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Texas A&M Transportation Institute

Texas Electric Vehicle Charging Infrastructure Readiness Plan

Technical Report 0-7169-R1

Cooperative Research Program

TEXAS A&M TRANSPORTATION INSTITUTE
COLLEGE STATION, TEXAS

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16. Abstract

With the growing adoption of electric vehicles (EVs) in the United States and by Texans, Texas needs adequate and comprehensive coverage of EV charging infrastructure. Although currently comprising slightly more than 1 percent of all registered vehicles in Texas, many projections forecast that EVs could comprise up to 55 percent of all vehicles by 2040. The research included a review of the existing EV charging infrastructure state of practice to (a) understand needs and challenges in EV infrastructure; (b) assess tools available to guide statewide EV planning analysis; (c) develop an analysis of projected EV charging demand based on adoption trends and projections; (d) develop a policy analysis of the local, state, and federal statutory landscape to identify barriers and opportunities; (e) analyze funding opportunities and develop frameworks for funding models; and (f) develop strategies to improve the EV charging infrastructure system in Texas over the course of 5 to 10 years. The research team also conducted three stakeholder workshops to assess stakeholder needs and concerns, opportunities for stakeholder coordination, and long-term EV infrastructure strategy considerations, and conducted interviews with peer states and metropolitan planning organizations. The research efforts resulted in three products, submitted as separate deliverables: product P1, Assessment of EV Planning Analysis Tools, product P2, Policy Analysis Framework, and product P3, Long-Term Statewide EV Infrastructure Strategic Plan.

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DISCLAIMER

This research was sponsored by the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Edgar Kraus, P.E. (Texas Registration #96727).

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LIST OF ACRONYMS AND ABBREVIATIONS

AAMPO	Alamo Area Metropolitan Planning Organization
AB	Assembly Bill
AC	Alternating Current
ACN-Data	Adaptive Charging Network Data
ADA	Americans with Disabilities Act
ADOT	Arizona Department of Transportation
AEO	Annual Energy Outlook
AFC	Alternative Fuel Corridor
AFDC	Alternative Fuels Data Center
AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
AFV	Alternative Fuel Vehicle
AHJ	Authority-Having Jurisdiction
ANL	Argonne National Laboratory
APS	Arizona Public Service
BABA	Build America, Buy America
BEV	Battery Electric Vehicle
BIL	Bipartisan Infrastructure Law
BTU	British Thermal Units
Caltrans	California Department of Transportation
CARB	California Air Resources Board
CCS	Combined Charging System
CDOT	Colorado Department of Transportation
CEC	California Energy Commission
CEJST	Climate and Economic Justice Screening Tool
CEO	Colorado Energy Office
CFI	Charging and Fueling Infrastructure
CFR	Code of Federal Regulations
CHAdeMO	Charge De Move
CHIPS	Creating Helpful Incentives to Produce Semiconductors Act
CMAP	Chicago Metropolitan Agency for Planning
CMAQ	Congestion Mitigation and Air Quality
ComEd	Chicago Commonwealth Edison Company
CPUC	California Public Utilities Commission
CRTC	Capital Region Transportation Council
CTZ	Clean Transportation Zone
DBE	Disadvantaged Business Enterprise
DC	Direct Current
DCFC	Direct Current Fast Charger
DEP	Department of Environmental Protection
DFW	Dallas/Fort Worth
DMV	Department of Motor Vehicles
DOT	Department of Transportation
DVRPC	Delaware Valley Regional Planning Council
EA	Electrify America

EEI	Edison Electric Institute
EIA	Energy Information Administration
EMS	Emergency Medical Services
EO	Executive Order
EPA	Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
ETC	Equitable Transportation Community
EV	Electric Vehicle
EVI	Electric Vehicle Infrastructure
EVI-Pro	Electric Vehicle Infrastructure Projection
EVITP	Electric Vehicle Infrastructure Training Program
EVSE	Electric Vehicle Supply Equipment
EZMT	Energy Zones Mapping Tool
FAST	Fixing America's Surface Transportation
FHWA	Federal Highway Administration
GHG	Greenhouse Gas
GO-Biz	California Governor's Office of Business and Economic Development
GWh	Gigawatt-Hour
HEV	Hybrid Electric Vehicle
H-GAC	Houston-Galveston Area Council
HOA	Homeowner's Association
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
IIJA	Infrastructure Investment and Jobs Act, also known as the Federal Bipartisan Infrastructure Law of 2021
IRA	Inflation Reduction Act
ISO	International Standardization Organization
km	Kilometer
kW	Kilowatt
kWh	Kilowatt-Hour
L1	Level 1
L2	Level 2
LCFS	Low Carbon Fuel Standard
LCRA	Lower Colorado River Authority
LDV	Light-Duty Vehicle
MAG	Maricopa Association of Governments
MAP-21	Moving Ahead for Progress in the 21st Century Act
MCS	Megawatt Charging System
MFD	Multifamily Dwelling
MFH	Multifamily Housing
MHD	Medium- and Heavy-Duty
MHDV	Medium- and Heavy-Duty Vehicle
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
MW	Megawatt
MWh	Megawatt-Hour

NACS	North American Charging System
NCDOT	North Carolina Department of Transportation
NCTCOG	North Central Texas Council of Governments
NEHC	National Electric Highway Coalition
NEVI	National Electric Vehicle Infrastructure
NHS	National Highway System
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NPMRDS	National Performance Management Research Data Set
NREL	National Renewable Energy Laboratory
NYPA	New York Power Authority
NYSERDA	New York State Energy Research and Development Authority
ODOT	Ohio Department of Transportation
PennDOT	Pennsylvania Department of Transportation
PEV	Plug-In Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PSC	Public Service Commission
PSE&G	Public Service Electric and Gas Company
PSO	Particle Swarm Optimization
PUC	Public Utility Commission
RAISE	Rebuilding American Infrastructure with Sustainability and Equity
REV	Regional Electric Vehicle
RPS	Renewable Portfolio Standard
RUC	Road User Charge
SAE	Society of Automotive Engineers
SB	Senate Bill
T&D	Transmission and Distribution
TCEQ	Texas Commission on Environmental Quality
TDLR	Texas Department of License Regulations
TDOT	Tennessee Department of Transportation
TERP	Texas Emissions Reduction Plan
TRC	Texas River Cities
TTI	Texas A&M Transportation Institute
TxDOT	Texas Department of Transportation
USC	United States Code
USDOE	United States Department of Energy
USDOT	United States Department of Transportation
V2G	Vehicle to Grid
V2H	Vehicle to Home
VMT	Vehicle Miles Traveled
VW	Volkswagen
Wh	Watt-Hour
ZEV	Zero-Emission Vehicle

CHAPTER 1. INTRODUCTION

With the growing adoption of electric vehicles (EVs) in the United States and by Texans, Texas has a need for adequate and comprehensive coverage of EV charging infrastructure. Although currently comprising slightly more than 1 percent of all registered vehicles in Texas, a number of projections forecast that EVs could comprise up to 55 percent of all vehicles by the year 2040 (*1*). This significant industry shift will require considerable and proactive efforts to support the transition, focusing on infrastructure readiness; customer experience; interregional connectivity, equity, and economic impacts; and other consequences related to the closure or repurposing of gas stations. Texas needs to identify optimal places where infrastructure will be needed in advance of federal and local funding that will be available to build out EV charging infrastructure. Since implementation of EV charging infrastructure will occur in phases over multiple years, a long-term vision is necessary to guide the development of EV infrastructure, ensure that the Texas Department of Transportation (TxDOT) meets the needs of EV stakeholders, and maximize financial opportunities available to the state. Researchers developed a long-term strategic plan to support that vision and guide infrastructure investment across the state, with a goal of a stable and consistent EV charging network.

The Texas A&M Transportation Institute (TTI) reviewed the existing EV charging infrastructure state of practice to (a) understand needs and challenges in EV infrastructure, including deployment models, grid connectivity and upgrades, and evolving technologies such as in-road charging, swappable batteries, and future-proofing of existing technology; (b) assess tools available to guide statewide EV planning analysis, such as Electric Vehicle Infrastructure Projection (EVI-Pro) and other platforms; (c) develop an analysis of projected EV charging demand based on adoption trends and projections; (d) develop a policy analysis of the local, state, and federal statutory landscape to identify barriers and opportunities in comparison to peer states; (e) analyze funding opportunities and develop frameworks for funding models, including private-public partnerships, that will consider the state of practice, federal funding opportunities, and alternative funding sources; and (f) develop strategies to improve the EV charging infrastructure system in Texas over the course of 5 to 10 years, including an evaluation of variables that affect the placement of new EV charging locations and the necessity and viability of battery storage and off-grid capabilities. These efforts resulted in a tool to estimate electric vehicle charging demand, a policy analysis framework, and long-term statewide EV infrastructure strategies.

This report summarizes the work completed throughout the research. Subsequent chapters cover the following topics:

- Chapter 2 includes a literature review encompassing plans and activities at the federal, state, and local levels; federal and state rules and regulations affecting EV charging infrastructure; EV charging demand models and estimates; and research related to EV infrastructure charging demand models.
- Chapter 3 provides a summary of the stakeholder workshops, including workshop findings, stakeholder needs and concerns, opportunities for stakeholder coordination, and considerations for long-term EV infrastructure strategies.

- Chapter 4 presents an assessment of tools and analysis of EV charging demand, including an overview of relevant datasets and tools, an evaluation of tool capabilities, and a description of a prototype tool to forecast EV charging demand in Texas.
- Chapter 5 provides an analysis of policies and funding opportunities for EV charging infrastructure based on a review of legislation, regulations, and policies at the federal level, in peer states, and in selected metropolitan regions and cities in those states.
- Chapter 6 offers conclusions and recommendations for implementation.

In addition, the report includes several appendices that provide a comprehensive account of the tools and materials that the research team used to meet the objectives of the project:

- Appendix A includes agendas of the conducted workshops.
- Appendix B provides the invitations to the workshops.
- Appendix C lists the workshop attendees.
- Appendix D includes the workshop presentations and handouts.
- Appendix E presents EV registration data.
- Appendix F shows daily charging demand data for Texas.
- Appendix G provides narratives of interviews with peer states and metropolitan planning organization (MPOs).
- Appendix H presents an estimation of the value of research.

Separate, standalone deliverables of this project are the following:

- Product P1, *Tool to Estimate Electric Vehicle Charging Demand*. The deliverable includes a description of the tool and the tool itself in the form of a Microsoft Business Intelligence dashboard.
- Product P2, *Policy Analysis Framework.*
- Product P3, *Long-Term Statewide EV Infrastructure Strategies*.

CHAPTER 2. LITERATURE REVIEW

INTRODUCTION

TxDOT is leading the adaptation of the state's multimodal transportation infrastructure to support electrified mobility. Plans are underway to close gaps in EV charging stations along the state's multimodal transportation infrastructure, ensuring equity in access to EV charging stations. EV charging infrastructure supports TxDOT's plan for statewide infrastructure improvement by improving air quality, supporting economic development, and enhancing transportation equity. Equity in this context is defined as minimized social and economic barriers to EVs and fair and equal access to EV charging infrastructure. This chapter documents and summarizes a literature review, completed in November 2022, that focused on applicable literature, programs, guidance, regulations, research results, and updated program information with regard to the following:

- Plans and activities related to EV charging infrastructure at the federal, state, and local/MPO level.
- Federal and state rules and regulations affecting EV charging infrastructure, including updated rules, new programs, and implementation plans.
- Federal and state utility accommodation rules, including updates to federal policies and guides that are being developed.
- EV charging demand models and estimates, and potential data sources for characterizing and investigating current EV activities in Texas.
- Research and tools to optimize EV charging infrastructure locations.
- Private EV charging infrastructure investments.
- Updates regarding implementation of the Texas Commission on Environmental Quality's (TCEQ's) Alternative Fueling Facilities Program, and execution of the Volkswagen Infrastructure Funding Program.

Two major categories of plug-in electric vehicles (PEVs) are currently available: battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). BEVs are powered by an electric propulsion system that does not rely on an internal combustion engine (*2*). Although the current and future estimates of EVs within Texas are difficult to quantify due to current record-keeping procedures, PEVs are expected to make up a substantial part of the state's future vehicle fleet (*3*). Sales of new PEVs in the United States doubled between December 2018 and December 2021, and by the fourth quarter of 2021, PEVs accounted for approximately 5 percent of U.S. new light-duty vehicle sales (*4*). According to the U.S. Energy Information Administration's (EIA's) *Annual Energy Outlook* (AEO) 2021 reference case projections, light-duty PEVs' vehicle miles traveled (VMT) will continuously increase and reach 2 percent and 8 percent of the total light-duty vehicles' VMT by 2030 and 2050, respectively (*5*).

A major factor in a driver's decision to switch to a BEV is the vehicle's range. A total of 26 BEV models are available in the United States, with an average range of 250 miles (*6*). PHEVs, which have both an internal combustion engine and an electric motor, are charged by plugging into a power source. PHEVs can run for only a relatively small distance on their electric motor before switching over to their internal combustion engine. There are currently 32 PHEVs available in the United States, with an average electric operation range of 30 miles (*6, 7*).

The most recent data published by the Texas Department of Motor Vehicles (DMV) show that there were 60,528 BEVs registered in Texas in fiscal year (FY) 2021, which corresponds to a 319 percent increase from FY 2018 (*8*). Texas DMV does not currently track PHEVs as a separate category from non-plug-in hybrid vehicles. In 2021, there were 256,654 hybrid vehicles registered in Texas, representing an increase of 10 percent from FY 2018. In 2022, EVs increased to 105,807, a 75 percent increase from the previous year (*9*). In the same time period, electric hybrid and gas vehicles increased by 35 percent to 346,471.

Key factors affecting the market penetration rate of EVs include conventional fuel cost, battery cost, EV range, charging infrastructure, and government policies (*10*). The increase in the price of gasoline makes EVs more economical. The cost of battery technologies also impacts the market penetration of EVs. Batteries make up a large part of an EV's cost, and $100 per kilowatt-hour (kWh) is often cited by industry analysts as the threshold that will enable electric cars to become truly cost competitive with traditional gasoline-powered vehicles. The cost to replace a battery pack for a BEV can be over $15,000, not including labor (*11*). However, recent advancements in battery technology have started to lower this concerning amount. As shown in Figure 1, since 2013, the average market cost of battery packs has decreased by 81 percent, from $684/kWh to $132/kWh. Car manufacturing companies such as Renault in Europe and Ford in the United States have set targets of $80/kWh by 2030. New battery technologies are expected to further reduce the cost and significantly improve the energy density and overall performance of battery packs by the 2030s (*12*).

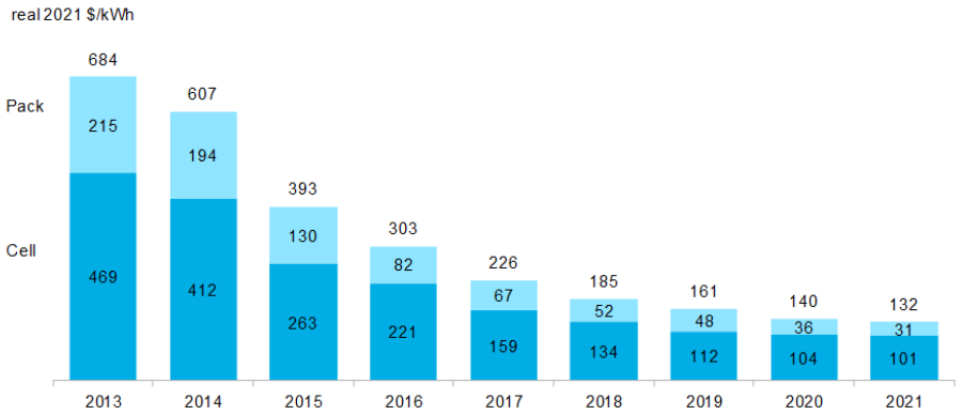


Figure 1. Volume-Weighted Average Cost of Lithium-Ion Battery Packs (*13*).

Government policy is another key factor impacting EV market penetration. Legislation and policies that could encourage the adoption of EVs include providing financial incentives to customers who purchase an EV, giving EVs access to high-occupancy vehicle lanes, funding research to advance battery technology to reduce the cost and increase the range of miles, enforcing emissions standards for conventional vehicles, and advocating for producing EVs and advancing their technology (*10*).

Another important factor affecting consumers' decisions regarding EVs is the availability of charging infrastructure. Lack of availability of public charging stations and the cost of installing residential charging stations can negatively affect the adoption of EVs. Three main types of EV charging infrastructure exist: Level 1, Level 2, and Level 3 or direct current fast charge (DCFC) (*14*). Level 1 charging uses a standard 120-V plug and requires no additional equipment. These

types of chargers are generally used in homes and provide 2–5 miles of range for every hour of charging. Level 2 requires charging equipment to be installed and runs on 240-V (residential) or 208-V (commercial) electricity. Level 2 charging adds 10–20 miles of range per hour of charging. The third type of charger, DCFC, uses 480-V direct current power and requires specialized charging equipment as well as special equipment in the EV being charged.

ELECTRICITY INFRASTRUCTURE

Electricity infrastructure has four main components: electricity generation, transmission, distribution, and end use. Currently, Texas is the largest energy-producing and energy-consuming state in the United States (*15*). In 2018, net electricity generation in Texas reached more than 477 million megawatt-hours (MWh). The Electric Reliability Council of Texas (ERCOT) manages the flow of electric power to more than 26 million Texas customers, which represents about 90 percent of Texas's electric load (*16*). The electricity generated is transformed and transmitted to all end users through the transmission and distribution (T&D) network, also known as the power grid. Power demand on the grid changes throughout the day and across regions. To strike a balance between the changing demand and supply, power generation load on power plants varies continuously and can be broken into two parts: base load and peak load. A small amount of energy is lost during the T&D process, which must be accounted for when determining the accurate amount of electricity supply (*17*). In an ongoing project, TTI is using U.S. Environmental Protection Agency (EPA) Clean Air Markets Program Data and National Emissions Inventory data to predict hourly electricity demand resulting from EV charging, along with corresponding emissions of nitrogen oxides and greenhouse gases (GHGs) from electricity generation units (*18*).

The implementation and widespread use of EVs are expected to have major impacts on the electricity generation and delivery system and related air pollution. As part of TxDOT research project 0-7024, TTI reviewed and evaluated existing methods and sources of charging behavior information (*19*). Based on this evaluation effort, the research team adopted and expanded the charging profiles developed by the National Renewable Energy Laboratory (NREL) to estimate the hourly electricity demand resulting from charging EVs in the Dallas/Fort Worth (DFW) and Houston areas (*20*). The team also used EV registration data to develop projections of expected BEV and PHEV populations for future years (Figure 2).

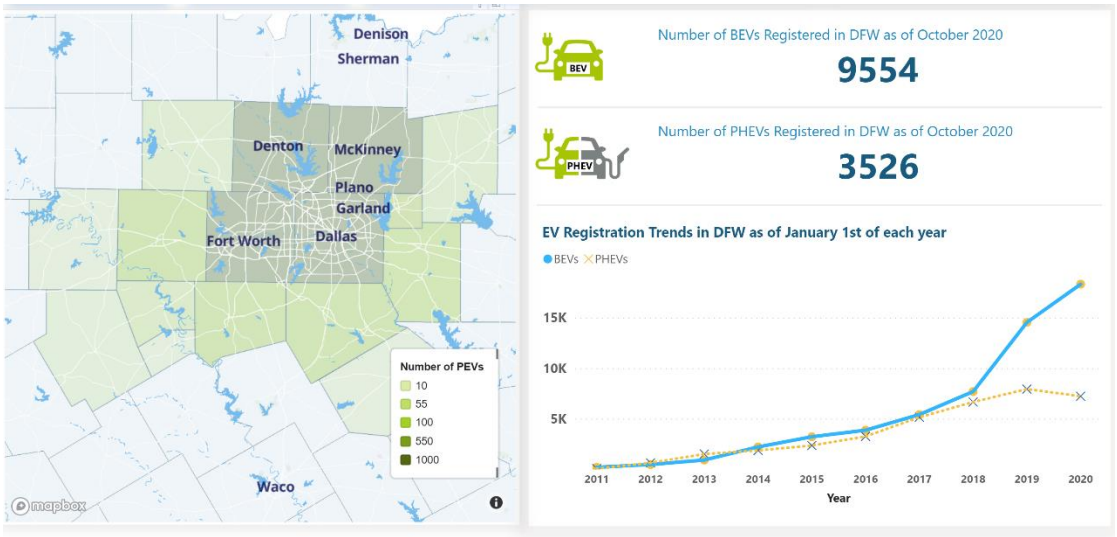


Figure 2. PEV Population in the North Central Texas Council of Governments (NCTCOG) Area.

Researchers from The University of Texas reported that in 2018, Texas would need approximately 290 gigawatt-hours (GWh) per day to charge a fully electrified fleet of personal cars (assuming all vehicles were EVs), which was less than the available surplus generation capacity in state (*21*). Therefore, theoretically, Texas could charge all EVs if they were charged during off-peak hours (see Figure 3). However, if all EVs were charged during peak hours, then to meet the electricity demand, Texas would need to produce 28 percent more electricity (see Figure 4) (*21*).

