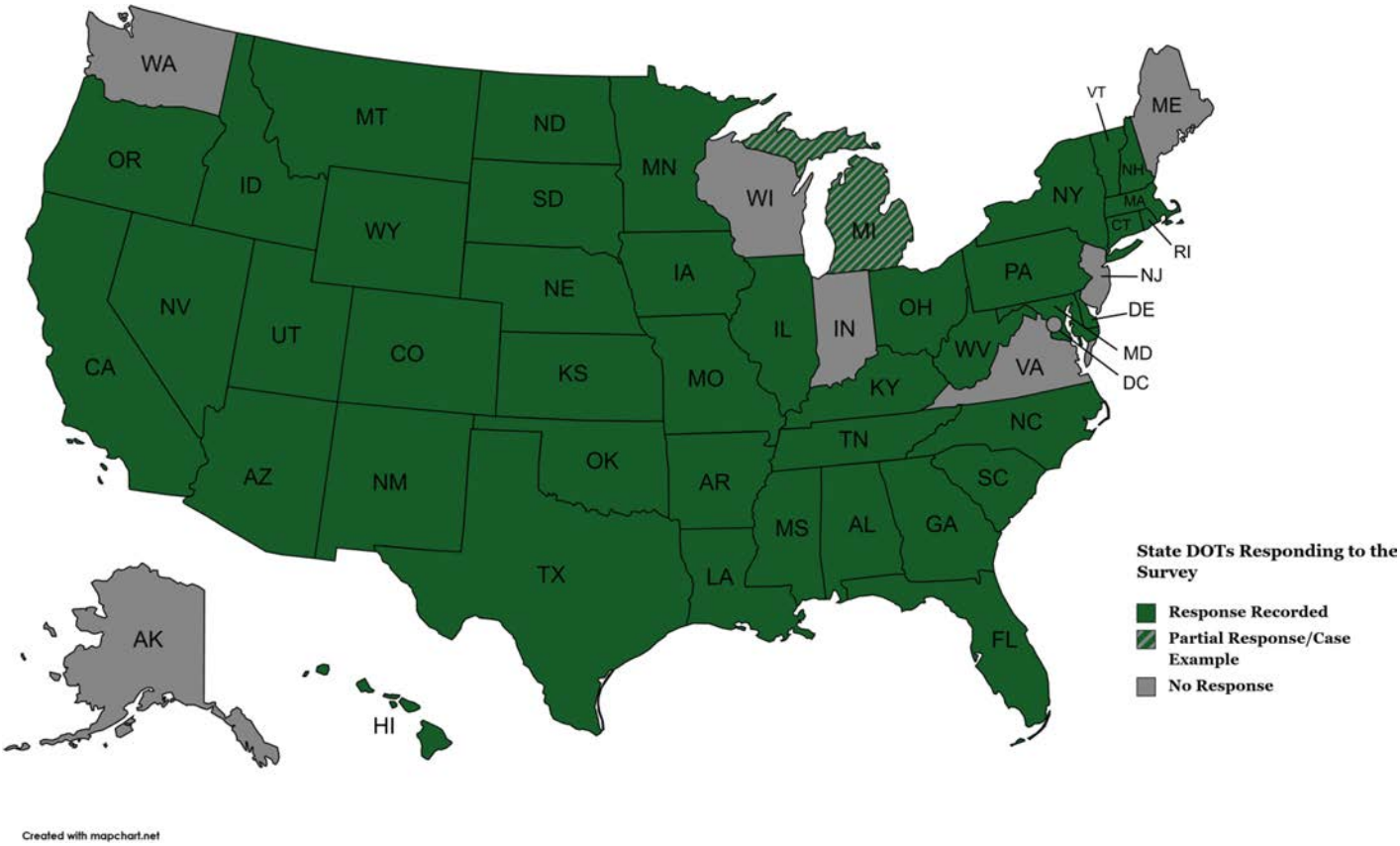


Figure 1.3. Map of states responding to survey.

The facilitation of the survey questionnaire captured the state of the practice regarding EV charging infrastructure deployment by state DOTs. The survey began with general findings of EV charging infrastructure deployment, then captured policies and guidance for EV charging stations. Next, the survey collected current practices related to the operation and management of EV charging infrastructure and finally collected evaluation methods and challenges in EV charging infrastructure deployment. In addition, the analysis of relevant documents obtained from the survey is also included to support the findings. The survey was developed in an online survey platform and was electronically distributed to the voting membership of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Planning. This distribution included representatives from all 50 state DOTs and Washington, DC. The findings of the survey are presented in Chapter 3 and are based on 42 state DOT respondents. The complete survey is presented in Appendix A with individual state DOT responses provided in Appendix B. Figure 1.3 shows the map of state DOTs that responded to the survey. Michigan DOT is noted as a partial response as they were not able to complete the entire survey within the time limitations of this study. However, because of the national attention garnered by the state of Michigan in awarding the first contract to install in-road EV charging infrastructure in the United States, they were interviewed to provide a case example.

Following the analysis of survey responses, subsequent case examples were conducted to gather further detailed information on EV charging infrastructure deployment by state DOTs. Six state DOTs were selected for case example interviews. These state DOTs were California, Hawaii, Massachusetts, Michigan, Tennessee, and Vermont. Details of the individual interviews are outlined in Chapter 4, and the questions asked during the interviews can be found in Appendix C.

CHAPTER 2

Literature Review

This literature review summarizes background information, recent research, and current practices regarding strategies and programs for EV charging at state DOTs. Initial literature discovery indicated a vast array of resources, ranging from theoretical to application-based documentation and guidance. Because the synthesis is intended to collect the current state of the practice, the decision was made to focus on the application-based literature. The information within this chapter begins with a continuation of the overview for understanding EV charging and infrastructure from Chapter 1, including associated practices and policies employed by selected state DOTs. This information was influential to the development of the survey questionnaire and its accompanying presentation of the responses as described in Chapter 3. The literature reviewed also informed the collection of the case examples described in Chapter 4.

The topics of investigation for the literature included an overview of EVs and charging infrastructure, practices for EV charging infrastructure deployment and siting, domestic and international implementation, and policy and funding approaches. These topics also encompassed the synthesis areas of interest listed in Chapter 1 when relevant literature was available.

2.1 Overview of EVs and Charging

The landscape associated with EVs is rapidly evolving. This is evidenced by Sanguesa et al. (2021) and the National Research Council (2013), who note that EV price reductions, climate and environmental awareness, and advancements in battery and charging technologies, among other influences, are resulting in increased adoption of EVs in general. The types of EVs were defined within Chapter 1, and in this synthesis, EV is used to include both BEVs and PHEVs. The growth and potential growth of EVs are captured in many references. Zou et al. (2020) illustrate the EV sales in several markets from 2013 to 2018 along with growth in market share. This is presented in Figure 2.1.

Nicholas et al. (2019) also present market growth and a projection to 2025 for various U.S. markets, as seen in Figure 2.2.

According to the International Energy Agency's "Global EV Outlook 2022," there were about 120,000 EVs sold worldwide in 2012, and in 2021, that many were sold in a single week (IEA 2022a). All indications from these and additional resources point to increasing growth at this stage of adoption for EVs. According to the Department of Energy, EV sales in the United States nearly doubled from 2020 to 2021. This is presented in Figure 2.3. Even with this growth, EVs make up less than 1% of the light-duty vehicles in the United States.

As the United States market shifts, there is a need for growth in EV charging infrastructure to support this shift.

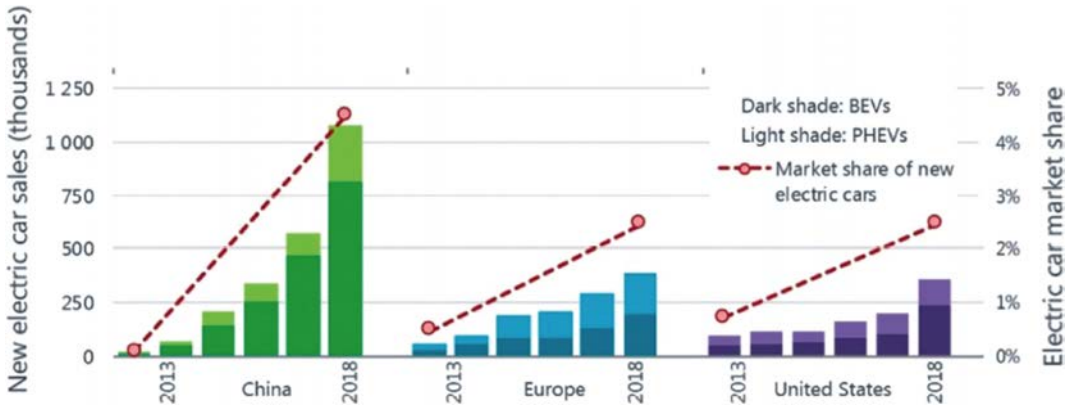


Figure 2.1. EV sales and market share growth in various markets (Source: Zou et al. 2020).

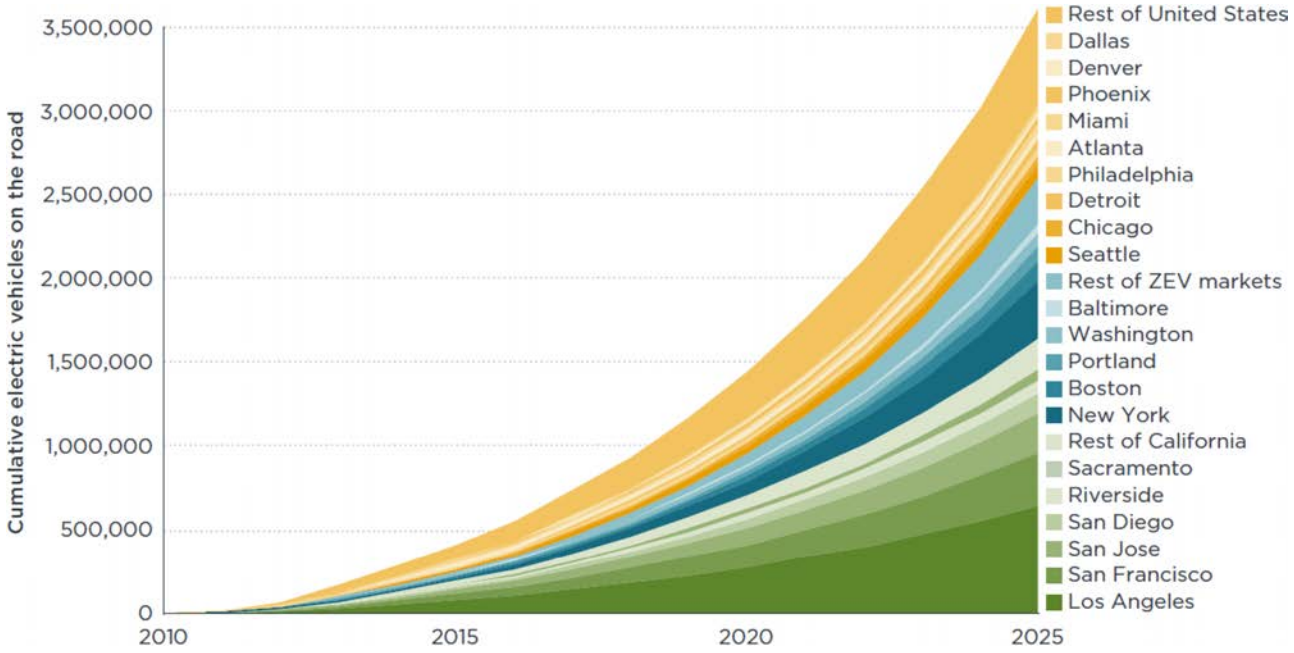


Figure 2.2. EV market trends in U.S. markets (Source: Nicholas et al. 2019).

2.2 Charging Infrastructure

EV supply equipment is a term used interchangeably with EV charging infrastructure. EVSE refers to the infrastructure and equipment necessary to provide charging service to EVs. The increasing percentage of EVs making up the United States fleet has a complex makeup. Just as there are variations among gasoline vehicles, not every EV is the same. There are variations in onboard technology, space, range, and many other attributes. Regardless of EV attributes and use cases (local, regional, or long-distance trip types), charging infrastructure will be needed to support all EV uses. It is important to note that this needed charging infrastructure also varies. As presented in Chapter 1, varying levels of charger provide varying current and wattage for charging speed. This is presented in Figure 2.4 (Ralston and Nigro 2011). Chargers can vary by current type and power output, among other features.

The arrangement at a charging station may also entail varying infrastructure. Figure 2.5 presents the hierarchy of the infrastructure at a station (Brown et al. 2022). At a single station, EVSE

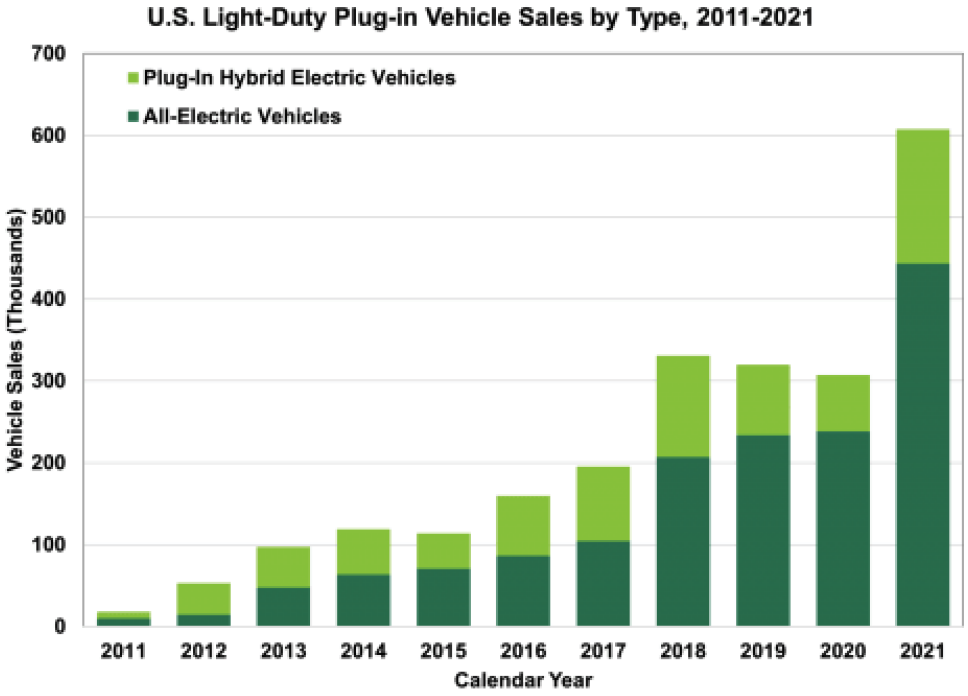


Figure 2.3. EV sales growth in the U.S. (Source: Office of Energy Efficiency and Renewable Energy 2022).

LEVEL	CURRENT	ELECTRIC POTENTIAL DIFFERENCE (V)	CURRENT (A)	POWER (KW)	BEV CHARGING TIME** (MINUTES)			
					3.3kW charger	7kW charger	20kW charger	45kW charger
Level 1	AC	120	12/16	1.4/1.92	1,020			
Level 1	DC	200-450	80	36	-	-	72	-
Level 2	AC	240	80	19.2	420	210	72	-
Level 2	DC	200-450	200	90	-	-	-	20
*Level 3**	DC	200-600	400	240	-	-	-	<10

* There is no official Level 3 today. This is the proposed standard by the SAE.

** Assumes 25kWh of usable capacity beginning at 20 percent state of charge (SOC). If power provided can charge the battery in less than one hour, then charging stops at 80 percent SOC. AC charging uses an on-board charger. DC charging uses an off-board charger.

Figure 2.4. Charging levels included in the SAE J1772 Standard (Source: Ralston and Nigro 2011).

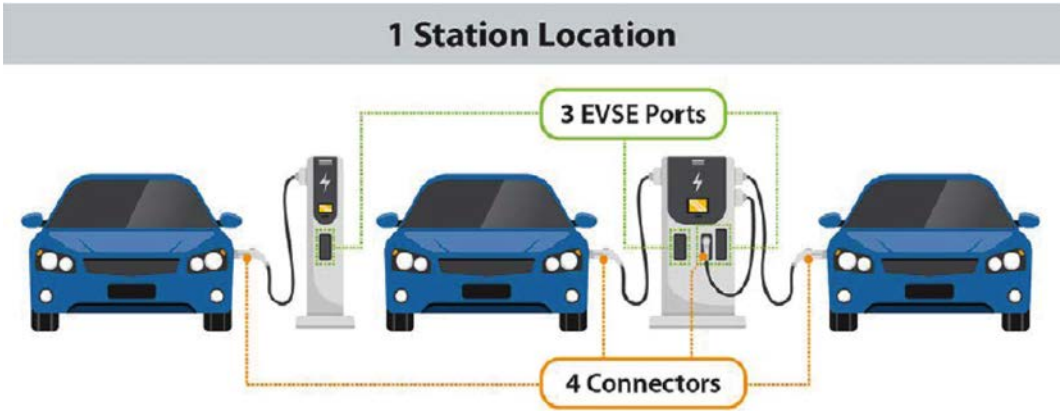


Figure 2.5. EVSE hierarchy (Source: Brown et al. 2022).

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ports represent the hardware necessary to run a connector. EVSE ports provide the power to charge the EVs and are only able to charge one vehicle at a time, though one port may have multiple connectors. The EVSE ports are contained in a unit that is sometimes called a charging post. These charging posts may have one or more EVSE ports. From the port, a cable is plugged into the EV via a connector to charge it. Multiple connectors and connector types can be available on one EVSE port, but again, only one vehicle can charge at a time at any port (Brown et al. 2022).

The quarterly reports by the National Renewable Energy Laboratory such as the fourth quarter report for 2021 by Brown et al. (2022) present EVSE trends in growth and usage. This service collects information from stations that are connected and integrated into their EVSE locator. Brown et al. also list the varying connectors that may be available. The connectors vary by EV manufacturer and country. The possible connectors in the United States include the following:

- NEMA
- J1772
- Combined Charging System (CCS)
- CHAdeMO
- Tesla

While these are the possible connector types, the most available Level 2 connectors tend to be J1772, while the most available DC fast charging (DCFC) connectors tend to be CCS, CHAdeMO, and Tesla. It is also likely that the NPRM regarding the NEVI Formula Program will result in the CCS connector being the most common since it is identified as the industry standard and required for installations per NEVI requirements (U.S. DOT 2022).

Brown et al. present the growth in EVSE along various criteria, and Figure 2.6 provides one example.

These reports indicate there is potential in EVSE to support the EV growth previously mentioned. As with the consideration and variables associated with EV selection, there is a range of considerations to account for in deploying and prioritizing EVSE siting.

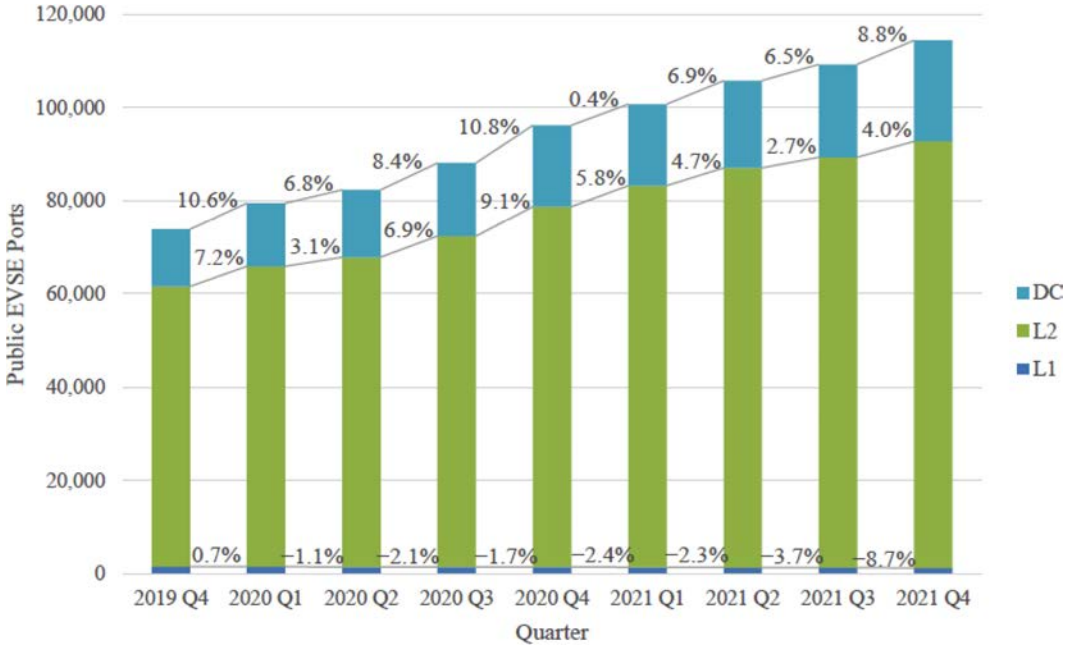

Figure 2.6. Quarterly growth in public EVSE ports by level (Source: Brown et al. 2022).

Table 2.1. Effects of charging infrastructure on motivations for installation (Source: National Research Council 2015).

Infrastructure Category[b]	PEV Class	Effect of Infrastructure on Mainstream PEV Owner	Who Has an Incentive to Install?
Home AC levels 1 and 2	Long-range BEV Limited-range BEV Range-extended PHEV Minimal PHEV	Virtual necessity Virtual necessity Virtual necessity Virtual necessity	Vehicle Owner, Utility
Workplace AC levels 1 and 2	Long-range BEV Limited-range BEV Range-extended PHEV Minimal PHEV	Range extension, expands market Range extension, expands market Increases eVMT and value proposition; expands market Increases eVMT and value proposition; expands market	Business Owner, Utility
Intracity[c] AC levels 1 and 2	Long-range BEV Limited-range BEV Range-extended PHEV Minimal PHEV	Not necessary Range extension, increases confidence Increases eVMT and value proposition Increases eVMT and value proposition	Utility, Retailer, Charging Provider, Vehicle Manufacturer
Intracity[c] DC fast charge	Long-range BEV Limited-range BEV Range-extended PHEV Minimal PHEV	Not necessary Range extension, increases confidence NA – not equipped NA – not equipped	Utility, Charging Provider, Vehicle Manufacturer, Government
Intercity[c] DC fast charge	Long-range BEV Limited-range BEV Range-extended PHEV Minimal PHEV	Range extension, expands market 2 × Range extension, increases confidence NA – not equipped NA – not equipped	Vehicle Manufacturer, Government
Interstate DC fast charge	Long-range BEV Limited-range BEV Range-extended PHEV Minimal PHEV	Range extension, expands market Not practical for long trips NA – not equipped NA – not equipped	Vehicle Manufacturer, Government

Frades (2014), in "A Guide to the Lessons Learned from the Clean Cities Community Electric Vehicle Readiness Projects," presents range, site design, security, access, business model, use cases, and surrounding infrastructure as some of the factors to consider with selecting EVSE sites. In mentioning business cases, sites provide certain incentives to attract those installing EVSEs. The National Research Council provides insight into this regard as presented in Table 2.1.

While the growth in EVSE sites presents a positive trend, Nicholas et al. (2019) highlight the gap in EV charging infrastructure needs in the United States. Figure 2.7 presents the available public and workplace charging infrastructure in place in 2017 and compares this to the estimated needs of 2025. The graphic shows much more infrastructure is needed. In fact, to meet the needs of 2025, the United States would need to see growth in EVSE of 20% per year from 2017. Figure 2.7 emphasizes this by showing that 88 of the 100 areas shown have less than half of the total needed charging infrastructure for 2025 (Nicholas et al. 2019).

Frades (2014), in "A Guide to the Lessons Learned from Clean Cities Community Electric Vehicle Readiness Projects," presents some reasoning as to why more EVSE infrastructure may not be available as seen in Table 2.2.

2.3 Domestic Implementation

The EVSE needs projected and challenges previously discussed provide the context for EV charging implementation in the United States. Within this context, there are important considerations and recognized practices in the areas of deployment approaches, site selection, site and system security, rural and equitable charging locations, charging for medium and heavy-duty vehicles, electric grid impacts, and decarbonization and transportation electrification.