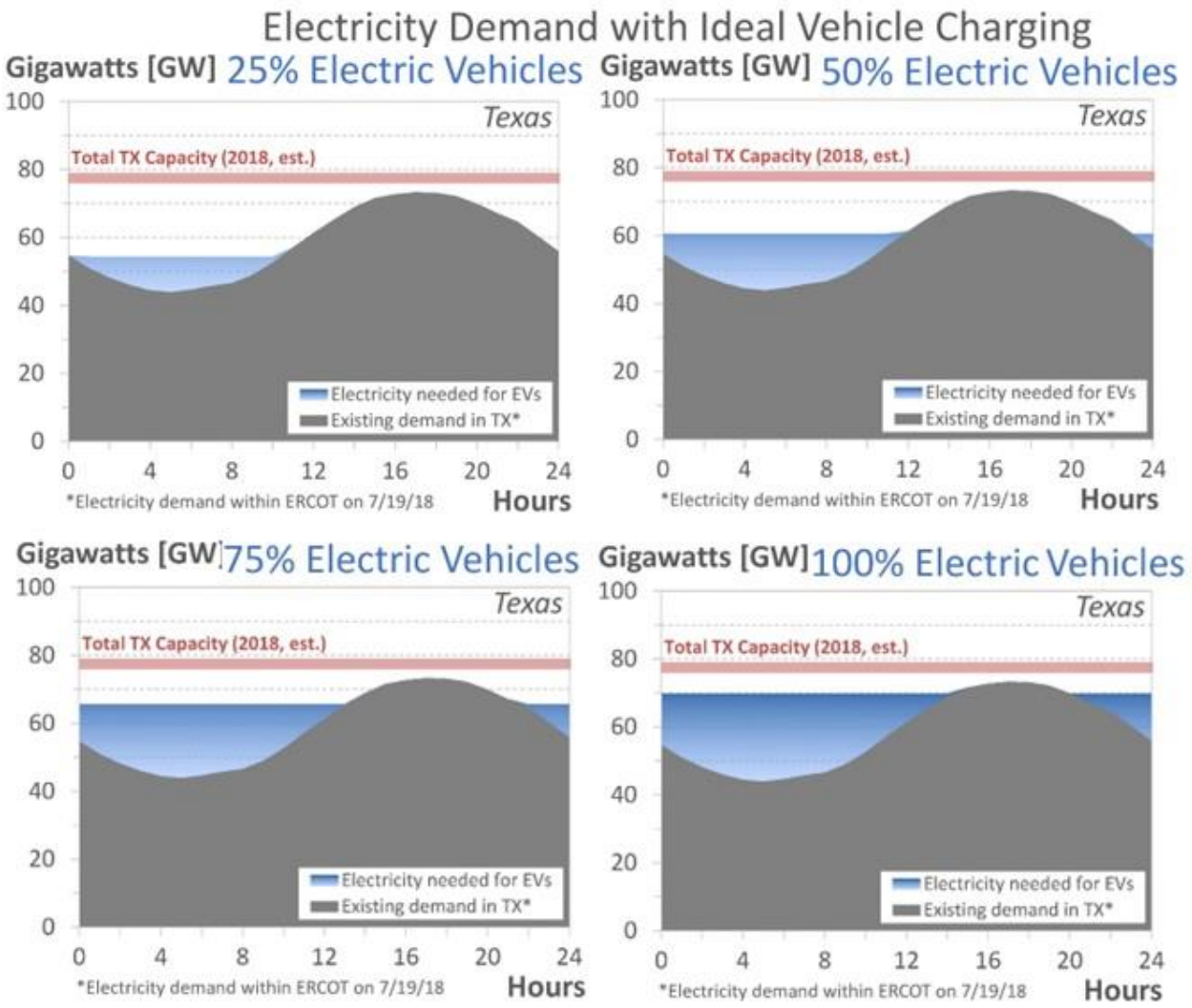


Figure 3. Electricity Demand with Ideal Vehicle Charging Based on EV Adoption (*21*).

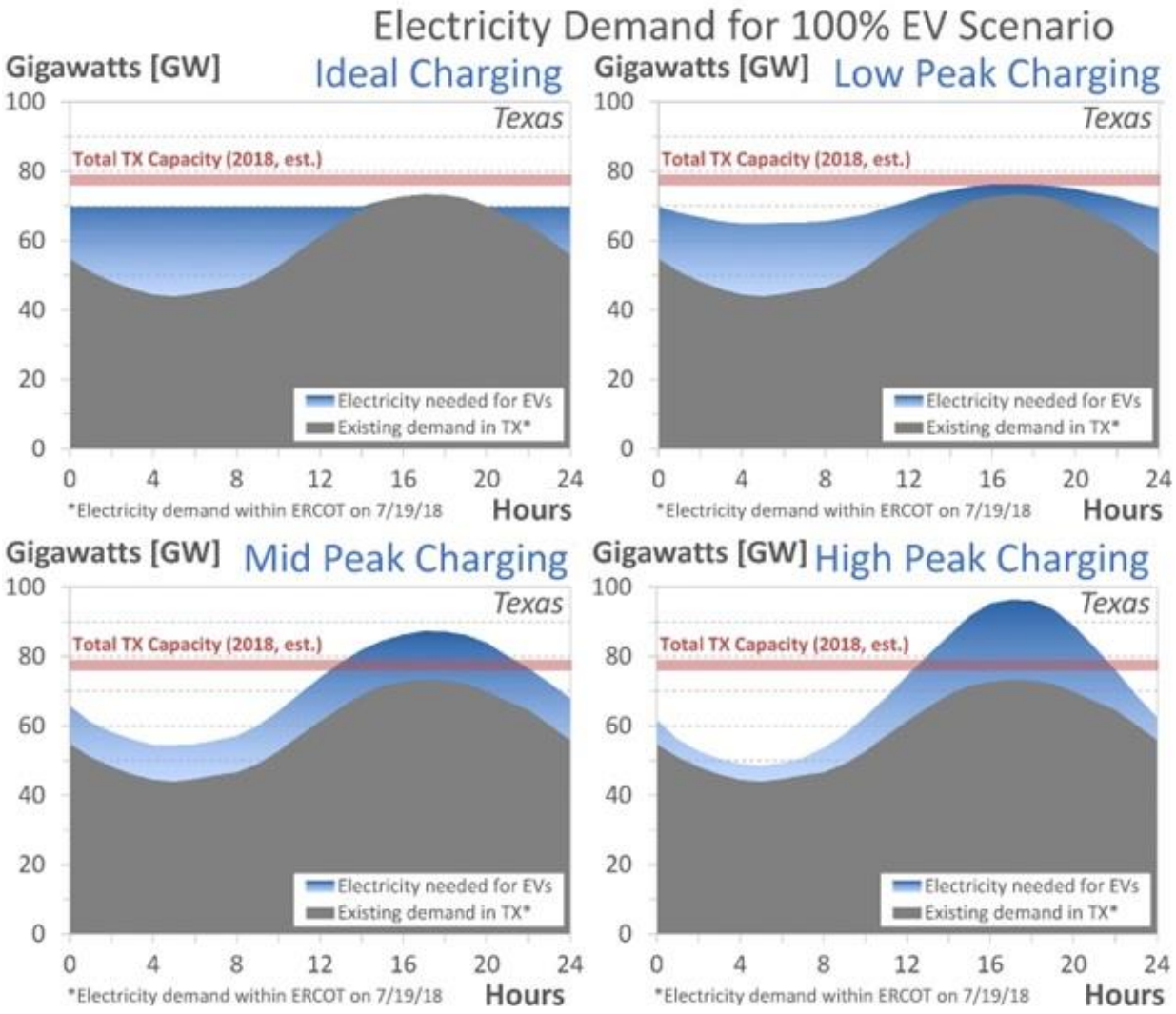


Figure 4. Electricity Demand for 100 Percent EV Scenarios during Various Charging Peaks (*21*).

CURRENT AND PROJECTED EV ADOPTION IN THE UNITED STATES AND TEXAS

Numerous studies have investigated different methodologies to predict future EV charging demand. Most focus on predicting EV activity and energy demand based on a combination of variables, including penetration rates due to financial and behavioral factors. These studies use two approaches: top-down and bottom-up. The top-down approach predicts the total future vehicles or transportation energy demand and gives the total EVs (or electricity load) based on forecasts for penetration rates. The bottom-up approach uses assumptions to predict the local count of EVs (or their trips) and aggregates the predictions to determine a future total count of EVs and electricity load. This section reviews important sources and studies on future EV estimation and modeling.

EV Charging Demand Models and Estimates

EIA's AEO, which is released on an annual basis, includes projections of U.S. energy markets for the future three decades. AEO projections are based on a reference case and multiple side cases that include different assumptions regarding energy prices, economic activity, and technology. AEO projections are widely relied upon in the United States for policymaking and research. The AEO includes projections of population, VMT, and energy use of different vehicle categories, including various types of BEVs. The recent AEO (March 2022) projects that the sales of internal combustion engine (ICE) light-duty vehicles (LDVs) (including gasoline, diesel, flex-fuel, natural gas, and propane powertrains) will decrease from 92 percent in 2021 to 79 percent in 2050 because of growth in sales of BEVs, PHEVs, and hybrid electric vehicles (HEVs) (*22*). It estimates that through the projection period, 200- and 300-mile BEV sales will grow, increasing from 0.34 million in 2021 to 1.52 million in 2050, while sales of PHEVs will increase from 144,000 in 2021 to 521,000 in 2050. Its analysis of PHEVs demonstrates fast growth and market penetration between 2021 and 2024. Growth in PHEV sales will slow after 2024 due to declining battery prices, which pushes BEVs into the highest electric LDV market share.

Besides AEO projections, various models and methods have been developed to analyze factors affecting the sales of PEVs. In a 2018 study, TTI compared 40 market diffusion models of PEVs to understand the similarities and differences among the models and provide future advice for model development (*23*). Existing EV projections for the U.S. market vary greatly by the sources, assumptions, inputs, and methodology. Figure 5 shows the annual EV sales projections provided by a sample of sources (*24*). As highlighted in this figure, the range of the projected EV sales varies significantly among the different sources, with AEO projections usually being on the conservative side compared to other sources.

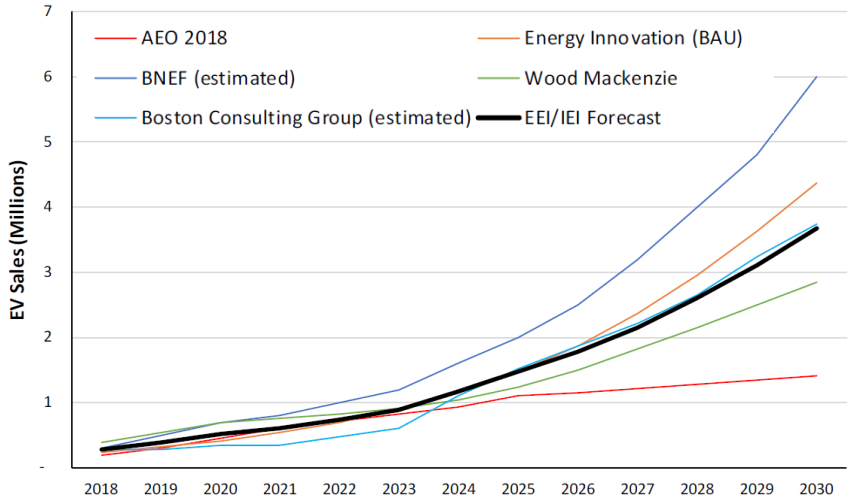


Figure 5. U.S. Market EV Sales Projections.

Figure 6 shows a comparison of energy consumption in Texas based on data available from the U.S. Department of Energy (USDOE) (*25*). The graph shows annual motor gasoline consumed by the transportation sector in Texas in blue and electricity consumed (i.e., sold to) by the transportation sector in Texas in orange, using a secondary axis on the right, in billion British

thermal units (BTU). While the amount of electric energy consumed is much smaller than motor gasoline, it is evident how much faster electric consumption has grown over the last 20 years compared to gasoline consumption.

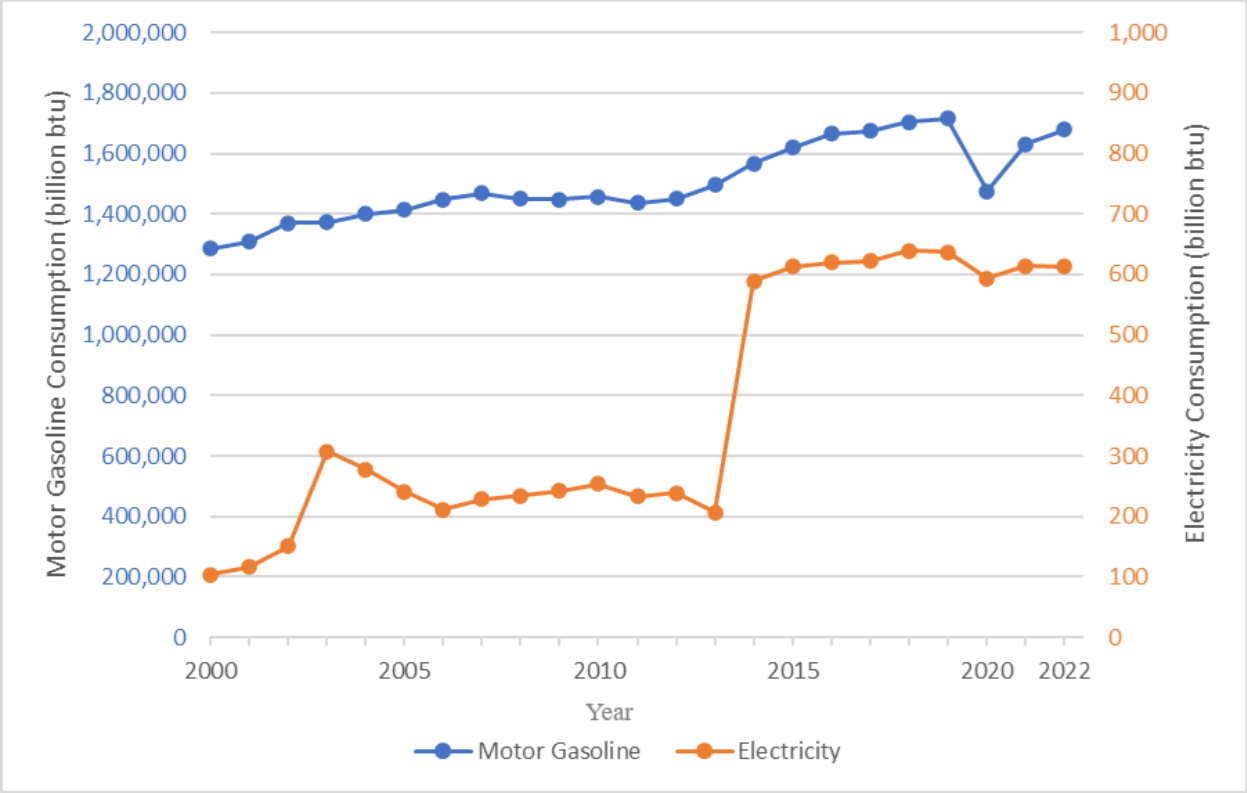


Figure 6. Energy Consumption in the Transportation Sector in Texas, Motor Gasoline and Electricity in Billion BTU (*25*).

At the national level, motor gasoline consumption has declined since it peaked in 2006. Between 2006 and 2022, motor gasoline consumption declined by 10 percent in the United States (*25*). Between 2006 and 2020, motor gasoline declined by 20 percent, in part due to travel restrictions related to the COVID-19 pandemic. U.S. gasoline consumption in 2022 declined by about 6.5 percent since pre-pandemic levels in 2019 (Figure 7).

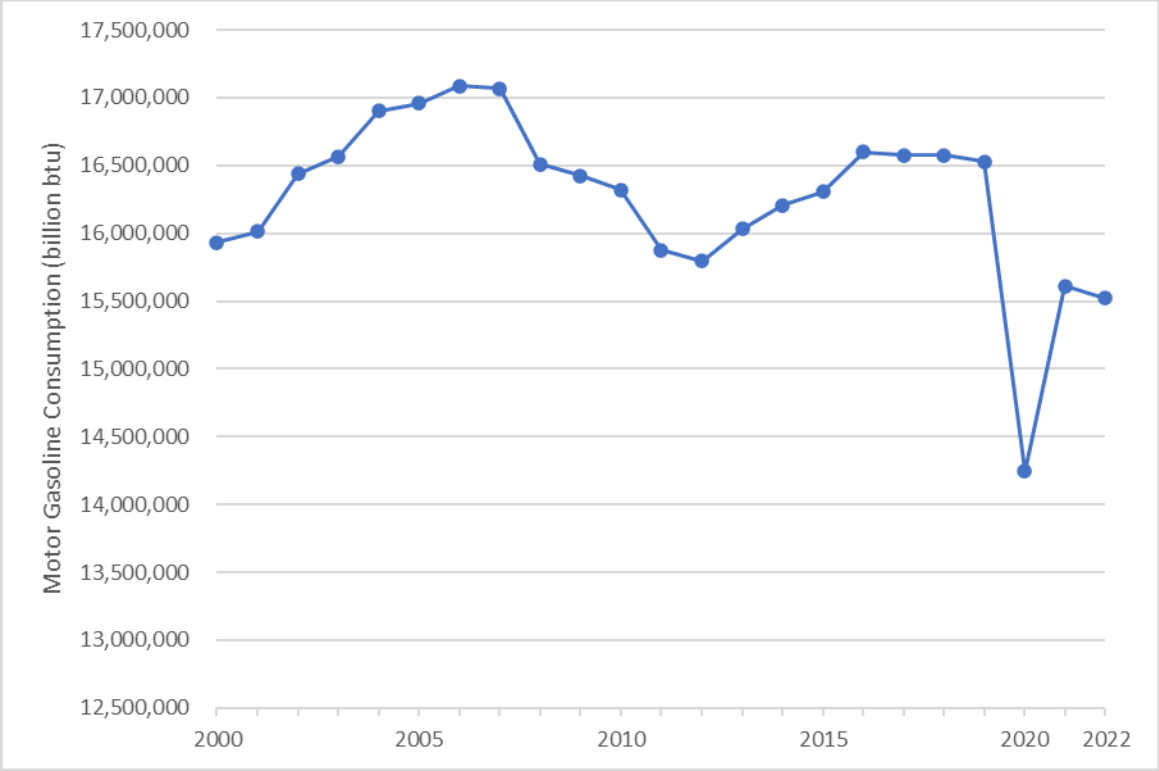


Figure 7. Motor Gasoline Consumption in the Transportation Sector in the United States, in Billion BTU (*25*).

National Plug-In Electric Vehicle Infrastructure Analysis is a comprehensive report of a study conducted by USDOE in 2017. The study investigated how much PEV charging infrastructure will be needed in the United States in 2030 to support both PHEVs and BEVs (*26*). The analysis was organized around the nonresidential charging infrastructure network required to meet consumer coverage expectations and satisfy consumer demand in high-PEV-adoption scenarios. The coverage and charging demand estimated the needs for chargers in four specific geographic areas: cities, towns, rural areas, and interstate highway system corridors. This study established a central scenario with PEV market conditions and used a parametric sensitivity analysis for the key variables of the PEV infrastructure modeling framework. The variables explored are listed in Table 1.

Table 1. PEV Market Conditions for the Central Scenario and Sensitivities Explored.

Variable	Central Scenario		Sensitivity	
PEV Total	15 million (linear growth to 20% of LDV sales in 2030)		9 million (growth to 10% of 2030 sales)	
			21 million (growth to 30% of 2030 sales)	
PEV Mix (range preference)		Mix		Long/Short
	PHEV20	10%	PHEV20	0%/40%
	PHEV50	35%	PHEV50	50%/0%
	BEV100	15%	BEV100	0%/50%
	BEV250	30%	BEV250	40%/0%
	PHEV20-SUV	5%	PHEV20-SUV	0%/10%
	BEV250-SUV	5%	BEV250-SUV	10%/0%
Share of PEVs in Cities (w/ pop. > 50,000)	83% (based on existing HEVs)		71% (based on existing LDVs)	
			91% (based on existing LDVs)	
PHEV: BEV Ratio	1:1		4:1 to 1:4	
PHEV Support	Half of the full support		No PHEV support to full support (maximize PHEV eVMT)	
SUV Share	10%		5% to 50%	
% Home Charging	88%		88%, 85%, and 82%	
Interstate Coverage	Full interstate		Mega-regions, 89% of long-distance trips (traveler analysis framework), and full interstate	
Corridor DCFC Spacing	70 miles		40 to 100 miles	
DCFC Charging Time	20 minutes (150 kW)		10 to 30 minutes (400 to 100 kW)	

Note: BEVxxx = battery electric vehicle with a range of xxx miles; PHEVxxx = plug-in hybrid electric vehicle with a range of xxx miles.

A series of assumptions were applied across all scenarios in the USDOE study (*26*). For example, consumers were simulated as preferring to perform most charging at their home location. This resulted in 88 percent of PEV charging taking place at home locations due to the large amount of time vehicles were parked there and relatively short typical daily driving distances. The study predicted the total PEVs, percentage of BEVs, and plug counts for all states in 2030. For Texas, it estimated there would be 835,000 PEVs, with 57 percent BEV (among all EVs). It predicted the need for 18,300 "Work Level 2 Plugs," 12,400 "Public Level 2 Plugs," and 1,720 "Public DCFC Plugs" by 2030. This study is an example of a top-down approach to estimating future required EV infrastructure.

The latest ExxonMobil *Outlook for Energy* expects that while personal vehicle energy demand will peak and decline by 2025 due to growing electrification and fuel efficiency, commercial transportation will offset that reduction as increased economic activity and personal buying power raise the demand for more goods and infrastructure (*27*). This report explains policy, technology, and consumer preferences as the three main drivers of energy demand in the future (*27*).

The McKinsey Center for Future Mobility collaborated with the Public and Social Sector Practice on the evaluation of different aspects of EV charging station needs (*28*). According to

this report, the nation's limited charging station network probably discourages many prospective buyers, and while the Bipartisan Infrastructure Law (BIL) highlights equity as a specific priority, electricity purchased at a public charger can cost five to 10 times more than electricity at a private one. The study found that by 2030, the United States would require 1.2 million public EV chargers and 28 million private chargers. Researchers estimated that the country's fleet of EVs would grow from about 3 million to more than 48 million in 2030, about 15 percent of all vehicles in the United States (in a scenario in which the nation reaches the federal PEV sales target). They estimated that the annual demand for electricity to charge EVs would surge from 11 billion kWh to 230 billion kWh in 2030, which represents approximately 5 percent of the current total electricity demand in the United States. Nearly 30 million chargers would be needed to deliver so much electricity (*28*).

The Edison Electric Institute (EEI) estimates 26.4 million EVs on U.S. roads in 2030, more than 10 percent of the 259 million vehicles (cars and light trucks) expected to be on U.S. roads in 2030 (*29*). It predicts that the annual sales of EVs will be nearly 5.6 million in 2030, about 32 percent of annual LDVs in 2030. It emphasizes the importance of the availability of EV charging infrastructure in the growth of EVs and estimates that 12.9 million charge ports will be needed in 2030.

In a previous study for TxDOT, TTI developed an analytical framework to incorporate EVs into an emissions analysis for Texas (*10*). TTI used a consumer choice model to estimate the number of EVs at the sub-fleet level (HEVs, PHEVs, and BEVs) for the target regions. The key parameters in this framework include energy price, government policy and incentives, emissions rates for EVs, and their share of the regional on-road transportation activity expressed as VMT. Energy price assumptions were made based on the AEO. TTI also collected second-by-second activity (location and speed) data from a sample of EVs operating in Texas. TTI developed BEV- and PHEV-specific drive cycles based on these data. This study showed the difference between the speed-acceleration profile of BEV drive cycles and other EV types and emphasized the importance of the driving differences in future projections.

ERCOT developed a process to produce EV load forecasts, with the expectation to begin using the forecasts in transmission planning studies in 2023 (*30*). ERCOT estimated between 4 and 6 million EVs, including 0.8 to 1.3 million pickup trucks, for an increase of 77 percent of miles driven by heavy electric trucks by 2035 (*31*). ERCOT used estimates from the annual Bloomberg *Electric Vehicle Outlook 2022*, which evaluated the global fleet size and estimations for the future and concluded that the rising cost of batteries does not derail near-term EV adoption (*32*).

The prediction of charging demand can be based on real-world mobility data. In this approach, the hourly traffic volume on roadways and the count of trips from and to specific areas (or any other indicator of traffic activity) can be used to estimate the charging demand. In this bottom-up approach, different assumptions can be made in different scenarios to reflect the uncertainties in influential variables, including number and length of trips, EV penetration rate, EV charging characteristics, charging time, and charging power. For example, researchers used real-world historical traffic distribution data and weather conditions in South Korea to predict the EV charging demand in different areas. Using machine learning methods, they predicted the charging starting time determined by real-world traffic patterns and the initial state of charge of the battery. They showed the different charging load profiles of EVs in the residential and

commercial sites during weekdays and weekends, in summer and winter. In addition to mobility data, charging records can be used to predict energy consumption, as researchers did at the University of California, Los Angeles (*33*). In this study, researchers used charging record data (customer data that contains the beginning and end of the charging event and the acquired energy for each charging event) and the station record (a 5-minute log of voltage, current, and power factor) to predict the energy consumption in the next 24 hours at charging outlet level. Researchers used historical data, Monte Carlo simulation, and machine learning methods in their predictive models. Researchers found that the analysis of customers' data is faster but creates privacy concerns, although the data are to some degree anonymous. The study did not find a statistically significant difference between prediction errors using these two different datasets.

Potential Data Sources for Characterizing and Investigating Current EV Activities in Texas

PEVs are expected to be a substantial part of the state's future vehicle fleet (*3*). The most recent data published by the Texas DMV show a total of 60,528 BEVs registered in FY 2021, which corresponds to a 319 percent increase from FY 2018 (*8*). Texas DMV does not currently track PHEVs as a separate category. PHEVs are reported as hybrid vehicles, which also include non-plug-in hybrid vehicles. There were 256,654 hybrid vehicles registered in Texas, representing an increase of 10 percent from FY 2018.

Registration data seem to be the best source for characterizing and predicting the EV counts. According to USDOE, Texas had the third-highest number of EVs registered by the end of 2021 (*34*). Figure 8 shows the vehicle registration counts of all EVs, HEVs, and PHEVs by the state as of December 31, 2021. California has the greatest number of EVs, with approximately 39 percent of EVs nationwide. Florida has the second-highest count, followed by Texas (with 80,900 registered EVs). Texas has the second-highest and fourth-highest count of HEVs and PHEVs, with 304,700 and 30,600 registered vehicles, respectively (*35*). The latest count of electric charger stations comes from the Alternative Fuels Data Center (AFDC), which shows the availability of 2,228 stations with 5,621 public ports in Texas. These ports are comprised of 13 Level 1, 4,357 Level 2, and 1,251 DCFCs (*36*).

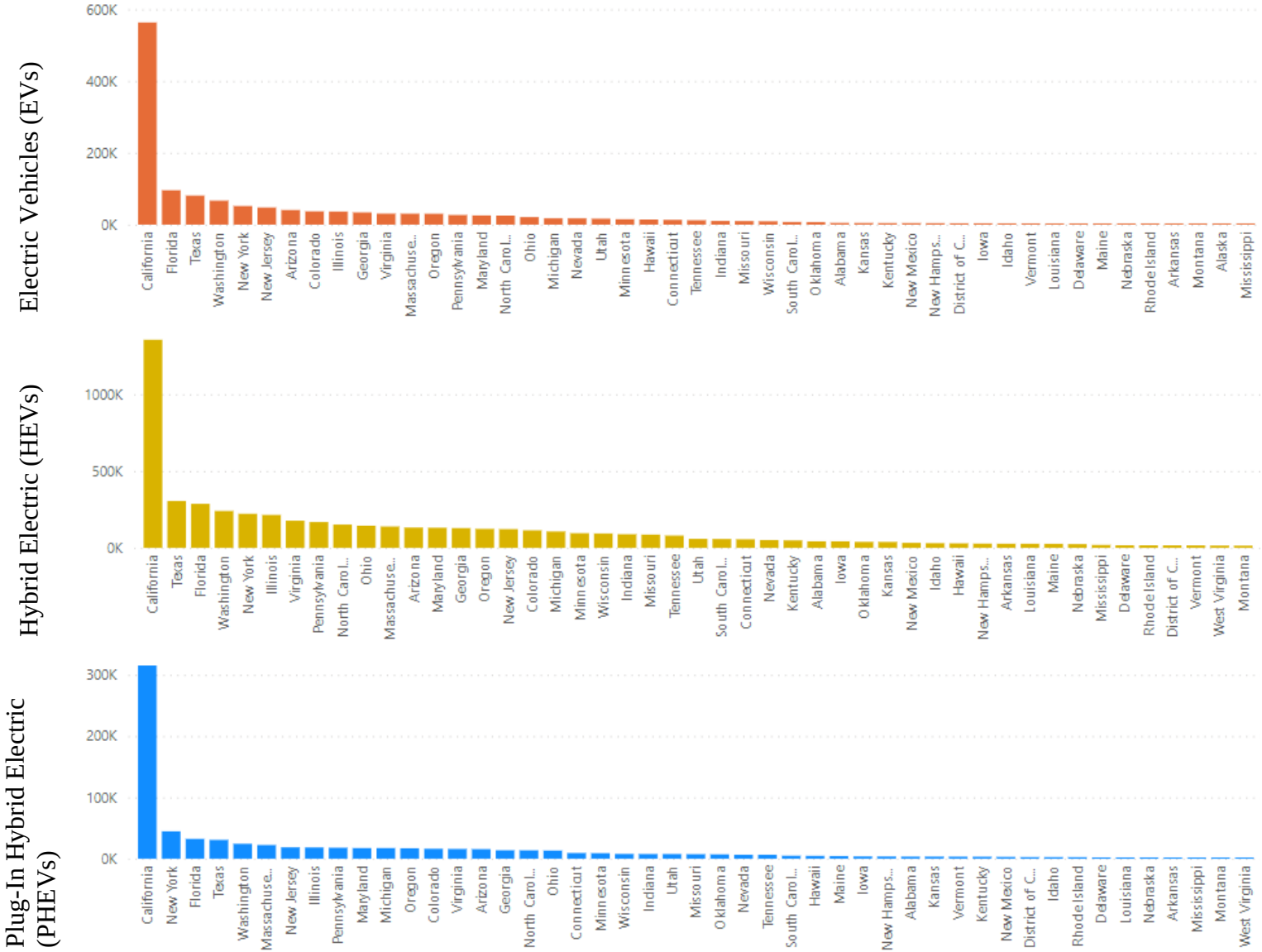


Figure 8. Vehicle Registration Counts by State (December 2021) (*34*).

The most up-to-date source of EVs registered in Texas is the DFW Clean Cities, a USDOE program (*37*). This program collects and provides the monthly count of EVs registered in zip codes in Texas since September 2021. As such, there were 154,758 EVs registered in Texas as of October 2022. Figure 9 shows the EV registration by region and percentage of all registered vehicles in different areas in Texas as of May 2024. The variation of EV percentages of all registered vehicles over the five categories shows the importance of spatial variation of EV activities. The Texas Electric Vehicle Mapping Tool lists EV charging stations by type and designated electric corridors by status (Figure 10). Most charging stations are within major cities, but accessibility will continue to improve because Texas will receive $408 million over the next 5 years (*38*) from the bipartisan Infrastructure Investment and Jobs Act (IIJA) to continue expanding the EV charging network. According to the Texas Electric Vehicle Infrastructure Plan (*39*), DC stations will be expanded over the 5-year plan (shown in Figure 11). The estimate of max energy consumption of the EV charging network outlined in this plan is 666.7 MW. The most up-to-date statistics of EV chargers and their locations, along with valuable information such as the estimated costs in Texas, can be found on TxDOT portals (*40, 41*).

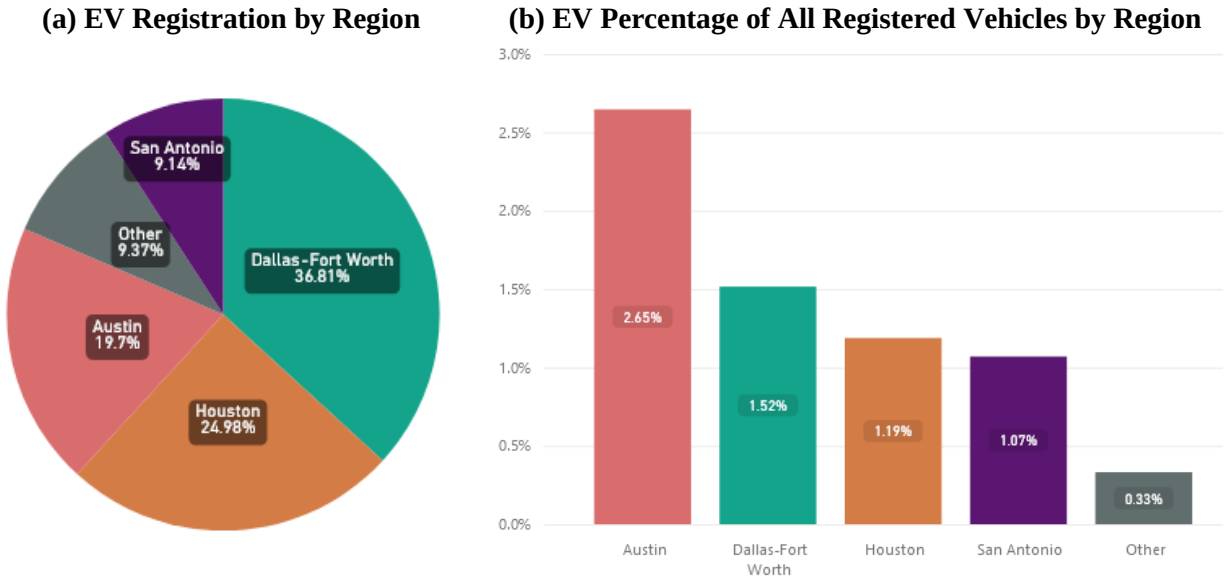


Figure 9. (a) EV Registration by Region, and (b) EV Percentage of All Registered Vehicles by Region in Texas as of May 2024.

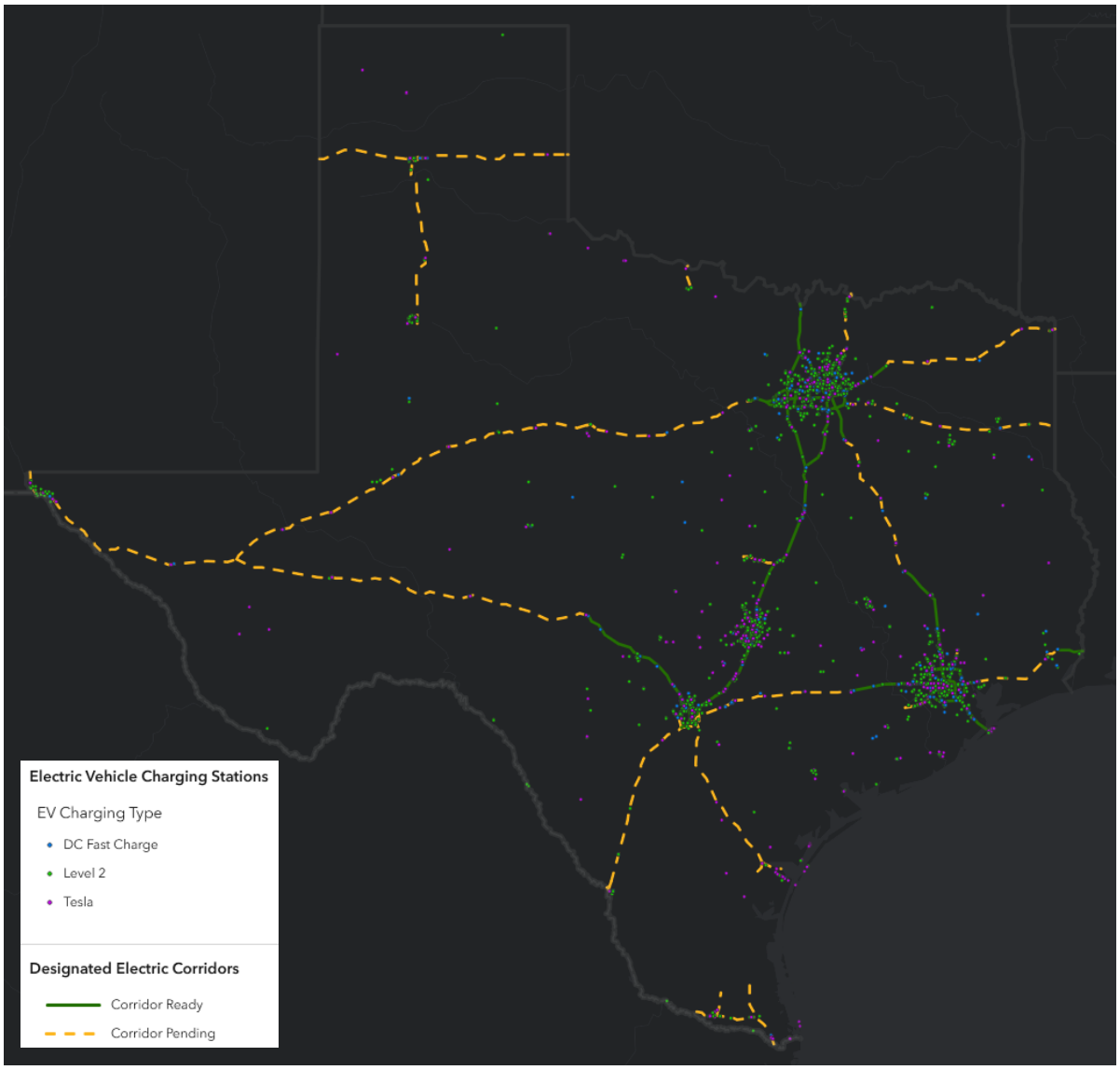


Figure 10. Electric Charging Stations (by Type) and Designated Electric Corridors (by Status) in Texas (as of May 2024).

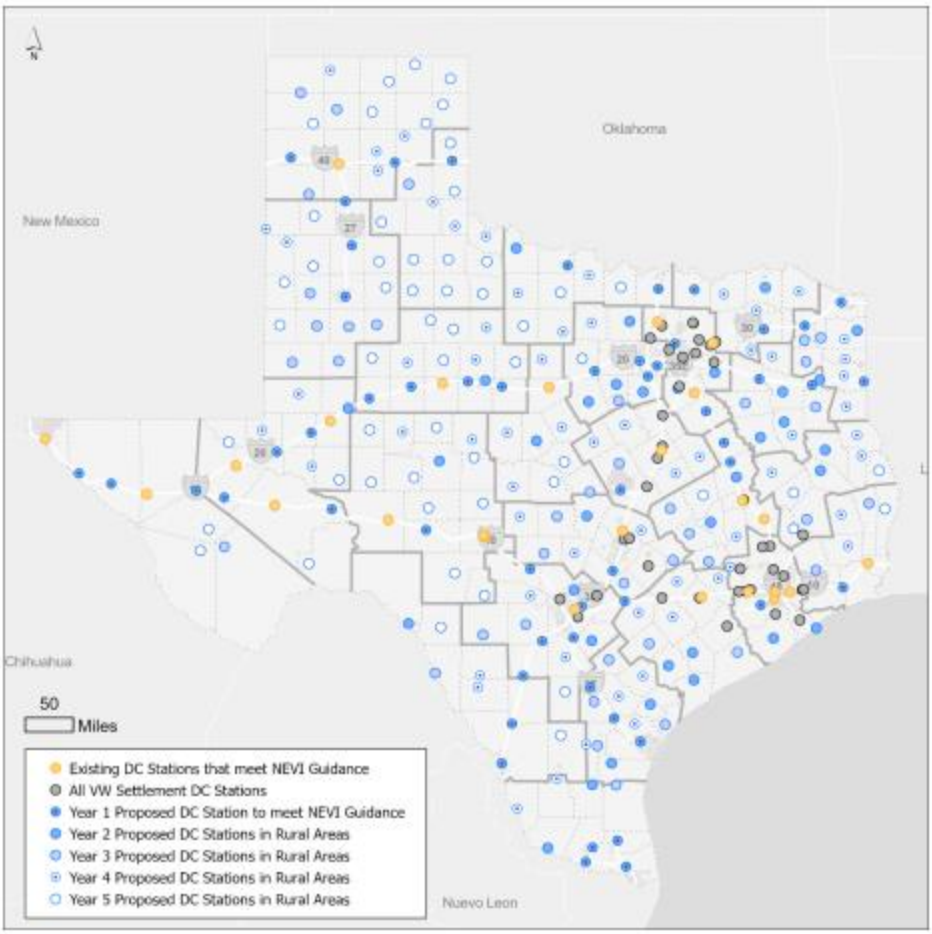


Figure 11. Existing Fast Chargers That Meet the National Electric Vehicle Infrastructure (NEVI) Program Plan, and Proposed DC Stations.

The analysis of registration data in Texas shows that more than 50 percent of EVs had the model year of 2021 and 2022 as of October 2022 (*37*). Moreover, Tesla vehicles (Models 3, Y, and S) account for more than 50 percent of EVs in Texas. The Texas EV data classified by age and model provided by the DFW Clean Cities program can be used to characterize EVs and evaluate their trend within Texas.

Considering the importance of EVs in statewide grid load, ERCOT evaluates EV status and predicts the growth of EVs for upcoming years. ERCOT estimates 1 million EVs on Texas roads by 2028. Using current EV growth trends, Texas DMV estimates Texas will reach 1 million EVs by 2031. The estimations provided by ERCOT on EV counts and electricity loads, as well as the grid capacity and considerations, are critical parts of EV data analysis in Texas (*30*).

ERCOT expects a significant increase in the adoption of EVs in the near future, according to the December 2021 *ERCOT Report on Existing and Potential Electric System Constraints and Needs* (*30*). In this report, the impact of EV growth on load forecasts depends on the adoption rates and charging patterns associated with different types of EVs (passenger vehicles, trucks, buses, etc.). ERCOT developed a process to produce EV load forecasts, with the expectation to begin using

the new forecasts in transmission planning studies in 2023. These analyses and their datasets as well as their assumptions can be used to characterize current and future EV activities in Texas.

Vehicle telematics datasets are more readily available now and are a valuable source to better understand on-road transportation mobility. One mobility data provider, Wejo, can provide access to data curated from multiple motor manufacturers and a sample of the diverse range of connected vehicles and demographic types (*44*). A recent study on Wejo mobility data showed its sample rate (penetration) of greater than 4 percent on interstate and greater than 5 percent on non-interstate roadways in Texas (*45*). In other words, the Wejo mobility dataset can provide the location and speed of about 5 percent of passenger cars in Texas. Analysis of this type of dataset gives valuable insight on the behavior of all drivers, including EV drivers, which can be useful for forecasting EV activities. TTI used cloud computing methods to process and analyze this dataset to develop the temporal and spatial EV profiles for TxDOT project 0-7024 (*19*). The latest mobility dataset can be used to develop representative temporal and spatial profiles of likely EV charging events as well as associated vehicle activity parameters for the selected pilot study area in Texas. The analysis focuses on understanding and characterizing how (i.e., charger type), when, and where EVs are likely to be charged as a function of critical parameters such as land use, remaining battery power, amount of driving, vehicle technology, demographics, transportation network characteristics (capacity, volume, speed), and other potential factors.

Census data indicating the spatial distribution of the population and demographic indicators can be used along with transportation activity (*46*). This dataset can be used to determine the trend of changes in population and their needs for future EV forecasts based on different assumptions.

Probe data are a resource to meet the federal requirements of monitoring and reporting congestion and freight performance enacted in the Moving Ahead for Progress in the 21st Century Act (MAP-21) (*47*). To assist agencies with meeting MAP-21 regulations, the Federal Highway Administration (FHWA) provides free access to the National Performance Management Research Data Set (NPMRDS), a national database of probe-vehicle-based speed and travel time data (*48*). The travel time on Texas roadways can be used to develop location-specific profiles of vehicles on different trips.

Pecan Street Dataport claims to be the world's largest resource for residential energy use data (*49*). Data on the electricity consumption of HVAC, pool pump, and EV chargers can be obtained from Pecan Street Inc. Residential EV charger real-world data can give valuable insight into charging trends and characteristics. This dataset was used to evaluate the potential contribution of EV demand scheduling to flatten the duck curve (*50*). In this study, the data of individual charging sessions of EVs from a university campus and real energy consumption data in California were used. Data on battery storage and solar panels can also be obtained from this provider.

Daley and Helm (*51*) evaluated the use of telematics data to study the fleet vehicle suitability for transition to EVs. The researchers created a data-source-agnostic platform to analyze the telematics data collected through various smartphone-based mobile applications and traditional telematics devices. Telematics data were used to assess the EV suitability using drive cycles and driving behavior of fleet vehicles. The study revealed that the smartphone-based data collection approach is valuable and can be used in conjunction with traditional telematics technology (*51*).

EV CHARGING INFRASTRUCTURE RESEARCH

A considerable amount of research investigates different aspects of EV infrastructure, including evaluating environmental impacts and benefits, modeling and determining optimal EV charger locations, and evaluating diversity, equity, and inclusion considerations related to EV charging stations. Several studies analyzed the impact of EV charging on the electrical grid (*52*). Other studies focused on synergies of EV charging stations and alternative energy production, including solar (*53*). Some research has focused on meeting EV charging demand using limited infrastructure capacity (*54*). One study highlighted the need for EV charging data rather than data derived from ICE vehicles to develop and evaluate EV charging location algorithms (*55*). This study also announced a publicly available dataset called Adaptive Charging Network Data (ACN-Data), which provides information about EV charging sessions at workplace locations for use in EV research (*56*). These data could be useful to examine capacity for demand response, build and evaluate related statistical models, and develop indicators to plan and evaluate EV charging infrastructure. A similar dataset, focusing on residential EV charging, is available through the Pecan Street Dataport (*49*).

Other studies have predicted user behavior and evaluated proposed scheduling algorithms using data collected from a charging network in Los Angeles (*57*). Several recent studies have developed or evaluated optimization algorithms for EV charger locations. For example, a recent study conducted by Michigan State University focused on the optimization of EV charging locations and numbers of chargers for intercity trips (*58*). Study considerations included minimization of infrastructure costs and user delays caused by detours, waiting in queues, and EV charging. The study also created a sensitivity analysis investigating various deployment, battery, and EV charging technology scenarios. A similar study conducted by Michigan State University in 2020 analyzed the optimization of EV charger locations in urban areas, focusing on intracity trips (*59*). Other research has focused on the interaction between electric power transmission systems and transportation networks. For example, Wert et al. developed a framework for coupled infrastructure between electric transmission and transportation networks in Travis County, Texas (*60*).

Research and Tools to Optimize EV Charging Infrastructure Locations

This section investigates the tools and research that can guide the planning for EV infrastructure. These tools use location-specific data and apply different coefficients to provide indicators of future electricity demand in a designated area for specific scenarios.