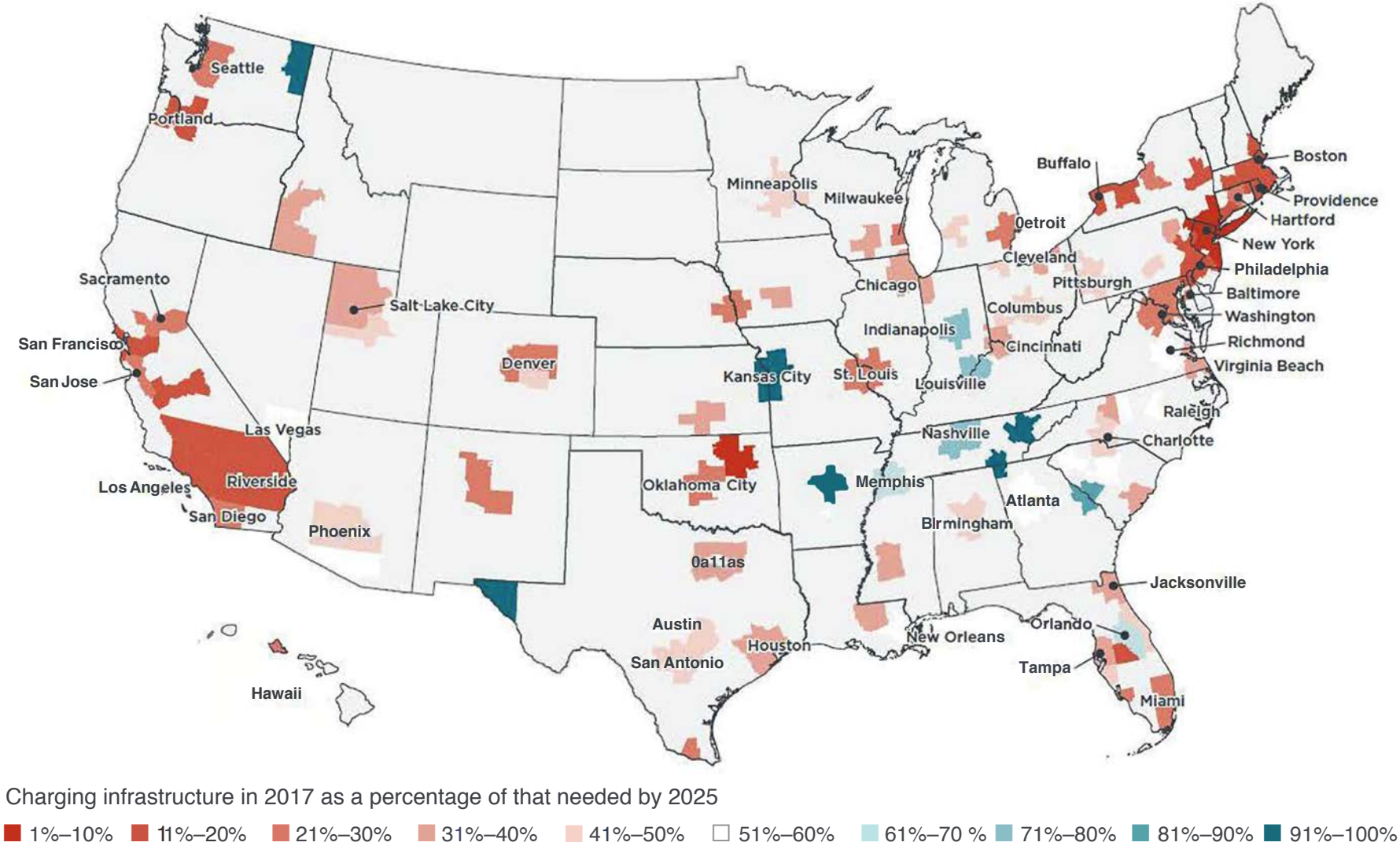

Figure 2.7. Public and workplace charging infrastructure in 2017 as a percentage of infrastructure needed by 2025 by metropolitan area (Source: Nicholas et al. 2019).

Table 2.2. Barriers to charging station installation and utilization (Source: Frades 2014).

Financial	• Home charging equipment often not sold or financed with AEV purchase at the dealership
	• Cost of home charging equipment, installation, and permitting
	• Difficulty establishing a profitable business case for charging stations
	  ○ Charging stations experience low utilization rates during early PEV market development
	  ○ Low margins on electricity sales relative to upfront costs and maintenance costs of charging stations
	  ○ Demand charges by electric utilities for fast charging, especially in less populated areas
	  ○ Difficulty establishing the terms under which charging providers can offer service in regulated markets
	• Lack of established public or private funding for the purchase and/or maintenance of charging infrastructure

Information and coordination	• Difficulty providing charging stations at multi-unit residential, workplace, and other shared parking sites (i.e., cost, fairness, ownership, administrative, and legal issues) • Consumers unaware of existing public charging stations • Long charge times inconvenient for drivers, especially where public charging stations are highly utilized and drivers may have to wait for others to finish • Uncertainty among public planners and private investors about the future intensity and location of demand for public charging stations • Uncertainty about the optimal level of charging power to install at public stations given the tradeoffs between speed of charging and station cost, as well as uncertainty about demand from AEVs (higher power needs) versus PHEVs (lower power needs) • Lack of compatibility among charging station payment methods, communications, and fast-charging standards • Uncertainty about best practices for planning parking sites with public charging stations, including Americans with Disability Act (ADA) compliance • Efforts to support charging station installation not fully leveraged due to lack of communication and coordination among potential partners
Policy	• Insufficient signage directing PEV drivers to charging stations and non-uniform charging station signage • Expensive, complex, protracted, and/or non-uniform permitting and inspection procedures for residential and workplace charging station installation • Local zoning rules vague or arduous for charging station siting • Charging-only use of public charging spaces cannot be enforced without new ordinances

Deployment Approaches and Associated Roles and Responsibilities

According to the United States Department of Energy, Office of Energy Efficiency and Renewable Energy Alternative Fuels Data Center (AFDC), considerations of deployment must include the site host's goals for utilization, equity, and social justice, among other factors. As public owners, state DOTs should consider the following AFDC Infrastructure Development Checklist.

- Determine project scope, budget, funding mechanism, and timeline using the following considerations.
- Determine ideal project site, based on existing infrastructure and infrastructure needs.
- Determine the number, type(s), and costs of charging equipment needed, typically:
  - Workplaces and multifamily housing should consider Level 1 and Level 2 charging
  - Public charging hosts should consider Level 2 and DC fast charging.
- Decide whether the stations will need to be networked, including if utilization data will be collected and if payment capabilities are necessary.

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- Determine if a formal solicitation is needed.
- Choose a network and/or charging infrastructure manufacturer and provider.
- Identify installation needs and costs, including upgrades to electrical wiring, and find a certified electrical contractor.
- Obtain required permits.
- Determine additional site needs, including signage and security.
- Identify project partners, including electric utilities and Clean Cities coalitions.
- Assess charging infrastructure maintenance and operation needs and costs.
- Confirm the station is included in the AFDC Alternative Fueling Station Locator (Office of Energy Efficiency and Renewable Energy n.d.).

From the guidance provided, the United States Department of Energy AFDC also provides access to a case study in public procurement entitled the Colorado Energy Office: EV Fast Charging Corridors Grant Program. The AFDC guidance and case study note several forms of possible funding from grant programs and associated regulations along with considering ownership options, fee structures, equipment selection, operations and maintenance, and more. It is important that these considerations be determined according to the procurement methods chosen and as allowed. In some cases, procurement may require a formal selection process. In cases of state DOT ownership, fee structure and cost recovery may be limited. In summary, the deployment of EVSE can be vastly complex and is likely regulated by the funding or grant opportunities utilized. Ownership, roles, and responsibilities could vary in form and even be part of public-private partnerships. The AFDC includes many resources to support these decisions.

Site Selection

AFDC also presents site selection as a complex set of considerations. Considerations of needs, parking usage, local points of interest, and many other factors must be assessed for site selection. This is further highlighted in the "Site Selection Guide for EV Charging Stations" as provided by Energetics (Energetics n.d.). This guide categorizes consideration along the areas of

- Desire, need, or requirement;
- Parking demographics;
- Site characteristics; and
- Other considerations.

The intent of the guide is to present those considering deployment with important factors. For instance, matching charging equipment type with parking demographics and utilization is a consideration for those deploying EVSE. In areas where a user may park for an extended period, slower-charging infrastructure may provide a more cost-effective solution and still provide users with the power needed. The guide and AFDC point to the need to consider more than utilization and site security in the selection of EVSE sites.

Site and System Security

While still a consideration for the deployment sites of EVSE, site security is imperative for ensuring charging infrastructure is utilized. The GMR *Electric Vehicle Charging Station Security Guidebook* (2021) notes that people are vulnerable during charging by being tethered to EVSE and likely by being distracted or even napping (GMR 2022). As such, a site providing convenient access and egress, lighting, connectivity, and adjacent facilities reduces risks of crime. Other elements of safety, such as environmental hazards or the potential for falling or injury, must also be considered. As regulations may require sites to function at all hours, approaches to reduce crime risk and even vandalism of the EVSE become important considerations.

Another element of security is system security. A consideration of EVSE selection is in the connectivity of the equipment. The AFDC points out that EVSE may be standalone equipment or network connected for evaluating utilization or collecting other data. Therefore, a relatively recent discussion in EVSE is the cybersecurity of the system. Any system that deals with personally identifiable information or collects electronic forms of payment, will need to be cognizant of security to protect that information. The National Renewable Energy Lab (NREL) website on electric vehicle grid integration notes that EVs pose unique cybersecurity threats by being connected to the electric grid (NREL n.d.). Cyber threats could include manipulating the chargers, causing charger or grid damage, or wasting energy. NREL is working to provide guidance and security against these threats.

Rural and Equitable Charging Locations

Another challenge in EVSE is ensuring equitable access. Deployments of EVSE may involve private partners seeking financial gain. As the AFDC points out, low-income and underserved communities may be excluded from installations if gains are not expected. Yet with these communities being exposed to a higher proportion of environmental hazards, EV charging infrastructure may encourage EV adoption to reduce those impacts (Office of Energy Efficiency and Renewable Energy n.d.). The AFDC also includes guidance on EV charging infrastructure to support multifamily housing that could be typical of these areas.

Along similar lines, rural area charging may not be attractive to capital-seeking EVSE deployments because of lower expected utilization. Support for extended trips and corridors necessitates the consideration of rural deployments. The United States Department of Transportation prepared the Rural EV Toolkit to present the benefits, challenges, and effective practices associated with rural EVSE (U.S. DOT 2022). The toolkit notes that rural areas are home to 20% of Americans and almost 70% of the United States road-miles. The toolkit serves as a one-stop shop for rural communities planning rural EVSE deployment and notes that Federal funding is becoming available to specifically support rural communities in these endeavors.

It should also be noted that rural deployments and equitable access are highlighted within the NEVI Formula Program and are specific points of interest within the NEVI Discretionary Program.

Heavy- and Medium-Duty Charging

The NREL Electric Vehicle Grid Integration website also notes the complexities of providing EVSE for heavy- and medium-duty EVs. They present mega-watt and larger solutions and the need to consider

- Load profiles for regional-haul trucks,
- Optimal battery-charge-control algorithms,
- Site-integrated charging for improved operations and equipment costs,
- Thermal challenges associated with cables and connectors,
- High-power conversion equipment, and
- Grid impacts of a multi-port, publicly accessible charging station. (NREL n.d.)

In its white paper, "Co-locating the Transport of Vehicles, Energy, and Information," NextGen Highways (2021) notes that medium-duty EV charging presents challenges even on a regional level, and that heavy-duty EV charging is currently not possible for existing electric grid systems. The result has been delays in the production of a heavy-duty EV fleet. NextGen Highways notes that the 1.6 megawatts of power needed by one heavy-duty EV is equivalent to roughly 1,200 average households or 30 DC fast-chargers for passenger cars. The amount of power needed for medium and heavy-duty EV charging presents significant grid challenges.

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Electric Grid Impacts

Both the NextGen Highways white paper and the NREL website note grid challenges brought on by EV charging. Both sources also note the need to implement strategies and technology to manage, control, and oversee grid demands posed by EV charging equipment. Flattening energy demand and the use of energy storage are a couple of the approaches mentioned.

NextGen Highways also promotes the advancement of transportation electrification to bolster the grid with high-voltage, direct-current transmission. This buried high-voltage, direct-current macro-grid would provide grid duplication and support, and could potentially follow interstate ROW. Along with NREL, NextGen Highways presents that for every $1 spent on such a macro-grid system, the United States could expect $2-$3 in return on that investment.

Decarbonization and Transportation Electrification

The United States Environmental Protection Agency notes that in 2020, the transportation sector was responsible for 27% of the greenhouse gas emissions in the United States (U.S. EPA 2022). A shift from gasoline-powered vehicles to EVs provides a steep reduction in carbon emissions. It is also noted that the power generated to support those EVs could also be produced in cleaner methods for further decarbonization. The NextGen Highways white paper presents that there is a need for a cleaner electric grid to support the transition to transportation electrification to truly trend toward transportation decarbonization (NextGen Highways 2021).

The Ray is another organization that supports these initiatives:

> The Ray is a 501(c)(3) nonprofit charity and net-zero highway testbed, located on 18 miles of Interstate 85 between LaGrange, Georgia and the Georgia-Alabama state line. The stretch of interstate is named in memory of Ray C. Anderson (1934-2011), a Georgia native recognized as a leader in green business when he challenged his company, Interface, Inc., to pursue a zero environmental footprint. "The Ray Highway" testbed is paving the way for a zero carbon, zero waste, zero death highway system to build a safer and more prosperous future for all. (The Ray n.d.)

The team interviewed a representative of the Ray to discuss EV charging infrastructure. It is important to note that the Ray has a formal charter agreement with Georgia DOT focusing on sustainability, safety, and innovation in transportation. With no end date to this charter, the intention is for the work to outlive all those involved. The charter also includes the FHWA division office. The Ray has a solar EV charging station (Peachtree Corners) and solar pavements along with being involved in additional EV charging projects.

Their work with GeoTab analyzes truck travel moments along I-20 from Texas to Atlanta, tracking truck starting and stopping and travel demand to inform potential EV charging for medium- and heavy-duty EVs. This was a pilot study but will expand to other corridors to inform the needs of supporting medium and heavy-duty charging. In the periphery, the Ray has been supportive of NEVI planning work of state DOTs as they look toward outsourcing ownership of the EVSE in general. They also assist in the consideration of challenges such as promoting solar and battery backup for rural areas where grid trickle charging supports charging needs. The Ray is beginning to focus more on medium- and heavy-duty freight EVs, because of the support already existing for passenger EVs.

With medium- and heavy-duty EVs, there are many considerations, and the Ray has been working with NextGen Highways to better understand grid impacts and with the Aspire Center at Utah State University to research wireless in road-charging approaches. As mentioned, with NextGen Highways, the Ray is promoting grid upgrades because while the current grid can support passenger EVs with proper planning, it cannot handle EV charging for medium- and heavy-duty fleets. Other power considerations for these fleets are hydrogen fuel cells, but there is still much to consider with EV versus hydrogen. There may be considerations for both sources

of energy for regional versus long-haul trips. The Ray notes that in the long term, the grid has to be addressed for resiliency, decarbonization, and electrification of transportation.

2.4 International Implementation

An excellent source of EV-related information from a global perspective is provided by the International Energy Agency (IEA). In their "Global EV Outlook 2022," they note China and Europe are leading the growth in EV adoption (IEA 2022a). One reason for the growth in Europe is their goal to sell only EVs in the passenger sector by 2030. Notable global challenges include many of those already mentioned, such as grid upgrades and the need to address medium- and heavy-duty EVs, but there is also a concern for the availability of minerals for battery production demands as EV sales continue to rise. The IEA also notes that government support for EVs and transportation electrification are assisting in EV sales growth and adoption. Another global challenge is how to support EV adoption in developing countries. While the United States, Europe, and others continue to support their own EV adoption, a true global decarbonization of transportation will require the adoption of EVs in developing countries as well.

The European Automobile Manufacturers Association produced a 2022 white paper on their *European EV Charging Infrastructure Masterplan* (ACEA 2022). This white paper notes that 6.8 million public charging points will be required by 2030. That means that up to 14,000 public charging points need to be installed per week, on average. Currently, Europe is only seeing about 2,000 installations per week. Again, additional challenges noted are in providing upgrades to the electric grid. The master plan focuses on two deployment approaches: demand-driven and utilization-driven. These approaches are noted to be complex considerations as described in the domestic literature, and the European Masterplan likewise notes EVSE as the major bottleneck for EV development and adoption.

2.5 Policy and Funding

Policies and funding are necessary to support EVSE deployment to backfill the need seen domestically and abroad. Before the BIL, support for EVSE deployment was largely provided through grant programs. The most notable additional support for the grant programs was established by the Volkswagen (VW) Settlement funding. According to the United States Environmental Protection Agency, the government and VW settled allegations that VW violated the Clean Air Act by selling approximately 590,000 vehicles equipped with defective diesel emissions. The settlement involved VW providing $2.9 billion. This settlement resulted in the creation of Electrify America, an EVSE company that began an initial network of chargers across the United States. Electrify America worked with many states to deploy EVSE, but EV market growth was outpacing their abilities (Printz 2021).

Certainly, regarding policy and funding, the United States government is attempting assistance and additional support to EVSE grant programs. The FHWA's NEVI Formula Program is legislatively tapped to provide $5 billion to strategically deploy EVSE and to establish an interconnected network to facilitate data collection, access, and reliability. An additional $2.5 billion becomes available through the Discretionary Grant Program for Charging and Fueling Infrastructure. This funding and associated details will be available at a later date. NEVI funding is available for up to 80% of eligible project costs, including

- The acquisition, installation, and network connection of EVSE to facilitate data collection, access, and reliability;
- Proper operation and maintenance of EVSE (for up to 5 years); and
- Long-term EVSE data sharing.

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The policy requires the EVSE to be non-propriety, allow open-access payment methods, be publicly available or available to authorized commercial motor vehicle operators from more than one company, and be located along designated FHWA Alternative Fuel Corridors. Once it is determined (state designation with U.S. DOT Secretary Certification) that all their Alternative Fuel Corridors have been fully built-out, then the states can propose alternative public locations and roads for EVSE installation. To be considered as built-out, the NEVI Formula Program requires the installation of charging stations every 50 miles along Alternative Fuel Corridors, with at least four DCFC ports capable of charging four EVs with at least 150kW power output. Additionally, CCS connectors are required at the charging stations and the stations are required to be located within 1 mile of the freeway.

According to the NPRM for NEVI, states are also advised to site EVSE in areas allowing for safe 24-hour access, such as having egress means, being co-located with other facilities, and not being subject to risks such as flooding (FHWA 2022). Notably, the NPRM confirms that NEVI funding must comply with Title 23 of the United States Code and administration must comply with 2 CFR (Code of Federal Regulations) Part 200. 2 CFR notes compliance with price and the like, while Title 23 employs siting and construction requirements and limitations. Of concern to many states, Title 23 requires NEVI deployment to comply with the NEPA (National Environmental Protection Act) process, Americans with Disabilities Act requirements, and Buy America Act provisions. While in general, it is believed that EVSE sites would be considered Categorical Exclusions within the NEPA process, the process and required documentation must still be completed. There are deeper concerns about complying with the Buy America Act and the availability of EVSE that may comply accordingly. The NEVI-related funding, and most DOT sources funds, would need to comply specifically with Buy America requirements, though there may be some variations by agency. An additional challenge is restricting advertising (labels on EVSE) under these requirements. The NPRM does provide areas of guidance, such as considering procurement through public-private partnerships and considerations for siting. This appears to be the approach many state DOTs will take, according to the case examples in Chapter 4.

2.6 Synthesis Challenges and Timeline

As mentioned in Chapter 1, the NEVI program timing provided complexity to this synthesis but also allowed for capturing the state of the practice during ongoing changes. While details continue to develop during the collection of this synthesis, the information captured will serve those deploying EVSE through the NEVI Formula Program and other grant opportunities.

The information and resources summarized within this chapter provided the background from which to conduct the survey discussed in the following chapter.

CHAPTER 3

Results of the Survey Questionnaire

This chapter presents current strategies and practices in use by state DOTs to facilitate and coordinate the provision and operation of EV charging facilities. As noted in Chapter 1, an online survey questionnaire was distributed by email to the voting members of the AASHTO Committee on Planning. The survey was initially distributed on February 22, 2022, with a majority of the responses completed by mid-April 2022. A total of 42 state DOT responses were received. This chapter reports the results of key survey questions. In addition, the analysis of relevant documents obtained from the survey is also included to support the findings. The chapter begins with reporting the general findings of EV charging infrastructure deployment. It then presents policies and guidance for EV charging stations. Next, the chapter discusses the current practice related to the operation and management of EV charging. Finally, the chapter presents the evaluation of and challenges in EV charging infrastructure deployment. It is important to note that the 42 state DOT respondents were not required to respond to all questions in the survey. As a result, the sample size (*n*) of each question varies. Additionally, in some questions, the summary of all responses is not equal to 100% because the respondents were able to select multiple options. Appendix A provides the complete survey questionnaire and Appendix B provides individual agency responses to each survey question. The following sections discuss the key findings from the survey in detail.

3.1 General Findings of EV Charging Infrastructure Deployment

State DOTs have employed a variety of approaches to the deployment and operation of EV charging stations. Out of 42 DOT respondents, 22 state DOTs (52%) reported that they have installed or contracted to have EV charging stations installed in either public-facing areas or their facilities, such as the DOT headquarters or buildings (Figure 3.1). Twenty state DOTs (48%) reported that they have not deployed EV charging stations. However, 14 out of these 20 state DOTs reported that they have a plan or are currently planning to deploy EV charging infrastructure. At the time of the survey being conducted (before the requirement of NEVI plans), four state DOTs had not planned the deployment of EV charging infrastructure, including Alabama, Arkansas, Missouri, and Mississippi. Two state DOTs (Arizona and Nebraska) are not sure if they have planned or are currently planning a deployment of EV charging infrastructure.

For the state DOTs that indicated they deployed EV charging stations, the survey respondents were asked to identify the types of EV charging stations associated with their deployed locations. Table 3.1 summarizes the result of this question, which indicates that the Level 2 charging is typically deployed at DOT/state-owned buildings but non-public facing (73%), at DOT/state-owned public-facing buildings (55%), and at parking areas in DOT/state-owned right-of-way (41%).

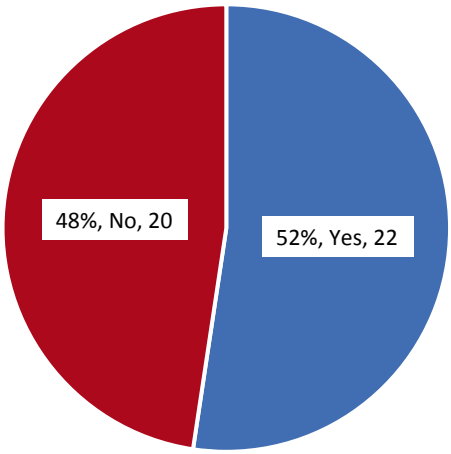

Figure 3.1. State DOTs deploying EV charging stations (n = 42).

For the Level 1 charging, the typical DOT deployed locations include DOT/state-owned buildings but non-public facing (14%) and parking areas in DOT/state-owned right-of-way (9%). Finally, DCFC is typically deployed at locations along high-traffic corridors (36%), in local-government or metro-owned right-of-way (32%), and at public-facing facilities along DOT/state-owned right-of-way (i.e., rest areas) (27%).

Figure 3.2 shows the barriers experienced by DOTs in their current or planned deployment of EV charging infrastructure. These responses were provided by the six state DOTs that have not deployed nor planned to deploy EV charging infrastructure. The responses indicated that

Table 3.1. Deployed locations for EV charging stations (*n* = 22).

DOT Deployed Locations	Level 1 Charging (%)	Level 2 Charging (%)	DC Fast Charging (%)
At DOT/state-owned buildings but non-public-facing (for government use only)	14	73	5
At DOT/state-owned public-facing buildings (i.e., offices or driver's licensing locations) for public use	5	55	23
At public-facing facilities along DOT/state-owned right-of-way (i.e., rest areas)	5	32	27
Along urbanized curb sections (i.e., along downtown sections)	5	9	0
At parking areas in DOT/state-owned right-of-way	9	41	18
Along high-traffic corridors	5	27	41
In local-government or metro-owned right-of-way	0	5	5
At private-owned locations (i.e., by lease)	0	9	18
At toll roads or other interstate segments as "grandfathered in" under 23 U.S.C. 111(a).	0	9	18

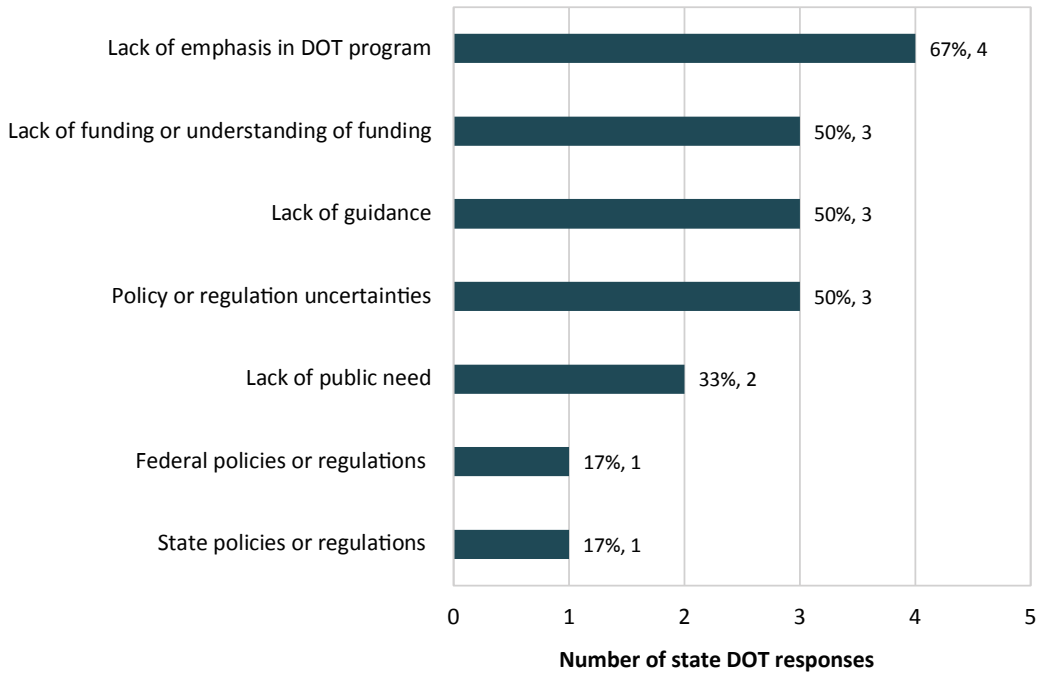

Figure 3.2. Barriers preventing state DOTs' current or planned deployment of EV charging (n = 6).

the main barriers (those mentioned by more than one state) preventing their current or planned deployment of EV charging stations include

- A lack of emphasis in the DOT program,
- A lack of funding or understanding of funding,
- A lack of guidance,
- Policy or regulation uncertainties, and
- A lack of public need.

3.2 Policies and Guidance for EV Charging Stations

The survey respondents were asked to indicate the impact of federal policies and regulations on their deployment of EV charging infrastructure. Figure 3.3 summarizes the result of this question. More than 60% of 35 state DOT respondents that deployed or planned to deploy EV charging indicated that the federal policies and regulations have affected the siting and location of EV chargers (83%), material used such as Buy America Act requirements (69%), the type and levels installed of EV charging (66%), and the number of EV charging stations installed (63%). Nineteen out of 35 state DOTs (54%) also reported that the federal policies and regulations have affected fee structures and cost recovery for EV charging infrastructure deployment.

Additionally, Kansas DOT reported that the federal policies and regulations have affected the timeline of implementing secondary and tertiary EV station priorities. Massachusetts DOT indicated that the federal policies and regulations have affected the ability to charge a fee for electricity on non-grandfathered locations on Interstate ROW. New York DOT pointed out that the main barrier for EV charging infrastructure deployment is 23 U.S. Code § 111 - Agreements relating to use of and access to rights-of-way—Interstate System. This is the law restricting the ability to generate revenue from services provided on Interstate rights-of-way alluded to by the Massachusetts DOT.

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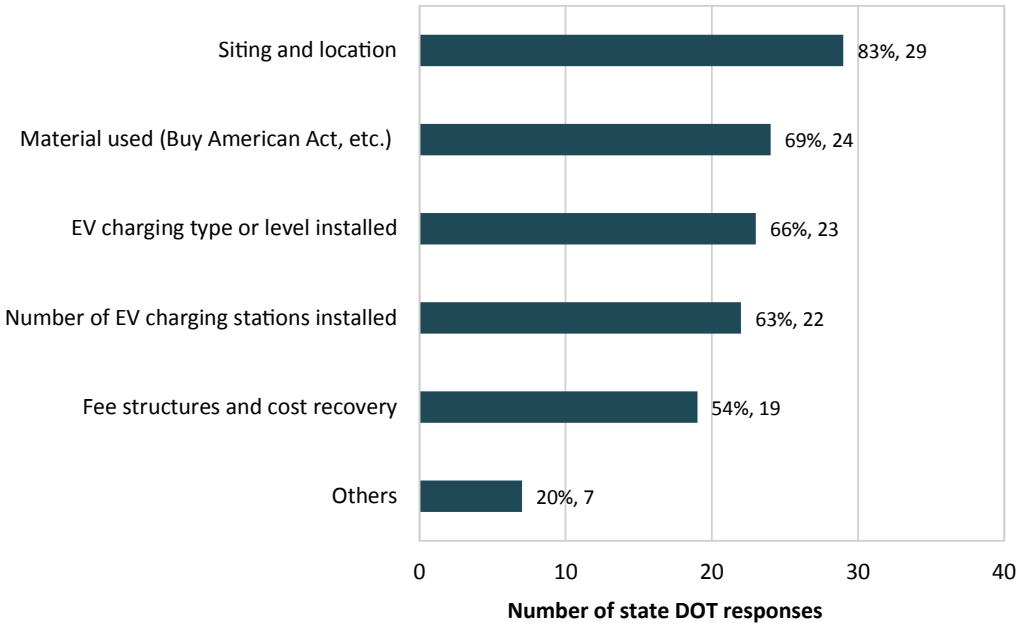

Figure 3.3. Aspects of EV charging infrastructure deployment impacted by federal policy and regulations (n = 35).

The survey results also revealed that only two DOTs (Florida and Minnesota) out of the 42 DOTs that participated in this study have developed EV charging infrastructure guidelines. Specifically, the EV Infrastructure Master Plan in Florida aims at providing a comprehensive course of action to deploy EV charging infrastructure efficiently and effectively (FDOT 2021). Figure 3.4 summarizes the three main objectives of the EV Infrastructure Master Plan in Florida.

The Minnesota DOT (MnDOT) has developed guidance to provide information for facilities staff and the public about EVs and general guidance for installing EV charging stations. The EV Guidance focuses on three main areas: charging basics, site design, and MnDOT-specific guidelines related to installing and operating EV charging stations at MnDOT facilities (MnDOT 2021).

Next, state DOTs were asked to identify if they have provided guidance or technical assistance to local governments regarding deployment, or planned deployment of EV charging infrastructure including rezoning needs for home-based charging facilities or charging for public and private parking lots and garages. Figure 3.5 shows that most of the state DOTs (65%) reported that they have not provided guidance or technical assistance to local governments regarding deployment, or planned deployment of EV charging infrastructure. Only four state DOTs (Colorado, Hawaii, Vermont, and New York) reported that they have currently provided guidance or technical assistance to local governments for the deployment of EV charging infrastructure. Eight

Figure 3.4. Primary objectives of EV master plan in Florida (Source: FDOT 2021).

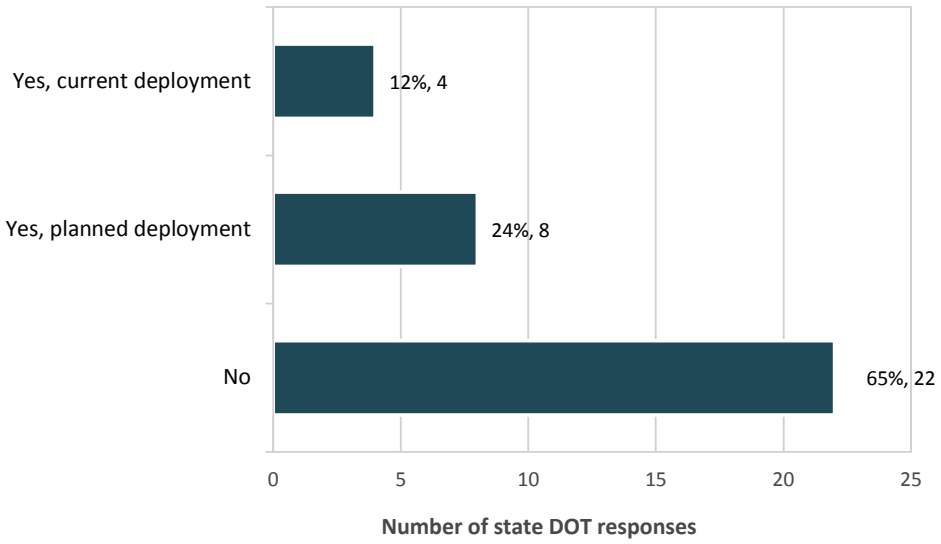

Figure 3.5. DOT-provided technical assistance or guidance to local governments (n = 34).

out of 34 state DOTs respondents (24%) indicated that they have provided technical assistance to local governments for the planned deployment of EV charging infrastructure.

3.3 Operation and Management Strategies for EV Charging

This section summarizes the current state of the practice related to the collection of user fees, rate recovery mechanisms, or other opportunities for cost savings. It also discusses operations and maintenance of the charging infrastructure (either through in-house or contracted forces), and site prioritization by vehicle type and location for the EV charging infrastructure. Figure 3.6 shows the results of how state DOTs collect user fees for EV charging. Out of 31 state DOT

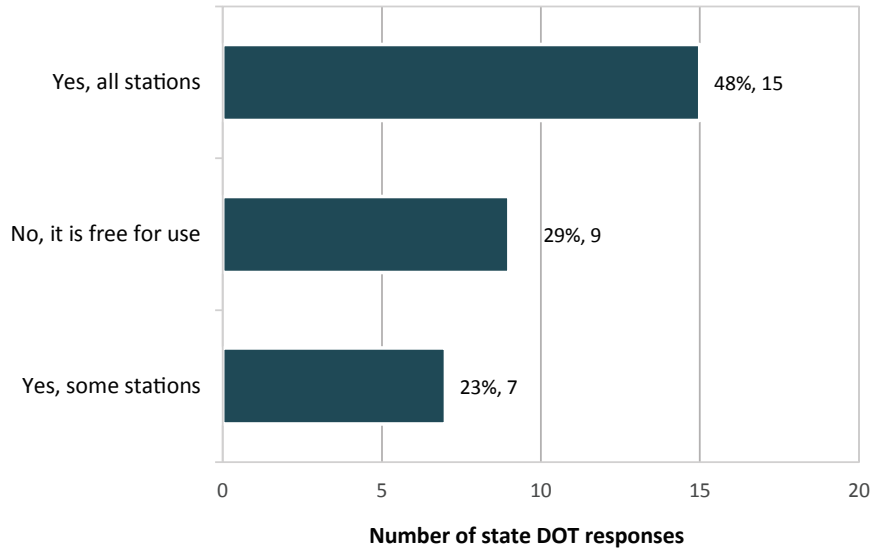

Figure 3.6. Collection of user fees for EV charging (n = 31).

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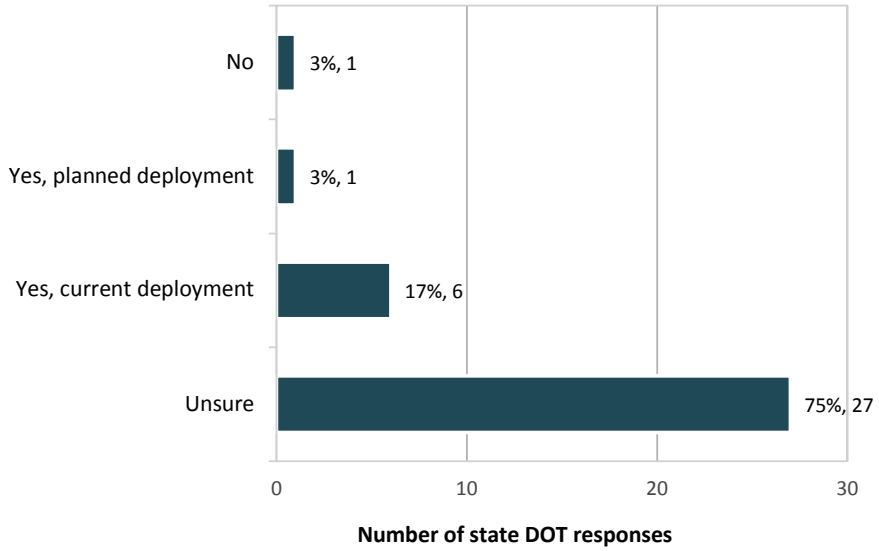

Figure 3.7. Rate recovery or cost saving for EV charging (n = 36).

respondents that deployed or planned to deploy EV charging, 15 DOTs (48%) indicated that they collect user fees for all EV charging stations; nine DOTs (29%) reported that they do not collect user fees; and seven DOTs (23%) specified that they collect user fees for some EV charging stations. An example of a state DOT that only charges fees at some stations is California, which charges fees at park-and-ride facilities but not at rest areas.

The survey respondents were asked if they intended to make use of rules allowing for rate recovery mechanisms or other opportunities for cost savings. Figure 3.7 shows the results of this question. Out of 36 state DOT respondents that deployed or planned to deploy EV charging, 28 DOTs (78%) are unsure about this usage; six state DOTs (17%) are currently allowed to use rules for rate recovery mechanisms or cost savings; Colorado DOT has in place use rules for its planned EV deployment, and New York State DOT indicated that it does not intend to make use of rules allowing for rate recovery mechanisms or other opportunities for cost savings.

Figure 3.8 shows the survey results related to state DOTs' plans to provide operations and maintenance of the EV charging infrastructure either through in-house or contracted forces.

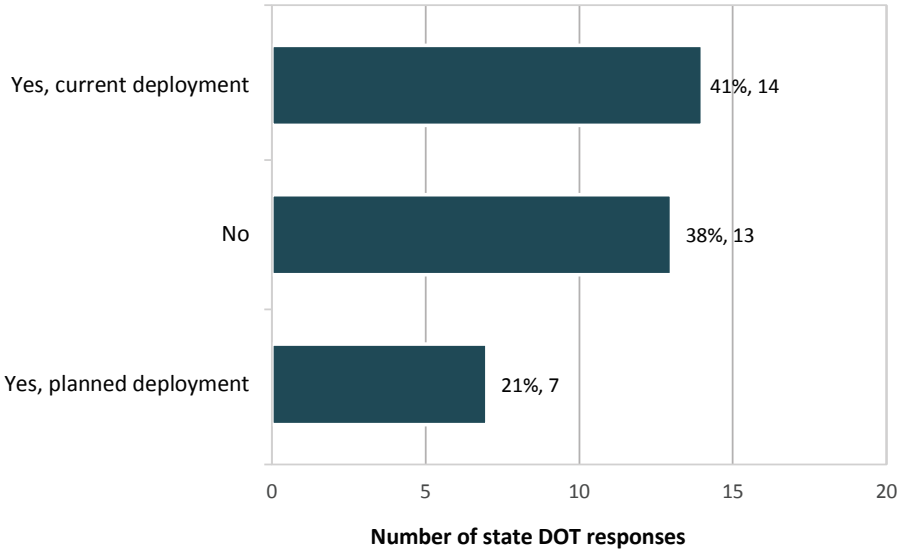

Figure 3.8. Operations and maintenance for EV charging (n = 34).

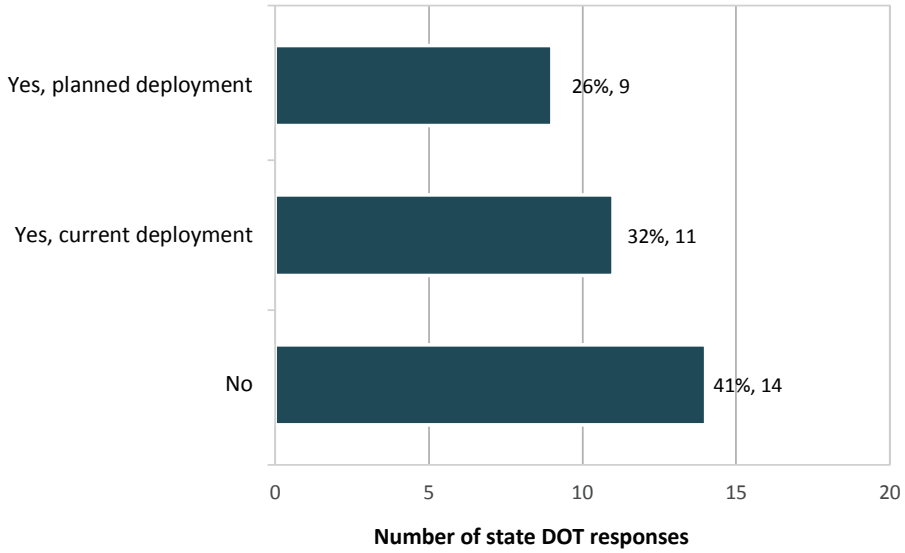

Figure 3.9. Site management and monitoring for EV charging (n = 34).

Out of 34 state DOT respondents that deployed or planned to deploy EV charging, 14 DOTs (41%) indicated that they have a plan for providing operations and maintenance of the EV current charging infrastructure; 13 DOTs (38%) reported that they do not have a plan for providing operations and maintenance; and seven DOTs (21%) indicated that they plan to include to provisions for operations and maintenance of their EV planned charging infrastructure deployment.

In addition, Figure 3.9 shows that out of 34 state respondents, nine DOTs (26%) and 11 DOTs (32%) have a plan to provide site maintenance (e.g., snow removal) and monitoring of the charging infrastructure for their planned and current EV deployment, respectively. Fourteen DOTs (41%) reported that they do not have a plan for the maintenance and monitoring of their EV charging infrastructure.

The survey respondents were asked if they have a third party (i.e., the lessee, grantee, or vendor) provide operations and maintenance of their EV charging infrastructure. Figure 3.10 summarizes the results of this question. Out of 34 state DOT respondents that deployed or planned to

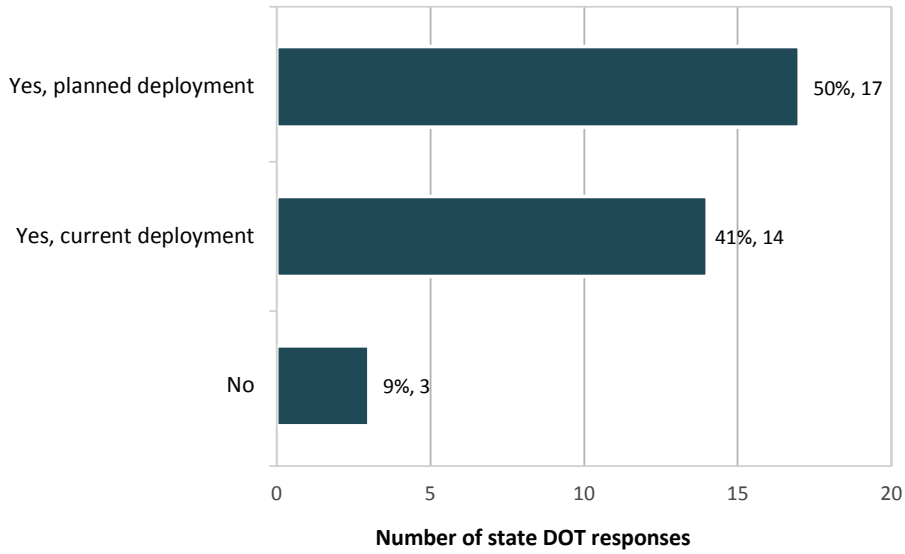

Figure 3.10. Operations and maintenance for EV charging by the lessee, grantee, vendors (n = 34).

deploy EV charging, 17 DOTs (50%) with planned EVSE deployments and 14 DOTs (41%) with current EVSE deployments reported that they include operations and maintenance as a part of the agreement with the lessee, grantee, vendor, or service provider. Georgia, Maryland, and Oklahoma DOTs indicated that they do not have the third party provide operations and maintenance of their EV charging infrastructure.

Figure 3.11 shows the survey results related to the prioritization of vehicle types (passenger travel, freight travel, or transit) or locations (corridor basis or site-specific opportunities including multi-dwelling housing or community destinations) for EV charging. Seven DOTs (21%) and 16 DOTs (47%) indicated that they include prioritization of vehicle types or locations for their current and planned EV deployment, respectively. Eleven DOTs (32%) reported that they do not include prioritization of vehicle types or locations for their EV charging deployment.

Figure 3.12 shows the main entities involved in EV charging deployment. Out of 35 state DOT respondents that deployed or planned to deploy EV charging, the top five entities involved in EV charging deployment include

- Utility companies (such as negotiating demand charges or infrastructure upgrades),
- State energy agencies,
- State environmental agencies,
- Public-private partnerships (e.g., funding or provision of space), and
- Other government agencies/branches.

Additionally, for state DOTs with planned EV charging deployment, they also consider the following entities:

- State economic development agencies,
- Private investors, and
- Nonprofit entities.

The survey respondents were asked if they used a pilot program before implementing a full-scale build-out of their EV charging infrastructure. Figure 3.13 summarizes the results of this question. Twenty-four DOTs out of 34 state DOT respondents (71%) reported that they do not

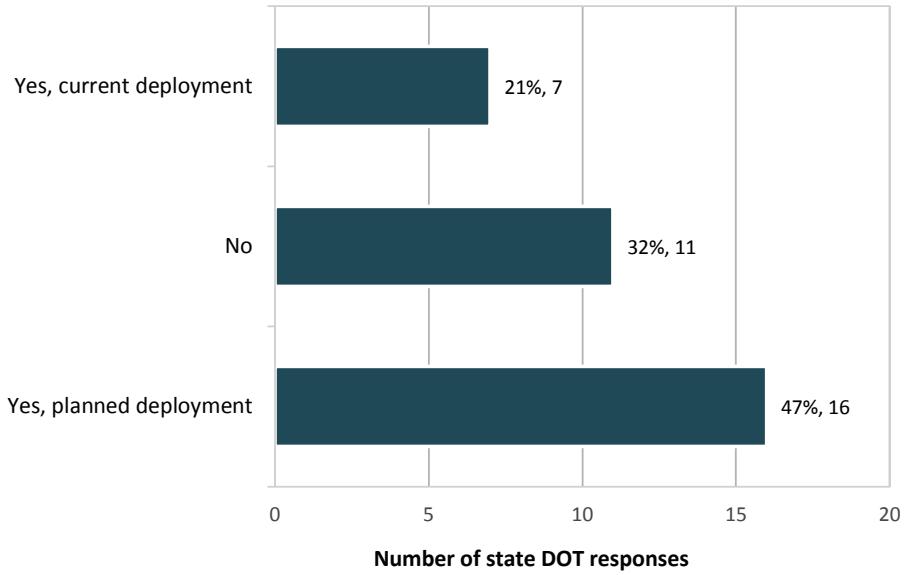

Figure 3.11. Prioritization of vehicle types and locations for EV charging (n = 34).

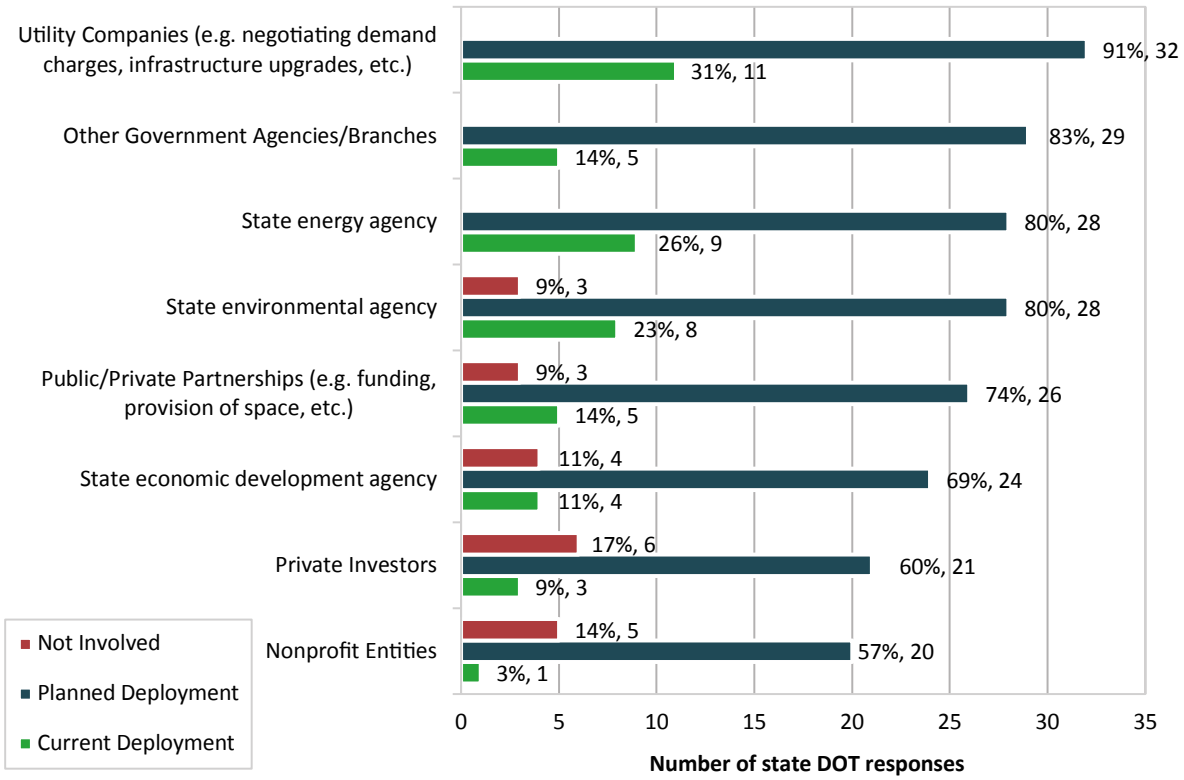

Figure 3.12. Participation in EV charging deployment (n = 35).

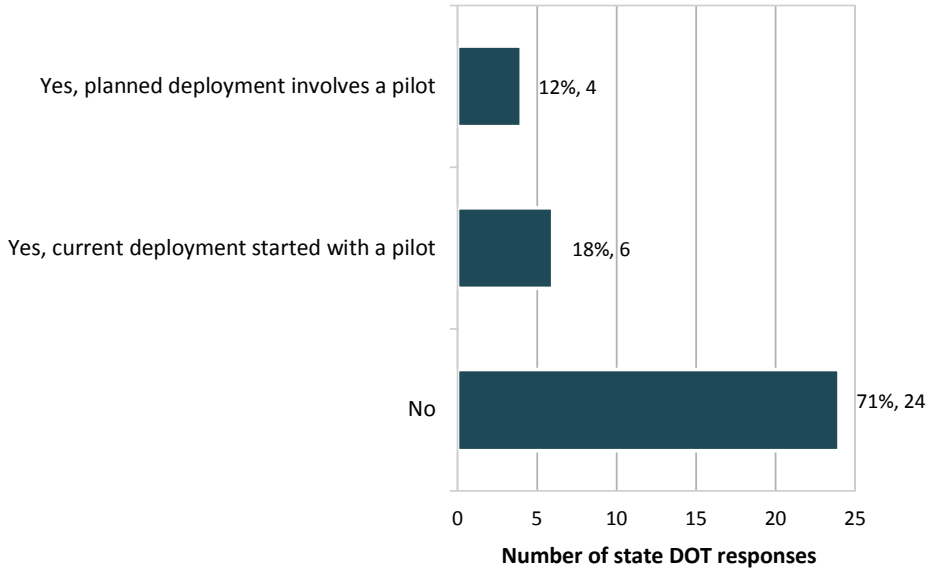

Figure 3.13. Pilot programs for EV charging (n = 34).

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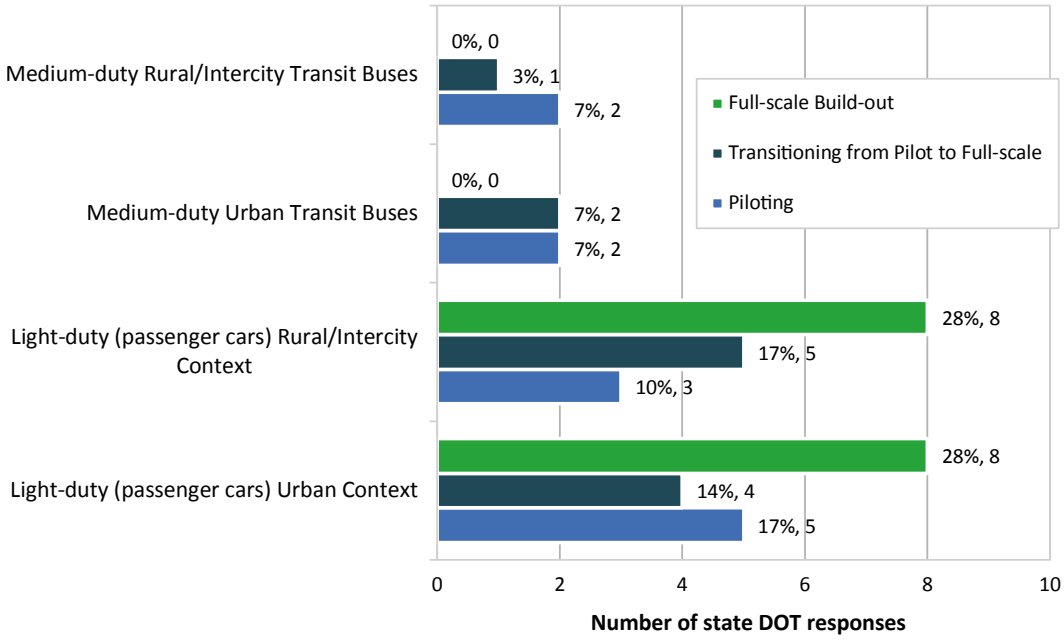

Figure 3.14. Status of current deployment of EV charging (n = 29).

involve a pilot program; only six DOTs (18%) that currently deployed EV infrastructure started with a pilot program; and four DOTs (12%) with planned EV charging deployment reported that they will involve a pilot program before implementing a full-scale build-out.