NREL has developed one of the primary tools for predicting electric vehicle infrastructure (EVI) in the United States. NREL's EVI modeling suite informs the development of large-scale EV charging infrastructure deployment at different levels, from the regional and state level to site and facility operations (*61*). This suite includes three groups of modules and tools: network planning, site design, and financial analysis. These tools are updated regularly, and some new models are also under development. One example is the EVI-Pro tool, which estimates the required EV charging stations in a designated area for a given EV fleet size. EVI-Pro uses a bottom-up approach to estimate PEV charging requirements with the fundamental element of 24-hour daily driving schedules from real-world vehicles (*62*). EVI-Pro can be used to analyze the typical daily travel patterns of LDVs, estimate related charging demand, and design

infrastructure capable of meeting the demand. It can also be used to include the variations and uncertainty in vehicle and charger technologies, user demographics, market adoption conditions, shared use of chargers, and EV travel and charging preferences (*20*). A simplified, web-based version of this tool, called EVI-Pro Lite, is geared for use by U.S. cities and states to estimate their charging infrastructure needs and the associated power demands on the grid (*63*). EVI-Pro Lite can provide the count of different types of chargers needed in a state or an urban area for a given count of EVs. It also provides the hourly profile of electric load for a given scenario that can be defined by the fleet size, average daily miles traveled per vehicle, average ambient temperature, percentage of PEVs, percentage of sedan PEVs, percentage of Level 1 and Level 2 chargers, percentage of access to home charging, and charging strategy. Figure 12 shows the predicted electric load profile (weekdays and weekends) in Austin for a hypothetical scenario with a PEV fleet size of 50,000, an average daily 25 miles traveled, and an average ambient temperature of 68°F.

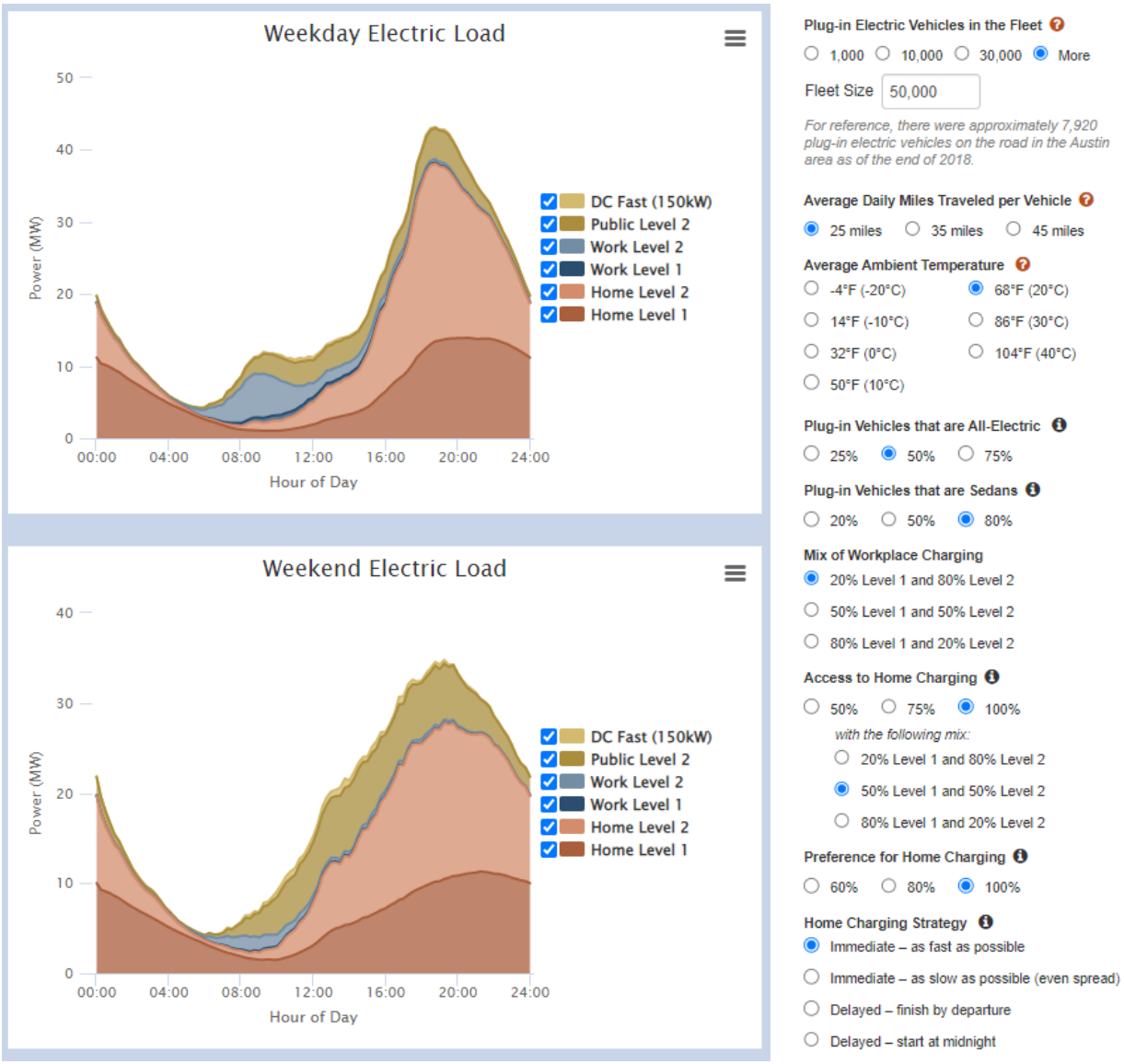


Figure 12. EVI-Pro Lite Prediction of Electric Load Profile in Austin (Left Panel) for a Hypothetical Scenario (Right Panel).

StreetLight is a data provider and analysis company that has built a commercial dashboard tool to guide planning for EV charging infrastructure. The data-driven tool is designed to help evaluate different scenarios for choosing EV charging locations (*64*). StreetLight uses cell phone, vehicle navigation device, commercial fleet, and other mobility data in conjunction with safety, land use, weather, and demographic data to predict travel behavior and charging demand. StreetLight also has information on existing Level 1, 2, and 3 EV chargers through available NREL data.

ElectroTempo is an analytics-as-a-service company that was founded in 2020 to specifically provide data insights to support the deployment of EV charging infrastructure. ElectroTempo's software is based on modeling tools developed by TTI that have since been spun into a

commercial venture. The software unifies data and simulation infrastructure by integrating transportation demand, grid assets, land use, demographics, and emissions to accelerate EV infrastructure deployment. The software provides shared views, aims to maximize return to all stakeholders, and measures impacts on climate and equity. The ElectroTempo platform allows stakeholders from across the EV infrastructure value chain to gain a shared view of existing infrastructure constraints and the need for critical investments to account for future demand. For example, Figure 13 shows the spatial dimensions of predicted EV demand throughout the Greater Houston Region, with existing EV charging stations and income levels in each community overlayed on the map. The projected demand in this scenario highlights several areas (in dark orange) where existing infrastructure (pin markers) will be insufficient to meet future demand and almost no neighborhoods in which lower-income demographics (densely dotted segments) have any existing infrastructure.

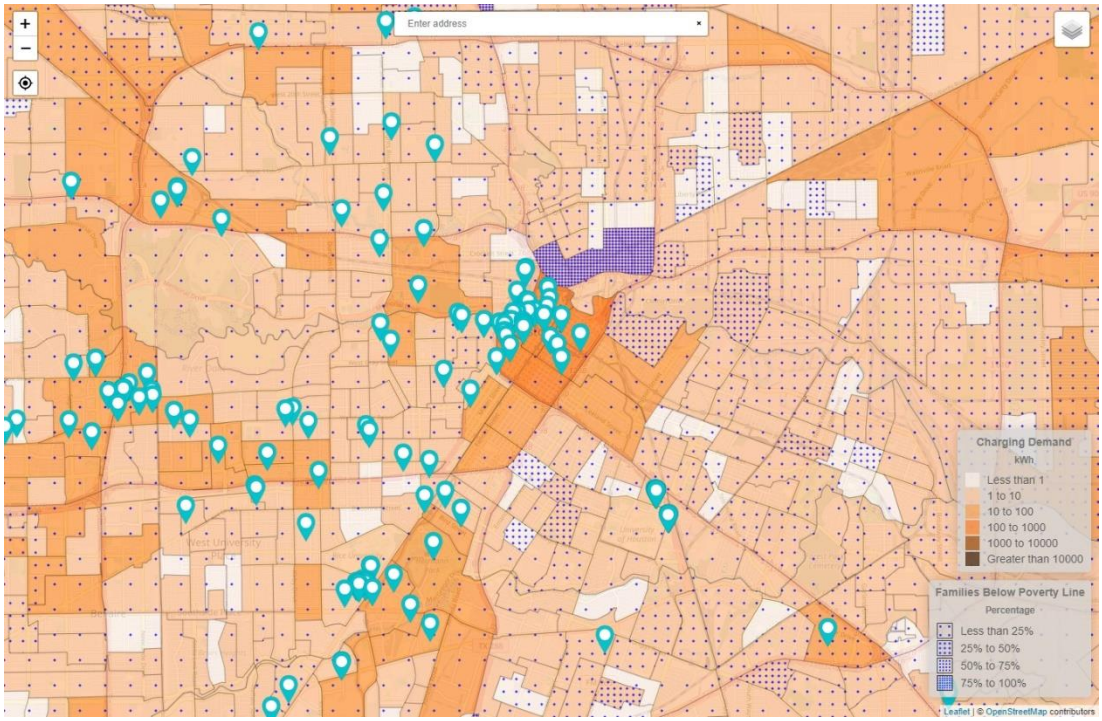


Figure 13. ElectroTempo EV Demand Projection, Existing Charging Station Infrastructure, and Income Level.

The Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool, available from Argonne National Laboratory (ANL), allows users to create estimates of environmental and economic costs and benefits of alternative fuel vehicles (AFVs) (*65*). ANL also created the EV Charging Justice40 Map Tool to help EV charging planning efforts align with the Justice40 goal of 40 percent of the benefits of federal investments in clean transportation going to disadvantaged communities (*66*). Further, ANL provides a tool called Energy Zones Mapping Tool that allows users to identify energy zones that may be suitable for power generation and energy corridors (*67*).

The Office of the Under Secretary for Policy of the U.S. Department of Transportation (USDOT) has developed the Rural EV Toolkit, which lists a host of EV infrastructure planning resources

potentially useful for research, including tools to analyze charging and energy needs, cost analysis, equitable planning, and environmental and social impact (*68*).

Atlas EV Hub is an online platform designed to provide information on the EV market (*69*). It developed the Highway Revenue Assessment Tool, built in Microsoft Excel, to provide users with insights on how the road network is funded by motor fuel taxes and how that revenue will change with new market conditions. This Excel tool uses FHWA statistics and AEO 2019. It forecasts the annual revenue changes due to different oil price scenarios between 2019 and 2030 for different states.

Numerous studies have been conducted on predicting required EV chargers and electric load in different locations using different methodologies and assumptions. For example, researchers used National Household Travel Survey (NHTS) data to predict the stochastic demand for residential EV charging (*70*). In this study, the time of arrival, time of departure, and driven distance data of Texas were obtained from NHTS and analyzed to get their probability distribution. Obtained distributions were used to create EV charging demand scenarios for a Monte Carlo simulation. The created EV charging load profiles were distributed in the Iowa Distribution Test System to explore the electric distribution grid impacts of EV charging.

Researchers classified the techniques for optimal placement and sizing of EV charging stations into two main areas: economics and power-grid-related concepts (*71*). EV charging placement methods that consider only economic benefits use various cost functions, such as land, fixed, construction, operating, and transportation costs, for siting and sizing EV charging stations. Genetic algorithm, particle swarm optimization (PSO), integer programming, and IBM ILOG CPLEX Optimization Studio commercial software are widely used for EV charging station optimization. Station placement methods with grid impact include different power system issues and various cost functions to find the optimal location and sizing of EV charging stations. The same optimization techniques, like the methods that consider only economic benefits, can be used for optimal EV charging station placement and sizing problems that consider the power grid. For example, researchers used PSO to optimize the combination of all three types of chargers (Levels 1, 2, and 3) for efficiently managing the EV load while minimizing installation cost, losses, and distribution transformer loading (*72*). The motivation of this study was the fact that installation of fast chargers (Level 3) at every possible site is not techno-economically justifiable since they may cause violation of critical system parameters due to their high-power consumption. Because of the uncertain nature of vehicle users, EV load was modeled as a stochastic process. Results showed that an optimized combination of chargers placed at judicious locations can greatly reduce cost, daily losses, and distribution transformer congestion.

Private EV Charging Infrastructure Investments

The majority of EV charging equipment is privately developed, owned, and operated. Key investors in charging infrastructure include electric utilities, specific electric vehicle supply equipment (EVSE) providers, as well as some vehicle manufacturers. This private investment can be leveraged by public entities in the form of public-private partnerships. Public-private partnerships in transportation are contractual relationships, often between a state or local government and a private entity, for the development of an asset (*73*). In terms of EV charging infrastructure, the ability to partner with a private-sector partner that has existing expertise and

assets can provide numerous cost savings. Depending on the nature of the partnership, the public entity can decide to own and operate the asset, with the private company designing, constructing, and installing the infrastructure, or the public entity can develop an arrangement to maintain ownership in a lease or hybrid arrangement. Oregon, through the Oregon Innovation Council, made an investment in Forth (previously Drive Oregon) in 2011 to develop the electric mobility industry within the state (*74*). This public-private partnership has spurred investment in EV charging infrastructure, developing the first fully electrified highway across California, Oregon, and Washington, as well as successful coordination with electric utilities and technology companies for demonstration projects. Washington State has also developed an extensive program to support private investment. In 2017, Washington used $1 million in grant funding to leverage an additional $1.5 million in investment through both public and private matching funds for fast chargers in 15 different communities across the state (*75*). The Zero-Emission Vehicle Infrastructure Partnerships grant has announced $8 million in funding for 2022 (*76*). Other public-private partnerships in the EV space have been driven by the private sector; Blink Charging, ChargePoint, and Volta Charging have all worked with public entities to provide charging infrastructure across offices, campuses, and cities. Electric utilities have also worked to develop both incentives for users as well as their own charging infrastructure investments and plans.

Utility Investment in Charging Infrastructure

A key investor in EV charging infrastructure is electric utility companies; their connection to the grid as well as understanding of the different components required enables them to scale EV charging efficiently and effectively within their regions. The National Electric Highway Coalition (NEHC) is a collaboration of more than 60 investor-owned and municipal electric companies across the United States (*77*). This coalition merges two previous groups, the Midwest EV Charging Collaboration and the Electric Highway Coalition, to support the deployment of charging stations on major travel corridors across the United States (*77*). This type of collaborative effort ensures careful planning in terms of location, load capacity, and equipment needs across major corridors and transportation facilities while sharing expertise and best practices. The NEHC has also stressed the importance of reliability and set standards to ensure a smooth customer experience state to state (*78*). Utilities under the NEHC are developing fast-charging infrastructure to meet the needs of their customers and region. Charging infrastructure investment by utilities may utilize partnerships with some of the key private providers in the space to provide the hardware, software, or maintenance services.

Electrify America

Electrify America operates an extensive public charging network in the United States, with its Electrify Commercial arm providing a turnkey solution to businesses, utilities, and government entities. Electrify Commercial has recently partnered with both the Arizona Public Service (APS) and the New York Power Authority (NYPA), through Mirabito convenience stores, to provide EV charging equipment (*79, 80*). APS will own the charging stations, with Electrify Commercial providing support in terms of site acquisition, design and development, charging equipment, and networking, as well as ongoing operations and maintenance (*80*). NYPA will construct, own, and operate its charging stations in cooperation with the site hosts (*79*).

EVgo

EVgo operates one of the largest networks of fast-charging stations in the United States, including solutions for governments and utilities (*81*). EVgo has developed the Connect the Watts initiative to provide guidance on best practices, planning considerations, and permitting issues for both states and utilities (*82*). EVgo partnered with the Washington State Department of Transportation to develop Washington's part of the West Coast Electric Highway along with the Port of Seattle and Forth, a nonprofit organization located in Washington State (*83*). EVgo also has partnerships with Public Service Electric and Gas Company (PSE&G), Green Mountain Power, and the City of Sacramento. EVgo has also developed a program, Communities Charging for Change, to support EV charging in certain California communities disproportionately impacted by pollution.

Tesla

Tesla owns and operates standalone charging solutions, such as its superchargers and destination charging at hotels, restaurants, and other businesses, as well as provides home charging equipment. Tesla provides the equipment and software for the charging solution, but the commercial partner is the owner of the asset and responsible for maintenance costs (*84*). Until 2022, Tesla chargers can only be utilized by Tesla vehicles; however, the network was opened in 2022 to include other charging connections and vehicles. Tesla conducted the Non-Tesla Supercharger Pilot to determine the demand and need for expansion of its infrastructure (*85*).

Blink Charging

Blink Charging utilizes Sourcewell to contract for its EV charging equipment with public entities. Contracts can include alternating current (AC) Level 2 chargers, DC Level 3 chargers, and residential charging, as well as either a hybrid ownership agreement or a Blink-owned agreement (*86*). Blink currently partners with cities like Portland and San Diego, public agencies, and business owners (*87, 88*). In Texas, Blink Charging has partnered with the City of San Antonio to build out Level 2 charging facilities. Blink and CPS Energy collaborated to develop strategic locations for the chargers. The public-private partnership leverages funds from the Texas Volkswagen Environmental Mitigation Program and splits the revenue generated from charging between Blink and the city (*89*).

ChargePoint Network

ChargePoint has one of the largest networks of EV charging stations in the United States, with an integrated portfolio of hardware, cloud services, and support (*90*). ChargePoint offers both AC and DC charging infrastructure with options specifically designed for fleets as well as an all-purpose charging unit (*91*). ChargePoint partners with a variety of different public entities, including cities such as Denver and New York, as well as MPOs and federal and state agencies (*90, 92*). ChargePoint offers its partners the ability to track key sustainability metrics to aid in justification of the investment as well as provide them with the data to understand the impact of this equipment on their area. Public partners have noted that familiarity with the ChargePoint network and brand is useful in their purchasing decision for EV charging equipment (*93, 94*).

Volta Charging

Volta Charging provides both an EV charging and a media solution through marketing and advertising opportunities built into its EVSE (*95*). Volta also owns a proprietary EV network planning tool, PredictEV, that uses behavioral science and machine learning to determine appropriate locations, as well as the requirements for these locations, for its charging solutions. The revenue considerations with Volta differ slightly due to the focus on branding partnerships and advertising. This revenue can be utilized as a cost-savings measure for drivers or partners. Volta and the City of Hoboken recently announced a partnership to develop an initial network of 25 charging stations at no cost to the city (*96*, *97*). The costs incurred by Volta will be covered by advertising revenue from its media displays.

FEDERAL REGULATIONS, GUIDANCE, AND INITIATIVES

The passage of the IIJA has increased the federal focus on EVs; however, the new programs and funding opportunities included in the IIJA are also subject to both new and existing federal regulations. The NEVI program focuses on designated AFCs throughout the United States, with the potential to designate new corridors due to IIJA requirements. Due to the focus on highway corridors, often interstates, existing guidance on the use of the right-of-way will need to be considered. The Biden Administration has an expansive set of goals associated with EVs that are actionable through the IIJA, the Inflation Reduction Act (IRA), and the Creating Helpful Incentives to Produce Semiconductors (CHIPS)—Science Act. This slate of legislation has numerous funding opportunities to promote the adoption of EVs and the expansion of EV charging infrastructure, which will be discussed in this section. Existing funding opportunities, such as the Congestion Mitigation and Air Quality (CMAQ) Improvement Program, have new guidelines to broaden the scope of applicable projects. Finally, initiatives from both the Biden Administration and USDOT have emphasized the importance of equity. The Justice40 Initiative aims to ensure that the benefits of climate-focused investment are directed toward disadvantaged communities.

Equity, Environmental Justice, and Justice40 Initiative

In determining EV charging site locations, the potential equity implications of these decisions and investments must be taken into account. Ensuring that the benefits of increased EVs reach disadvantaged communities requires careful consideration of a range of factors, including access to both infrastructure and vehicles as well as the potential impacts to land use and the cost of living. The current administration is focused on ensuring equity and justice throughout federal programs, especially new investments in infrastructure, such as EV charging stations. The Justice40 Initiative, Executive Order (EO) 13985, Advancing Racial Equity and Support for Underserved Communities Through the Federal Government, and requirements through new and existing federal grant and formula funds all charge the federal government, and those receiving federal funds, to give greater weight to equity in their practices, processes, and decision-making.

The Justice40 Initiative was incorporated into EO 14008, Tackling the Climate Crisis at Home and Abroad, in January 2021 (*98*). Justice40 is aimed at providing 40 percent of the benefits from relevant federal programs and investments to disadvantaged communities. The federal government developed an online tool to assist in the determination of those communities, which

was released in beta form in February 2022. The Climate and Economic Justice Screening Tool (CEJST) shows communities that have been identified as disadvantaged using publicly available and nationally consistent databases (*99*). The tool identifies communities as disadvantaged based on eight categories and their relevant criteria:

- Climate change.
- Clean energy and energy efficiency.
- Clean transit.
- Affordable and sustainable housing.
- Reduction and remediation of legacy pollution.
- Critical clean water and wastewater infrastructure.
- Health burdens.
- Training and workforce development.

Prior to its launch, interim guidance provided broad definitions to help agencies carry out the directive. Community is defined as "either a group of individuals living in geographic proximity to one another, or a geographically dispersed set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions" (*100*). Disadvantaged includes low income, high unemployment or underemployment, linguistic isolation, racial or ethnic residential segregation, high housing cost burden, high transportation cost burden, and other factors that address energy, healthcare, and environmental conditions (*101*). USDOT has adopted an interim definition while the CEJST is still in beta that includes qualifying census tracts, any Tribal land, and any territory or possession of the United States within the definition. The interim definition includes 22 indicators that were grouped into six categories of transportation disadvantage. The six categories are:

- Transportation access disadvantage—communities that spend more time getting where they need to go or accessing destinations.
- Health disadvantage—communities associated with adverse health outcomes, disability, and environmental exposures.
- Environmental disadvantage—communities with disproportionately high levels of air pollutants among other environmental hazards.
- Economic disadvantage—populations with high poverty, low wealth, limited local job opportunities, low homeownership, low educational attainment, and high inequality.
- Resilience disadvantage—communities with vulnerabilities to hazards caused by climate change.
- Equity disadvantage—communities with a high percentile of persons over 5 who speak English "less than well" (*102*).

USDOT also developed a mapping tool to assist applicants in determining whether a project is located in a disadvantaged community (*103*). This tool is currently used for the Reconnecting Communities Notice of Funding Opportunity as an option for determining whether a community is economically disadvantaged (*102*). Each agency was responsible for determining its own benefits calculation methodology, and USDOT has committed to a comprehensive approach to Justice40 as well as the collection of community input for the methodology. USDOT conducted two public meetings in 2021 to begin this effort and asked participants to define community,

disadvantaged, and benefits during these meetings. Feedback from those meetings was used to develop the definition of disadvantaged community for department of transportation (DOT) programs. Once the methodology is developed and approved, the agency must also consider appropriate reporting requirements to meet the needs of this initiative.