Figure 3.14 summarizes the status of the deployment of different types of current EV charging equipment. Out of 29 state DOT respondents to this question, eight DOTs (28%) reported that they have full-scale build-outs of charging equipment for light-duty (passenger cars) in both urban and rural/intercity contexts. Five DOTs (17%) indicated that they are in pilot programs of deploying charging equipment for light-duty passenger cars in an urban context. Five DOTs (17%) specified that they are in the transition from piloting to full-scale deployment of light-duty (passenger cars) charging equipment in a rural/intercity context. Figure 3.14 also indicates that two or fewer DOTs have deployed charging equipment for medium-duty urban transit buses or medium-duty rural/intercity transit buses either through piloting or as transitioning from pilot to full-scale build-outs.

3.4 Evaluation of EV Charging Infrastructure

The survey respondents were asked if they have evaluated the effectiveness or quantified the benefits of their current deployment or planned deployment of EV charging infrastructure. Figure 3.15 summarizes the results of this question. Out of 35 state DOT respondents that deployed or planned to deploy EV charging, seven DOTs (20%) and eight DOTs (23%) reported that they have evaluated the effectiveness of their current and planned EV charging deployment, respectively. Twenty DOTs out of 35 state DOTs (57%) reported that they have not evaluated the effectiveness or quantified the benefits of their EV charging infrastructure.

Figure 3.16 shows the result of state DOTs' evaluation and consideration of using technologies to enhance their EV charging infrastructure based on 33 DOT respondents to this question. Two types of technologies that state DOTs use to enhance the EV charging infrastructure include the use of battery storage to reduce demand charges (20 DOTs or 61%) and implementing

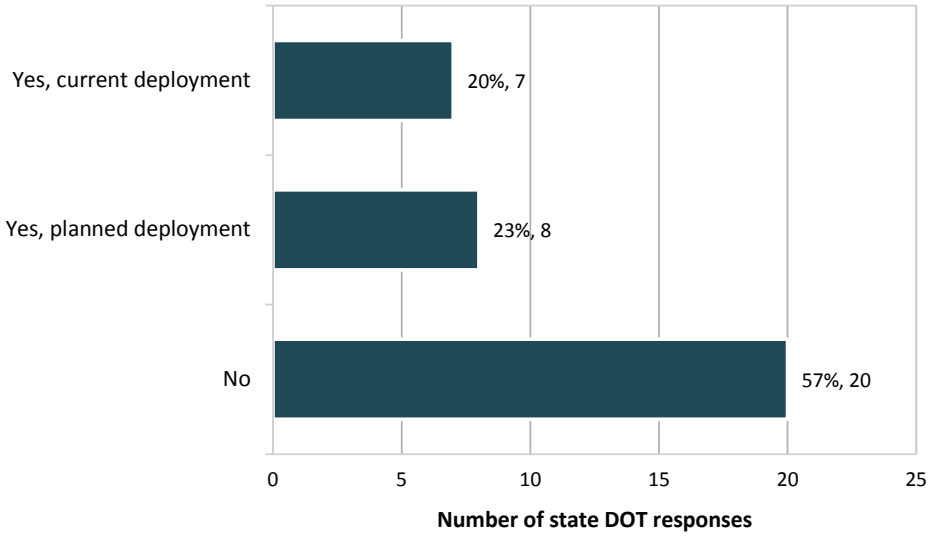

Figure 3.15. Evaluation of the effectiveness of EV charging (n = 35).

renewable energy sources (16 DOTs or 48%). Nine DOTs (27%) also reported that they use inductive in-road charging to enhance their EV charging infrastructure. However, 18 DOTs (55%) and 13 DOTs (39%) noted that they do not use inductive in-road charging or implemented renewable energy sources, respectively. Ten DOTs (30%) reported that they do not use battery storage to reduce demand changes for their EV charging infrastructure.

The survey respondents were asked if they have evaluated or considered how they may increase the investment in their EV charging infrastructure regarding cost/benefit analysis, feasibility, or approaches for cost recovery. Figure 3.17 summarizes the results of this question. Out of 33 state DOT respondents that have evaluated or considered technologies to enhance EV charging infrastructure, nine DOTs (27%) reported that they have evaluated or considered increasing the investment in technologies to improve their EV charging infrastructure;

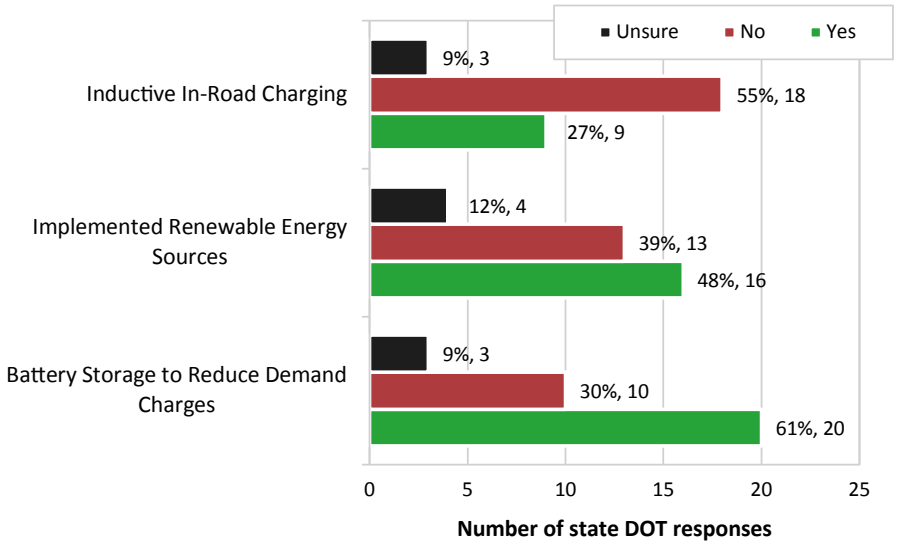

Figure 3.16. Use of technologies to enhance EV charging infrastructure (n = 33).

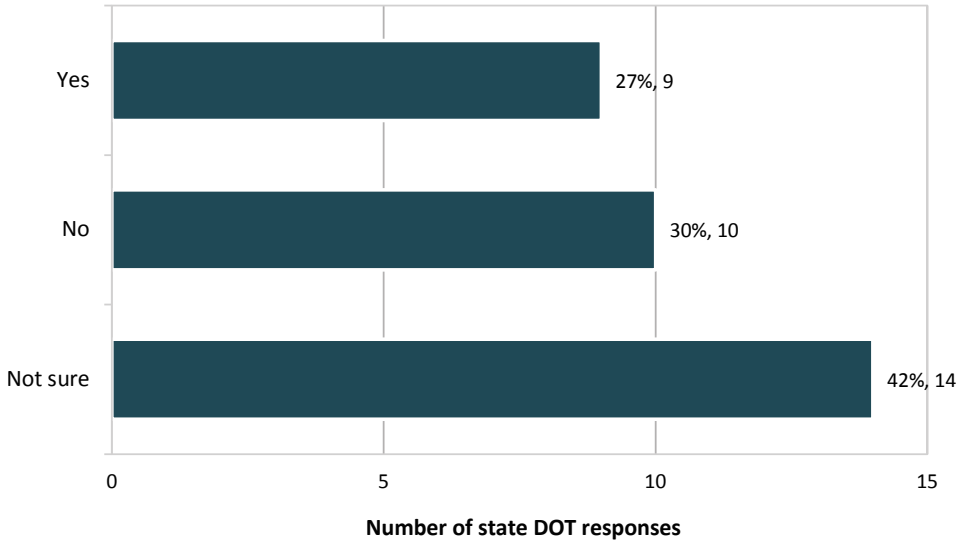

Figure 3.17. State DOTs' evaluating technologies for EV charging infrastructure (n = 33).

ten DOTs (30%) noted that they do not evaluate or consider how they may increase the investment in technologies in their EV charging infrastructure; and 14 DOTs (42%) were unsure about how to evaluate technologies used to improve their EV charging infrastructure. Note, that responses will not total 100% because multiple selections were possible.

3.5 Challenges in Deployment of EV Charging Infrastructure

Figure 3.18 shows the main challenges state DOTs have experienced with EV charging infrastructure deployment. State DOTs were provided a list of challenges and asked if they encountered these challenges or not. Based on the 33 DOT responses to this question, the top five challenges that state DOTs encountered are

- Commercialization (fees) restrictions at rest areas and in ROW (21 DOTs, 64%),
- Procurement of infrastructure (15 DOTs, 45%),
- Instituting fees for charging service (15 DOTs, 45%),
- Buy America requirements for EV charging infrastructure (15 DOTs, 45%), and
- Plans for operation and maintenance (14 DOTs, 42%).

The survey respondents were also asked if they had deployed strategies to overcome the challenges presented in Figure 3.18. Figure 3.19 summarizes the results of this question based on 33 DOT respondents. The top five challenges overcome by DOT-deployed strategies are

- Plans for operation and maintenance (10 DOTs, 30%),
- Ability to pay for EV charging infrastructure (nine DOTs, 27%),
- Site development experience (seven DOTs, 21%),
- Procurement of infrastructure (seven DOTs, 21%), and
- Lack of sufficient power infrastructure experience (six DOTs, 18%).

Some state DOTs provided specific challenges related to their EV charging infrastructure deployment. For example, Vermont DOT indicated that all of their EV investments to date have been through either the VW settlement funds, state capital funds, or state transportation funds. The Vermont DOT has used these types of funds to contract with third parties to install, own, and operate EV charging. As a result, they have faced minimal challenges, though there

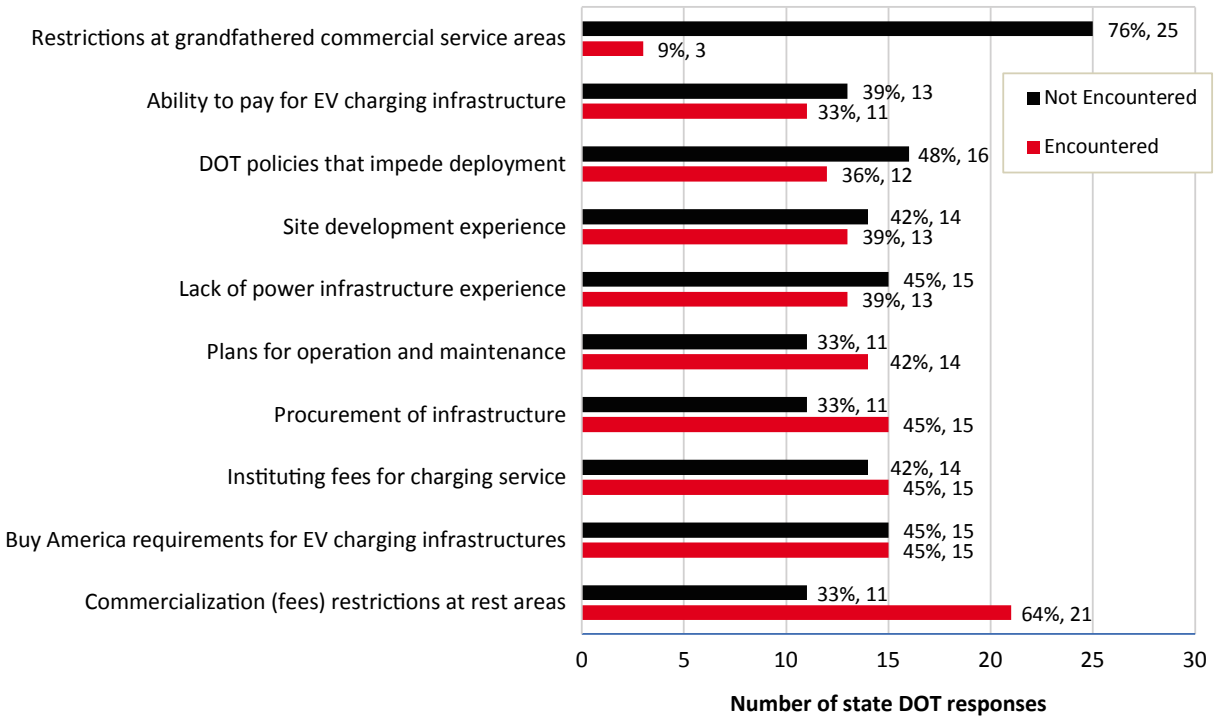

Figure 3.18. Main challenges in deployment of EV charging infrastructure (n = 33). See Figure 3.19 for complete legend text.

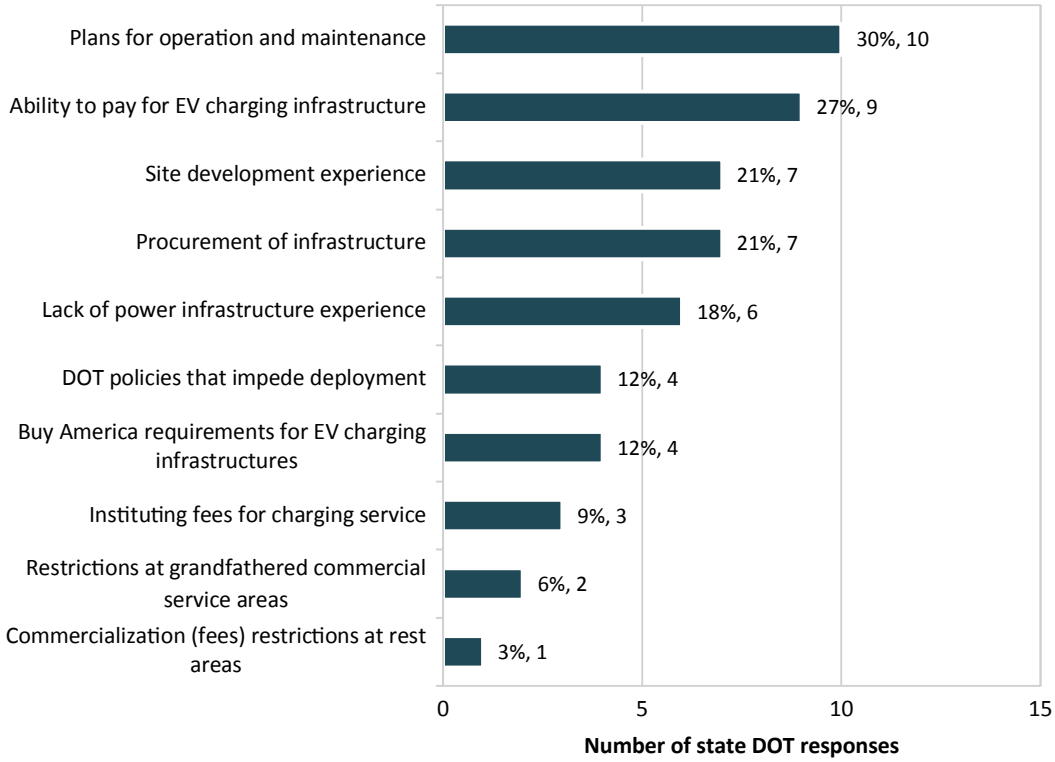

Figure 3.19. Challenges overcome by DOT strategies in deployment of EV charging infrastructure (n = 33).

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Table 3.2. Challenge levels for deployment of EV charging infrastructure.

Challenges	Average Ranking (*)
Commercialization (fees) restrictions at rest areas (*n* = 22)	4.14
Buy America requirements for EV charging infrastructure (*n* = 21)	3.67
Procurement of infrastructure (*n* = 23)	3.43
Lack of power infrastructure experience (*n* = 22)	3.27
Site development experience (*n* = 22)	3.00
Instituting fees for charging service (*n* = 22)	3.00
Plans for operation and maintenance (*n* = 24)	2.83
DOT policies that impede deployment (*n* = 20)	2.75
Ability to pay for EV charging infrastructure (*n* = 22)	2.68
Restrictions at grandfathered commercial service areas (*n* = 13)	1.15

(*) 5 = Very High, 4 = High, 3 = Moderate, 2 = Low, 1 = Very Low, 0 = NA .

are some, including local demand charges. However, the Vermont DOT anticipates new challenges such as Buy America Act requirements with incoming federal funding. North Carolina DOT indicated that state laws are the main challenges that impede their EV deployment. Texas DOT reported that their main challenges involved broadband or other connectivity issues for payment systems and data collection.

Finally, the survey respondents were asked to rank the challenges in their EV charging infrastructure deployment based on an ordinal scale (5 = Very High, 4 = High, 3 = Moderate, 2 = Low, 1 = Very Low, 0 = NA). As summarized in Table 3.2, the results of this question show that the top five challenges based on the average ranking score include

- Commercialization (fees) restrictions at rest areas,
- Buy America requirements for EV charging infrastructure,
- Procurement of infrastructure,
- Lack of power infrastructure experience, and
- Site development experience.

3.6 Summary

This chapter describes the current practices in use by state DOTs to facilitate and coordinate the provision and operation of EV charging facilities through analyzing 42 DOT respondents of the national survey distributed in the spring of 2022 to 50 state DOTs plus Washington, DC (82% response rate).

CHAPTER 4

Case Examples

As noted in Chapter 1, follow-up case examples were conducted to gather further details regarding EV charging infrastructure deployment by state DOTs. In the end, six state DOTs were selected for case example interviews. The selection was initially based on the following survey questions:

- Has your DOT deployed (installed or contracted to have installed) EV charging stations either in public-facing areas or at their own facilities (i.e., DOT headquarters or buildings)?
- Does your deployment, or planned deployment, of EV charging infrastructure collect user fees for charging?
- Would you be willing to participate in a short follow-up phone interview?

Further, there was a desire to have geographic dispersion among the case examples, relying largely on the four AASHTO regions to achieve this objective. Based on initial contact with a listing of identified states, the following selected states and their applicable criteria for selection are portrayed in Table 4.1.

In considering emerging trends, Michigan DOT recently captured national media attention for their pilot project to install conductive in-road charging for transit. Additionally, they presented this pilot effort at the AASHTO Committee on Right of Way, Utilities and Outdoor Advertising Control. Based on this interest, an additional case example was collected for Michigan DOT.

Table 4.1. State DOT selections information for case examples.

State	Has your DOT deployed (installed or contracted to have installed) EV charging stations either in public-facing areas or at their own facilities (i.e. DOT headquarters, buildings, etc.)?	Does your deployment, or planned deployment, of EV charging infrastructure collect user fees for charging?	Would you be willing to participate in a short follow-up phone interview?	AASHTO Region
California	Yes	Yes	Yes	4
Hawaii	Yes	Yes	Yes	4
Massachusetts	Yes	Yes	Yes	1
Michigan*	No	Yes	N/A	3
Tennessee	No	Yes	Yes	2
Vermont	Yes	Yes	Yes	1

*Partial survey response but selected because of conductive in-road charging pilot.

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The finalized list of state DOTs interviewed for the case examples was California, Hawaii, Massachusetts, Michigan, Tennessee, and Vermont. Details of the individual interviews are outlined in the following. The interviews were conducted using a semi-structured approach and the questions and talking points for the interviews can be found in Appendix C. Each state was invited to provide its narrative along with the provided talking points. The case examples are summarized using distinct sections: overview; program deployment approach; procurement and funding; maintenance approach; program effectiveness, benefits, and challenges; and lessons learned.

4.1 California Department of Transportation Case Example

The California Department of Transportation (Caltrans) is a mature agency for EV charging because of the laws and regulations of the state of California pushing for the use of alternative fuel vehicles. Caltrans has deployed numerous EV charging stations across the state and continues to plan for more locations. Currently, Caltrans is developing its NEVI plan for further statewide deployment, investigating fleet electrification, and installing EV charging stations at DOT sites. The Caltrans staff in the Zero-Emissions Hub from the Sustainability Office provided the following information on the current state of the practice in the planning and deployment of EV charging stations for California's traveling public.

4.1.1 Program Deployment Approach

The initial EV charging deployment with Caltrans was to place EV stations at park-and-ride locations, which started in 2014. The initial thought was to install a few of these stations at park-and-ride locations and see what happens. Prioritization of the park-and-rides focused on locations in underresourced communities and those under construction, and Caltrans added the EV charging scope of work. The EV charging stations installed at park-and-rides have been in service for about 5 years.

Caltrans also has a program called 30 in 30. This initiative was to have Caltrans install 30 DC fast-charging stations at 30 rest stops across the state within 30 months. Caltrans prioritizes rest-stop locations with no other charging infrastructure nearby so that the rest-stop charging station would fill a gap in the EV charging system. The rest stops initiative has successfully deployed EV fast charging to rest stops in locations that do not have easy access to charging. Due to state and federal laws prohibiting such collection, Caltrans cannot charge a fee to use the rest-stop fast chargers.

Caltrans acknowledged that they self-designed the rest stop locations and realized some locations and layouts were costly to install. Getting adequate power close to rest stops in rural areas has become challenging and it is expensive to get the power infrastructure to a location that provides the DCFC requirements. Therefore, Caltrans is considering soliciting vendors to handle the planning, development, deployment, operations, and maintenance of EV charging stations for future deployments.

In San Diego County, Caltrans partnered with San Diego Gas & Electric (SDG&E) to distribute EV charging stations to park-and-ride locations. Caltrans provided the locations, while SDG&E provided the funding. The EV chargers installed at park-and-rides are Level 2 chargers, as people who use the park-and-rides typically park for longer and can utilize the slower charging from Level 2 chargers. For these park-and-ride locations, users are charged a fee to use them. These EV stations at San Diego park-and-ride locations were energized just as the COVID-19 pandemic was initially occurring in the spring of 2020. Therefore, Caltrans does not yet have clear information on user rates and the program's effectiveness.

For municipalities, the City of Los Angeles has been installing curbside EV charging locations. These locations are within the right-of-way (ROW), but in some instances, the power provided to these sites comes from nearby lighting, which does not provide adequate power for

some Level 2 charging and all DCFC that requires three-phase power. However, this has shown that EV owners in cities want curbside charging. Policies and guidelines are in development by Caltrans for the curbside deployment of EV charging in urban downtown areas.

The future deployment of EV charging stations will follow the NEVI plan. The NEVI plan is in development at Caltrans and will be submitted in August 2022. Caltrans is setting up the plan to use the funding for charging service providers to work with site hosts not located on Caltrans property or ROW. Private service providers will be able to charge a fee, and the fees will be similar throughout all locations. Caltrans would not own any of these station locations. With site hosts and private property locations, Caltrans expects these EV charging stations to present a similar gas station experience with chargers, convenience stores/restaurants, and restrooms. Site hosts can make locations safer with proper layout and lighting for 24-hour use.

For the NEVI plan, the focus is on light-duty vehicles to help increase public adoption of EVs. However, Caltrans is working with other agencies investing in mid- to heavy-duty EVs and associated charging needs. In one instance, all trucks used at California ports must be EVs by 2024. Therefore, all ports will need mid- and heavy-duty charging solutions soon. In addition, for wide-scale deployment, one idea is to offer light-, mid-, and heavy-duty charging options at the same location, such as travel centers across the state.

4.1.2 Procurement and Funding

In deploying the 30 rest-stop charging stations, Caltrans solicited bids, with some rest stops bundled into one contract. The contracts are for the installation of the station based on Caltrans's design. Caltrans then owns, operates, and maintains the rest-stop EV charging stations.

For cost recovery, one challenge that Caltrans has run into is that California state law does not allow for Caltrans to charge a fee to use EV charging. Currently, Caltrans does not have the authority to charge for using EV stations located on Caltrans property and ROWs (e.g., rest areas). Therefore, Caltrans continues to work on this situation, especially for charging at rest stops, and they are looking toward more privatization of EV charging stations in their NEVI program. Caltrans also needs to determine how to set up a cost-recovery system for rest stops and have the collected fees feed into the general state highway account, which is required by state law. Caltrans staff acknowledged that the electrical bills do start to add up and are concerned that if fees are deposited into the state general highway fund, they may not be able to access it to pay the electrical bills. A solution to this situation is still a work in progress.

Caltrans also received funding from the VW settlement. These funds were mainly used by the California Air Resources Board for people to apply for grants to put EV charging infrastructure in place. Most of these funds were rolled out to private companies, while Caltrans used a portion for maintenance.

For EV charging equipment, Caltrans purchases the equipment through a state contract with the Department of General Services. For future deployment, the service providers that Caltrans contracts will be responsible for procuring the correct equipment. Caltrans will provide specifications for the equipment, such as equipment must be at least 150kW, allowing providers to select a higher power (300kW) if required for a particular location.

4.1.3 Maintenance Approach

For the initial deployments, Caltrans operates and maintains EV charging stations. However, with NEVI, Caltrans would like to eliminate the operations and maintenance and plans to use contracts to have third-party vendors handle the operation and maintenance for EV charging stations. With the maintenance agreements in place, service providers are to measure the performance of the EV charging stations. However, the current maintenance agreements do

not incentivize vendors to quickly repair EV stations, meaning repairs may take longer than they should, leading to complaints from the traveling public. Caltrans plans to address this in its NEVI plan and subsequent deployment.

4.1.4 Program Effectiveness, Benefits, and Challenges

Caltrans and the University of California, Davis are conducting a study on the rest-stop EV stations. This partnership is the first real study Caltrans has taken on to determine the performance and effectiveness of the rest-stop charging program. As of Fall 2021, all 30 rest-stop EV charging stations are in operation, and researchers are now collecting usage data and expenses. In addition, Caltrans is also working with its utility partners (e.g., SDG&E) to get feedback on performance and effectiveness. This information will help Caltrans be more strategic in its future deployments.

Caltrans mentioned challenges in planning and deploying EV charging stations across California. Challenges mentioned by Caltrans staff include the following:

- Charging use fees: Caltrans has placed EV Charging stations at park-and-ride locations. However, state of California laws do not allow Caltrans to charge a fee to use these, as electric vehicle charging is not considered a utility. Therefore, in the case of the San Diego park-and-ride charging stations, a third party, SDG&E, can charge a fee. Caltrans provided the location, and SDG&E handled the operation and maintenance. Additionally, with NEVI, Caltrans recognized that private industry partners could make charging stations more sustainable for operations and maintenance than they can; therefore, they are looking to more public-private partnerships for future development and deployment.
- Consistent adequate power: One of the significant barriers to installation, especially at the rest-stop stations, was having the correct power levels near the station. In some rural locations, the power infrastructure had to be brought closer to the rest stops, including three-phase power, which is needed for DCFC. Bringing the power infrastructure close to rest stops has been extremely expensive.
- Urban area power supply: Issues have emerged in urban areas where sufficient power supplies exist, but the system is overworked and does not provide the power necessary at EV charging stations. Boosters and other options are being investigated to ensure the correct power supply is available.
- Self-managing charger equipment: Typically, the Level 2 chargers have very few issues. However, Caltrans has had issues with DC fast chargers, such as not having enough power, using different cables, and fast charging equipment being more expensive to purchase and maintain than Level 2 chargers.
- Supply chain issues: The worldwide supply chain issues because of the COVID-19 pandemic made it difficult to get equipment and has made maintenance very difficult in obtaining parts quickly for repairs.
- Buy America Act: Caltrans is uncertain how to follow the Buy America Act (BAA), especially for the NEVI program. Some initial vendors were BAA compliant but have since moved operations overseas, and they no longer provide just American-made products. Caltrans worries that the BAA will complicate the matter. It can currently take 6 to 12 months to get chargers for any vendor, let alone just from American vendors due to all state DOTs using these American vendors.

4.1.5 Lessons Learned

From the experiences of Caltrans in the development, planning, and deployment of EV charging stations, there are lessons learned to share to help others with their EV charging programs. Lessons learned include the following:

- Start discussions with utilities: Before doing any work, start by having discussions with the utility companies. For example, Caltrans staff noted that it could be better to locate some of their EV charging stations closer to the existing power infrastructure to decrease installation costs.
- Let the transportation industry take care of it: With Caltrans having the experience of owning, operating, and maintaining EV charging stations, they have realized that a DOT is not set up to be a supplier of fuels for vehicles. Therefore, Caltrans plans for future NEVI deployments to have the industry and vendors with the expertise to handle the operations and maintenance of EV charging stations.
- Discuss with other state DOTs: It is essential to share information about EV charging programs among other states as they are experiencing many of the same trials and tribulations. Learning what works and what does not work from others helps to eliminate state DOTs running into the same issues, and sharing of information might provide a solution that already exists.

4.2 Hawaii Department of Transportation Case Example

The Hawaii Department of Transportation took an interest in EVs and required charging infrastructure beginning with their own DOT fleet. This was in support of the initiatives that began with the Hawaii Clean Energy Initiative. This initiative began in 2008, starting Hawaii's aggressive trend toward clean energy and efficiency. The Hawaii Clean Energy Initiative includes a diverse set of stakeholders and provides a framework of statutes and regulations that support Hawaii's move to a clean energy future. One related stakeholder, the United States Department of Energy, provided $4.5 million for Hawaii's Transportation Energy Diversification EV Ready program to assist in EV and related infrastructure implementation. This support led to Hawaii exceeding the national average for charging ports and having 1,136 EVs on the road by 2012 (U.S. DOT 2022). In June 2021, Hawaii passed a law establishing clean transportation goals and requiring state agencies to transition to 100% zero-emission fleets for light-duty vehicles by the end of 2035. The Hawaii DOT had already begun looking at the use of EVs and in 2019 instituted an internal policy that all new light-duty purchases needed to be zero-emission vehicles.

4.2.1 Program Deployment Approach

The Hawaii DOT installed their initial chargers with a 2019 purchase of four EVs and associated charging infrastructure on their property (base yard) and for their fleet. Regarding public-facing EV charging infrastructure, the long-term plan was to rollout EV charging infrastructure to the public using a service contract mentioned in 4.2.2. The Oahu District Office was the first to install a small number of chargers that are publicly available free of charge for visitors to their office. With the onset of NEVI, Hawaii DOT is modifying its plan to determine how NEVI funds can support the charging infrastructure for both its fleet and the public. The procurement approach planned is to maintain the use of their service contract described in section 4.2.2.

The initial prioritization of deployment was for the Hawaii DOT to support its EV fleet with charging infrastructure and then provide additional public-facing chargers. This initial prioritization also gave it an opportunity to right-size its fleet by looking at vehicle usage. This usage provided information on charging needs as well as fleet size needs.

Again, Hawaii's plans changed with NEVI. To comply with NEVI, Hawaii DOT understands they will need to make four 150-kW charging ports available every 50 miles along interstates or Alternative Fuel Corridors. Like most states, Hawaii is working on their initial NEVI deployment plan, which was due by August 1, 2022. They are collaborating with their two power companies and other agencies and counties to determine where siting might work well or overlap to address needs. The priority for siting is state-owned DOT ROWs, then state-owned ROWs, then

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county ROWs, and finally private locations. To satisfy the NEVI siting requirements, Hawaii DOT has identified siting locations on each island. Hawaii does face some challenges with the NEVI requirements. Maui County, for example, includes an Alternative Fuel Corridor but also includes two smaller islands, one of which only has 13 miles of roadway but is more than 50 miles from Maui. Hawaii has already begun discussions with their FHWA Division Office to begin to understand the exceptions they will need to request because of their complexity as islands.

Hawaii DOT's priority with NEVI is to get their certification as being fully built-out. After the certification, they will have more flexibility in siting and the charging equipment selection for using the NEVI funding. One siting example post-certification would be along curbs, as it would make sense for use cases. This will take coordination with counties and in reviewing the overall charging network for comprehensiveness.

4.2.2 Procurement and Funding

The Hawaii DOT made its first purchase of EVs in 2019 and purchased four Chevrolet Volts. It found the cost to purchase the vehicle and charging infrastructure was $60,000–$65,000 per vehicle. With a fleet of 275 light-duty vehicles, the fleet replacement was cost-prohibitive. Hawaii DOT then looked at leasing possibilities. Because of the contractual nature of a governmental agency leasing a vehicle, a third-party financier would be required. In this arrangement, the lease payments were estimated to be equivalent to the purchase price by the end of the lease. After these challenges, the Hawaii DOT participated in a workshop in Colorado with peer states looking to electrify fleets. One concept discussed was the procurement of EVs and charging infrastructure as a service. The innovative approach appealed to the Hawaii DOT and it put a contract out for this procurement as a service. It also collaborated with the State of Hawaii Energy Office and made the contract available to all state and government agencies in Hawaii. The procurement was very broad to allow for a range of vehicle needs, and the contract was flexible to allow for new technologies, as EVs are rapidly evolving. This approach will allow Hawaii to meet its clean energy goals.

Hawaii DOT's fleet procurement started with Chevrolet Volts but its service contract provides flexibility in EV selection for usage and comparing fees per mile. The initial fleet conversion through the service contract was 43 Tesla Model Ys at an estimated usage fee of $600 per month per vehicle. The usage fee includes costs for infrastructure installation as well. The infrastructure installation was not complicated because of service availability in their base yard. Further savings from using EVs is realized through reduced maintenance costs versus gasoline vehicles. Hawaii DOT is also placing an active order for 128 Ford Lightning trucks for its maintenance forces.

Regarding fees, Hawaii DOT has thus far allowed free charging at its charging infrastructure; for the public and its employees. With NEVI, it has also not discussed what pricing method it might use. It plans to make these determinations collaboratively with the power companies. It will also work with the electric companies (to determine where they have capable infrastructure) and look to satisfy NEVI in selecting sites and the EVSE. Hawaii DOT plans to make these decisions through the use of its service contract to see available equipment and also what EVSE can meet Buy America requirements.

4.2.3 Maintenance Approach

The maintenance of the charging infrastructure is written into Hawaii DOT's service contract. The priority locations for the chargers will be public ROWs, and there may be some minor site maintenance. There are some concerns about vandalism, especially since the NEVI requirements entail 24-hour-a-day availability.

4.2.4 Program Effectiveness, Benefits, and Challenges

Hawaii DOT noted its initial program was not only good for its fleet and reducing its carbon footprint by replacing 44 gasoline-powered vehicles with 43 EVs, but it provided education and consideration of EVs to employees. Some feedback of their employees noted being surprised by the power, technology, and ease of use. The education has also eased range anxiety and put EVs in the public view.

The foremost challenge Hawaii DOT noted is the capital required for purchasing EVs and charging infrastructure. Procurement was also a challenge to navigate. Leasing did not work and outright purchase is too expensive. The innovative service contract approach has been successful, but the approach has to navigate multiple reviews through multiple offices, such as legal and procurement. Overall, the approach has worked smoothly and the contractor has been helpful and timely. Hawaii DOT's first order of 10 vehicles and charging equipment was satisfied within 2 months, with all 43 vehicles delivered within 6 months. From a funding standpoint, the contractor is putting forward the capital to provide the EVs and EVSEs. It does not get paid until usage fees are collected, so there is an incentive to keep the vehicles and chargers available. The success of the approach has been noted by other states who have contacted Hawaii DOT for using its contract and RFP documents.

Other concerns of Hawaii DOT involve the NEPA environmental and permitting impacts required for building out infrastructure to satisfy NEVI requirements, in addition to Buy America concerns and supply chain issues. These could present significant challenges for Hawaii DOT and their estimated six needed sites to comply with NEVI requirements.

4.2.5 Lessons Learned

The Hawaii DOT case example offers the following lessons learned. These were largely out of its approach to procurement after facing the challenges of purchase or leasing approaches. It notes that funding availability is commonly an issue but its approach has eased the immediate need for funding for procurement. It notes the following:

- Consider innovative procurement methods like service contracts. Hawaii DOT's approach has provided unique opportunities and places a shared burden on the third party providing the services. The initial capital shift to the service provider has been instrumental to the quick fleet conversion.
- Consider EV fleet conversions as a good time to optimize the fleet. While some states hire consultants to conduct fleet reviews before shifting to EVs, fleet analysis was provided by Hawaii DOT's service provider while the procurement was ongoing.
- Recognize the ancillary benefits of fleet conversion. Educating Hawaii DOT employees and the public on EVs stands to move the needle in other sectors.
- Have high-level state support. The Hawaii legislation to move to alternative fuel fleets by 2035 and a commitment to clean energy was the catalyst and driver of Hawaii DOT's success with EVs and EVSE.

4.3 Massachusetts Department of Transportation Case Example

The Massachusetts Department of Transportation (MassDOT) has managed EV charging programs to help build EV charging infrastructure for EV drivers in the Commonwealth of Massachusetts. MassDOT Highway Division has constructed several Level 2 and fast-charging EV chargers to help enable drivers of electric vehicles to travel long distances on highways in

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Massachusetts. Increasing driver range confidence may help accelerate the adoption of EVs in Massachusetts, which is one of the goals of the Massachusetts Clean Energy and Climate Plan for 2025 and 2030. MassDOT has recently completed a NEVI EV Infrastructure Deployment Plan.

The following information came from discussions with MassDOT staff in the Office of Transportation Planning and the Highway Division Chief Engineer's Office and reports on the current state of MassDOT's EV charging program for planning, developing, operating, and maintaining EV charging stations across the state.

4.3.1 Program Deployment Approach

The initial public DCFC EV charging deployment for the state of Massachusetts began about 7 years ago. One of MassDOT's primary partners in their EV charging program, the Department of Energy Resources Leading by Example group, was offering DCFC charging grants. Each grant was $50,000 for up to 20 total EV charging station sites statewide targeting locations identified on a range anxiety map. MassDOT Highway Division identified the MassDOT service plazas along the Massachusetts Turnpike (I-90) as some of the most suitable state-owned properties for fast charging. The service plazas are about 30 to 40 miles apart and offer amenities such as food, restrooms, and safety components such as 24-hour lighting. Six 50kW chargers were installed at service plazas in 2017. Each site has been future-proofed with higher-rated transformers and additional conduit to accommodate additional chargers as the need for charging expands. Each of the service plaza sites has curb side chargers.

Grant funds were deemed ineligible for I-90 because I-90 is a toll-funded road, and the source of the grant funds was Federal Highway Congestion Mitigation and Air Quality (CMAQ) funds. The six DCFC stations were ultimately installed with toll funds with equipment and services donated by EVGo.

Another public use deployment started a few years ago using Federal CMAQ with matching state funds. These Buy America-compliant EV fast chargers are being installed off the Massachusetts Turnpike corridor. MassDOT again worked with the Department of Energy Resources (who manages green government grants), which has managed an EV adoption rebate program, to verify conducive locations for EV charging. Most EV charging stations are located on limited-access highways on MassDOT service plazas. MassDOT is also installing Level 2 charging stations at various park-and-ride locations as an opportunity to utilize existing infrastructure located at those facilities.

MassDOT is in the process of determining future deployment of fast charging stations through the development and implementation of its EV Infrastructure Deployment Plan for the NEVI program. MassDOT, with consultant support, has developed a strategy for deploying DCFC on highways in Massachusetts, as described in this NEVI Plan. NEVI-funded DCFC will be built on MassDOT and/or private locations within 1 mile of an EV Alternative Fuel Corridor. A primary goal of plan implementation will be to support EV driver range confidence.

4.3.2 Procurement and Funding

Procurement for installing, operating, and maintaining EV charging stations at the service plazas was an open solicitation. Contracts included partnership language for operations and maintenance and accountability for the service provider. In one such contract, the service provider donated the EV supply equipment to MassDOT and provided five vices.

For the existing non-NEVI EV charging stations, MassDOT owns and operates the stations for the length of the service provider contract. MassDOT staff mentioned that they did not

envision MassDOT serving as a direct operator of alternative fueling stations. They mentioned that MassDOT's role in providing EV charging stations is to help catalyze private investment. One option MassDOT is considering is turning over the ownership and operations to the service provider once the initial agreement has expired. MassDOT procured a contractor who performed the work and paid the respective utilities for their work. Stations were donated by EVGo, with 5 years of service.

MassDOT charges a fee for EV drivers to use existing fast charging stations. The fee is typically around $0.35 per kW, which can be significantly more than the residential rate of charging an EV at home. These fees help recover a portion of the costs of operating and maintaining the EV charging stations. High monthly utility demand costs make it a challenge to recover all operating costs even when stations are very active.

Federal law prohibits MassDOT from charging for EV charger use in Interstate ROW locations. MassDOT currently has fast charging sites in Interstate ROWs at locations that have been grandfathered in, where a user fee can be charged for use of the stations. The EV chargers installed at park-and-ride lots also charge a fee for use.

For the implementation of the NEVI program in Massachusetts, MassDOT will use a transparent and competitive procurement process to find a partner or partners to manage the installation, operation, and maintenance of EV charging stations. MassDOT is interested in building a financially sustainable network of DCFC through a contracting method that will bundle potentially profitable and unprofitable sites together.

4.3.3 Maintenance Approach

For the initial deployment, MassDOT contracted service providers to install the EV stations (all construction work including site prep, trenching, cabinets, or electrical work) and provide operation and maintenance of EV charging stations, typically for 5 years.

For the subsequent deployment, with CMAQ and state matching funds, MassDOT procured a goods and services contract for a vendor to supply the stations, install, commission, and provide 5 years of service. MassDOT is partnering with the utility "Make Ready" programs where utilities perform/reimburse for all the infrastructure needed to service the stations (connection, transformers, cabinets, conduits, trench work, etc.). This approach has lower costs for MassDOT but has also led to delays at several sites because of project funding issues and supply chain delays on the utility end. As more EV stations come online, MassDOT expects maintenance costs to increase in the next few years, which will be the responsibility of the service provider. One potential issue in the maintenance of EV charging stations may be the difficulty in obtaining the necessary equipment and materials.

The maintenance approach that MassDOT will use for NEVI-funded stations will be determined during the plan implementation process.

4.3.4 Program Effectiveness, Benefits, and Challenges

For the implementation of the NEVI Plan, MassDOT will develop metrics to measure the performance of NEVI-funded EV charging stations. One metric that is being considered is a 97% station uptime requirement. In addition, MassDOT will survey Massachusetts residents to assess range confidence and understand the barriers to EV adoption. Service providers collect feedback from users. Positive comments help MassDOT to know they are meeting expectations. Negative comments tend to be frustrations from the traveling public when EV chargers are not maintained and operational when they want to use them.

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MassDOT mentioned challenges that have been encountered in planning and deploying EV charging stations across Massachusetts. Challenges mentioned by MassDOT staff include the following:

- Buy America Provisions: MassDOT had issues procuring Buy America-compliant EV charging stations for MassDOT service plazas. At the time, MassDOT found a limited number of service providers that could install, operate, and maintain EV charging stations and verify that all equipment and materials were American-made. Once a vendor and manufacturer were found to be Buy America compliant, they had to sign an affidavit.
- Supply chain issues: MassDOT is already experiencing issues with equipment shortages for EV charging equipment and associated electrical components, such as transformers for power. Many states are already vying for the same equipment, which will become more difficult once the NEVI funds are released to all the state DOTs.
- Different monitoring systems: Currently, MassDOT has three service providers, each with its own monitoring system for less than 24 total EV stations. MassDOT has to monitor three different systems to check performance. As more stations are constructed and come online, monitoring performance will become even more cumbersome. A more centralized single-source system would be preferable, and MassDOT is considering it for future deployment and management.

4.3.5 Lessons Learned

From MassDOT's experience with the development, planning, and deployment of EV charging stations, there are lessons learned to share to help others with their EV charging programs. Lessons learned include the following:

- Protect EV charging assets: MassDOT initially installed EV charging along curbs at service plazas. Vehicle collisions with these stations have taken stations offline and resulted in significant repair costs. Therefore, MassDOT is determining how EV charging stations built in the future can be both easy to access and protected from damage. MassDOT may use banks of chargers instead of curbside charging.
- Work with the utility companies: As EV stations are constructed, MassDOT recognizes the importance of having the utility company involved from the very beginning. Construction could be delayed if utilities have not completed the necessary work and energized the station once it is ready for operation.
- Provide range confidence: MassDOT data indicate that most trips in Massachusetts are 100 miles or less, which is well within the range of light-duty EVs. However, the small number of long-distance trips may represent a barrier to EV adoption for drivers concerned about their ability to recharge an EV when on these trips. Therefore, MassDOT has focused and will invest NEVI funds in EV charging sites that provide value to the traveling public and allow them to be confident that they can travel on highways in Massachusetts, knowing a nearby charging station can meet their needs.

4.4 Michigan Department of Transportation Case Example

The EV environment in Michigan entails unique collaborations among the Michigan Department of Transportation, the Michigan Department of Environment, Great Lakes, and Energy (EGLE), and the Office of Future Mobility and Electrification in the Michigan Economic Development Corporation – not to mention the insight provided from the local automakers and their transitions to EV manufacturing. In this environment, the Volkswagen Settlement funding,

through Electrify America, was not administered by the DOT but by the Michigan Department of EGLE to issue grants for eligible on- and off-road vehicles and equipment. The intent of the funded projects was to reduce nitrogen oxide emissions, improve air quality, and increase the adoption of zero-emission or alternative-fuel vehicles and equipment (United States Department of Energy 2022). The Michigan EGLE also offers funding for EVSE installation. Michigan also joined Illinois, Indiana, Minnesota, and Wisconsin in signing the Regional Electric Vehicle Midwest Coalition memorandum of understanding to accelerate EV implementation in the Midwest (United States Department of Energy 2022).

4.4.1 Program Deployment Approach

At Michigan DOT there is a key distinction among types of infrastructure not just among levels of plug-in charging (Level 1, Level 2, DCFC, etc.) but also between charging methods (plug-in charging, inductive, semi-inductive, and static charging). In Michigan, plug-in charging is led by the Office of Future Mobility and Electrification (within the Economic Development Corporation, not the DOT). Michigan State University conducted an in-depth study of EV charging infrastructure to identify where infrastructure currently exists and where there were gaps and needs. Beyond that, Michigan's objective is to get infrastructure in place using all available mechanisms possible. They are supporting EV charging infrastructure in a host of locations, including around the Great Lakes, and deploying EVSE at parks and tourism areas. Some of these deployments are at private companies, municipalities, and public spaces (park-and-ride, rest areas, etc.), though the conditions for ownership and operation are still being navigated through policy and law. However, Michigan DOT prefers to not be in ownership and operation of EVSE on state DOT ROW. The preference of Michigan DOT pre-NEVI was being developed by a Michigan DOT consultant hired to develop a strategic plan for charging infrastructure and for conversion of the Michigan DOT fleet to EVs. The plan was also to build from the Michigan State University study ways to support private EVSE installation along the Michigan road network. These plans gave way to NEVI, but there is hope to make use of some of them as Michigan DOT does want to have a specific strategy for EVs.

For the NEVI-planned installations, Michigan DOT's plan is to split funding into thirds and work in partnerships with utility companies and private partners (landowners) for installations. The funding would be matched in thirds, with NEVI providing one-third of the funding for the installation and match by one-third each from the utility company and private partner. That is the current direction subject to navigating demand and regulations. Michigan DOT is refocusing the Michigan State University study to consider where NEVI funding must be applied, so the prioritization of build-out would be along the Alternative Fuel Corridors. Michigan DOT has partnered with other states around the Great Lakes (through the previously mentioned memorandum of understanding) to ensure the corridors across state lines will align. They have noted that some rural areas that involve Great Lakes tourism may not support enough business to attract private installation and this is where public funding may be necessary to support EVSE installations.

Within the deployment space, the plug-in EV technology is certainly the most mature, but Michigan DOT is looking to emerging charging approaches and seeking to prepare for those installations as well. These charging types include inductive charging (in-motion charging, such as a one-mile pilot corridor project that was just announced), semi-dynamic charging (slow-moving charging, for example in a transit terminal), and static charging (such as a parked car, stopped vehicle, etc.). The basis of inductive charging is about extending capacity and trip length and confidence. Michigan DOT is working with all of these approaches. Inductive charging is an emerging area and Michigan DOT sees this space as a potential approach to accelerate the adoption of EVs. It is a strategic path from the governor's office with a desire to research the use of these approaches and investigate issues of seasons, salts, and so forth. It also provides

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a prime opportunity for the auto industry to develop technology in this space and have the infrastructure to conduct testing. There are finally the educational aspects of studying this space and including opportunities for FHWA and local agencies on the technology and for building community engagement. The goal is to stay on the cutting edge and work together with the auto manufacturers in the state.

The deployment of EVs and EVSE is supported throughout the organizational structure up to the governor's office. The MI Healthy Climate Plan includes a goal to prepare for 2 million EVs by 2030 and also presents the need to work with upgrading the utility sector to support this growth. Michigan's focus on carbon reduction goals revolves around EVs, including transit vehicles. Deployment approaches will aim to support these goals.

4.4.2 Procurement and Funding

Michigan uses a range of funding models to implement charging infrastructure; these include settlement funds, grant programs, public-private partnerships, and so on. The current objective is to promote the location of EVSE just off the Michigan DOT ROW. This is because of the complexities of ownership and operation, competing needs for funds, as well as standard DOT practice typically not involving fee collection.

Michigan DOT did increase registration fees for EVs but the legislature is also considering rebates for EV purchases. They are looking at a toll study to consider some of the losses of fuel taxes but they are not promoting charging for free and would be curious about the national direction of considering fee sharing from the infrastructure operated by private entities.

In terms of EVSE selection and their planned procurement, the NEVI approach mentioned and the agreements will detail the operations and maintenance and the requirements to be accessible, universal, and not proprietary.

4.4.3 Maintenance Approach

For the Michigan DOT and their planned public-private partnerships, the conditions of those agreements will detail the operations and maintenance responsibilities of the parties. The minimum EVSE technologies required by NEVI are DCFCs for using those funds. There is an expectation that further guidance is forthcoming regarding details of EVSE levels required. Michigan DOT would like to have some flexibility considerations for specific locations based on costs and use cases, but those clarifications are still forthcoming as NEVI guidance evolves.

4.4.4 Program Effectiveness, Benefits, and Challenges

The Michigan DOT does anticipate challenges in the deployment of EVSE. They certainly anticipate the Buy America Act will create challenges, but the nationwide implementation of NEVI will also likely lead to supply chain shortages and delays. While they do not see a current solution, they do see it potentially promoting technology development in Michigan.

Regarding Michigan piloting some of the induction charging methods, these pilots entail challenges of the technology not being as mature as the plug-in charging. This impacts all aspects of the pilots, including specifications, technology availability, and understanding applicable end users.

Michigan DOT sees the electric grid as being a potential challenge to the implementation of any EV regardless of charging method. The question remains if the electric grid can handle the demands growing in the area of EVs. With the constant evolution of EVs and EVSE, the

demand is difficult to understand, though there may be opportunities to level the demand and create more stable draws throughout the day. Exploration of new technologies is needed to help in this area.

4.4.5 Lessons Learned

Michigan DOT is on the leading edge in several aspects of the EV environment. They anticipate many lessons learned. They want peer state DOTs to understand their desire to be a partner and their willingness to work with peer states through these challenges and collaborate wherever possible. They believe working together early can lead to improved standardization.

They further recommend the careful review of policies and rulemaking documents and taking the opportunity to provide comments and concerns on these documents. Only when state DOTs present their concerns and issues with federal policies will a collective voice be heard. Michigan DOT noted that is also important to take the time to explain why something may be a challenge, beyond just noting it as such.