The interim guidance identified pilot programs for the initiative; these are the investments that were initially required to comply while guidance and assistance tools were developed. There are two programs under USDOT in the pilot: Bus and Bus Facilities Infrastructure Investment Program and Low or No Emissions Vehicle Program. These programs are both under the Federal Transit Administration's jurisdiction at USDOT. Under full implementation, covered programs include climate change, clean energy and energy efficiency, clean transportation, affordable and sustainable housing, training and workforce development (related to climate, natural disasters, environment, clean energy, clean transportation, housing, water and wastewater infrastructure, and legacy pollution reduction, including in energy communities), remediation and reduction of legacy pollution, critical clean water, and waste infrastructure. Energy communities are referenced in EO14008 and include coal, oil, and gas and power plant communities. On August 18, 2022, the full list of Justice40 covered programs was announced. Thirty-nine programs that fall under USDOT are considered covered programs, including Charging & Fueling Infrastructure Grants, the CMAQ Improvement Program, and the NEVI Formula and competitive programs (*102*).

In addition to Justice40, EO 13985 was signed in January 2021 to address racial equity and support to underserved communities (*104*). The EO recognizes the disparities in laws, institutions, and policies that have often denied equal opportunity to individuals and communities. The policy moving forward is advance equity for all, especially those who have been historically underserved, marginalized, and adversely affected by poverty and inequality. Specifically, the EO calls for the allocation of federal resources to advance fairness and opportunity as well as promotes the equitable delivery of government benefits and opportunities (*104*). USDOT released an Equity and Access policy statement that affirmed the agency's support for EO 13985 and emphasized the importance of removing language barriers and seeking environmental justice to comply with the EO. USDOT intends to incorporate environmental justice and equity principles into all transportation planning and decision-making processes (*105*). EO 13985 and USDOT's response are now emphasized in criteria and guidance for both formula-based and competitive funding at the federal level, which highlights the need for all levels of government to plan with equity in mind.

The importance of environmental justice and equity for clean transportation, especially the expansion of EV charging infrastructure, is clear from these executive orders and recent guidance on transportation funds. The NEVI Formula Program includes equity considerations within the guidance that emphasize the potential benefits from installing and increasing access to charging infrastructure as well as highlighting concerns like gentrification. States must engage with rural, underserved, and disadvantaged communities when developing their plans and should show how the plan complies with EO 14008 and the interim Justice40 guidance (*106*). The emphasis on equity under NEVI as well as the requirements to meet targets related to equity and justice is likely to continue with future federal funding opportunities, especially for clean transportation. In developing a statewide charging network, these requirements must be considered. Recent research has indicated that clean transportation and equity goals can be met

without undercutting each other and that the benefits of clean transportation can be realized for underserved and low-income communities with the right planning and policies in place (*107, 108*). Availability of affordable vehicles, infrastructure in convenient locations, and considerations for shared mobility and transit will all be required to ensure an inclusive clean transportation transition.

Other federal requirements for charging infrastructure will include considerations for people with disabilities under the Americans with Disabilities Act (ADA). While the ADA does not have specific design standards for the accessibility of EV charging stations, the U.S. Access Board has developed *Design Recommendations for Accessible Electric Vehicle Charging Stations* (*109*), and USDOE has guidance on complying with the ADA for workplace charging installations (*110*). Guidance includes a recommended number of accessible charging spaces per lot, if charging stations are located in a parking lot, as well as spacing and access standards. Any charger that is intended for public use will likely fall under ADA requirements, and access for people with disabilities will be a key consideration in the rollout of public charging infrastructure.

Alternative Fuel Corridors

The Fixing America's Surface Transportation (FAST) Act required USDOT to designate national alternative fuel corridors (AFCs), based on nominations from state and local officials and other considerations, as defined in 23 USC 151 (*111*). The goal of the AFCs is to improve the mobility of passenger and commercial vehicles that employ electric, hydrogen fuel cell, propane, and natural gas fueling technologies across the United States. In 2016, FHWA issued its first notice and solicitation of nominations for designation of AFCs, which resulted in 34 nominations (*112*). Since then, FHWA has issued annual solicitations, which have resulted in a designation of about 58,980 miles of the National Highway System (NHS) in 48 states and the District of Columbia, including 106 segments of interstates and 104 segments of U.S. highways and state roads (*113*). In the earlier nominating rounds, EV corridor ready meant an NHS segment that has public DC fast-charging equipment no greater than 50 miles between stations/sites that are located no greater than 5 miles off the highway, and each fast-charging station should have both Society of Automotive Engineers (SAE) J1772 Combined Charging System (CCS) and Charge de Move (CHAdeMO) connectors. EV corridor pending meant that EV charging stations are separated by more than 50 miles but are still no more than 5 miles off the highway. Figure 14 shows locations of J1772, CHAdeMO, and a combination of charger types overlayed on the AFC network in Texas based on data from USDOE (*114*).

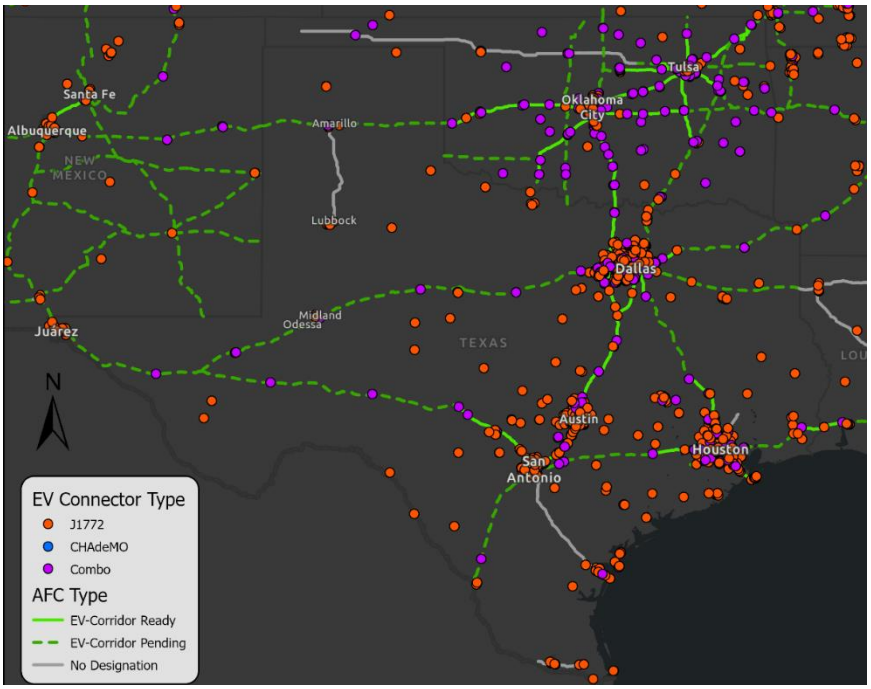


Figure 14. Location and Type of Fast EV Chargers in Texas (*114*).

Based on the information available from USDOE, there are currently 2,210 publicly accessible stations in Texas with 5,246 EVSE ports, including 223 proprietary Tesla charging stations. Of the nonproprietary charging stations, 92 percent are J1772 chargers and the rest (with few exceptions) are combo chargers. Level 1 charging stations account for 17 locations with 27 EVSE ports, 2,012 charging stations are Level 2 chargers with 4,258 EVSE ports, and 252 locations are DCFCs with 961 EVSE ports.

The IIJA amended 23 USC 151 to update requirements related to the designation of national AFCs, including an update and redesignation of the corridors and the development of a recurring process to regularly update and redesignate by May 15, 2022 (*115*). On February 10, 2022, FHWA published a request for nominations to the sixth round of AFC designations, which was due to FHWA on May 13, 2022 (*116*). In the request, FHWA outlined priorities and a process for nominating new corridors to the national AFC network, including the following:

- The initial round of designations in 2016 allowed the use of Level 2 chargers. These should be given priority for corridor upgrades to SAE CCS chargers.
- FHWA encourages nominations along interstate corridors, but nominations anywhere on the NHS are permitted.
- Corridor designations must identify near- and long-term needs and locations of alternative fueling infrastructure.
- Corridor-ready segments should have at least two public DC fast-charging stations no greater than 50 miles between one station and the next on the corridor, and each DC fast-charging site should have both CCS and CHAdeMO connectors.
- Corridor-pending segments should have public DC fast-charging stations separated by more than 50 miles between one station and the next.

Round six of nominations also included a few changes to nominations from the previous five rounds, including:

- A state may request certification of a determination that designated EV corridors are "fully built out" with EV chargers placed every 50 miles and within 1 mile of that highway, with exceptions. All designated corridors within that state will need to meet the considerations outlined in the NEVI Formula Program Guidance to be certified (*106*).
- Corridor-ready and corridor-pending segments are now defined as having charging stations located at a distance of no more than 1 mile from an interstate exit or highway intersection, with some exceptions. Current AFCs will not need to be redesignated if they do not comply with this provision but will not be certified as "fully built out."
- Corridor-ready charging stations should have power capability no less than 600 kW, supporting at least 150 kW per port across four ports, and maximum charger power per DC port should not be below 150 kW.
- Corridor-pending locations must be included in a strategic plan and timeline for improvements.
- States are encouraged to target at least 40 percent of resources and benefits toward disadvantaged communities in line with EO 14008 and the interim Justice40 guidance (*98*).

Round six of nominations also highlighted several areas of interest that states should consider, including converting AFC-pending corridors to AFC-ready corridors, expanding access in rural areas and disadvantaged communities, and coordinating nominations with state plans such as EV deployment plans, state freight plans, and long-range transportation plans.

Federal Goals and the Infrastructure Investment and Jobs Act

On March 31, 2021, the Biden Administration announced a plan to improve the infrastructure in the United States (*117*). As part of the plan, the administration announced a goal to build a national network of 500,000 EV chargers by 2030. On August 5, 2021, President Biden signed EO 14037, Strengthening American Leadership in Clean Cars, which set a goal that 50 percent of all new passenger cars and light trucks sold in 2030 be zero-emission vehicles (*118*). In addition, EO 14057, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, signed on December 8, 2021, set a goal that by 2027, all LDVs acquired by the federal government must be zero emission, and by 2035, all vehicles acquired must be zero emission (*119*). IIJA provides approximately $1 trillion transportation, broadband, and electric grid infrastructure funding. Of this funding, the bill invests $7.5 billion to build out a national network of EV chargers. The bill also invests $73 billion to upgrade and expand power infrastructure, including new construction of transmission lines to facilitate the expansion of renewable energy.

The Biden-Harris Administration released the Electric Vehicle Charging Action Plan on December 13, 2021. The plan involves developing the Joint Office of Energy and Transportation, gathering diverse stakeholder input, preparing guidance and standards for states and cities regarding IIJA, developing a request for information from domestic manufacturers on their needs to support the plan, and soliciting applications for AFCs.

On December 14, 2021, U.S. Secretary of Energy Granholm and U.S. Secretary of Transportation Buttigieg signed a memorandum of understanding (MOU) to create the Joint Office of Energy and Transportation (*120*). The joint office supports the deployment of $7.5 billion for a national EV charging network through the establishment of two programs, a grant-based national EV charging program and a competitive charging and fueling infrastructure program.

On November 29, 2021, FHWA published a public notice and request for information titled Development of Guidance for Electric Vehicle Charging Infrastructure Deployment (*121*). In response, FHWA received 477 public comments from various public and private stakeholders, including the American Association of State Highway and Transportation Officials, state DOTs, automobile manufacturers, special interest groups, and private persons. A review of these comments found that many remarks center around a variety of similar concerns, including questions related to alternative energy production and commercial activities in controlled-access right-of-way, environmental streamlining, and application of the Justice40 Initiative.

IIJA directed USDOT and USDOE to develop guidance for the strategic deployment of EV charging infrastructure through the national EV charging program by February 15, 2022, and to develop minimum standards and requirements applicable to EV chargers under these programs by May 15, 2022. On February 10, 2022, FHWA issued new guidance for the NEVI Formula Program (*106*). The guidance referenced the updated FHWA policy published in December and described rules and provisions of the NEVI Formula Program, including funding features, deployment plans, eligibility provisions, program administration, and available technical assistance and tools. The NEVI Formula Program required that each state develop an EV infrastructure deployment plan that described how the state intended to use its apportioned NEVI Formula Program funds in accordance with the guidance issued by FHWA. The plan had to be submitted to the Joint Office of Energy and Transportation no later than August 1, 2022, and approved by FHWA by September 30, 2022, before program funding could be obligated to the state. Among several items, the plan needed to include the following components and discuss the following:

- **Existing and Future Conditions Analysis**. The plan had to identify existing conditions at the time of plan creation as it pertained to EV charger deployment vision and challenges; current and future temperature and precipitation patterns; industry/market conditions, including an overview of existing EV charging, current and projected EV ownership, location of existing EV charging stations, and roles of DC fast-charging stations; public transportation needs; freight and other supply chain needs; grid capacity necessary to support additional EV charging infrastructure; electric utilities that service the study area; land use patterns; travel patterns; EV charging infrastructure; information dissemination about EV charging station availability; and known risks and challenges for EV deployment.
- **EV Charging Infrastructure Deployment**. This section was expected to discuss EV charging infrastructure installations and associated policies to meet the vision and goals of the plan.
- **Implementation**. This section needed to discuss EV charging operations and maintenance programs and EV charging infrastructure data collection and sharing.

- **Civil Rights and Equity Considerations**. The plan was expected to discuss how the state would comply with federal and state civil rights laws, including Title VI of the Civil Rights Act and accompanying USDOT regulations, the ADA, and Section 504 of the Rehabilitation Act. The plan also had to be developed through engagement with rural, underserved, and disadvantaged communities to ensure that diverse views were heard, and that the deployment, installation, operation, and use of EV charging infrastructure would achieve equitable and fair distribution of benefits and services. The plan needed to also be consistent with the interim Justice40 guidance issued by USDOT.

Noteworthy in this discussion is that at the discretion of FHWA, development of plans qualified for an environmental exclusion under 23 CFR 771.117(c)(1) as an activity that does not lead directly to construction (*122*). Installation of EV charging stations are not expected to result in significant environmental impacts and could therefore qualify for categorical exclusions under this section, specifically (c) (2) utility installations, (c) (19) operating and maintenance equipment in transit facilities, (c) (22) certain projects within existing operational right-of-way, (c) (23) small federally funded projects, and (d) additional projects as authorized by agreement.

Since the passage of the IIJA, further progress has been made through legislation and executive orders to implement President Biden's goals of increasing EV sales and building out an EV charging network. The IRA, signed into law on August 16, 2022, intends to create more clean energy jobs within the United States through provisions for the use of American-made equipment for clean energy production as well as incentivize the production of clean energy technologies (*123*). Also included within the bill are incentives for buyers of new and used EVs and grants to deploy zero-emission heavy-duty vehicles (*124*). The CHIPS and Science Act, signed into law on August 9, 2022, provides critical investment in domestic semiconductor manufacturing that will support the growth of the EV industry (*124*). This series of legislation has spurred private-sector investment in EV manufacturing, batteries, and battery material processing, as well as charging infrastructure and networks.

Federal Funding for Strategic Deployment of Electric Vehicle Charging Infrastructure

The passage of the IIJA has introduced new funding opportunities and programs, as well as expanding or amending existing programs. to indicate a focus on clean transportation, especially EVs. The NEVI Formula Program is the largest investment, with $5 billion available to build out a national charging network. The Discretionary Grant Program for Charging and Fueling Infrastructure is intended to fill in the gaps left after the planned NEVI investments are installed. The IIJA also includes programs to address heavy-duty vehicles, as well as expand the applicability of existing grants and formula funding. The Inflation Reduction Act of August 2022 provides additional funding and credits to support clean transportation.

National Electric Vehicle Infrastructure Formula Program

Section 11401 of this bill establishes a grant program to strategically deploy publicly accessible eligible infrastructure, including EV charging, hydrogen fueling, propane fueling, and natural gas fueling infrastructure along designated AFCs or certain other areas available to all drivers of vehicles using that infrastructure. The NEVI Formula Program provides $5 billion in formula funding to states and territories. Ten percent of the NEVI Formula Program is a set-aside each

fiscal year to provide discretionary grants to help fill gaps in the national network, using a separate process to be developed in the future. Over the next 5 years, starting with FY 2022, Texas is expected to receive about $408 million to support the expansion of EV charging infrastructure with a federal cost share of 80 percent (*117*). The law also requires that for each fiscal year, states must provide USDOT a plan describing how the state intends to use the funds under the EV charging program. USDOT may withhold or withdraw funding if the state fails to submit this plan, or if USDOT determines that the state has not taken action to carry out the plan. In September 2022, USDOT approved the NEVI plans from all 50 states; states now have access to FY22 and FY23 NEVI formula funding that totals over $1.5 billion (*125*). NEVI funding is directed at AFCs, so states have been encouraged to first focus on interstate highway needs before assessing other corridors when developing their plans. States that have already built their charging network along the AFCs are able to suggest alternative sites in their NEVI plan.

Discretionary Grant Program for Charging and Fueling Infrastructure

The Discretionary Grant Program for Charging and Fueling Infrastructure is a competitive grant program to strategically deploy eligible infrastructure, which includes publicly accessible EV charging infrastructure and hydrogen, propane, and natural gas fueling infrastructure. The eligible infrastructure may be deployed along designated AFCs or in certain other locations accessible to all drivers of EVs. The program will allocate $2.5 billion over 5 years starting in FY 2022 to states, MPOs, local governments, and other public authorities with a transportation function. Projects will have a federal cost share of up to 80 percent and will be distributed as part of two distinct $1.25 billion initiatives:

- **Corridor Charging Grant Program.** This program will strategically deploy publicly accessible EV charging infrastructure and hydrogen, propane, and natural gas fueling infrastructure along designated AFCs using a competitive process.
- **Community Charging Grant Program.** This program will strategically deploy publicly accessible EV charging infrastructure and hydrogen, propane, and natural gas fueling infrastructure in communities using a competitive process. The law requires that USDOT give priority to projects that expand access to eligible infrastructure in rural areas, low- and moderate-income neighborhoods, and communities with a low ratio of private parking spaces to households or a high ratio of multiunit dwellings to single-family homes.

About $300 million was set aside for states for the FY 2022 under the Discretionary Grant Program for Charging and Fueling Infrastructure (CFI) (*38*). However, the first round of funding was only made available on January 11, 2024, in the amount of $600 million (*126*). This benefited 47 projects in 22 states and Puerto Rico that involved construction of about 7,500 EV charging ports. At the time, FHWA received applications for six times the amount that was granted in January (*127*). On May 30, 2024, FHWA opened round two of funding in the amount of $1.3 billion; $520 million of the round two funding is reserved for some unselected applicants of the first round of funding. A key difference for EV projects applying for the second round of funding is that the maximum distance from an AFC has been increased from 1 mile to 5 miles, which aligns the requirement with other types of fuels eligible under the CFI program (*128*).

Additional new programs within IIJA that have yet to release full guidance, or a notice of funding opportunity, include the zero-emission vehicle (ZEV) and infrastructure grants program. This program will provide funding for heavy-duty ZEVs and the associated infrastructure, which can cover the capital, installation, and maintenance costs of charging or refueling infrastructure (*129*).

Existing Funding Opportunities

Alongside new funding opportunities, the recent slate of legislation at the federal level has increased the applicability of certain existing funding opportunities or changed the requirements. The CMAQ program provides funding for nonattainment areas to help meet the requirements of the Clean Air Act. Funding is available to reduce congestion and improve air quality for areas that do not meet the National Ambient Air Quality standards (*130*). The FAST Act expanded the project eligibility listing to include EV and natural gas infrastructure (*131*). The IIJA continues this flexible funding program and adds new project eligibilities, which include the purchase of diesel replacements, or medium-duty and heavy-duty ZEVs and related charging equipment, as well as vehicle refueling infrastructure that would reduce emissions from nonroad vehicles and engines used in construction projects and port-related freight operations (*130*).

The Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program provides discretionary grant funding for roads, rail, transit, and port projects that will achieve national objectives. RAISE was previously known as Better Utilizing Investments to Leverage Development (BUILD) and Transportation Investment Generating Economic Recovery (TIGER) (*132*). Due to the funding connection with national objectives, potential RAISE-eligible projects would include support for modal shift away from GHG-emitting options, support for EVs, and ZEV infrastructure (*133*).

The Inflation Reduction Act

The IRA includes several new programs that support the development of the clean transportation industry, but it also makes changes to the Alternative Fuel Infrastructure Tax Credit and introduces the Neighborhood Access and Equity grant program. Beginning in 2023, the tax credit for alternative fueling equipment will provide a credit for 30 percent of the cost, or 6 percent in the case of property subject to depreciation, not to exceed $100,000. Permitting and inspection fees are not counted as part of the covered costs. Fueling equipment must be installed in census tracts where either the poverty rate is at least 20 percent or the median family income is less than 80 percent of the state medium family income level. Purchases of qualified residential fueling equipment are eligible for a tax credit of $1,000 (*134*). The Neighborhood Access and Equity grant will provide $3 billion to reconnect divided communities. The projects can include mitigation or remediation from the negative impacts imposed by the facility that divided the community. Investments in technologies, activities, and infrastructure to reduce surface transportation-related GHG emissions and other pollution are covered by the grant requirements (*135*). Grants are available for economically disadvantaged communities as described by the bill.

Guidance for Use of Controlled-Access Right-of-Way

On April 27, 2021, FHWA issued guidance to provide clarification on certain uses of controlled-access highway right-of-way that address public needs related to climate change, equitable communication access, and energy reliability (*136*). The guidance highlights that currently there are two methods to accommodate clean energy projects, such as renewable energy projects, alternative fueling, electrical transmission and distribution, and broadband projects in the right-of-way of a federal-aid highway. The first option is to accommodate the project as a utility under 23 CFR Part 645, and the second option is to accommodate the project as an alternative use of the right-of-way under 23 CFR Part 710.

Accommodation as a utility is feasible if the installation is in the public interest and does not adversely affect highway or traffic safety, among other requirements. If projects are accommodated as a utility, there are no federal requirements for fair market rent or other fees, and fees may be set at the discretion of the state. Further, there are no federal requirements for secondary access to facilities located adjacent to ramps, interchanges, corridor parking facilities, or within rest areas. In addition, a utility facility serving the public is not a prohibited commercial activity under 23 USC 111, unless such project also qualifies as an automotive service station or other commercial establishment. Accommodation as a utility is FHWA's stated preferred option.

The second option provides that clean energy projects may be approved by FHWA if such projects are in the public interest and will not impair the highway, among other requirements specified in 23 CFR 1.23. Such projects are subject to a requirement to charge fair market value for the lease or disposal of highway right-of-way if the property was acquired with federal-aid funding (23 USC 156).

The memorandum states that FHWA has determined that clean energy projects, including broadband installations, are non-highway alternative uses in the public interest if they comply with the rules in 23 CFR 1.23 and 710, and 23 USC 111, and projects must also follow certain requirements for planning and design defined in 23 CFR 710.405. Further, FHWA can approve an exception of the fair market value requirement for projects with a social, environmental, or economic purpose defined in 23 USC 156(b) and 23 CFR 710.403(e). The memorandum also encourages states to consider an alternative fuel facility's proximity to off-highway travel centers and fuel retailers when siting these facilities along the highway right-of-way.

More recently, FHWA has provided answers to a series of related questions with regard to EV charging stations to provide clarity under existing law, requirements, and policy (*137*). FHWA clarifies that a state DOT, utility, or any other public or private party can assess a fee for EV charging at locations outside of the interstate right-of-way, but not inside of the interstate right-of-way. There are a few exceptions to this prohibition of commercial establishments on interstates in 23 USC 111:

- Sections of the interstate where federal-aid highway funds have never been used, typically older toll roads.
- Park-and-ride facilities (or fringe and corridor parking facilities) that use federal-aid funding. However, fees are subject to limitations in 23 USC 137, 23 USC 142, and

23 CFR 810, which limit fees to amounts not in excess of the costs required to operate and maintain a facility.
- Federal post roads unless the road was constructed with federal-aid funds and designated as part of the interstate system.

The guidance also notes that if a state DOT acquires property adjacent to the interstate right-of-way and uses it as a rest area, the rest area becomes part of the interstate right-of-way as long as there is direct access from the intestate to the rest area.

The District DOT has established guidelines to safely cover a charging cord crossing a sidewalk or a public right-of-way to promote curbside charging of EVs where residents do not have dedicated off-street parking (*138*). A Forth Mobility report stated that installing chargers in public parking spaces on the right-of-way will be critical in meeting the emerging EV charging demand (*139*). Portland's Affordable Housing Green Building Policy states that 4 percent of the parking spaces on certain city-supported multifamily and mixed-use buildings must be EV charging stations. The City of Boston has a right-to-charge law, which allows tenants to install EV charging stations in the rental property (*139*).

STATE AND REGIONAL REGULATIONS, GUIDANCE, AND INITIATIVES

Planning efforts, regulations, and initiatives at the state and multistate level are key to developing an EV infrastructure network that is efficient and effective. Multistate coordination ensures the availability of charging infrastructure when crossing state lines and promotes the sharing of best practices, regulatory options, and successful initiatives. Reviewing regulations and guidance at the state level provides a baseline understanding of key areas for regulation, or where to avoid creating a complicated patchwork of rules. These state-level efforts will also inform regional agreements, plans, and documentation for MPOs and individual cities. Reviewing regulation and guidance across all levels of government can highlight areas for coordination as well as aid in understanding the need for flexibility.

Multistate Coordination

Developing a cohesive charging network across the United States requires not just intrastate but also interstate coordination. Groups such as Regional Electric Vehicle West (REV West) help to coordinate infrastructure at state borders as well as provide a forum for exchanging best practices. In a similar manner, organizations focusing on the local level, such as the Clean Cities Coalition, provide an avenue for planning at a smaller scale.

Regional Electric Vehicle Plans

REV West includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming, and provides a framework to create an intermountain EV corridor that will allow an EV to seamlessly drive across the western states' transportation corridors (*140*). The plan was established by signing an MOU in 2017 that outlines activities that member states will undertake to support the goals of the plan, including voluntary minimum standards related to administration, interoperability, operations, and management of publicly available DC fast-charging stations. REV West published voluntary minimum station standards in 2019 that define

standards with respect to station siting and operation, location, technical requirements, and signage (*141*). Texas will interface with the developments of REV West in New Mexico, which installed DC fast-charging stations along Interstates 40 and 25.

Clean Cities Coalition Network

The Clean Cities Coalition Network (Clean Cities) is a network of 75 active coalitions across the United States that work on the implementation of alternative fuels, fuel-saving technology, and new mobility choices. Clean Cities operates as part of the USDOE's Vehicle Technologies Office with a goal to foster economic, environmental, and energy security of the United States through local coalitions. Members of Clean Cities are businesses, fuel providers, vehicle fleets, state and local government agencies, and community organizations (*142*). Austin, DFW, Houston, and San Antonio are members of Clean Cities in Texas. In Texas, recent projects have focused on innovative vehicle technologies, including electrified fleets of medium-duty trucks in urban areas and last-mile on-demand shuttle service in rural communities. Nationwide, there have been numerous pilot projects for demonstrating applications and use of various modes of EVs and electric vehicle charging technology.

National Highway Charging Collaborative

The NATSO organization (formerly called National Association of Truck Stop Operators), representing U.S. travel plazas and truck stops, and ChargePoint Inc., a developer of EV charging technology, signed an MOU in February 2020 that defined collaboration between the two organizations and formally created the National Highway Charging Collaborative (*143*). The focus of the collaborative is to leverage public and private funding to provide EV charging infrastructure at strategic locations, connect existing FHWA-designated AFCs, and advocate for policies supporting the collaborative's objectives. The goal of the collaborative is the installation of EV charging infrastructure at 4,000 truck stops, travel plazas, and fuel retailers, leveraging $1 billion by 2030. The collaborative will identify gaps in EV infrastructure along corridors to target and prioritize EV charging infrastructure installations.

Overview of State Regulations, Guidance, and Programs

The development of state NEVI plans has identified several strategy, policy, and regulatory implications, as well as programs that will be relevant when moving beyond the build-out of the interstate, or alternative fuel corridor, network through NEVI funding. For example, many states have developed working groups, committees, and expanded partnerships to avoid replication and ensure redundancy within the network. States such as Alabama, New Jersey, and California have developed taskforces or committees that expand beyond their state to include both bordering states as well as other potential partners. Several states have developed, or are developing, guidance that will ease permitting and installations, as well as ensure strict cybersecurity protocols, such as adherence to UL2594, the Open Charge Point Protocol, and International Standardization Organization (ISO) 15118 (*144*). In terms of policy and regulatory changes, key areas for many states are building codes, permitting rules, and parking minimums or requirements that may need reviewing to enable further development of the EV infrastructure network.

In terms of location criteria, states have utilized traffic, tourism, and existing infrastructure as a general guide. However, some states have also considered the availability of three-phase power to reduce the burden in terms of utility needs for providing the DCFC stations that are required under NEVI. This strategy could help to realize cost savings for both the state and utility companies. In addition, many states have noted the challenge of siting charging stations in remote and rural areas where demand will be lower and the private sector may be less inclined to install and operate infrastructure. Strategies to overcome this challenge include potential state ownership of certain infrastructure, providing incentives through additional funding for maintenance, or project bundling. Project bundling involves developing a contract for multiple stations, some with high market potential and some with low market potential. Bundling different locations enables the state to meet charger requirements while reducing the risk to the private partner. Kentucky is even considering a master contract where one developer builds out the entire network, either through contracts or utilizing its own stations. Another option is a franchise operation where the private contractor would lease out the charging stations to other private entities to operate and maintain; both solutions would occur under a specific form of design-build-finance-operate-maintain structure for EVSE. However, the overall challenge for EVSE purchasing will be the Buy America requirements; Oregon has a Made in America Office within its Office of Management and Budget that will be leveraged to ensure compliance when completing its NEVI investments (*145*).

Another key consideration for Texas and other states is the importance of evacuation routes. Evacuation routes are essential to ensure safe travel when hurricanes or other emergency events occur. These routes pose challenges when considering the potential for downtime as well as enhanced demand stressing the system. Developing robust systems with multiple redundancies will be key to ensure safe evacuations.

Policies and Regulations Relating to Electric Vehicle Infrastructure

Policies and regulations relating to EVSE range from whether the infrastructure is classified as a utility due to the provision of electricity to building code updates to ensure easy installation.

EVSE or charging stations provide electricity to refuel a vehicle; some states' definition of a utility or public utility may apply to the owners of charging stations or equipment. The rules and regulations for public utilities are extensive and can be prohibitive for the installation, operation, and maintenance of charging equipment. In order to address these issues, 43 states and the District of Columbia have specified that their definition of a public utility does not include owners of EV charging stations (*146*). Depending on the state, the language of the regulation can be a broad exclusion of EV charging facilities from the definition of a public utility, or it can specify that charging facilities owned by non-utilities will not be regulated as a public utility.

Missouri, Montana, New Mexico, North Carolina, and Vermont passed bills to exempt EV charging stations from public utility regulation in 2019, while utilities commissions in Kentucky and Iowa issued decisions to clarify that charging stations do not fall under public utility jurisdiction (*147*). Montana's legislation exempts EV charging stations from public utility regulations; however, it does not allow owners of EV charging stations to charge users by the usage (*147*). Table 2 shows the list of states that exempt EV chargers from the public utility regulations (*148, 149*).

Table 2. List of States That Exempt EV Chargers from Public Utility Regulations (*148, 149*).

States That Exempt EV Chargers from Public Utility Regulations	Enacted Date	References
Alabama	2018-06-22	Docket No. 32694
Alaska	2021-06-24	
Arizona	2022-04-06	Docket No. RU-00000A-18-0284
Arkansas	2017-02-28	SB 272 (2017), Arkansas Code § 23-1-101(9)
California	2011-10-06	AB 631, PU Code § 216(i)
Colorado	2012-05-03	HB 12-1258 Col. Rv. Stats Ch. 40 §101–104
Connecticut	2016-06-07	HB 5510 (2016) and Section 16-1 of the 2016 supplement to gen. statutes
Delaware	2019-12-19	Public Service Commission (PSC) Docket No. 19-0377—Order No. 9516
Florida	2012	Fl. Rev. Stat. §27-366.94
Hawaii		Ha. Rev. Stat. §269-1
Idaho		Idaho Code Section 61-119
Illinois	2012-08-28	220 ILCS 5/3-105 cha 1112/3 par 3-104 enacted 1-24-12
Indiana	2022-03-11	
Iowa	2019-11-27	Docket No. RMU-2018-0100
Kansas	2021-04-09	
Kentucky	2019-06-14	Case No. 2018-00372
Maine		LD 593 Sec. 1. 35-A MRSA § 313-A
Maryland		SB 997, HB 2390, Chapters 631 and 632, Acts 2012 State Govt. Code 1-101(j)
Massachusetts	2014-08-04	Case D.P.U. 13-182-A
Michigan		Case Nos. U-17990 & U-20162
Minnesota		Minn. Stat. § 216B.02 (Subdivision 4.[3])
Missouri	2019-08-28	HB 355 (2019) RSMo 386.020
Montana		
Nevada		SB 145, NRS 704.021 (11)
New Hampshire	2018-08-11	RSA 236:133 as amended by SB 575 of 2018
New Jersey	2020-01-17	S. 2252 (c. 362, 2019)
New Mexico	2019-04-03	HB 521 (2019)
New York		Case 13-E-0199 NY PSC
North Carolina	2019-07-17	HB 329
North Dakota	2021-03-31	
Ohio	2020-07-01	PUCO Case No. 20-434-EL-COI
Oklahoma	2019-01-31	OAC 165:35-13-l(c)
Oregon	2003-01-01	Or. Stats. § 757.005(1)(b)(G)

States That Exempt EV Chargers from Public Utility Regulations	Enacted Date	References
Pennsylvania		Final Policy Statement Order, M-2017-2604382
Rhode Island		R.I.G.L. Section 39-1-2
South Carolina		
South Dakota	2022-02-10	
Texas		
Utah	2014-03-20	HB 19 (2014) Utah Code § 54-2-1
Vermont	2019-06-14	Sec. 39.30 V.S.A. § 203 as amended by Act No. 59 of 2019
Virginia	2011-03-23	Va. Code Ann. § 56-1.2 and 56.1.2:1
Washington, DC		Council Bill 19-749
Washington		SHB 1571 Chapter 28 Laws 2011 Rev. Code of Wash. 80.28.230
West Virginia		W. Va. Code § 24-2D-3
Wyoming	2022-02-16	

As vehicle manufacturers move toward fully electric models, states are also limiting the sales of ICE vehicles. In August 2022, the California Air Resources Board (CARB) adopted a regulation that would ban the sale of new gasoline-powered cars and light trucks by 2035 (*150, 151*). This follows a similar measure by New York State, where Senate Bill (SB) 7788 stipulates that all in-state sales of new passenger vehicles and trucks will be zero emission by 2035 (*152, 153*).

Renewable fuel standards require that a specific percentage of total fuel sold be renewable, while a mandate requires that each gallon of fuel sold have sold certain renewable content percentage (*154*). According to AFDC, there are 17 renewable fuel standards or mandates across the United States, including a federal Renewable Fuel Standard Program. These standards can be a broad goal for all fuel sold in the state or specific to state agency vehicles. Renewable fuel standards or mandates are often in addition to broader renewable portfolio standards (RPSs) and goals. As of 2021, 27 states, including Texas, and the District of Columbia had active RPSs (*155*). RPS programs are important to consider with the switch to EVs because their ability to support climate goals will be reliant on reducing the use of fossil fuels for electricity generation.

Policies and codes can help ease the installation of the EVSE at both commercial and residential locations. According to AFDC, 10 states have enacted right-to-charge policies or laws that allow for the placement of charging equipment at multifamily dwellings (MFDs), condominiums, or properties covered by homeowner's associations (HOAs) (*156*). Policies differ by state, with certain policies stating that owners or HOAs cannot prohibit a resident from placing EV charging equipment, while others allow owners to develop rules around placement, which can prohibit certain specific locations. Certain states have specific protections for MFDs to ensure charging equipment can be installed (*157*).

Ensuring easy access to charging can be partially accomplished through building codes and standards that require buildings to be EV-ready or requirements for a minimum number of parking spaces with EV charging equipment. Make-ready requirements and codes reduce the

time to install if EVSE is required in the facility after construction. Currently, nine states and the District of Columbia have building code requirements that address the need for charging infrastructure.

Guidance for Planning, Permitting, and Installation of Electric Vehicle Infrastructure

The need for greater planning, zoning, and permitting guidance is clear as increased funding levels for EVSE necessitate new sites for charging equipment. California has developed a robust guide to planning and permitting considerations for station developers and local authority-having jurisdictions (AHJs) (*158*). One key consideration is including future-proofing requirements in building codes, as well as easing permitting requirements. Future-proofing requires EV-capable or EV-ready sites to be developed during construction rather than attempting to retrofit existing facilities to accommodate EV charging. Other planning considerations include changes to parking minimums and other zoning requirements. For example, some AHJs have zoning amendments that count EV charging station spaces as two parking spaces.

In terms of permitting, California Assembly Bill (AB) 1236 requires that all cities and counties create a streamlined permitting process for all levels of EV charging stations. The purpose of the bill was to avoid breakdowns in communication that were occurring between AHJs and applicants, reduce the burden on the applicant, and streamline the process for reviews to ensure timely responses. Most cities and counties have developed online permit applications with easy-to-understand checklists to comply with the bill. The guidance also recommends designating a ZEV ombudsperson, a single point of contact who ensures that applicants receive timely, accurate responses to any questions.

California's guidebook also covers accessibility—in order to meet federal requirements and ensure inclusive charging infrastructure is deployed—grid connections, and considerations for construction, commissioning, and operation. Signage will play a key role in accessible charging infrastructure. Accessible spaces should be clearly marked and include courtesy signs to indicate these spaces are reserved for those with disabled placards or license plates unless no other charging space is available. Siting these spaces and infrastructure near pathways or closer to buildings will also provide more accessibility. While grid connections are not essential, depending on the type of charger, most EV charging stations are hardwired. Exploring non-grid connected options can add flexibility into charging systems. Finally, ensuring a smooth approval to operate after permitting requires a harmonization of understanding between AHJs and station developers. Consistent communication on the requirements between the two entities can reduce the overall permitting burden.

New Jersey has developed an EVSE ordinance that the state is mandating as a standard to ensure streamlined practices in terms of land use, installation, and parking requirements as they relate to charging equipment (*159*). The ordinance covers accessory uses in zoning, minimum parking mandates, and EV parking spaces required for new parking areas. Municipalities may deviate from the reasonable standards set by the model ordinance to address installation, sightline, and setback requirements or other health- and safety-related specifications. This does require a supplemental ordinance to the standard EVSE ordinance. The state has provided advice to municipalities on streamlining the process with similar guidance as California, such as

promoting online applications, checklists, and information on the approval requirements and agency reviews.

The Interstate Renewable Energy Council's Sustainable Energy Action Committee's Electric Vehicle Working Group is developing standards and guidelines for local regulations relating to siting and installing EVSE. The guidance document will be available in early 2023. In addition, the Fuels Institute Electric Vehicle Council has developed a best practice guide for EVSE regulations (*160*). Initial findings indicate that many localities are not prepared, in terms of policies and permitting, to install EVSE within their boundaries.

State Programs and Initiatives

Incentive programs have generally focused on expanding EV purchases and usage, but programs that support EVSE generally exist alongside those incentives and are growing with increased EV registrations and the federal focus on clean transportation. State-level grants, rebates, and tax credits can promote the installation of charging infrastructure while also directing efforts toward goals of equity, GHG emissions reduction, and economic development. Financial tools are one way to promote strategic deployment of infrastructure. While rebates and grants represent a cost to the state or local government funding the program, they can further climate goals and generally do not disrupt transportation funding to the same degree as lost revenue from fuel taxes (*161*). Programs have provided funding for the installation of charging infrastructure with additional funding available for chargers in transportation-disadvantaged communities (*162*). Other programs can focus on charging at MFDs or in residential areas that lack good options for home chargers. In Texas, TCEQ offers several grant programs for alternative fuel facilities.

The Alternative Fueling Facilities Program is one of several programs under TCEQ's Texas Emissions Reduction Plan. The program offers grants to construct or expand fueling stations that provide alternative fuels, including natural gas, hydrogen, biodiesel, propane, methanol, and electricity, in an effort to reduce nitrogen oxide emissions from mobile sources within the Clean Transportation Zone (CTZ) (*163*). The CTZ comprises 82 counties across east, south, and north Texas plus El Paso County (*164*). In 2021, TCEQ awarded $11.6 million for 182 projects in eligible areas. Of those projects, 106 were awarded for EV charging projects—either new construction or expansion projects—totaling $4.2 million or 36 percent of project funds.

Another TCEQ program is the Volkswagen Infrastructure Funding Program. TCEQ is the lead agency for the administration of funds received from the Volkswagen State Environmental Trust. The trust is part of a settlement agreement in the litigation between the U.S. EPA, the State of California, and Volkswagen. The trust allocated a minimum of $209 million to Texas for projects that reduce nitrogen oxides in the environment.

The Beneficiary Mitigation Plan for Texas published by TCEQ in May 2020 summarizes use of the mitigation funds allocated to Texas under the trust and establishes four major goals for use of mitigation funds to alleviate air quality impacts (*165*). One of the plan's goals is to prepare for increased and sustained use of ZEVs. The plan notes that under the trust agreement, up to 15 percent of the funds (about $31 million) may be used for equipment to supply light-duty ZEVs with electricity or hydrogen. In October 2021, TCEQ announced that $20.9 million will be awarded as grants statewide for the purchase and installation of DCFCs for LDVs in a public

place, workplace, or multiunit dwelling and light-duty hydrogen fuel cell vehicle supply equipment (*166*). In addition, TCEQ requested applications for grants to distribute $10.4 million to help fund Level 2 electric charging infrastructure (*166*).

The DC fast-charging request opened October 6, 2021, and TCEQ suspended acceptance of applications on November 3, 2021. TCEQ received 250 applications, all of them for EV charging infrastructure, for a total of 712 charging units and requesting a total of $89 million. The average project cost was $359,000, with an average per-charger unit cost of $126,000.

EV promotion through rebates and grants is helpful when increasing the adoption of clean transportation for environmental goals, but it does create transportation funding issues. Transportation funding is heavily reliant on fuel tax revenue, which was already declining with increases to fuel efficiency and is severely impacted by the increased adoption of AFVs. To address this issue, states have enacted additional registration fees and tested VMT fees, also known as road usage charges (RUCs). Currently, 31 states have an additional registration fee for AFVs, such as hybrids, PHEVs, and EVs. Since 2013, the Texas Legislature has introduced 17 bills aimed at establishing an AFV fee, but so far none have passed (*167*). Oregon and Utah have both developed RUC programs as an alternative to either registration fee increases or the fuel tax for ICEs. Utah's RUC is a voluntary program offered as an alternative to paying an additional registration fee. The legislation enacting the RUC first passed in 2018 and offered a 1.5 cent per-mile alternative to registration fee increases for hybrids, PHEVs, and EVs. In March 2022, HB 186 made amendments to the program by reducing participants to just EVs. Hybrid and PHEV owners will still be assessed an additional registration fee, but EV owners will have the option to pay an additional registration fee or opt into the RUC (*168*).

Overview of MPO and Local Regulations, Guidance, and Programs

Increased funding at the federal level provides an opportunity for local and regional investment through MPOs. While EV charging planning is occurring within most cities across Texas, MPOs will also have a role in coordinating federal funding to support the build-out of a national network. Development of an effective regional charging siting will require coordination between local entities and the MPO to ensure the efforts are included in planning documents for federal funding eligibility.

North Central Texas Council of Governments

NCTCOG is developing a ZEV corridor plan along Interstate 45 from Dallas to Houston that will define a strategy for building infrastructure to support electric and hydrogen fuel cell vehicles, with an emphasis on medium- and heavy-duty (MHD) trucks and buses (*169*). The plan will further support future strategic initiatives in the corridor with respect to automated vehicle technology and truck platooning strategies. The work is funded through USDOT AFC Deployment Grant Awards that were made to five state DOTs and MPOs, including NCTCOG (*170*).

NCTCOG started work as a subgroup in August 2020 to guide plan development, lend expertise, and ensure that appropriate details are addressed (*171*). The group discussed the need to expand DC fast-charging stations along the 290-mile corridor that accounts for nearly half of truck

freight movements in Texas and provided estimates for electricity demand. Based on assumptions that one station would have 20 DCFCs with a future estimated capacity of 350 kW, total demand would be 7 MW per station, or 35 MW assuming five stations along the corridor. The impact on ERCOT's grid was estimated to be 0.05 percent of the 75,000 MW peak ERCOT demand in 2020, or 1.1 percent of the 3,100 MW annual peak demand growth between 2020 and 2021.

NCTCOG has been working on estimates for truck volumes along the corridor, origin/destination estimates, potential fuel volumes needed, and port-specific information. NCTCOG has developed two related surveys, requesting input from alternative fueling providers and from fleet providers, and it is in the process of developing a tool for alternative fuel stations similar to the Map Your Experience tool for customer feedback (*172*). For the development of EV charging stations, NCTCOG is considering a phased approach consisting of pilot, launch, scale-up, and deployment phases (*173*). According to the plan, the launch phase will demonstrate the business case, involve 10 vehicles, and include three EV charging sites with two to four charging ports per station, one each in the DFW, Houston, and mid-corridor areas. During the scale-up phase, one site will be added in DFW and one mid-corridor for up to 50 vehicles.

Outside of NCTCOG, planning at the MPO level is in the early stages for EV charging and development. Planning and funding cycles can play a role in the limited discussion of EVs, but with the recent influx of federal funding, plan updates may now include EV charging infrastructure at key sites in MPO regions. The Capital Area Metropolitan Planning Organization currently lists EVs under the Future Technologies section of its long-range plan, but the plan was adopted in 2020 before the passage of IIJA. The Houston-Galveston Area Council (H-GAC) does not include EVs within its planning documents, but it has been noted as a future focus area in meeting minutes. The Alamo Area Metropolitan Planning Organization (AAMPO) updated its plan in 2022 and specifically referenced IIJA, indicating projects that are currently incorporating EVSE, such as at transit centers and park-and-rides (*174*).