4.5 Tennessee Department of Transportation Case Example

The Tennessee Department of Transportation (TDOT) is in the planning stages of its EV charging deployment and operation program. The EV charging program at TDOT currently focuses on planning for light-duty vehicles, and limited planning has considered fleet and heavy-duty vehicles. As with all state DOTs, TDOT's continued planning and future deployment depend on the NEVI plan (was due in August 2022) they are developing for approval to access funding for EV station deployment. The details in this section include information from TDOT staff in the Office of Long-Range Planning on the current state of the practice in the planning and future deployment of EV charging stations for Tennessee.

4.5.1 Program Deployment Approach

While TDOT is in the planning stages and deployment has not been set yet, the state of Tennessee has planned for deployment through other agencies besides TDOT. The first instance of EV station deployment occurred through the State Energy Office, Office of Energy Programs within the Tennessee Department of Environment and Conservation, which worked with the Tennessee Valley Authority and local power companies using the Volkswagen settlement funds for the Fast Charge Tennessee Network program. The focus was not necessarily to have DCFC but to develop a broad network of EV charging stations across the state. Therefore, Level 2 charging requirements with at least two chargers per station were the plan before NEVI. The plan included placing the EV stations in non-designated corridor areas. An initial round of solicitations occurred, but further solicitations and overall deployment will not occur until after the NEVI plan is complete and approved.

One of the components of NEVI restricts funding for EV charging station locations to designated Alternative Fuel Corridors. Therefore, TDOT is awaiting to see what NEVI will fund so that the Volkswagen funds and other grants are used in areas not covered by NEVI.

As TDOT staff plans to deploy EV charging stations across the state, they have identified gaps in the location of EV stations along designated corridors. These stations will be the focus of initial funding from NEVI. Discussion on the prioritization of these locations has not occurred as TDOT is working to determine if the solicitation will be statewide, regional, or individual property owner contracts.

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Additionally, TDOT is not considering locating EV stations in their right-of-way. Putting EV chargers in the ROW becomes the responsibility of TDOT, which they do not want as TDOT is not in the business of providing fuels (gasoline, electricity, natural gas, etc.) for vehicles. The locations for EV charging stations may be determined by individuals interested in reaping the benefits of having a charging station on their property, similar to gas stations today for combustion-engine vehicles. Proper lighting, other amenities such as convenient stores and restrooms, and safe and easy access are all components that TDOT would like to have at private EV charging station locations.

Tennessee is also working with the city of Nashville on a project called Connect Downtown, a neighborhood traffic program entailing signaling, controls, transit, and curbside management. The partnership for this program includes the Nashville DOT, WeGo Public Transit, the Nashville Downtown Partnership, and TDOT. The curbside management component of the program can include curbside EV charging. In addition, TDOT and its partners on this project are aware of the upcoming mid-duty truck vehicles that may have difficulty using curbside charging. Therefore, TDOT is exploring EV charging station layout options that may increase the footprint and costs but can accommodate more types of EVs.

TDOT has engaged with the University of Tennessee-Knoxville on an FHWA grant for an initial deployment plan of alternative fueling stations (including EV charging stations) along the I-40 corridor, which travels east to west across the state. TDOT and UT-Knoxville are also working with Arkansas and North Carolina to build a continuous network of EV charging stations along I-40 in the southeast U.S. Part of the program is to develop a list of criteria to help score potential EV charging sites. Scoring potential sites helps TDOT staff determine a good site for an EV station and potential other amenities. Comparisons of different sites can occur to prioritize sites, determine whether one site is better than another in the same location, and determine if a site passes a threshold of feasibility. The criteria, which may include signal strength, access to power, ease of access, safety, lighting, and other factors, will be developed and finalized by August 2022.

4.5.2 Procurement and Funding

To deploy EV charging stations, TDOT is currently working to determine the procurement approach. Partnerships have not necessarily been established, and solicitation of partners is still to be determined. TDOT needs to develop the appropriate mechanisms for developing, deploying, operating, and maintaining EV charging stations. TDOT does not want to own and operate another asset, and it would be easier to have a third party handle that. Therefore, TDOT will require vendors that can take ownership, operate, and maintain the EV stations for a set period of time. Vendors will be in charge of land purchase, equipment purchase, installation, operation, and maintenance. The agreement may resemble a public-private partnership or outright private investment and location (such as a gas station, but for EVs). Still, the correct mechanisms need to be included. For one, incentives should be provided so that vendors keep stations operational and maintained properly. Overall, TDOT is helping to push the initial infrastructure for EV charging stations but does not plan to do this long-term.

For funding, all EVs in Tennessee pay an additional $100 fee for their vehicle registration. This $100 is there to offset the lost gas tax revenue that these vehicles do not pay since they do not use gasoline. The registration fee is added to the state highway fund, just like the gas tax. TDOT does not charge the $100 registration fee for hybrid vehicles.

TDOT is not investigating charging for EV station use, as they plan to pass along ownership to third-party firms that will have the ability to charge the fee they determine. Additionally, one of the components of NEVI restricts funding for EV charging station locations to designated

Alternative Fuel Corridors. Therefore, TDOT is awaiting to see what NEVI will fund so that the Volkswagen funds and other grants can be used in areas not covered by NEVI.

4.5.3 Maintenance Approach

As TDOT is not planning to own, operate, or maintain any EV charging stations, the maintenance of each site will be the responsibility of the vendor or owner. TDOT expects all maintenance as a part of the contract, and all service providers will then be responsible for all operations and maintenance for a site, which will be at least 5 years.

4.5.4 Program Effectiveness, Benefits, and Challenges

TDOT has not measured program effectiveness at this point, but that is because they are in the planning stages and do not have any tracking or monitoring information for EV charging stations.

TDOT mentioned challenges in the planning for deploying EV charging stations across Tennessee. Challenges mentioned by TDOT staff include the following:

- Buy America Act: Difficulties finding vendors that can meet or certify that all materials and equipment are American-made and supplied. Many vendors provide sufficient equipment that works the majority of the time and do not charge an exorbitant fee. However, these service providers may be overseas and cannot adhere to the Buy America Act. TDOT believes this may limit the vendors they can solicit for deployment, especially with the NEVI funds. However, a recent vendor in TDOT has stated that they will be Buy America compliant, although TDOT has not verified this.
- Cybersecurity: Protecting the EV stations and systems from attacks. TDOT expects cybersecurity requirements in the contract agreements with service providers, which are responsible and held accountable for the cybersecurity of EV charging stations.
- Environmental: Concerns with the environmental justice and NEPA guidelines that could impact the layout, footprint, and usability of EV charging stations.
- Workforce development: TDOT has noted that internal staff will require development to help administer the EV charging station contracts. Also, the vendors will need to provide a workforce that can plan, install, operate, and maintain the EV charging stations according to the contract. Technological skill sets will be crucial for operation and maintenance.

These challenges will be addressed in the forthcoming NEVI plan for TDOT; TDOT noted the date of August 2022 for completion.

4.5.5 Lessons Learned

As TDOT continues to plan the initial deployment of EV charging stations, they are awaiting more clarification once the NEVI plan is submitted in August. Therefore, TDOT has only limited information and lessons learned at this time. One aspect mentioned by TDOT staff is gathering information from other states to help them with their program. Sharing information between state DOTs could be significant in developing a practical approach to the deployment, operations, and maintenance of EV charging stations.

4.6 Vermont Agency of Transportation Case Example

The Vermont Agency of Transportation (VTrans) is an agency that is working with other state agencies in the planning, development, deployment, and operation of EV charging stations. These agencies have formed an interagency work group, including VTrans staff from the

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Policy, Planning, and Intermodal Development Division, who provided the information in this section. Overall, VTrans and the working group have a goal that 100% of the state's population will be no more than 30 miles from the closest EV charging station. With this goal in mind, VTrans envisions growth in purchasing and using light-duty EVs, and the infrastructure will need to be there for this to happen.

4.6.1 Program Deployment Approach

In 2017, the state of Vermont created an interagency workgroup to collaboratively handle the deployment of EV charging stations across the state. This workgroup includes VTrans, the Public Service Department (the state's energy office), the Agency of Natural Resources (the state's environmental protection agency), and the Agency of Commerce and Community Development. The Agency of Commerce and Community Development leads the workgroup.

The initial deployment of EV stations in Vermont occurred using the Volkswagen settlement funds and public grants. The first EV stations installed were Level 1 and Level 2 charging in downtown areas and municipal spots. Then, the interagency workgroup decided to build EV fast-charging stations along major corridors.

The interagency workgroup solicited two rounds of EV fast-charging stations, one in 2020 and one in 2021, for a total of 17 locations. The first round was awarded to a national charging service provider for 11 stations with 150 to 175 kW power supplied. Each EV station has fast charging and a Level 2 charger for redundancy. VTrans expects the first 11 EV fast-charging stations to be energized and operational by summer 2022.

The second round of six stations was awarded in 2021 to a local charging service provider. VTrans identified these six stations to help fill gaps in the system to help achieve the goal of every person in Vermont being within 30 miles of an EV fast-charging station. However, with the current build-out, the system lacks redundancy. Future plans are to include more redundancy of EV chargers at station locations.

The interagency workgroup determined from the NEVI information that they would continue to work on community EV charging as developing stations in downtown areas contribute to economic vitality, and these locations become a high priority. In one case, Vermont approved $1 million in state funding for community charging for multi-unit housing. There are to be 37 EV charging locations built out from 13 awards. The interagency workgroup designed the pilot program and awarded funding in this manner to see what works best and is the most cost-effective for community EV charging deployment.

VTrans also has an agreement with the Vermont Energy Investment Corporation, a nonprofit that is assisting VTrans with an EV charging deployment plan for the next 10 years. The EV charging plan developed will be reviewed and updated annually. This agreement and the NEVI guidelines have VTrans adapting its processes and EV program. Additionally, VTrans follows the model used in California and is one of 16 state transportation agencies that signed a memorandum of understanding to follow regulations for adopting advanced clean cars, including EVs.

4.6.2 Procurement and Funding

Before NEVI, procurement for EV stations through the interagency workgroup has been led by the Agency of Commerce and Community Development, which has solicited vendors for installing and operating EV charging stations. The contracts are structured as grant agreements, and the service provider is to install the EV station and provide operation and maintenance for 7 years.

For VTrans and EV charging procurement, they will be in charge of contracting for the upcoming NEVI-funded projects. However, VTrans has a policy that a service contract cannot be longer than 2 years and can apply for two 1-year extensions for a total of 4 years. VTrans is looking at using 5-year or longer agreements, and for them to do that, they will have to apply for exceptions to lengthen the service provider contract.

The economics of EV charging station deployment becomes a concern for VTrans in its ability to attract private investment and the operation of stations. A lack of vendors, the different types of stations and locations, and the different charging requirements complicate the potential to build out EV charging across the state cost-effectively. In addition, once the NEVI funds begin to distribute to state DOTs, the demand for vendors and equipment will increase, which VTrans anticipates will drive up costs and reduce competition.

The business case for supporting high-powered fast charging for EVs does not currently exist in some locations, as the market is not there, with too few EVs in use to justify building out an expensive EV station with low demand. VTrans has bundled low-demand, rural locations with higher-demand locations to attract potential service provider interest to overcome this situation. However, only two companies showed interest when soliciting for the fast charging stations.

4.6.3 Maintenance Approach

VTrans management has made it clear that the agency is not in the business of owning and operating EV charging stations. Contract agreements for charging providers contain operations and maintenance for a set number of years. The agreements also include reporting usage information to the Public Service Department. The initial EV stations came online in 2020, and service providers are now submitting data and reports.

VTrans requires 97% uptime for all EV charging stations, meaning the service providers should have stations working 97% of the time, and maintenance is key to achieving this goal. However, the contract does not incentivize service providers to achieve 97% uptime. One potential approach VTrans staff mentioned to overcome this lack of encouragement to complete maintenance quickly could be to withhold 5% of the contract amount until the end of the multi-year agreement.

4.6.4 Program Effectiveness, Benefits, and Challenges

The EV charging program has built-in performance metrics and data reporting requirements that service providers report to VTrans and the interagency workgroup. These metrics and reporting requirements have been included in all EV charging contracts since 2014. However, the challenge is compliance from the service providers. Most EV stations have come online in the past few years, and reporting information is now being submitted. Yet, the data reported have been minimal, and the Public Service Department is unsure what to do with the data. VTrans is working with the Public Service Department to be the agency to collect and consolidate all the data. Additionally, VTrans is awaiting further guidance on specifications for consistent and effective data collection and reporting so that VTrans can compare performance within the state and with other states.

One of the benefits of working with other state agencies is the information other agencies can provide to VTrans. The largest utility company in Vermont mapped out the location of three-phase power across the state, which has helped determine the locations of the EV fast-charging stations. VTrans can keep the costs more manageable for EV stations when locating them close to three-phase power. For the smaller utilities, VTrans has used Google maps and conducted field investigations of sites to see the power supply in the area. Some locations in

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southern Vermont do not have three-phase power within a mile of a corridor and may not have commercial activity occurring. The lack of three-phase power makes it more difficult to site an EV station, as getting the three-phase power to the site will add significant costs.

VTrans mentioned challenges in planning and deploying EV charging stations across Vermont. Challenges mentioned by VTrans staff include the following:

- Costs for installing, operating, and maintaining EV charging stations: A concern for VTrans is the costs involved with building out EV charging in corridors and communities. While VTrans has credit card readers set up for payment when using an EV charging station, VTrans estimates that for each EV charging station, one kW costs $1,000. Therefore, an EV fast-charging station at 150kW would cost $150,000 for the procurement and installation costs (exclusive of operating and maintenance costs). Additionally, many EV owners in Vermont have models that use an older charging system called CHAdeMO. Vermont envisions that locations should include at least one EV station with this type of connection, along with the required CCS ports, which adds costs.
- Compliance with NEVI: With the NEVI plan in development, VTrans recognized that while they have good coverage regarding Alternative Fuel Corridors, none of the current EV stations would meet the NEVI guidelines. Therefore, one of the first tasks VTrans has is to upgrade the existing EV stations while they are under construction or shortly after construction is complete. The upgrades may need to be completed using state funds to avoid more challenging contract processes.

4.6.5 Lessons Learned

From VTrans's experience with the development, planning, and deployment of EV charging stations, there are lessons learned to share to help others with their EV charging programs. Lessons learned include the following:

- Future-proofing sites: VTrans recognized that some of the initial EV charging stations were built for current conditions before NEVI. As EVs and charging needs change, VTrans is now investigating how to easily upgrade completed sites and revise them based on the changing conditions and the upcoming mid- and heavy-duty EVs.
- Work with other state agencies: There are many different departments involved in deploying EV charging, including transportation, economics, housing, natural resources, commerce, and environment. It has been effective to have multiple agencies discussing things and gaining different perspectives.
- Openness to learn and flexibility: VTrans acknowledged that as rules, regulations, and guidance continue to be developed and changed, it is essential to be open to learning from the process and have flexibility in the plan and design of EV charging stations.
- Public engagement: While VTrans has conducted minimal public engagement for their initial EV charging station deployment with NEVI funds, they have a plan in place to reach out to the public and take a deep dive into communities that are in underserved or underresourced rural areas. This will help VTrans incorporate the public wants into their plan and how they will continue investing in EV charging.

CHAPTER 5

Summary of Findings

The objective of this synthesis was to document current strategies and practices in use by state DOTs to facilitate and coordinate the provision and operation of EV charging facilities. The synthesis includes current plans to address the future maturity of EV charging, such as preparation for medium- and heavy-duty electrification, and investigates how EV charging has been deployed by DOTs, and what strategies and programs have been adopted or adapted. The scope of the synthesis is confined to the deployment of EV charging approaches by and affiliated with state DOTs but includes associations of public-private partnerships and other stakeholders where interaction with state DOTs is relevant.

The synthesis began with a literature review to develop the initial understanding of the current state of research and practice regarding EV charging infrastructure deployment by state DOTs. The findings of the literature review can be seen in Chapter 2. Beyond the classification of EVs and their charging infrastructure, it is also important to provide background regarding the context of the current policy environment. NEVI was established as part of the BIL, or the IIJA, and signed into law on Nov. 15, 2021. The Joint Office of Energy and Transportation was also established by this legislation in December 2021 (Joint Office of Energy and Transportation n.d.). NEVI entails a $5 billion program over 5 years that will strategically deploy EV charging infrastructure and an additional $2.5 billion will be available at a later date. Initial guidance for NEVI was made available in February 2022 with a notice of proposed rulemaking in June 2022. Initial funding under NEVI requires state plans for the deployment of EVSE along designated Alternative Fuel Corridors. Guidance suggests that state DOTs may own or lease EVSE or contract with private service providers who will purchase, install, own, and maintain the chargers. To be eligible for the NEVI funding, state DOTs must have submitted an infrastructure deployment plan by August 2022.

Next, the existing literature and previous discussions with DOTs assisted with the development of the survey questionnaire. The facilitation of the survey questionnaire captured the state of the practice regarding EV charging infrastructure deployment by state DOTs. The survey began with general findings of EV charging infrastructure deployment, then captured policies and guidance for EV charging stations. The survey collected current practices related to the operation and management of EV charging infrastructure and finally collected evaluation methods and challenges in EV charging infrastructure deployment. In addition, the analysis of relevant documents obtained from the survey is also included to support the findings. The survey was developed in an online survey platform and was electronically distributed to the voting membership of the AASHTO Committee on Planning in the spring of 2022 (before NEVI plan submissions). This distribution included representatives from all 50 state DOTs and Washington, DC. The findings of the survey are presented in Chapter 3 and are based on 42 state DOT respondents. The complete survey is presented in Appendix A with individual state DOT responses provided in Appendix B. Figure 1.3 shows the map of state DOTs that responded to the survey.

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Through analyzing 42 DOT respondents of the national survey distributed to 50 state DOTs, 22 DOTs reported that they have installed or contracted to have installed EV charging stations and 14 DOTs have a plan or are currently planning to deploy EV charging infrastructure. The survey results show that the top deployed locations for the Level 1 charging are: (1) at DOT-/state-owned buildings but non-public facing (for government use only) and (2) at parking areas in DOT-/state-owned rights-of-way. The top deployed locations for the Level 2 charging are: (1) at DOT-/state-owned buildings but non-public facing (for government use only), (2) at DOT-/state-owned public-facing buildings (i.e., offices, driver's licensing locations, etc.) for public use, (3) at parking areas in DOT-/state-owned rights-of-way, and (4) at public facing facilities along DOT-/state-owned rights-of-way. The top deployed locations for the DCFC are: (1) in local-government- or metro-owned rights-of-way, (2) along high-traffic corridors, and (3) at public-facing facilities along DOT-/state-owned rights-of-way.

For policies and guidance for EV charging stations, the survey results indicated that most of the state DOTs (65% out of 34 DOT respondents) reported that they have not provided guidance or technical assistance to local governments regarding the deployment or planned deployment of EV charging infrastructure. The survey results also indicated that federal policies and regulations influence state DOTs' deployment of EV charging infrastructure on the following issues:

- Siting and location (29 DOTs),
- Material used such as Buy America Act requirements (24 DOTs),
- The EV type and charging levels installed (23 DOTs),
- The number of EV charging stations installed (22 DOTs), and
- Fee structures and cost recovery (19 DOTs).

For the operation and management of EV charging, out of 34 state DOT respondents that deployed or planned to deploy EV charging, 22 DOTs indicated that they collect user fees for all EV charging stations. However, only six DOTs intend to make use of rules allowing for rate recovery mechanisms or other opportunities for cost savings. Twenty DOTs also reported that they include a plan to provide operations and maintenance of the current or planned EV charging infrastructure. Additionally, 31 state DOTs indicated that they include operations and maintenance to be provided by the lessee, grantee, vendor, or service provider for their planned and current EV charging deployment. The survey results also showed that nine DOTs out of 34 state DOT respondents used a pilot program before implementing a full-scale build-out of their EV charging infrastructure.

For the evaluation of EV charging infrastructure deployment, 20 state DOTs out of 35 respondents have not evaluated the effectiveness or quantified the benefits of their EV charging infrastructure. States were also asked what technologies are used to enhance their EV charging infrastructure; two technologies that state DOTs noted in the enhancement of their EV charging infrastructure include the use of battery storage to reduce demand charges, and the use of renewable energy sources (e.g., solar). Regarding these technologies, state DOTs were asked if there was an evaluation of how their use increases the value of the investment in EV charging infrastructure (regarding cost/benefit analysis, feasibility, or approaches for cost recovery, etc.). Twenty-four state DOTs reported that they are unsure or do not evaluate their investment in technologies to support their EV charging infrastructure.

Finally, the survey results showed that the top five challenges that state DOTs encountered when deployment of EV charging stations include

- Commercialization (fees) restrictions at rest areas,
- Procurement of infrastructure,
- Instituting fees for charging service,

- Buy America requirements for EV charging infrastructure, and
- Plans for operation and maintenance.

The challenges ranging from moderate to very high impact on the deployment of EV charging stations include

- Commercialization (fees) restrictions at rest areas,
- Buy America requirements for EV charging infrastructure,
- Procurement of infrastructure,
- Lack of power infrastructure experience, and
- Site development experience.

The follow-up case examples were largely selected based on survey responses and their applicable AASHTO region to achieve diverse regional feedback. Based on their leading-edge approach to inductive charging, Michigan DOT became an added case example. The final interviewee list included California, Hawaii, Massachusetts, Michigan, Tennessee, and Vermont.

The case examples presented various effective practices but also pointed out common challenges to the deployment of EV charging infrastructure. Some of the common challenges from the cases include

- Responsibilities for paying for the service lines for the EVSE;
- Supply chain challenges, such as electric companies being able to find transformers;
- Compliance with Buy America;
- Understanding of EV strains on the electric grid; and
- The implementation and unknowns regarding NEVI.

This synthesis presents an opportunity to use the state of the practice as captured and promote additional research to address the guidance gap just noted. This study overall points to a significant knowledge gap within Topic 53-08: "Strategies and Programs for Electric Vehicle Charging." The gap noted is the development of summarized, AASHTO–type guidelines that can inform state DOTs regarding

- EVSE siting;
- Design, construction, and EVSE selection for sites based on current and future needs based on criteria such as use cases, trips, and range; and
- Applicable funding and implementation of the NEVI funding.

This guidance is needed for standardization and to capture how state DOTs (working with joint offices) use public-private partnerships among other areas of development. There may also be a need to understand more details of roles and responsibilities associated with ownership, such as how EVSE might revert or not to the state DOT and what associated removals might be contractually required.

Further needs will occur as state DOTs begin their implementation of NEVI, a deeper understanding of state DOTs' role in decarbonization, and impacts on the electric grid along with support for medium and heavy-duty EVs.

List of Acronyms

AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating current
AFDC	Alternative Fuels Data Center
BEV	Battery electric vehicle
BIL	Bipartisan Infrastructure Law
Caltrans	California Department of Transportation
CCS	Combined Charging System
CMAQ	Congestion Mitigation and Air Quality
DC	Direct current
DCFC	Direct current fast charging
EGLE	Michigan Department of Environment, Great Lakes, and Energy
ER-EV	Extended-range electric vehicle
EV	Electric vehicle
EVSE	Electric Vehicle Supply Equipment (interchangeable with "charging infrastructure")
HEV	Hybrid electric vehicle
IEA	International Energy Agency
IIJA	Infrastructure Investment and Jobs Act
MassDOT	Massachusetts Department of Transportation
MnDOT	Minnesota Department of Transportation
NEPA	National Environmental Protection Act
NEVI	National Electric Vehicle Infrastructure Formula Program
NPRM	Notice of public rulemaking
NREL	National Renewable Energy Lab
PEV	Plug-in electric vehicle (interchangeable with "EV")
PHEV	Plug-in hybrid electric vehicle
ROW	Right-of-way
SDG&E	San Diego Gas & Electric
TDOT	Tennessee Department of Transportation
U.S. DOT	United States Department of Transportation
VTrans	Vermont Agency of Transportation

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APPENDIX A

Survey Questionnaire

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NCHRP PROJECT 20-05 SYNTHESIS TOPIC 53-08

STRATEGIES AND PROGRAMS FOR ELECTRIC VEHICLE CHARGING

State Department of Transportation Survey

The objective of NCHRP Project 20-05 Synthesis Topic 53-08 is to document current strategies and practices in use by State Departments of Transportation (DOTs) to facilitate and coordinate the provision and operation of electric vehicle (EV) charging facilities. The synthesis will also include current plans to address the future maturity of EV charging, such as preparation for medium and heavy-duty electrification.

The survey questions will gather information relating to:

- Practices for EV charging infrastructure deployment, delineation of operating and maintenance responsibilities, public/private partnerships, procurement and contracting, and pricing strategies;
- Practices prioritizing the deployment of EV charging;
- Practices on planning for EV charging, including for expanding pilot programs into full-scale build-outs;
- Practices in working with utilities;
- Practices for funding and complying with funding regulations, Buy America requirements, commercialization of rest area regulations including grandfathered commercial service areas, etc.;
- Practices on evaluating the effectiveness of programs, quantification of benefits, cost recapture, and experiences in overcoming barriers to implementation;
- Practices on providing guidance or technical assistance to local governments from DOTs; and
- Policies for EV charging stations along state-owned roadways or in public rights-of-way.

This survey is being sent to the voting members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Planning. If you are not the correct contact for this survey within your DOT, please respond with the correct contact or forward the survey link to that representative.

Pilot tests indicated an average time of [X] minutes to complete the survey. DOT survey responses will be shown in the published synthesis report. However, the identity of survey respondents will remain anonymous.

Please complete the online questionnaire by [date]. If you have questions or would prefer to complete a paper copy questionnaire, please contact:

Name: Roy Sturgill

Survey Guidance

This survey contains question logic such that your answers will dictate the additional questions that are made available to you. A PDF file of the entire survey is attached to the email request for review prior to completing the survey. Survey progress will be saved and you may continue the survey at a later time. This feature works by using cookies within your browser. To be effective, you must continue the survey using the same computer and browser software. If you would like to collaborate on this survey with a colleague (i.e. partially answer the survey and send it to someone else for completion), please contact Roy Sturgill for a unique survey link.