Local Regulations, Programs, and Initiatives

Higher adoption rates of EVs in urban areas has led to greater development in terms of regulations, programs, and initiatives in certain instances than at the state level. Local regulations can include vehicle acquisition requirements. For example, the City of Alexandria in Virginia has targeted reducing the GHG emissions of its fleet by 25 percent. Reducing emissions will require a switch to AFVs, such as EVs. Infrastructure requirements are another regulatory tool to ensure the development of EVSE; these regulations prohibit owners or landlords from preventing the installation of charging equipment or requiring a minimum number of charging spaces in parking areas (*175*). Other local regulations have been directed by the state, such as make-ready ordinances and right-to-charge policies.

Educational programs as well as purchase, parking, and public charging incentives have been developed at the local level in Texas. Austin Energy, the public utility serving the city, provides educational content and has invested in and owns charging infrastructure across the city (*176*). Austin Energy also provides incentives to charging with its publicly available stations. El Paso Electric has similar educational content and has developed an electrification plan for New Mexico (*177*).

The importance of charging infrastructure at the local level has also necessitated planning efforts to leverage private investment. These efforts should be considered when partnering with MPOs to develop regional redundancies. Coordination between local, regional, and state plans and investments will avoid overlap and could help to advance other goals. For example, Austin and San Antonio both have climate action plans that include EVs as part of their transportation strategy (*178, 179*). Key to meeting climate goals will be switching energy generation that powers EV charging to renewable sources. Early and effective communication between state and local governments will allow for more efficient bundling of projects, as well as the potential to co-locate renewable energy generation such as solar. In addition, Houston and the Texas River Cities (TRC) region, which includes cities across 10 counties in Texas, have developed EV infrastructure plans that highlight key areas for investment and provide information on permitting and communication (*180-182*). The TRC plan was developed by Austin Energy and is aimed at utilities, while Houston's recent efforts have been developed by a nonprofit, Evolve Houston.

CHAPTER 3. REGIONAL STAKEHOLDER WORKSHOPS

INTRODUCTION

TTI conducted three stakeholder workshops to inform the research on a long-term plan for EVs in Texas. The purpose of the workshops was to discuss current TxDOT plans related to EV charging infrastructure with stakeholders and to collect feedback from workshop participants regarding priorities, active initiatives, and planned activities. TTI solicited information about estimating energy demand and factors that drive energy demand, policy considerations, and potential strategies, including financial strategies. TTI considered current state and federal policies with requirements tied to funding as a priority in the stakeholder engagement process.

WORKSHOP PARTICIPANTS

During the workshop planning activities, TTI identified workshop participants who were both traditional and nontraditional transportation and energy subject matter experts in related transportation sectors that are gaining relevance and importance as electric mobility matures and becomes more widely adopted. TTI started a list of potentially interested stakeholders that included representatives from the following agencies:

- TxDOT.
- FHWA.
- Local public agencies and MPOs.
- Freight industry.
- Automotive industry representatives.
- Automobile associations.
- Utilities.
- Infrastructure providers.
- Technology providers.
- Electric charging providers.
- Fleet owners and managers.
- Fuel station owners and operators.
- Disadvantaged community representatives.
- Public Utility Commission of Texas.
- ERCOT.
- TCEQ.
- State Energy Conservation Office.
- Texas Department of Licensing and Regulation (TDLR).
- Texas DMV.
- Texas Department of Housing and Community Affairs.
- Texas State Affordable Housing Corporation.
- Texas Division of Emergency Management.
- Texas Economic Development and Tourism Office.

TxDOT provided a starting point of potential stakeholders by supplying a list of interested stakeholders from TxDOT's outreach activities during the development of the NEVI plan. In

addition, research panel members provided a listing of potentially interested stakeholders. For the third workshop, the hosting agency, NCTCOG, also distributed registration information to its Clean Cities Coalition contacts. Researchers also encouraged stakeholders to invite colleagues and connections known to be relevant in the field of vehicle electrification.

WORKSHOP LOCATIONS

TTI discussed options of how best to conduct the three workshops with the research panel to maximize participation from stakeholders. Discussions included potential topics to focus on in each workshop, potential presenters, topics for breakout discussions, workshop durations, and logistical questions—such as availability of rooms of adequate size. Following these discussions, TTI made plans to conduct the first workshop virtually only, the second workshop in person only at the TxDOT Stassney Office Building and Campus facilities, and the third workshop as a hybrid involving either in-person attendance or virtual attendance for part of the workshop. In January, TxDOT requested a change of the research project's title to better differentiate research activities from TxDOT's own activities to implement and refine its NEVI plan for EV charging infrastructure. As a result, TTI changed the title of the third workshop accordingly. TTI conducted three workshops as follows:

- Workshop 1: Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop, conducted virtually on November 9, 2022, from 8:00 a.m. to 12:00 p.m.
- Workshop 2: Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop, conducted in person on December 9, 2022, from 9:00 a.m. to 12:00 p.m. at TxDOT, 6230 E. Stassney Lane, Austin, Texas, 78744.
- Workshop 3: Post-NEVI Electric Vehicle Infrastructure Research (Freight, Fleet, and Multifamily Housing [MFH]) Workshop, conducted in person and virtually on February 22, 2023, from 9:00 a.m. to 4:00 p.m., NCTCOG Main Office, Centerpoint II, 616 Six Flags Drive, Arlington, Texas, 76011.

Workshop 3 was initially scheduled for February 1, 2023, at NCTCOG but was postponed due to a winter storm at the workshop location. Agendas for each workshop are included in Appendix A, workshop invitations that were sent to stakeholders are included in Appendix B, lists of attendees for each workshop are included in Appendix C, and selections of workshop presentations given at each workshop are included in Appendix D.

WORKSHOP INVITATIONS

Workshop invitations were distributed approximately 3–4 weeks ahead of each workshop date. Prior to sending invitations, the research team assembled an approved, finalized list of stakeholders and their contact information. This list included (a) stakeholders previously identified by TxDOT as having an interest in EV planning in the state, and (b) additional contacts provided by the project panel. Before the second workshop in Austin, researchers sent a workshop announcement to members of the Utility Engineering and Surveying Institute of the American Society of Civil Engineers. Researchers set up an online registration form to keep track of event registrations. The invitation included an anonymous registration link and encouraged stakeholders to forward the invitation to others who might be interested. Invitation content included the following:

- Project background and workshop purpose.
- Working agenda.
- Confirmed date, time, and location (link for virtual).
- Registration information.

The following section provides a summary of the overall findings of the three workshops. Three subsequent sections present information on each of the three workshops, providing an overview of the activities the research team conducted, results of a follow-up survey to improve workshops two and three, and workshop findings in the form of panel presentation and breakout session discussion summaries. The topics that were discussed and are summarized here reflect the opinions, needs, concerns, and biases of the stakeholders who attended the workshops.

SUMMARY OF WORKSHOP FINDINGS

This section provides a summary of the discussions with stakeholders at the three workshops. The section organizes the discussions in terms of needs and concerns that were voiced by stakeholders, opportunities to improve the coordination among stakeholders, considerations for TxDOT long-term EV infrastructure strategies, and other important topics.

Stakeholder Needs and Concerns

The following bullet list provides a summary of stakeholder needs and concerns:

- **Understanding Local EV Adoption and Demand.** Some stakeholders were concerned about how to determine or estimate current and future numbers of EVs in order to determine current and future demand for EV charging infrastructure.
- **Return on Investment for EV Charging Infrastructure.** Many stakeholders agreed that it is currently challenging to determine the estimated return on investment for EV charging infrastructure.
- **Understanding Grant Programs.** Many stakeholders were concerned with the number of potential grant programs in the EV space, along with understanding what government programs are available and how to apply.
- **Ability to Apply to Funding Programs.** Many stakeholders were concerned about having sufficient staff, expertise, and necessary data to support applications for funding programs.
- **Grant Preparedness Workshops.** It would be beneficial to have future workshops that bring private and public stakeholders together to prepare for and discuss strategies for upcoming grants. These events could be held regionally, leveraging stakeholder engagement in the NEVI program. Meetings should include the MPO's local planning partners.
- **Identifying EV Charging Infrastructure Locations.** Having the right tools and expertise to use the tools to identify EV charger locations is a challenge for many stakeholders. In addition, the process of identifying EV charger locations is unclear to some stakeholders, as is knowing whether TxDOT, the county, or the city has any say about what locations are permissible. Parking regulations and zoning ordinances may need to be modified to accommodate EV charging infrastructure. It would be useful to have model ordinances as a starting point.

- **EV Charging Site Considerations.** Stakeholders had questions about amenities, restrooms, restaurants, and security that should be available at an EV charging location. For example, do restrooms and other amenities need to be open and accessible 24 hours a day or can availability be limited? Scoring of available amenities may help with site selection.
- **EV Charger Accessibility.** Stakeholders discussed the need to make EV chargers accessible for the disabled population. In addition, charging should be as simple as possible and not include unnecessary technological hurdles, such as requirements for certain applications or payment systems.
- **Addressing Rural EV Charging Infrastructure Needs.** In rural areas, where there may not be a clear financial incentive for the private sector to provide EV charging services, an approach modeled on utility cooperatives may be needed to ensure access and service to customers and EV users.
- **Need for EV Charging Infrastructure Guidance.** During planning, it is important to note that the installation of chargers may involve more work than placing a charger. Electrical infrastructure may need to be updated, and the location may need to be approved and permitted.
- **Blocking of EV Charger Parking Spots.** There was concern on how to enforce the misuse of EV charging parking spots by ICE vehicles. A related issue is EVs parked in quick-charging spots overnight. Since they are not charging the entire time they are parked there, another EV could be charging at that location. One possible solution is to have a sensor to track if the EV is still there. Then, a gross amount could be charged for parking over the allotted amount of time needed to charge the EV.
- **EV Fast-Charging Installation Costs.** The main items that have increased the EV fast charger installation cost include the electrical grid interconnection to make the site ready and the ADA accessibility requirement. The interconnection cost is very location-specific and will vary depending on where chargers are located. Although TxDOT cannot help with the make-ready cost, TxDOT may be able to bring awareness to the issues involved in the make-ready cost.
- **Equity Considerations.** Equity can have many dimensions, such as geographic equity that distributes EV chargers equitably over a region. There is also price equity, which takes into consideration the time cost to access EV chargers, and land use equity, which considers equitable use of available public space.
- **Guidance for Justice40 Initiative.** Stakeholders mentioned that there does not seem to be much guidance available to implement the Justice40 Initiative. There also seems to be an overall lack of discussion or thought leadership. One issue is that there are so many options to address the requirements. For example, job opportunities, charger placement, air quality improvements, or direct health outcomes could be included, but some benefits will be difficult to prove.

Opportunities for Stakeholder Coordination

The following bullet list provides a summary of opportunities for stakeholder coordination:

- **Coordination Leadership.** Stakeholders in general perceived TxDOT as the clear leader or convenor for ensuring interagency coordination statewide. This leadership is supported

by TxDOT's role in the NEVI program and its role in coordinating other transportation-related initiatives statewide. Stakeholders mentioned that a bill introduced in the current legislative session will require, if passed, the establishment of a Texas Transportation Electrification Council made up of senior representatives from a range of public entities and administratively located at TxDOT (*183*). Regardless of the outcome of the bill, it was noted that TxDOT will be expected to play a lead role in coordination efforts, whether mandated by state law or otherwise.

- **Interagency Coordination Challenges.** Agencies are working with accelerated timelines to address EV charging issues, which in itself makes effective interagency coordination challenging. Another challenge that may have to be overcome for successful interagency coordination is the need to balance inclusivity with stakeholder fatigue; involving a diverse group of stakeholders sometimes results in too many meetings. If possible, meetings or events should be combined with other stakeholder engagement processes. It is also a challenge to find the right organizations to include in meetings, as well as the right people within the organization.
- **Balancing Coordination Goals.** Interagency coordination should balance state-level goals with local goals. A model of interagency coordination mentioned by participants was the Volkswagen (VW) mitigation settlement funding allocation process (*184*). Another example was the improvement of traffic safety in a process coordinated by the National Highway Traffic Safety Administration (NHTSA) that required each state to establish a high-level safety office as part of the governor's office or at a similar level (*185*).
- **Partnership with TxDOT.** Stakeholders discussed how TxDOT could support activities of local public transportation agencies. Although TxDOT has a large amount of data, it is not always clear how the data can be used. However, once performance measures are developed, data needs will be clearer. Under the NEVI program, utilization data at individual charging stations will be reported quarterly, which will be useful. The level of needed data aggregation, however, is not clear at this point.
- **Central Information Repository.** It would be beneficial to have a central location for information related to the EC charging infrastructure development. For example, a website can list contacts for those interested in working within the state. Municipalities can list information, certification, or registration requirements to conduct local business. Other states—for example, Colorado and Louisiana—use simple tools such as Google forms to build this database (*186*).
- **Database of Grant Applications.** It would be very useful to have a database of grant applications, including grants that did not get approved. Even if they were not successful for the NEVI program, they might be useful for other programs.
- **MPO Coordination.** Coordination is needed among MPOs to share best practices and approaches with regard to EV charging infrastructure planning. Smaller MPOs might not currently have a platform to engage. However, collaboration might be limited by federal discretionary funding programs if MPOs are competing for funding against each other.
- **Non-Metro Coordination Coalitions.** The Clean Cities Coalition Network has greatly promoted EVs and provided resources, but it is geared toward more urban areas. A coalition-type approach would be beneficial in supporting currently underserved areas, similar to the Clean Cities Coalition Network model. This approach would be a creative way to help stakeholders and promote equity across Texas. Similar types of organizations

for the non-metro areas of the state would also be helpful. Since the needs are different in less populous areas of the state, there may be a need for a different perspective for the coalitions, which may include more infrastructure facilitation than an emphasis on clean air/clean cities.

- **Coordination among Fleet Transition Stakeholders.** Depending on the type of fleet, some attendees are engaging with fire, emergency medical services (EMS), sustainability, and parking organizations. The internal communication is still being worked out for most organizations who want to electrify their fleets. There are a lot of internal groups to consider and include in the conversation. Some of the outside stakeholders to engage with include the local electrical utility companies. Collaborative programs between stakeholders are also being established. A partnership called Resilient Now, between the City of Houston and CenterPoint Energy, was established to develop a regional master energy plan (*187*). This action should help the city prioritize its investment in transitioning its fleet.
- **Interpretation of ADA Requirements for EV Charging.** Complaints regarding a municipality's lack of ADA accessibility for EV chargers were filed with TDLR. Now that federal guidelines have been released, cities must adhere to TDLR rules at the state level. It seems that TDLR and TxDOT interpret the guidelines differently. There was discussion regarding how legislation at the state level may solve some of the challenges cities and others are facing when looking to install EV chargers and infrastructure.

Considerations for TxDOT Long-Term EV Infrastructure Strategies

The following bullet list provides a summary of considerations for TxDOT long-term EV infrastructure strategies:

- **EV Teaming Dashboard.** Several states have created central websites to provide information about EVs, including adoption rates, charging information, and other related information; one example is Oregon DOT (*188*). TxDOT could expand its current NEVI website to add more information that stakeholders are looking for.
- **Community Engagement and Education.** A program to provide outreach to communities on the benefits of EVs and to involve the community in assisting with EV charger site selection may be helpful. Job training programs could be a key for community engagement.
- **Resources and Training Opportunities for Grant Programs.** Stakeholders voiced interest in the following:
    - How to communicate benefits and use of EVs.
    - Case studies, success stories, and general implementation best practices.
    - Implementation of best practices in rural areas with predominantly heavy-duty and farm vehicles.
- **Creating Needed Data Products.** Providing support that is specifically geared toward the data needs of specific federal EV funding programs may be helpful.
- **Support for EV Charging Location Determination.** Providing support to identify potential locations for EV charging infrastructure based on local priorities and requirements could be beneficial.

- **Programs for Commercial Vehicle Electrification.** Many EV programs currently focus on passenger vehicles. There is a need for federal and/or state programs that focus on electrification of MHDVs or commercial vehicles.
- **Analysis of EV Charging Demand.** Texas needs an analysis of EV charging demand that includes local, regional, and interstate demand. This analysis should be regularly updated and widely shared with EV charging stakeholders.
- **EV Charging Station Maintenance.** Addressing EV charging station maintenance in areas with lower use and lower or no profitability could be helpful. Charging locations in areas with less demand or non-NEVI corridors might operate at a loss. There should be a discussion on how interagency cooperation can help small business owners avoid EV charger deployments that are not profitable.
- **Electric Grid Infrastructure for Fleet Charging.** Upgrading electric networks to enable fleet charging may be a challenge since fleets may want to charge quickly, will have a high electricity demand, and will have many vehicles. That combination could be a challenge from an electric grid perspective. As of today, fleets are expected to take a minimum of 6 years to electrify, while electrification of school buses may take 12 to 14 years. Although it remains to be seen how quickly fleet charging will be adopted in Texas, it is expected to be a gradual process and therefore should be manageable from an electric grid infrastructure planning perspective. Fleet charging is seen as a point problem since a great amount of electricity is needed at a particular location. Point problems may be addressed by providing charging at multiple locations since EVs can drive to a location where the grid has power. Thus, fleet EVs may need to be flexible in terms of charging locations. The availability of suitable fleet charging locations could affect actual versus planned operation of fleet EVs and fleet EV charging infrastructure.
- **EV Charging Data.** TxDOT will receive data from EV charging infrastructure every quarter and will share it with others. These data will be an important source of information for ongoing EV charging infrastructure development.
- **Adaptable EV Charging Implementation Process.** Uncertainty with the current predictions of EV adoption exists, so the EV charging implementation process should be flexible and adaptable. Continual feedback and updates to the EV implementation model are important to ensure that the growth expected is in line with the capacity of the electric infrastructure in the time period needed. The number of chargers in the NEVI plan are only 8 to 10 percent of the number of chargers that will ultimately be needed in Texas.
- **EV Charging Technology Improvements.** NEVI and other programs are intended to provide funding for several years, during which technology will likely change and improve. For example, a minimum of 150-kW charging capacity might not be sufficient in a few years.
- **EV Charging during Emergency Events.** Uncertainty exists regarding EV infrastructure and vehicles in areas that are prone to flooding and areas prone to weather events like hurricanes. It is not clear what safety measures need to be in place for the vehicles and infrastructure. For example, during a hurricane, many gas stations have gas but no electricity to pump the gas into vehicles. Emergency evacuation routes have an infrastructure shortage to support existing EVs during an emergency. TxDOT should focus on resiliency and redundancy for evacuation routes and consider mobile charging trucks to be used during emergencies. Some private companies have started using mobile

trucks for roadside assistance, but they may not be able to support future demand during emergencies.

- **Fleet EV Transition Guidance.** Guidance on how fleets can transition to EVs would be helpful. The Transportation Research Board and National Cooperative Highway Research Program may have some guides and information. There may be some information on how to determine locations for EV charging infrastructure, if not for fleets. It might be useful to partner or talk with EMS for fleet EV transition.
- **EV Charging Performance Specifications.** It is unclear whether EV charging stations need to be operational by the end of 2023 to meet performance requirements. It is estimated to take 6 to 18 months to complete the installation of a charging station. There is no guaranteed delivery date due to supply chain disruptions for the EV charging equipment. This issue affects partnering with equipment providers and manufacturers.
- **EV Charger On-Site Energy Storage.** The NEVI plan for EV charging stations does not include sufficient funds for on-site energy storage, which can be critical during peak hours. In some cases, regulations might not allow EV charging stations to generate energy on-site and store it in batteries to sell during peak-hour demand. TxDOT might be able to help with the infrastructure to store energy on-site and use it as needed.
- **Alternative Energy Sources for EV Charging.** Stakeholders discussed the range of alternative energy sources for electricity generation, including wind and solar, and the importance to plan for the efficient use of all types of energy sources. However, the installation of solar infrastructure at EV charging stations might reduce the competitiveness of the bid.
- **EV Charging at Multifamily Housing Units.** Some stakeholders were concerned about renters who cannot install a charger in their home. Due to the lack of sufficient charging options, there are a lot of unsatisfactory trade-offs for EV owners who are renting. From a public charging perspective, apartment complexes and offices will need at minimum Level 2 if not Level 3 chargers. One solution could be on-street charging.
- **New EV Grant Programs.** Stakeholders discussed what new grant programs would be useful to address current equity problems and support EV adoption. For example, it would be great to have a program to support neighborhood EVs in disadvantaged and low-income communities. Programs could also support micromobility options, such as partnerships with rideshare companies. Grants are also needed to support the needs of transit agencies. Finally, stakeholders noted that current efforts are focused on electrifying the status quo of mobility and vehicle ownership but should be focused on improving mobility overall.

Other Workshop Findings

The following bullet list provides a summary of other workshop findings:

- **Direct Pay Programs.** A direct pay program implemented by the state in lieu of a tax credit will benefit not-for-profit agencies that do not have a tax liability.
- **Electric Rate Incentives.** Electric companies can set rates that are advantageous to the adoption of EVs. For example, they can allow charging at night at low or no cost. This strategy should be accompanied by education and outreach to EV owners.

- **Medium- and Heavy-Duty Vehicle Electrification.** Electric trucks and MHDVs are still more expensive than vehicles using ICEs. Programs and funding are needed to bring electric MHDVs closer to cost parity with ICE vehicles.
- **Capturing Sales Tax Revenue for EV Charging.** In some areas, such as malls and other commercial areas, EV charging could induce revenue that could be captured by a sales tax. This option could become part of the discussion to replace the declining gas tax revenue.
- **Impacts on Electric Grid Infrastructure.** Incentives may be important to ensure more electrical generation infrastructure is built in a timely manner to support EVs.
- **DC Fast Charging for Fleet Vehicles.** For a fleet vehicle that is in use 12–14 hours a day and has a large battery on board, the only option is using DCFCs. A concern is that relying on DC fast charging alone will decrease battery life over time. Some DCFC technology for fleet vehicles exists, but it is still expensive, difficult to implement, and not yet widely available.
- **Small Business Support Programs.** Stakeholders discussed ideas to support the goals of disadvantaged business enterprise (DBE) programs. TxDOT will be in a good position to support these goals and can make sure that contractors follow these programs. Ideas included the use of DBE lists that could be published by TxDOT, new DBE goals for lead contractors and not just subcontractors, and requirements for DBE outreach.
- **EV Charging Infrastructure Workforce Development.** Stakeholders talked about apprenticeship programs for electricians. Some local/municipal programs are focused on that topic—such as the City of Dallas Green Job Skills initiative—but it is uncertain whether there will be funding available to build new or maintain existing programs (*189*). Texas State Technical College and the Texas Workforce Commission could be great resources in this area.

WORKSHOP 1—STATEWIDE VIRTUAL WORKSHOP

Workshop Activities

Researchers conducted the virtual workshop using WebEx video conferencing software that allowed participants to see the presenters and their presentations virtually. Participants were able to post questions using the software's chat feature, which was monitored by a research team member. Later during the workshop, participants joined virtual breakout rooms in which participants were able to talk directly to each other.