Definitions

The following definitions are intended to provide clarity to the references within the questionnaire. They are provided from the U.S. Department of Energy, Alternative Fuels Data Center (https://afdc.energy.gov/fuels/electricity_infrastructure.html):

- **Electric Vehicles (EV):** Within the context of this survey, EV is used to represent vehicles requiring access to plug-in charging. These vehicles are sometime referred to as plug-in electric vehicles (PEV) and also include plug-in hybrid electric vehicles (PHEV).

- **Charging Station:** is a site providing access to free or paid charging for EVs by way of one or more EVSE ports.

- **Electric Vehicle Supply Equipment (EVSE) Port:** provides power for charging one vehicle at a time, though it may include multiple connectors. EVSE ports are often housed in a charging post, which can have more than one EVSE port.

- **Connector/Plug:** is the hardware used to connect, or plug-in the vehicle. There are numerous connector types based on vehicle and EVSE port.

- **Open Charge Point Interface (OCPI):** is common standard for classification of charging stations by a hierarchy including location, EVSE port, and connector.

- **Level 1 Charging:** is charging via a 120 volt, alternating current (AC) plug providing typically 2 to 5 miles of range per hour of charging. This typical of a common residential outlet.

- **Level 2 Charging:** is charging via a 240 volt (typical in residential applications) or a 208 volt (typical in commercial applications) electrical service providing typically 10 to 20 miles of range per hour of charging. In residential applications, this would often involve installation of Level 2 charging equipment.

- **DC Fast Charging:** is direct-current (DC) rapid charging usually provided along heavy traffic corridors, capable of providing typically 60 to 80 miles of range per hour of charging. There are three types of DC fast charging systems, SAE Combined Charging System (CCS), CHAdeMO, and Tesla.

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Electric Vehicle Charging Survey

1. Please select your state department of transportation (DOT) from the drop-down list.

   Please enter your name, title, email address and phone number.

2. Has your DOT deployed (installed or contracted to have installed) EV charging stations either in public facing areas or at their own facilities (i.e. DOT headquarters, buildings, etc.)?

   ☐Yes ☐No

3. If the answer of Question 2 is "Yes," please check all that apply regarding your deployment of EV charging stations:

DOT Deployed Locations	Level 1 Charging	Level 2 Charging	DC Fast Charging
At DOT/state-owned buildings but non-public facing (for government use only)	☐	☐	☐
At DOT/state-owned public facing buildings (i.e., offices, driver's licensing locations, etc.) for public use	☐	☐	☐
At public facing facilities along DOT/state-owned right of way (i.e. rest areas, etc.)	☐	☐	☐

DOT Deployed Locations	Level 1 Charging	Level 2 Charging	DC Fast Charging
Along urbanized curb sections (i.e. along downtown sections, etc.)	☐	☐	☐
At parking areas in DOT/state-owned right of way	☐	☐	☐
Along high traffic corridors	☐	☐	☐
In local-government or metro owned right of way	☐	☐	☐
At private-owned locations (i.e. by lease, etc.)	☐	☐	☐
At toll roads or other interstate segments as "grandfathered in" under 23 U.S.C. 111(a).	☐	☐	☐
Other:_____	☐	☐	☐

4. Has your DOT planned or are they currently planning a deployment of EV charging infrastructure?

☐Yes ☐No ☐Not sure (Contact for further information?____)

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If no selected, in both Question 2 and Question 4, display Question 4a and then survey is complete.

4a. What barriers are preventing your current or planned deployment of EV charging infrastructure? (Select all that apply)

☐ State policies or regulations

☐ Federal policies or regulations

☐ Policy or regulation uncertainties

☐ Lack of emphasis in DOT program

☐ Lack of guidance

☐ Lack of funding or understanding of funding

☐ Lack of public need

☐ Other: _____

5. Please check all that apply regarding your planned deployment of EV charging stations:

DOT Deployed Locations	**Level 1 Charging**	**Level 2 Charging**	**DC Fast Charging**
At DOT/state-owned buildings but non-public facing (for government use only)	☐	☐	☐
At DOT/state-owned public facing buildings (i.e., offices, driver's licensing	☐	☐	☐

DOT Deployed Locations	Level 1 Charging	Level 2 Charging	DC Fast Charging
locations, etc.) for public use			
At public facing facilities along DOT/state-owned right of way (i.e. rest areas, etc.)	☐	☐	☐
Along urbanized curb sections (i.e. along downtown sections, etc.)	☐	☐	☐
At parking areas in DOT/state-owned right of way	☐	☐	☐
Along high traffic corridors	☐	☐	☐
In local-government or metro owned right of way	☐	☐	☐
At private-owned locations (i.e. by lease, etc.)	☐	☐	☐
At toll roads or other interstate segments as "grandfathered in" under 23 U.S.C. 111(a).	☐	☐	☐

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DOT Deployed Locations	Level 1 Charging	Level 2 Charging	DC Fast Charging
Other:_____	☐	☐	☐

6. Has your DOT developed an EV charging infrastructure policy/guidelines (which may include conditions of placement along curbs of state-owned roadways or in public rights of way)?

   ☐Yes ☐No

   If yes, please provide the policy (file upload, PDF) or link here: _____

7. Please select any of the following elements of your planned or actual EV charging infrastructure deployment that has been affected by federal policy or regulations:

   ☐ Fee structures and cost recovery

   ☐ Siting and location

   ☐ EV charging type or level installed

   ☐ Number of EV charging stations installed

   ☐ Material used (Buy American Act, etc.)

   ☐ Other: _____

8. Does your deployment, or planned deployment, of EV charging infrastructure collect user fees for charging?

   ☐Yes, all stations ☐Yes, some stations ☐No, it is free for use

   If yes, please provide details of your pricing strategy (file upload, PDF) or link here: _____

9. Does your deployment, or planned deployment, intend to make use of rules allowing for rate recovery mechanisms or other opportunities for cost savings?

☐Yes, current deployment ☐Yes, planned deployment ☐No

☐Unsure, as we do not have a good understanding of those rules

10. Does your deployment, or planned deployment, include a plan for the DOT to provide operations and maintenance of the charging infrastructure (either through in-house or contracted forces)?

☐Yes, current deployment ☐Yes, planned deployment ☐No

11. Does your deployment, or planned deployment, include a plan for the DOT to provide site maintenance (e.g. snow removal, etc.) and monitoring of the charging infrastructure (either through in-house or contracted forces)?

☐Yes, current deployment ☐Yes, planned deployment ☐No

12. Does your deployment, or planned deployment, include operations and maintenance of the charging infrastructure to be provided by the lessee, grantee, vendor, or others?

☐Yes, current deployment ☐Yes, planned deployment ☐No

13. Does your deployment, or planned deployment, include prioritization, such as by vehicle type (passenger travel, freight travel, transit, etc.) or location (corridor basis or site-specific opportunities, such as multi-dwelling housing or community destinations, etc.)?

☐Yes, current deployment ☐Yes, planned deployment ☐No

14. Does your deployment, or planned deployment, involve participation with/from any of the following (select all that apply)?

Entities Involved	Current Deployment	Planned Deployment	Not Involved
Utility Companies (e.g. negotiating demand charges, infrastructure upgrades, etc.)	☐	☐	☐
Private Investors	☐	☐	☐
Public/Private Partnerships (e.g. funding, provision of space, etc.)	☐	☐	☐
State energy agency	☐	☐	☐
State environmental agency	☐	☐	☐
State economic development agency	☐	☐	☐
Other Government Agencies/Branches	☐	☐	☐
Nonprofit Entities	☐	☐	☐
Other (1): _____	☐	☐	☐
Other (2): _____	☐	☐	☐

15. Did your deployment, or does your planned deployment, involve a pilot program prior to implementing a full-scale build-out?

☐Yes, current deployment started with a pilot

☐Yes, planned deployment involves a pilot

☐No, we did not institute or plan to institute a pilot

16. What quantity of EV charging stations and charge ports has your DOT currently deployed (or been involved in) and how many are planned in total (current plus future planned)?

EV Charging Planned or Deployed	**Level 1 Charging**	**Level 2 Charging**	**DC Fast Charging**
Charging Stations-Currently Deployed			
Charging Stations-Total Planned			
Charging Ports-Currently Deployed			
Charging Ports-Total Planned			

17. Please specify the scale or status of your current deployment of EV charging infrastructure:

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Deployment Type	N/A	Piloting	Transitioning from Pilot to Full-scale Program	Full-scale Build-out Program
Light-duty (passenger cars) Urban Context	☐	☐	☐	☐
Light-duty (passenger cars) Rural/Intercity Context	☐	☐	☐	☐
Medium-duty Urban Transit Buses	☐	☐	☐	☐
Medium-duty Rural/Intercity Transit Buses	☐	☐	☐	☐
Heavy-duty Urban Freight	☐	☐	☐	☐
Heavy-duty Long-distance Freight	☐	☐	☐	☐

18. Has your DOT evaluated the effectiveness or quantified the benefits of your deployment, or planned deployment[, of] EV charging infrastructure?

☐Yes, current deployment ☐Yes, planned deployment ☐No

19. Has your DOT provided guidance or technical assistance to local governments regarding deployment, or planned deployment[, of] EV charging infrastructure (this may include rezoning needs for home-based charging facilities, charging for public and private parking lots and garages, etc.)?

☐Yes, current deployment ☐Yes, planned deployment ☐No

20. Please indicate your DOT's experience with the following challenges associated with EV charging infrastructure deployment (multiple answers):

Challenge	**Encountered**	**Deployed Strategy to Overcome**	**Not Encountered**	**Level of Challenge (5 = Very High, 4 = High, 3 = Moderate, 2 = Low, 1 = Very Low, 0 = NA)**
Procurement of Infrastructure	☐	☐	☐	
Instituting fees for charging service	☐	☐	☐	
Ability to pay for EV charging infrastructure	☐	☐	☐	
Buy America requirements for EV charging infrastructure	☐	☐	☐	
Commercialization (fees) Restrictions at Rest Areas	☐	☐	☐	
Restrictions at Grandfathered Commercial Service Areas	☐	☐	☐	

Challenge	Encountered	Deployed Strategy to Overcome	Not Encountered	Level of Challenge (5 = Very High, 4 = High, 3 = Moderate, 2 = Low, 1 = Very Low, 0 = NA)
Plans for Operation and Maintenance	☐	☐	☐	
DOT Policies that impede deployment	☐	☐	☐	
Other: _____	☐	☐	☐	

21. Has your DOT evaluated or considered any of the following technologies to enhance your EV charging infrastructure?

Technologies	Yes	No	Unsure
Battery Storage to Reduce Demand Charges	☐	☐	☐
Inductive In-Road Charging	☐	☐	☐
Implemented Renewable Energy Sources	☐	☐	☐
Other (1): _____	☐	☐	☐
Other (2): _____	☐	☐	☐

22. For any of technologies above, has your DOT evaluated or considered how they may increase the investment in your EV charging infrastructure (regarding cost/benefit analysis, feasibility, or approaches for cost recovery, etc.)?

☐Yes ☐No ☐Not sure

23. Would you be willing to participate in a follow-up phone interview?

☐Yes ☐No

APPENDIX B

State DOT Survey Questionnaire Responses

Note: Empty cells in the tables throughout Appendix B indicate questions to which DOTs did not respond or options that were not applicable to any responding DOTs.

No.	Question 1: Please select your state department of transportation (DOT) from the drop-down list.	
1	Alabama	✓
2	Arizona	✓
3	Arkansas	✓
4	California	✓
5	Colorado	✓
6	Connecticut	✓
7	Delaware	✓
8	Florida	✓
9	Georgia	✓
10	Hawaii	✓
11	Idaho	✓
12	Illinois	✓
13	Iowa	✓
14	Kansas	✓
15	Kentucky	✓
16	Louisiana	✓
17	Maryland	✓
18	Massachusetts	✓
19	Minnesota	✓
20	Mississippi	✓
21	Missouri	✓
22	Montana	✓
23	Nebraska	✓
24	Nevada	✓
25	New Hampshire	✓
26	New Mexico	✓
27	New York	✓
28	North Carolina	✓
29	North Dakota	✓
30	Ohio	✓
31	Oklahoma	✓
32	Oregon	✓
33	Pennsylvania	✓
34	Rhode Island	✓
35	South Carolina	✓
36	South Dakota	✓
37	Tennessee	✓
38	Texas	✓
39	Utah	✓
40	Vermont	✓
41	West Virginia	✓
42	Wyoming	✓

Question 2: Has your DOT deployed (installed or contracted to have installed) EV charging stations either in public-facing areas or at their own facilities (i.e. DOT headquarters, buildings, etc.)?		
State DOT	Yes	No
Alabama		✓
Arizona		✓
Arkansas		✓
California	✓	
Colorado	✓	
Connecticut	✓	
Delaware	✓	
Florida	✓	
Georgia		✓
Hawaii	✓	
Idaho		✓
Illinois		✓
Iowa	✓	
Kansas		✓
Kentucky		✓
Louisiana		✓
Maryland	✓	
Massachusetts	✓	
Minnesota	✓	
Mississippi		✓
Missouri		✓
Montana		✓
Nebraska		✓
Nevada	✓	
New Hampshire		✓
New Mexico	✓	
New York	✓	
North Carolina		✓
North Dakota		✓
Ohio	✓	
Oklahoma	✓	
Oregon	✓	
Pennsylvania	✓	
Rhode Island	✓	
South Carolina		✓
South Dakota		✓
Tennessee		✓
Texas	✓	
Utah	✓	
Vermont	✓	
West Virginia	✓	
Wyoming		✓

Question 3: If the answer of Question 2 is "Yes", Please check all that apply regarding your deployment of EV charging stations at the list location types:			
DOT Deployed Locations	**Level 1 Charging**	**Level 2 Charging**	**DC Fast Charging**
At DOT/state-owned buildings but non-public facing (for government use only)	CA, VT, RI	CA, CO, CT, DE, FL, HI, IA, MN, VT, NV, NY, OR, PA, RI, TX, UT	RI
At DOT/state-owned public facing buildings (i.e., offices, driver's licensing locations, etc.) for public use	RI	CA, CO, CT, FL, MD, MN, MT, VT, OH, OK, RI, UT	CA, MD, MT, RI, UT
At public facing facilities along DOT/state-owned right of way (i.e. rest areas, etc.)	RI	CA, DE, MA, MN, VT, RI, UT	CA, MA, NV, NY, RI, UT
Along urbanized curb sections (i.e. along downtown sections, etc.)	VT	IA, VT	
At parking areas in DOT/state-owned right of way	VT, RI	CA, DE, MA, MD, MN, VT, NY, RI, UT	CA, MA, MD, RI
Along high traffic corridors	OR	MA, MD, MN, VT, OR, UT	GA, IA, MA, MD, VT, NV, OK, OR, UT
In local-government or metro owned right of way		IA	UT
At private-owned locations (i.e. by lease, etc.)		IA, VT	GA, IA, VT, OK
At toll roads or other interstate segments as "grandfathered in" under 23 U.S.C. 111(a).		MD, OH	CT, MA, MD, OH
Other:_____			

Question 4: Has your DOT planned or are they currently planning a deployment of EV charging infrastructure?			
State DOT	Yes	No	Not sure
Alabama		✓	
Arizona			✓
Arkansas		✓	
California	✓		
Colorado	✓		
Connecticut	✓		
Delaware	✓		
Florida	✓		
Georgia	✓		
Hawaii	✓		
Idaho	✓		
Illinois	✓		
Iowa	✓		
Kansas	✓		
Kentucky	✓		
Louisiana	✓		
Maryland	✓		
Massachusetts	✓		
Minnesota	✓		
Mississippi		✓	
Missouri		✓	
Montana	✓		
Nebraska			✓
Nevada	✓		
New Hampshire	✓		
New Mexico	✓		
New York	✓		
North Carolina	✓		
North Dakota	✓		
Ohio	✓		
Oklahoma	✓		
Oregon	✓		
Pennsylvania	✓		
Rhode Island	✓		
South Carolina	✓		
South Dakota	✓		
Tennessee	✓		
Texas	✓		
Utah	✓		
Vermont	✓		
West Virginia	✓		
Wyoming	✓		

Question 4a: What barriers are preventing your current or planned deployment of EV charging infrastructure? (Select all that apply)	
State policies or regulations	MS
Federal policies or regulations	MO
Policy or regulation uncertainties	AR, MO, MS
Lack of emphasis in DOT program	AZ, MO, MS, NE
Lack of guidance	AZ, MO, NE
Lack of funding or understanding of funding	AR, MS, NE
Lack of public need	MS, NE
Other:_____	NE: DOTs, traditionally are not in the energy/fueling business.

Question 5: Please check all that apply regarding your planned deployment of EV charging stations:			
DOT Deployed Locations	**Level 1 Charging**	**Level 2 Charging**	**DC Fast Charging**
At DOT/state-owned buildings but non-public facing (for government use only)	IL, VT, TX	CA, CO, CT, DE, HI, IL, LA, MT, NC, VT, NH, OR, PA, RI, TX, UT	CA, CT, DE, LA, VT, NV, RI
At DOT/state-owned public facing buildings (i.e., offices, driver's licensing locations, etc.) for public use		CO, CT, HI, IL, KS, KY, LA, MA, NC, VT, OR, RI, UT	DE, KS, MA, MT, OH, PA, RI, UT
At public facing facilities along DOT/state-owned right of way (i.e. rest areas, etc.)		CT, HI, IL, MA, NH, RI, UT	DE, IL, KS, KY, MA, MT, NM, NH, NM, NH, OH, PA, WV
Along urbanized curb sections (i.e. along downtown sections, etc.)		DE, IA, KY, VT, NH, OR	DE, KY, NH, OK
At parking areas in DOT/state-owned right of way		CT, DE, HI, MA, PA, RI, UT	DE, MA, MN, MT, NM, NV, RI, UT
Along high traffic corridors		CO, DE, IL, KS, LA, MA, VT, NH, RI, UT	AR, CO, CT, DE, GA, IA, ID, IL, KS, KY, LA, MA, MT, NM, NC, VT, NH, OH, OK, OR, RI, SE, SC, TX, UT, WV
In local-government or metro owned right of way		CO, DE, IA, IL, KS, KY, LA, VT, OR, RI, TX, UT	CO, DE, IL, KS, KY, LA, NM, OK, RI, TN, TX, UT, WV
At private-owned locations (i.e. by lease, etc.)	OR	IA, IL, LA, VT, NH, OR, TX, UT	AR, CT, GA, IA, ID, IL, KY, LA, MN, NM, NC, VT, NH, NV, OH, OK, OR, PA, SC, SD, TN, TX, UT, WY
At toll roads or other interstate segments as "grandfathered in" under 23 U.S.C. 111(a).		LA, NH	CT, KS, LA, NH, OK, PA
Other:_____			

Question 6: Has your DOT developed an EV charging infrastructure policy/guidelines (which may include conditions of placement along curbs of state-owned roadways or in public rights of way)?			
State DOT	Yes	No	Website Address for Policy/Guidelines
Alabama			
Arizona			
Arkansas		✓	
California		✓	
Colorado		✓	
Connecticut		✓	
Delaware		✓	
Florida	✓		
Georgia		✓	
Hawaii		✓	
Idaho		✓	
Illinois		✓	
Iowa		✓	
Kansas		✓	
Kentucky		✓	
Louisiana		✓	
Maryland		✓	
Massachusetts		✓	
Minnesota	✓		
Mississippi			
Missouri			
Montana		✓	
Nebraska			
Nevada		✓	
New Hampshire		✓	
New Mexico		✓	
New York		✓	
North Carolina		✓	
North Dakota		✓	
Ohio		✓	
Oklahoma		✓	
Oregon		✓	
Pennsylvania		✓	
Rhode Island		✓	
South Carolina		✓	
South Dakota		✓	
Tennessee		✓	
Texas		✓	
Utah		✓	
Vermont		✓	
West Virginia		✓	
Wyoming		✓	

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Question 7: Please select any of the following elements of your planned or actual EV charging infrastructure deployment that has been affected by federal policy or regulations:	
Fee structures and cost recovery	CA, CO, CT, FL, ID, KS, MA, MD, NM, NC, VT, NH, NY, OR, PA, TN, TX, UT, WY
Siting and location	CA, CO, CT, DE, FL, GA, HI, IA, ID, IL, KS, KY, LA, MA, MD, MT, NM, VT, NH, NY, OH, OK, OR, PA, SC, TN, TX, UT, WY
EV charging type or level installed	AR, DE, GA, HI, IA, ID, IL, KS, KY, LA, MN, VT, NH, NV, NY, OH, OK OR, PA, SC, TX, UT, WV, WY
Number of EV charging stations installed	AR,DE, GA, HI, IA, ID, IL, KS, KY, LA, VT, NH, NV, NY, OH, OR, PA, TN, TX, UT, WV, WY
Material used (Buy American Act, etc.)	AR, CT, DE, GA, IA, ID, IL, KS, KY, MA, MN, MT, NC, VT, NH, NV, OH, OK, OR, PA, SC, TN, TX, WY
Other:_____	CT: Energy Star Certified
	KS: Timeline of implementing secondary and tertiary EV station priorities
	MA: Ability to charge a fee for electricity on non-grandfathered locations on Interstate right-of-way
	NV: Maximum distance
	NY: 23 USC 111 is a major barrier
	RI: Still under works
	SD: Still developing deployment strategy

Question 8: Does your deployment, or planned deployment, of EV charging infrastructure collect user fees for charging?			
State DOT	Yes, all stations	Yes, some stations	No, it is free for use
Alabama			
Arizona			
Arkansas		✓	
California		✓	
Colorado			✓
Connecticut			✓
Delaware			✓
Florida			✓
Georgia			
Hawaii		✓	
Idaho	✓		
Illinois			
Iowa		✓	
Kansas		✓	
Kentucky	✓		
Louisiana		✓	
Maryland			✓
Massachusetts	✓		
Minnesota			✓
Mississippi			
Missouri			
Montana	✓		
Nebraska			
Nevada			✓
New Hampshire	✓		
New Mexico	✓		
New York			✓
North Carolina			✓
North Dakota			
Ohio	✓		
Oklahoma	✓		
Oregon	✓		
Pennsylvania			
Rhode Island			
South Carolina	✓		
South Dakota	✓		
Tennessee			
Texas	✓		
Utah	✓		
Vermont		✓	
West Virginia	✓		
Wyoming	✓		

Question 9: Does your deployment, or planned deployment, intend to make use of rules allowing for rate recovery mechanisms or other opportunities for cost savings?				
State DOT	Yes, current deployment	Yes, planned deployment	No	Unsure
Alabama				
Arizona				
Arkansas				
California	✓			
Colorado		✓		
Connecticut	✓			
Delaware				✓
Florida				✓
Georgia				✓
Hawaii				✓
Idaho				✓
Illinois				✓
Iowa				✓
Kansas				✓
Kentucky				✓
Louisiana				✓
Maryland	✓			
Massachusetts				✓
Minnesota				✓
Mississippi				✓
Missouri				✓
Montana				
Nebraska				
Nevada				✓
New Hampshire				✓
New Mexico				
New York			✓	
North Carolina	✓			
North Dakota				✓
Ohio				✓
Oklahoma				✓
Oregon				✓
Pennsylvania				✓
Rhode Island				✓
South Carolina				✓
South Dakota				✓
Tennessee				✓
Texas	✓			
Utah	✓			
Vermont				✓
West Virginia				✓
Wyoming				✓

Question 10: Does your deployment, or planned deployment, include a plan for the DOT to provide operations and maintenance of the charging infrastructure (either through in-house or contracted forces)?			
State DOT	Yes, current deployment	Yes, planned deployment	No
Alabama			
Arizona			
Arkansas			
California	✓		
Colorado	✓		
Connecticut	✓		
Delaware			✓
Florida		✓	
Georgia			✓
Hawaii	✓		
Idaho			✓
Illinois		✓	
Iowa			✓
Kansas	✓		
Kentucky		✓	
Louisiana			✓
Maryland	✓		
Massachusetts	✓		
Minnesota	✓		
Mississippi			
Missouri			
Montana		✓	
Nebraska			
Nevada			✓
New Hampshire		✓	
New Mexico	✓		
New York	✓		
North Carolina		✓	
North Dakota			
Ohio	✓		
Oklahoma			✓
Oregon			✓
Pennsylvania			✓
Rhode Island			
South Carolina			✓
South Dakota			✓
Tennessee	✓		
Texas			✓
Utah	✓		
Vermont	✓		
West Virginia			✓
Wyoming		✓	

Question 11: Does your deployment, or planned deployment, include a plan for the DOT to provide site maintenance (e.g. snow removal, etc.) and monitoring of the charging infrastructure (either through in-house or contracted forces)?			
State DOT	Yes, current deployment	Yes, planned deployment	No
Alabama			
Arizona			
Arkansas			
California	✓		
Colorado	✓		
Connecticut			✓
Delaware			✓
Florida		✓	
Georgia			✓
Hawaii	✓		
Idaho			✓
Illinois		✓	
Iowa			✓
Kansas		✓	
Kentucky		✓	
Louisiana			✓
Maryland			✓
Massachusetts	✓		
Minnesota	✓		
Mississippi			
Missouri			
Montana		✓	
Nebraska			
Nevada	✓		
New Hampshire			✓
New Mexico	✓		
New York	✓		
North Carolina		✓	
North Dakota			
Ohio	✓		
Oklahoma			✓
Oregon			✓
Pennsylvania			✓
Rhode Island			
South Carolina			✓
South Dakota			✓
Tennessee	✓		
Texas		✓	
Utah	✓		
Vermont		✓	
West Virginia			✓
Wyoming		✓	

Question 12: Does your deployment, or planned deployment, include operations and maintenance of the charging infrastructure to be provided by the lessee, grantee, vendor, or others?			
State DOT	Yes, current deployment	Yes, planned deployment	No
Alabama			
Arizona			
Arkansas			
California	✓		
Colorado	✓		
Connecticut		✓	
Delaware		✓	
Florida		✓	
Georgia			✓
Hawaii	✓		
Idaho		✓	
Illinois		✓	
Iowa	✓		
Kansas	✓		
Kentucky		✓	
Louisiana		✓	
Maryland			✓
Massachusetts	✓		
Minnesota		✓	
Mississippi			
Missouri			
Montana		✓	
Nebraska			
Nevada	✓		
New Hampshire		✓	
New Mexico	✓		
New York	✓		
North Carolina		✓	
North Dakota			
Ohio	✓		
Oklahoma			✓
Oregon	✓		
Pennsylvania		✓	
Rhode Island			
South Carolina		✓	
South Dakota		✓	
Tennessee	✓		
Texas		✓	
Utah	✓		
Vermont	✓		
West Virginia		✓	
Wyoming		✓	

Question 13: Does your deployment, or planned deployment, include prioritization, such as by vehicle type (passenger travel, freight travel, transit, etc.) or location (corridor basis or site-specific opportunities, such as multi-dwelling housing or community destinations, etc.)?			
State DOT	Yes, current deployment	Yes, planned deployment	No
Alabama			
Arizona			
Arkansas			
California		✓	
Colorado			✓
Connecticut		✓	
Delaware	✓		
Florida			✓
Georgia			✓
Hawaii			✓
Idaho		✓	
Illinois		✓	
Iowa	✓		
Kansas	✓		
Kentucky		✓	
Louisiana			✓
Maryland			✓
Massachusetts			✓
Minnesota		✓	
Mississippi			
Missouri			
Montana		✓	
Nebraska			
Nevada			✓
New Hampshire		✓	
New Mexico	✓		
New York			✓
North Carolina		✓	
North Dakota			
Ohio			✓
Oklahoma			✓
Oregon	✓		
Pennsylvania		✓	
Rhode Island			
South Carolina		✓	
South Dakota		✓	
Tennessee		✓	
Texas		✓	
Utah	✓		
Vermont	✓		
West Virginia		✓	
Wyoming		✓	

Question 14: Does your deployment, or planned deployment, involve participation with/from any of the following (select all that apply):			
Entities Involved	Current Deployment	Planned Deployment	Not Involved
Utility Companies (e.g. negotiating demand charges, infrastructure upgrades, etc.)	CA, CO, CT, IA, MD, MN, NV, NY, OR, RI, UT	CA, CO, CT, DE, GA,FL, HI, IA, ID, IL, KS, KY, LA, MD, MN, MT, NM, NC, VT, NH, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, WV, WY	
Private Investors	HI, IA, OR	CA, CO, CT, GA, FL, HI, IA, ID, IL, KS, KY, LA, MN, NC, NH, OK, OR, SD, TN, UT, WY	DE, MT, NM, NV, OH, WV
Public/Private Partnerships (e.g. funding, provision of space, etc.)	IA, VT, NV, OR, UT	CO, CT, GA, FL, IA, ID, IL, KY, LA, MN, MT, NM, NC, VT, NH, NV, OK, OR, PA, RI, SC, SD, TN, UT, WV, WY	CA, DE, OH
State energy agency	CO, CT, HI, IA, MD, VT, NV, NY, RI	CA, CO, CT, DE, GA, FL, HI, IA, ID, IL, KS, KY, LA, MT, NM, NC, VT, NH OH, OK, OR, PA, RI, SC, TN, TX, UT, WV, WY	
State environmental agency	CO,CT, DE, OA, VT, OH, OR, RI	CA, CO, CT, DE, GA, FL, IA, ID, IL, KS, KY, LA, MD, NM, NC, VT, NH, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, WY	MT, NV, WV
State economic development agency	IA,VT, NY, RI	CA, CT, DE, GA, FL, IA, ID, IL, KS, KY, LA, NC, VT, NH, OK, OR, PA, RI, SC, SD, TN, TX, UT, WV	CO, MT, NV, OH
Other Government Agencies/Branches	CO, CT, IA, OH, RI	CA, CO, CT, DE, GA, FL, HI, IA, ID, IL, KS, KY, LA, MT, NM, NC, VT, NH, NV, OH, OK, OR, RI, SD, TN, TX, UT, WV, WY	
Nonprofit Entities	IA	CA, CO, CT, GA, FL, IA, ID, IL, KS, KY, LA, NC, NH, OR, PA, SC, TN, TX, UT, WY	DE, MT, NV, OK, WV
Other: Clean Cities	CT	CT	
Other: EV-owner organizations		KS	

Question 15: Did your deployment, or does your planned deployment, involve a pilot program prior to implementing a full-scale build-out??			
State DOT	Yes, current deployment started with a pilot	Yes, planned deployment involves a pilot	No
Alabama			
Arizona			
Arkansas			
California	✓		
Colorado			✓
Connecticut	✓		
Delaware			✓
Florida			✓
Georgia			✓
Hawaii			✓
Idaho			✓
Illinois		✓	
Iowa			✓
Kansas			✓
Kentucky			✓
Louisiana		✓	
Maryland		✓	
Massachusetts	✓		
Minnesota		✓	
Mississippi			
Missouri			
Montana			✓
Nebraska			
Nevada			✓
New Hampshire			✓
New Mexico	✓		
New York	✓		
North Carolina			✓
North Dakota			
Ohio			✓
Oklahoma			✓
Oregon			✓
Pennsylvania			✓
Rhode Island			
South Carolina			✓
South Dakota			✓
Tennessee			✓
Texas			✓
Utah			✓
Vermont	✓		
West Virginia			✓
Wyoming			✓

Question 16 a: What quantity of EV charging stations and charge ports has your DOT currently deployed (or been involved in) and how many are planned in total (current plus future planned)?			
	Charging Stations-Currently Deployed		
State DOT	Level 1 Charging	Level 2 Charging	DC Fast Charging
Alabama			
Arizona			
Arkansas			
California	0	We count by port	We count by port
Colorado	0	26	0
Connecticut		29	
Delaware		31	
Florida		5	
Georgia			
Hawaii		4	
Idaho			
Illinois			
Iowa		27	12
Kansas			7
Kentucky			0
Louisiana	0	0	0
Maryland	0		
Massachusetts		9	6
Minnesota			
Mississippi			
Missouri			
Montana	0	0	0
Nebraska			
Nevada			2
New Hampshire			
New Mexico		2	
New York		28	6
North Carolina	0	0	0
North Dakota			
Ohio		4	
Oklahoma			
Oregon	44	44	44
Pennsylvania	4	5	
Rhode Island			
South Carolina			
South Dakota			
Tennessee			
Texas			
Utah		26	16
Vermont		89	41
West Virginia	0	0	0
Wyoming			

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Question 16 b: What quantity of EV charging stations and charge ports has your DOT currently deployed (or been involved in) and how many are planned in total (current plus future planned)?			
	Charging Stations-Total Planned		
State DOT	Level 1 Charging	Level 2 Charging	DC Fast Charging
Alabama			
Arizona			
Arkansas			
California	0	TBD	TBD
Colorado	0	TBD	TBD
Connecticut		68	60+
Delaware			
Florida			
Georgia			
Hawaii			
Idaho			
Illinois			
Iowa			
Kansas			NA
Kentucky			Under Development
Louisiana	0	10	1
Maryland	0	3	Transit Bus Charging
Massachusetts		5	7
Minnesota		42	
Mississippi			
Missouri			
Montana	0	0	Unsure
Nebraska			
Nevada			
New Hampshire		Cost Dependent	Cost Dependent
New Mexico			42
New York			
North Carolina			
North Dakota			
Ohio			
Oklahoma			
Oregon	60	25	286
Pennsylvania		39	
Rhode Island			
South Carolina			
South Dakota			
Tennessee			
Texas		20,000	260
Utah		36	74
Vermont		1,000	190
West Virginia	0	0	4
Wyoming			Unsure

Question 16 c: What quantity of EV charging stations and charge ports has your DOT currently deployed (or been involved in) and how many are planned in total (current plus future planned)?			
Charging Ports-Currently Deployed			
State DOT	Level 1 Charging	Level 2 Charging	DC Fast Charging
Alabama			
Arizona			
Arkansas			
California	Unknown	1,121	54
Colorado	0	52	TBD
Connecticut		54	
Delaware			
Florida		18	
Georgia			
Hawaii			
Idaho			
Illinois			
Iowa			
Kansas			21
Kentucky			0
Louisiana	0	0	0
Maryland	0	66	40
Massachusetts		unknown	12
Minnesota	30		
Mississippi			
Missouri			
Montana	0	0	0
Nebraska			
Nevada			
New Hampshire			
New Mexico			
New York		52	12
North Carolina			
North Dakota			
Ohio		8	
Oklahoma			
Oregon	44	44	44
Pennsylvania	4	10	
Rhode Island			
South Carolina			
South Dakota			
Tennessee			
Texas			
Utah		52	32
Vermont		178	82
West Virginia	0	0	0
Wyoming			

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Question 16 d: What quantity of EV charging stations and charge ports has your DOT currently deployed (or been involved in) and how many are planned in total (current plus future planned)?			
	Charging Ports- Total Planned		
State DOT	Level 1 Charging	Level 2 Charging	DC Fast Charging
Alabama			
Arizona			
Arkansas			
California	0	TBD	TBD
Colorado	0	TBD	TBD
Connecticut		111	100+
Delaware			
Florida			
Georgia			
Hawaii			
Idaho			
Illinois			
Iowa			
Kansas			NA
Kentucky			Under Development
Louisiana	0	10	1
Maryland	0	6	
Massachusetts		40	26
Minnesota			Unknown quantity - $68 million
Mississippi			
Missouri			
Montana	0	0	Unsure
Nebraska			
Nevada			2
New Hampshire		Cost Dependent	Cost Dependent
New Mexico			
New York			
North Carolina			
North Dakota			
Ohio			
Oklahoma			
Oregon	60	25	286
Pennsylvania		77	
Rhode Island			
South Carolina			
South Dakota			
Tennessee			
Texas		31,000	1,690
Utah		74	128
Vermont		2,000	232
West Virginia	0	0	16
Wyoming			Unsure

Question 17: Please specify the scale or status of your current deployment of EV charging infrastructure:				
Deployment Type	**N/A**	**Piloting**	**Transitioning from Pilot to Full-scale Program**	**Full-scale Build-out Program**
Light-duty (passenger cars) Urban Context	GA, IL, KS, MD, MT, NC, PA, SC, TX, WV, WY	CT, MN, NM, NY, OH	CO, DE, LA, VT	CA, FL, HI, IA, KY, MA, NV, OR
Light-duty (passenger cars) Rural/Intercity Context	GA, IL, KS, MD, MT, NC, PA, SC, TX, WV, WY	MN, NM, OH	CO, CT, DE, LA, VT	CA, HI, IA, KY, MA, NV, OR, UT
Medium-duty Urban Transit Buses	CA, CO, IA, GA, IL, KS, KY, MA, MN, NM, NC, OR, PA, SC, TX, WV, WY	MD, VT	CT, DE	
Medium-duty Rural/Intercity Transit Buses	CA, CO, GA, IA, IL, KS, KY, MA, MD, MN, NM, NC, OR, PA, SC, TX, WV, WY	CT, VT	DE	
Heavy-duty Urban Freight	CA, CO, CT, DE, GA, IA, IL, KS, KY, MA, MD, MN, MT, NM, NC, OR, PA, SC, TX, VT, WV, WY			
Heavy-duty Long-distance Freight	CA, CO, CT, DE, GA, IA, IL, KS, KY, MA, MD, MN, MT, NM, NC, OR, PA, SC, TX, VT, WV, WY			

Question 18: Has your DOT evaluated the effectiveness or quantified the benefits of your deployment, or planned deployment EV charging infrastructure??			
State DOT	Yes, current deployment	Yes, planned deployment	No
Alabama			
Arizona			
Arkansas			
California			✓
Colorado	✓		
Connecticut	✓		
Delaware			✓
Florida			✓
Georgia		✓	
Hawaii	✓		
Idaho			
Illinois			✓
Iowa			✓
Kansas			✓
Kentucky		✓	
Louisiana		✓	
Maryland	✓		
Massachusetts	✓		
Minnesota			✓
Mississippi			
Missouri			
Montana			✓
Nebraska			
Nevada			✓
New Hampshire		✓	
New Mexico			✓
New York	✓		
North Carolina			✓
North Dakota			✓
Ohio	✓		
Oklahoma			✓
Oregon			✓
Pennsylvania		✓	
Rhode Island			✓
South Carolina			✓
South Dakota			✓
Tennessee		✓	
Texas		✓	
Utah			✓
Vermont			✓
West Virginia			✓
Wyoming		✓	

Question 19: Has your DOT provided guidance or technical assistance to local governments regarding deployment, or planned deployment EV charging infrastructure (this may include rezoning needs for home-based charging facilities, charging for public and private parking lots and garages, etc.)?			
State DOT	Yes, current deployment	Yes, planned deployment	No
Alabama			
Arizona			
Arkansas			
California		✓	
Colorado	✓		
Connecticut		✓	
Delaware			✓
Florida		✓	
Georgia			✓
Hawaii	✓		
Idaho			
Illinois			✓
Iowa			✓
Kansas			✓
Kentucky			✓
Louisiana			✓
Maryland		✓	
Massachusetts			✓
Minnesota			✓
Mississippi			
Missouri			
Montana			✓
Nebraska			
Nevada			✓
New Hampshire		✓	
New Mexico			✓
New York	✓		
North Carolina			✓
North Dakota			
Ohio			✓
Oklahoma			✓
Oregon			✓
Pennsylvania		✓	
Rhode Island			✓
South Carolina			✓
South Dakota			✓
Tennessee		✓	
Texas			✓
Utah			✓
Vermont	✓		
West Virginia			✓
Wyoming		✓	

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Question 20a: Please indicate your DOT's experience with the following challenges associated with EV charging infrastructure deployment (multiple answers):			
Challenge	**Encountered**	**Deployed Strategy to Overcome**	**Not Encountered**
Procurement of Infrastructure	CA, IA, KS, MA, MD, NM, NC, NH, NV, NY, OH, OR, TN, TX, WV	CO, CT, FL, HI, KY, MN, UT	DE, GA, IL, KS, KY, LA, MT, OK, PA, SC, WY
Instituting fees for charging service	CA, CT, DE, KS, MA,MD, NM, NC, NM, NY, OH, OR, TN, TX, UT	CA, FL, MN	CO, GA, IA, IL, KS, KY, LA, MT, NV, OK, PA, SC, WV, WY
Ability to pay for EV charging infrastructure	CA, IA, MD, NC, VT, NH, NV, OH, OR, TX, UT	CA, CO, CT, FL, HI, KY, MA, MN, NY	DE, GA, IL, KS, KY, LA, MT, NM, OK, PA, SC, WV, WY
Buy America requirements for EV charging infrastructure	CA, CO, CT, KS, MA, MD, MN, NC, NH, OH, OR, TN, TX, UT, WY	FL, KY, PA, TN	DE, IA, IL, GA, KS, KY, LA, MT, NM, NV, NY OK, SC, WV, WY
Commercialization (fees) Restrictions at Rest Areas	CA, CO, CT, FL, IA, KS, MA, MD, MN, NM, NC, NH, NV, NY, OH, OR, PA, SC, TN, TX, UT	CA	DE, GA, IL, KS, KY, LA, MT, OK, SC, WV, WY
Restrictions at Grandfathered Commercial Service Areas	KS, MD, TX	CT, FL	CA, CO, DE, GA, IA, IL, KS,KY, LA, MA, MN, MT, NM, NC, NH, NV, NY, OH, OK, OR, PA, SC, TN, WV, WY
Plans for Operation and Maintenance	CA, CO, CT, DE, IA, MD, NM, VT, NH, OH, OR, TX, UT, WY	FL, HI, KY, MA, MN, VT, NY, OH, OR, WV	GA, IL, KS, KY, LA, MT, NC, NV, OK, PA, SC
DOT Policies that impede deployment	CA, MA, MN, NH, NY, OH, OR, PA, TN, TX, UT, WY	CT, FL, KY, OR	CO, DE, GA, IA, IL, KS, KY, LA, MD, MT, NM, NC, NV, OK, SC, WV
Site development Experience	CA, FL, IA, KS, MA, MD, LA, NH, NV, OH, OR, TX, UT	CO, CT, HI, KY, VT, TN, WV	DE, GA, IL, KS, KY, LA, MN, MT, NM, NC, OK, PA, SC, WY
Lack of power infrastructure Experience	CA, FL, IA, KS, MA, MD, NC, VT, NH, NV, OH, TX, UT	CO, CT, HI, KY, TX, WV	DE, GA, IL, KS, KY, LA, MN, MT, NM, OK, OR, PA, SC, TN, WY
Other: Experience	NC, OH, OR, SC, TX	CT	CO, GA, LA, MN, LA, VT, OK
Other-CT: Finding Energy Star certified equipment that had cord management software that kept the cord off the ground (L2 equipment).			
Other-KS: We're so early in the process of deploying our first round of funding for EV charging infrastructure that we have not encountered any of these issues, but we do expect to with many of them, as indicated above.			
Other-NC: State laws that impede deployment			
Other-VT: All of our EVSE investments to date have been through either VW settlement funds, state capital funds, or state transportation funds. We have used these to contract with third-parties to install, own and operate EVSE. We have therefore faced minimal challenges--though there are some like local demand charges--but anticipate new ones like Buy America requirements with incoming federal funding.			
Other-OH: I take exception to the wording "DOT Policies that impede deployment." Speaking mainly to the NEVI program, it should be made clear that Title 23 USC are the policies that will impede that program, NOT state DOT policies			
Other-OR: Issues surrounding leases in right of way (EVSPs need long term certainty) -@time and process for environmental/@cultural/@tribal/@other reviews			
Other-SC: Accomplishing a broad engagement with stakeholders to implement a fair and equitable plan.			
Other-TX: Broadband or other connectivity for payment systems and data collection			

Question 20b: Please indicate your DOT's experience with the following challenges associated with EV charging infrastructure deployment (multiple answers)										
Level of Challenge (5 = Very High, 4 = High, 3 = Moderate, 2 = Low, 1 = Very Low, 0 = NA)										
State DOT	Procurement of Infrastructure	Instituting fees for charging service	Ability to pay for EV charging infrastructure	Buy America requirements for EV charging infrastructure	Commercialization (fees) Restrictions at Rest Areas	Restrictions at Grandfathered Commercial Service Areas	Plans for Operation and Maintenance	DOT Policies that impede deployment	Site development Experience	Lack of power infrastructure Experience
Alabama										
Arizona										
Arkansas										
California	4	5	3	5	5		4	4	3	5
Colorado	3	0	2	4	5	0	3	0	3	2
Connecticut	4	5	3	2	5	3	4	3	4	5
Delaware		3					2			
Florida	3	2	1	4	5		3	3	3	4
Georgia										
Hawaii	3		3				3		3	4
Idaho										
Illinois										
Iowa	4	2	2	5	2	0	2	2	2	4
Kansas	5	3		4	3	3			4	4
Kentucky	2	0	1	3	0	0	3	2	2	3
Louisiana	3	3	2	3	3	3	2	2	3	1
Maryland	2	4	3	3	3	3	2		2	2
Massachusetts	2	3	3	5	5		3	3	3	3
Minnesota	3	3	3	5	3		2	5		
Mississippi										
Missouri										
Montana										
Nebraska										
Nevada	3	0	2	0	5	0	0	1	4	5
New Hampshire	3	3	5	3	2	0	4	4	2	3
New Mexico	3	3	0	0	5		2	0	0	0
New York	5	5	4		5		4	5		
North Carolina	3	5	4	5	5	0	0	0	0	3
North Dakota										
Ohio	5	1	1	5	5		5	5	5	5
Oklahoma										
Oregon	2	2	4	4	5	0	4	4	5	0
Pennsylvania				3	5			3		
Rhode Island										
South Carolina	5	5	2	5	5	0	4	4	4	5
South Dakota										
Tennessee										
Texas	4	4	4	4	5	3	4	2	4	4
Utah	3	5	3	5	5		4	3	3	4
Vermont			4				2		3	3
West Virginia	5						2		4	3
Wyoming										

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Question 21: Has your DOT evaluated or considered any of the following technologies to enhance your EV charging infrastructure?			
Technologies	**Yes**	**No**	**Unsure**
Battery Storage to Reduce Demand Charges	CA, CO, CT, DE, FL, GA, HI, KS, KY, MA, MD, NM, VT, NH, OR, PA, TN, TX, UT, WY	IA, IL, LA, MN, MT, NY, OK, SC, SD, WV	NC, NV, OH
Inductive In-Road Charging	CA, CO, FL, GA, KS, MD, PA, TN, UT	CT, IA, IL, KY, LA, MA, MN, MT, NM, VT, NH, NV, NY, OH, OK, SC, SD, WV	NC, TX, WY
Implemented Renewable Energy Sources	CA, CO, CT, DE, FL, HI, IL, KS, MD, MN, NM, OR, PA, TN, TX, UT	IA, KY, LA, MA, MT, NC, VT, NY, OH, OK, SC, SD, WV	GA, NH, NV, WY
Other: mobile services for hurricane evacuation	TX		

Question 22: For any of technologies above, has your DOT evaluated or considered how they may increase the investment in your EV charging infrastructure (regarding cost/benefit analysis, feasibility, or approaches for cost recovery, etc.)?			
State DOT	Yes	No	Not sure
Alabama			
Arizona			
Arkansas			
California			✓
Colorado			✓
Connecticut	✓		
Delaware			✓
Florida	✓		
Georgia			✓
Hawaii			✓
Idaho			
Illinois		✓	
Iowa		✓	
Kansas	✓		
Kentucky			✓
Louisiana			✓
Maryland	✓		
Massachusetts			✓
Minnesota	✓		
Mississippi			
Mississippi			
Montana		✓	
Nebraska			
Nevada			✓
New Hampshire		✓	
New Mexico	✓		
New York			
North Carolina			✓
North Dakota			
Ohio		✓	
Oklahoma		✓	
Oregon	✓		
Pennsylvania			✓
Rhode Island			✓
South Carolina		✓	
South Dakota		✓	
Tennessee			✓
Texas	✓		
Utah	✓		
Vermont		✓	
West Virginia		✓	
Wyoming			✓

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Question 23: Would you be willing to participate in a follow-up phone interview?		
State DOT	Yes	No
Alabama		
Arizona		
Arkansas		
California	✓	
Colorado	✓	
Connecticut	✓	
Delaware	✓	
Florida	✓	
Georgia		✓
Hawaii	✓	
Idaho		
Illinois	✓	
Iowa	✓	
Kansas	✓	
Kentucky		✓
Louisiana	✓	
Maryland	✓	
Massachusetts		✓
Minnesota	✓	
Mississippi		
Missouri		
Montana		✓
Nebraska		
Nevada	✓	
New Hampshire	✓	
New Mexico	✓	
New York	✓	
North Carolina	✓	
North Dakota	✓	
Ohio	✓	
Oklahoma	✓	
Oregon	✓	
Pennsylvania	✓	
Rhode Island		✓
South Carolina	✓	
South Dakota	✓	
Tennessee		✓
Texas	✓	
Utah	✓	
Vermont	✓	
West Virginia	✓	
Wyoming	✓	

APPENDIX C

Case Example Interview Topics

NCHRP PROJECT 20-05 SYNTHESIS TOPIC 53-08

STRATEGIES AND PROGRAMS FOR ELECTRIC VEHICLE CHARGING

State Department of Transportation Interview

The objective of NCHRP Project 20-05 Synthesis Topic 53-08 is to document current strategies and practices in use by State Departments of Transportation (DOTs) to facilitate and coordinate the provision and operation of electric vehicle (EV) charging facilities. The synthesis will also include current plans to address the future maturity of EV charging, such as preparation for medium and heavy-duty electrification.

Topics for the study include:

- Practices for EV charging infrastructure deployment, delineation of operating and maintenance responsibilities, public/private partnerships, procurement and contracting, and pricing strategies;
- Practices prioritizing the deployment of EV charging;
- Practices on planning for EV charging, including for expanding pilot programs into full-scale build-outs;
- Practices in working with utilities;
- Practices for funding and complying with funding regulations, Buy America requirements, commercialization of rest area regulations including grandfathered commercial service areas, etc.;
- Practices on evaluating the effectiveness of programs, quantification of benefits, cost recapture, and experiences in overcoming barriers to implementation;
- Practices on providing guidance or technical assistance to local governments from DOTs; and
- Policies for EV charging stations along state-owned roadways or in public rights-of-way.

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Electric Vehicle Charging Infrastructure Interview Topics

Topics for the discussion within the interviews may include:

Program Deployment Approach

- Deployment policies, prioritization, and planning for expansion;
- Collaboration and partnerships with other stakeholders (e.g. investors, utility companies, local agencies and governments, etc.);
- Ownership and Operation;
- Practices prioritizing the deployment of EV charging (passenger travel, route analysis, and/or freight, and corridor based or site-specific opportunities such multi-dwelling housing or community destinations, etc.) considering the bases of desires and permissibility of sites;
- Development of policies for EV charging stations along curbs of state-owned roadways or in public rights-of-way.

Procurement & Funding

- Procurement and contracting practices;
- Pricing strategies and funding approaches, rules and rate recovery mechanisms and opportunities for cost savings, as well as cost recovery if EV charging is provided as a free service;
- Delineation of the State DOT's role in selection of electric vehicle supply equipment (EVSE) as it may relate to EVSE ownership, host site (i.e. land) ownership, EVSE maintenance, site maintenance (e.g. snow clearance), and monitoring;

Maintenance Approach

- Delineation of operating and maintenance responsibilities;
- Practices regarding operations and maintenance, response times, reporting, monitoring services and whether in-house or contracted staff perform these services;
- Deployment plan of chargers by type and if using direct current fast-charging (DCFC) the type and location selected for those devices;

Program Effectiveness, Benefits and Challenges

- Practices on evaluating the effectiveness of programs, quantification of benefits, cost recapture, and experiences in overcoming barriers to implementation;
- Challenges associated with deployment and lessons learned
- Limitations or barriers encountered in deployment that may include federal and state laws and regulations, such as the Buy America Act;

Guidance to Other State DOTs

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GHSA	Governors Highway Safety Association
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S. DOT	United States Department of Transportation

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