A total of 107 stakeholders from 10 states representing 62 organizations attended the virtual workshop and participated in workshop activities. The workshop began with a short introduction from the research team on the project background and objectives and the purpose of the workshop to collect stakeholder input. TxDOT then gave a brief overview of the agency's plan for the NEVI program. This presentation included background on the federal formula funding provided through the IIJA and how it applies to Texas, an overview of existing and planned charging station distributions in Texas, timelines for planning and implementation, and how to find more information through TxDOT resources. The research team facilitated 20 minutes of questions and answers, during which stakeholders inquired about TxDOT's NEVI plan, about charger technologies and types, about TxDOT's role in the upcoming federal discretionary funding program, and about plans for heavy-duty alternative fuel options.

After the TxDOT overview, a panel consisting of the following three representatives from the energy industry discussed their plans and preparations for increased adoption of EVs in Texas:

- Chantelle Barretto, Lower Colorado River Authority (LCRA).
- Randy Boys, Oncor Electric Delivery Company.
- Jeff Billo, ERCOT.

Ms. Barretto presented background on LCRA and the Texas public power corridor, with a focus on how coalition-building and cooperation can drive strategic planning for grid support of transportation electrification. Mr. Boys discussed short- and long-term challenges and opportunities for utilities in an era of increasing transportation electrification, such as the need to increase capacity for heavier pulls from the grid and the potential for new technologies (e.g., non-wire alternatives) to emerge. He discussed vehicle-to-grid (V2G) and vehicle-to-home (V2H) integration, stressing that technologies to achieve bidirectional power transfer exist, but existing markets and social structures pose a barrier. Mr. Billo provided an overview of ERCOT's infrastructure and service provision, including generation, transmission and distribution, and sales. He then discussed transmission planning and how forecasts include EV adoption estimates broken down by vehicle class, geography, and usage. Following the presentations, panelists engaged with the audience, discussing topics such as collaborative approaches among stakeholders to prepare for EV infrastructure implementation and management of grid loads.

After a short break, participants were asked to join one of the following seven virtual breakout groups, each led by a facilitator of the research team. The breakout groups were titled:

- Funding and Finance.
- Equity and Inclusion.
- Energy Supply and Demand.
- Jobs and Workforce Development.
- Public Agency Fleet Transitions.
- Interregional Connectivity.
- Customer Experience.

All groups were attended by participants who provided perspective and insights for each breakout topic with the exception of Group 4, Jobs and Workforce Development, which had no participation by workshop attendees. A TTI facilitator led the discussions, ensured that all participants had an opportunity to contribute, and took notes summarizing the breakout discussions. Following these discussions, all participants reconvened in the main virtual room, and facilitators shared a brief summary of the topics that were covered in each breakout session.

Follow-Up Survey Results

A follow-up survey was sent to workshop participants on November 15, 2022, less than 1 week after the workshop. Nine participants responded to the survey. All nine survey respondents indicated the highest ranking of "very satisfied" in regard to the presentations at the workshop. Six were "very satisfied" with the web conference platform, seven were "very satisfied" with

opportunities to contribute, five were "very satisfied" with the breakout conversations, and seven were "very satisfied" with the overall peer exchange.

Qualitative comments from the survey responses showed that the only point of dissatisfaction was one participant whose breakout room had technical difficulties with unmuting participants, thus creating difficulties for people to share their opinions and experiences and ask questions. On a more positive note, another participant commented that they "left feeling more confident in the various state organizations and utilities and their plans for handling EV growth," and another said the workshop was "very helpful in terms of knowing what is happening around the state and how we might collaborate." For future workshops, participants suggested topics of managed charging, grid capacity, and NEVI funding implementation.

Workshop Findings

In the first half of the workshop, stakeholders engaged heavily with the panel of speakers, asking questions about the NEVI plan and charger types to be installed, showing interest in legacy and emerging technologies in EV charging, and showing concern regarding a diversity of charger connection types, speeds, and locations. In the second half of the workshop, stakeholders discussed EV-related topics in small groups. The following provides a summary of the overall workshop discussion and discussions of each breakout group. The topics that were discussed and are summarized here reflect the opinions, needs, concerns, and biases of the stakeholders who attended the workshops.

Funding and Finance

An electrical cooperative from a small town in Texas shared some of its concerns and perspective for developing and implementing EV infrastructure:

- **Return on Investment in EV Infrastructure.** The cooperative serves residential customers, other customers in rural areas, and dairies and ranches. Financial concerns are different for electric cooperatives than for a traditional electrical company. Fundamentally, electrical cooperatives have to forecast a return on investment because the cooperative invests the funds of the cooperative's members, which impacts their ability to invest in EV infrastructure. However, future charging patterns and needs are not well known.
- **Understanding Local EV Adoption.** The cooperative is seeing an uptick in EV adoption in the urban parts of its service area, but it is difficult to determine the actual number of EVs within that area. The cooperative is developing a program for EV owners to self-report to the cooperative so it will know what areas need to be serviced with EV infrastructure.
- **Fair Investments in EV Charging Infrastructure.** The cooperative has to serve all members, and it appears that urban areas have more interest in and higher adoption of EVs. As long as rural areas are not interested or have little interest in EVs, it is difficult to ask rural farmers and ranchers to subsidize EV infrastructure in urban areas.
- **Government Funding Programs for EV Charging Infrastructure.** The cooperative would like to know what government programs are available to pay for the installation of EV charging stations. Until government investment is available for rural EV

infrastructure, it will probably not be a priority for the cooperative. The cooperative will look carefully at the opportunities in the county seat areas outlined in the TxDOT NEVI plan.

- **Tracking Grant Opportunities and Writing Grants.** There may be a few areas of interest for EV charging infrastructure funded through the upcoming federal discretionary funding program. However, the cooperative does not have the staff to track funding opportunities or write grants. The cooperative has to partner with a grant writer any time it submits a grant application, and it takes time to coordinate with the grant writer and assemble the grant application.
- **Travel Demand Data and TxDOT Support.** TxDOT could help the cooperative by providing information regarding when EV travel demand on routes in its area reaches a point where the EV charging infrastructure is sustainable. TxDOT could further assist with data or tools to identify potential EV infrastructure locations and to assist with equity considerations.
- **Identifying EV Charging Locations.** The cooperative has considered building EV charging stations at service stations. One major concern is what EV charging customers will do while waiting for their vehicle to charge. In many potential locations for EV chargers, such as restaurants or stores, there is no business infrastructure other than traditional service stations to support lengthy charging.
- **Direct Pay Programs.** The federal government has adopted a direct pay program as an alternative to a tax credit. Under this program, the federal government pays the equivalent amount of the tax credit, which helps not-for-profit organizations that may not have a tax liability and cannot benefit from a tax credit. It would be great to see the state implement a similar direct pay program to incentivize EV infrastructure investment. Although Texas has no state income tax, there are other taxes, such as a sales tax.
- **Electric Rate Analysis.** Electric companies have the ability to set rates that are advantageous to the adoption of EVs, so a determination of what the rate should be needs to be determined. At this point, it is also unclear how V2G charging infrastructure will be standardized.

A manufacturer of commercial trucks and buses shared perspectives for developing and implementing EV infrastructure. The manufacturer is currently building a medium-duty electric truck and an electric school bus. The company is working on producing a heavy-duty electric truck in the near future and plans to electrify Class A vehicles in the 2025/2026 timeframe:

- **Cost Parity.** The need from a customer's standpoint is cost parity between diesel and EVs. Unfortunately, electric trucks are still about three times more expensive than traditional ICE trucks due to a number of reasons, including supply chain issues, inflation, and the cost of technology. The cost of electric heavy-duty trucks is expected to decrease when demand and production increase due to economies of scale. Funding and incentive programs to bring EVs closer to cost parity will be essential for the foreseeable future.
- **The Texas Emissions Reduction Plan.** The Texas Emissions Reduction Plan (TERP) is a TCEQ program that provides financial incentives to eligible individuals, businesses, or local governments to reduce emissions by upgrading or replacing polluting vehicles and equipment (*190*). By working to remove outdated vehicles and equipment from the road,

job site, or field, TERP is accomplishing its mission to cut nitrogen oxide emissions and reduce impacts on the environment. TERP offers grants for people and businesses in industries like trucking, farming, and construction. Recipients can use the funds for upgrading to newer, cleaner technology and retiring outdated pieces of machinery. TERP also offers rebates for electric or natural-gas-powered passenger vehicles and money to implement new technologies. However, TCEQ is no longer accepting applications for EVs since the current number of applications and reservations received by TCEQ for these vehicles exceeds the 2,000 rebate grants available for the funding period.

- **Battery Sourcing.** The most significant cost of an EV is the battery. The company has been looking at battery localization strategies in the United States and also at opportunities to leverage relationships with other producers of batteries. However, the cheapest batteries are currently manufactured in China with Chinese-mined materials.
- **EV Charging Infrastructure for Commercial Vehicles.** A lot of the EV infrastructure implementation is focused on passenger vehicles and not commercial vehicles. The needs are higher in commercial operations, so DCFC is recommended as a minimum charging standard for trucks. The industry is developing the megawatt (MW) charging system (MCS) that will be able to charge at a maximum rate of 3.75 MW (*191*). EV charging infrastructure development will be the key to increasing medium-duty EVs on Texas roads. A concern is the need to standardize the charging infrastructure.
- **NEVI Public-Access Requirement.** Due to the public-access requirement for EV infrastructure in the NEVI funding program, customers such as school districts interested in electric school buses are not eligible. However, there are other programs that support electric school buses.
- **NEVI Pull-Through Requirement.** The company supports the "pull-through" requirement for EV charging stations under the NEVI plan because it is difficult to charge MHDVs in light-duty charging configurations.

Equity

The equity-related breakout session discussed needs in terms of access and equity for smaller and rural communities. The group expanded to a wider-ranging discussion on concerns with regard to EV expansion and implications for Texas. The main takeaways from the discussion are summarized below:

- **Educational Resources about EVs, Assistance for Public Agencies, and Grant Opportunities.** Attendees would appreciate resources that help take advantage of grant and funding opportunities. Resources to help users navigate TxDOT's NEVI website and information would be welcomed. Because the TxDOT NEVI site contains so much information, the site can be overwhelming or difficult to use. A tutorial was mentioned as a way to help users learn to navigate the website and access the information. Communicating the benefits and use of EVs is important. Some of the benefits include cost savings for EV owners. It would be helpful to provide resources on how EV use can be successfully applied in rural settings—predominantly heavy-duty and farm vehicle applications. Success stories of EVs in rural settings could be useful.
- **EV Charging Infrastructure Network to Meet Travel Demand.** There is a need for a robust EV charging infrastructure network to serve local users as well as those from

urban areas making interstate and intrastate trips. Misconceptions about what constitutes charging facility availability often exist. For example, some statistics count locations at car dealerships and hotels. This finding might make it appear that an area is well served by chargers, but in reality, there may not be any chargers that are freely accessible to the general public. A systemwide perspective on EV charging needs is necessary to meet travel demand, not just within an area but also for EVs that come in or pass through that area. Focus has been on the Texas Triangle, but other areas need to be covered and served as well. In particular, the Gulf Coast needs special attention due to its hurricane evacuation routes.

- **EV Charging Systems.** CHAdeMO charging infrastructure is not included in NEVI. Some EVs sold in the United States are using the CHAdeMO charging technology and will be on the road for years to come. Not including this charging technology, found on more affordable EVs, raises equity concerns. Diverse EV charging systems should be included in the specifications for planned chargers since adding additional charging types afterward can be difficult and increase costs.
- **Funding and Finance of EV Charging Infrastructure.** Participants noted that generally speaking, EV charging stations are currently not profitable to the charging providers, even in urbanized areas with more EV adoption. EV charging locations in rural areas will likely have less usage than in urban areas and therefore less revenue and profits compared to urban areas. The lack of profitability might result in poor maintenance of the charger or even nonfunctional ability.
- **EV Revenue Models and Taxation.** The presence of EV chargers in malls and shopping areas could potentially attract customers. In the future, revenue models for EV charging could be developed to account for this induced revenue. A plan should exist to capture sales tax revenue from EV chargers located in commercial areas. Further, TxDOT and the Texas Legislature need to address the issue of the declining gas tax revenue and communicate the breakdown of costs for EVs versus ICE vehicles.
- **Infrastructure and Grid.** The V2G space appears to be in its infancy—while there are limited pilots studying the effectiveness of deploying fleets of EVs (such as school buses) for backup power generation, it is not clear if V2G will emerge as a viable technology for supporting grid resiliency in the future. From a grid capacity perspective, a lot of unknowns still exist regarding grid capacity in the face of increased EV proliferation and whether charging demand management is necessary to ensure grid performance and resiliency.
- **Need for Non-Metro Coordination Coalitions.** The Clean Cities Coalition Network has greatly promoted EVs and provided resources, but it is geared toward more urban areas. A coalition-type approach would be beneficial in supporting currently underserved areas, similar to the Clean Cities Coalition Network model. This process would be a creative way to help stakeholders and promote equity across Texas. Similar types of organizations for the non-metro areas of the state would be helpful. Since the needs are different in less populous areas of the state, there may be a need for a different perspective for different coalitions, which may include more infrastructure facilitation rather than an emphasis on clean air/clean cities.
- **Addressing Rural EV Charging Infrastructure Needs.** In rural areas, where there may not be a clear financial incentive for the private sector to provide EV charging services,

an approach modeled on utility cooperatives may be needed to ensure access and service to customers and EV users in these areas.

Energy Supply and Demand

Electrical providers are looking at how EVs may shift the energy demand and peaks to see if methods can be found to incentivize efficient use of available electricity and ensure electrical costs are reasonable. The main takeaways from the discussion are summarized below:

- **Impacts on Electric Grid Infrastructure.** The private sector will own and operate the network and equipment, not TxDOT. It is important to consider both the transmission and distribution side of the infrastructure. The electric infrastructure will have to be built to handle the additional demand from EV charging. Transformers may need to be changed to address additional load depending on how they were sized when installed. Changing out transformers is a normal consequence of operations and not a monumental task but needs to be addressed. Since electricity generation is market-driven, incentives may be important to ensure more electrical generation infrastructure is built in a timely manner.
- **Electric Grid Infrastructure for Fleet Charging.** Upgrading electric networks to enable fleet charging may be a challenge since fleets may want to charge quickly, will have a high electricity demand, and will have many vehicles. From an electric grid perspective, that combination may be a challenge. As of today, fleets are expected to take a minimum of 6 years to electrify, while electrification of school buses may take 12 to 14 years. Although it remains to be seen how quickly fleet charging will be adopted in Texas, it is expected to be a gradual process and therefore should be manageable from an electric grid infrastructure planning perspective. Fleet charging is seen as a point problem since a great amount of electricity is needed at a particular location. Point problems may be addressed by providing charging at multiple locations since EVs can drive to a location where the grid has power. Thus, fleet EVs may need to be flexible in terms of charging locations. The availability of suitable fleet charging locations may affect actual versus planned operation of fleet EVs and fleet EV charging infrastructure.
- **EV Charging Data.** All EV chargers today come with timers, and associated data can be used to better understand charging behavior. Not much historical data on EV charging exist, and it is important to begin collecting data from new charging sites and use the information to help predict future demand. TxDOT will receive data from EV charging infrastructure every quarter and will share it with others.
- **EV Charging Timing and Incentives.** Some procedures can be done in the electrical market that may allow providers to operate the electrical grid more efficiently, including incentives to change the behavior of electrical users. Incentive plans are available to households to charge EVs at night. One plan mentioned provides free electricity from 10:00 p.m. to 6:00 a.m. A lot of EV owners may not be aware of the incentives and savings. Education on charging vehicles is also important to ensure incentives are used.
- **Education to Improve Charging Behavior.** New EV owners tend to charge their cars too often. Educating new owners on how and when to charge EVs is needed. Dynamic messaging signs using short messages can be used to educate travelers about charging.
- **Adaptable EV Charging Implementation Process.** EVs are mechanically simpler than ICE vehicles and have a lower maintenance cost. When total cost of ownership reaches a

certain threshold, more EVs will be purchased. Class 3 vehicles, including pickup trucks and vans, are currently at that threshold. However, uncertainty with the current predictions of EV adoption exists, so the EV charging implementation process should be flexible and adaptable. Continual feedback and updates to the EV implementation model are important to ensure that the growth expected is in line with the capacity of the electric infrastructure in the time period needed. The number of chargers in the NEVI plan are only 8 to 10 percent of the number of chargers that will ultimately be needed in Texas.

Public Agency Fleet Transitions

This breakout discussed issues related to the transition of public agency fleet vehicles powered by ICEs to EVs.

- **EV Charging Infrastructure Permitting Process.** A discussion occurred on the permitting process and some of the issues that have been encountered by the City of Houston. Some of the infrastructure is dated and needs to be updated for the installation of chargers. During planning, it is important to note that the installation of chargers may involve more work than placing a charger. Electrical infrastructure may need to be updated and the location may need to be approved and permitted. Houston, since it is planning to upgrade the building's switchgear to help facilitate the installation of additional chargers, has been experiencing these issues. Some of the first charges were installed without going through the permitting process. The process to install chargers needs to be known to the groups that identify placement and install them to help ensure the placement meets the requirements of permitting and the installers go through the process and have the chargers permitted before installation. For example, some of the chargers installed without a permit were placed in a parking garage—seemingly a particularly good location for EV chargers—except the location of the garage was in the flood plain, which is a location that will not be permitted. This fact was realized only when the city attempted to get additional chargers permitted for installation in the garage. It may be good to have a checklist or some information on general items to consider for charger placement and local permitting. The chargers are being installed to electrify the fleet vehicles and not for public use. The city will approve the placement of chargers at the surface level but not in the garage, which is the secured parking lot for the fleet vehicles. If the chargers are placed at the surface, then the fleet vehicles will be parked in an unsecured area.
- **EV Charging during Emergency Events.** Uncertainty exists regarding EV infrastructure and vehicles in areas that are prone to flooding and areas prone to weather events like hurricanes. It is not clear what safety measures need to be in place for the vehicles and infrastructure. During the recent hurricane evacuation in Florida, people were asked to leave certain areas, and chargers for people to use during the evacuation may not have been available. In other words, EV owners were asked to drive to areas where they would not normally go using evacuation routes or other routes that do not provide EV charging capability.
- **EV Safety during Emergency Events.** There was discussion about EVs combusting due to saltwater infiltration from significant storms. EVs are currently being stored in areas prone to flooding. It is unclear to what degree this issue is a problem and how it will be addressed.

- **Fleet EV Transition Guidance.** Some guides for how fleets should transition to EVs would be good. The Transportation Research Board and the National Cooperative Highway Research Program may have some guides and information. There may be some information on how to determine public locations for EV chargers, if not for fleets. It might be useful to partner or talk with EMS for fleet EV transition.
- **EV Consumer Product Protections.** There was some concern about consumer product protection regarding sales of metered goods (scales, price verification inspection, package inspection). In this instance, the interest is in the calibration of the EV chargers. If the Metrology Lab of the Texas Department of Agriculture becomes the entity responsible for ensuring the EV chargers are calibrated correctly in Texas, additional staff and training might be needed since they currently have about 200 state inspectors in five regions across the state who are already busy.
- **Charging Time for Fleet EVs.** It is cheaper to charge at nonpeak times of the day. There are also sustainability considerations when charging at a time when more solar or wind energy is input into the grid.
- **Regulations of EV Chargers.** A breakout attendee was looking for some information on the regulations of EV chargers. One place to look for regulations is the NEVI guidelines. The federal government put out NEVI guidelines, and then each state developed a plan in accordance with the guidelines. A link to the Texas plan was shared at the beginning of the workshop.
- **EV Charger Supply Chain and Delivery.** The order time for EV chargers should be taken into consideration for any EV charger installation plans. A delivery time of 19 weeks for a project was quoted by an attendee. Besides supply chain issues trickling through different parts of the economy, there is also more interest in installing chargers, which will put more pressure on manufacturing and delivery of the actual chargers. Disruptions due to labor strikes were also mentioned. EVs ordered as fleet vehicles are on backorder, sometimes 6 months or more. There was also some discussion about switchgear backorders. One participant had a switchgear on order that required a wait time of more than a year.
- **Blocking of EV Charger Parking Spots.** Concern was raised on how to enforce the misuse of EV charging parking spots by ICE vehicles. Attendees experienced times when parking for EV charging had been blocked by non-EVs, including ICE vehicles. This issue is a growing concern, and an attendee mentioned that park-and-ride lots always fill up, and discussion should occur on how to prevent open EV charging spots from being taken up if they are the only open spots in the parking lot. It does not seem like a good use of police time to manage the use of EV charging spots. It may also be an issue for EVs parked in quick-charging spots overnight. They are not charging the entire time they are parked there. Another EV could be charging at that location. One possible solution might be to have a sensor to track if the EV is still there. Then a gross amount could be assessed for parking over the allotted amount of time to charge the EV.
- **Coordination with Fleet Transition Stakeholders.** Depending on the type of fleet, some attendees are engaging with fire, EMS, sustainability, and parking organizations. The internal communication is still being worked out for most organizations who want to electrify their fleets. There are a lot of internal groups to consider and include in the conversation. Some of the outside stakeholders to engage with include the local electrical utility companies. The electrical company has provided an overlay with the fleet facilities

that are being considered for electrification since not all of the fleet storage facilities are electrified or have current electrical service to support fleet electrification. This discussion helped identify areas in which adequate service is available from the electrical company. Collaborative programs between stakeholders are also being established. A partnership called Resilient Now between Houston and CenterPoint Energy was established to develop a regional master energy plan that should help the city prioritize its investment in transitioning its fleet (*187*).

- **Fleet EVs in TxDOT's NEVI Plan.** Not much fleet electrification is mentioned in the TxDOT NEVI plan. Attendees requested access to funding for fleet EV electrification. One item to consider is that fleets are not planning to provide charging to the public. There may be an opportunity to provide public charges in park-and-ride lots.
- **Fleet EV Workforce Issues.** On occasion, buses have caught on fire when charging. Thus, it may be a workforce issue if a worker has to stay with the bus at the charging location to ensure the EV charges correctly. With ICE buses, it is usual for the employee to perform other duties while the ICE bus is fueled.

Interregional Connectivity

This breakout session focused on interregional connectivity, which is providing EV infrastructure to connect EVs that travel long distance from one region to another region. Regions include major economic areas in Texas such as DFW, San Antonio, Houston, El Paso, and Laredo. Regions can also be major economic areas in states bordering Texas and Mexico connected by interstate travel.

- **Medium- and Heavy-Duty Vehicle Charging.** Electric truck technology for MHDVs supporting 350-kW charging exists. Some states, such as California, have requirements to invest in zero-emission trucks under certain circumstances, but there are no requirements for utility owners or charging station providers. There should be an incentive in Texas to focus on trucks and charging station providers.
- **EV Charging Station Locations.** EV charging stations must be properly located. The area grid should be robust enough to manage the additional load from EV charging. The stations also need to charge fast enough to meet demand. The charging time of an MHDV is currently 4 to 6 hours using a 350-kW charger. Using a 1-MW charger would reduce the charge time to 1 or 2 hours. By comparison, the average ICE MHDV can fuel up in 15 to 20 minutes. The only charging station for trucks in the country (Daimler Electric Island) is currently in Oregon, and it serves four trucks simultaneously (*192*). Stations should also be located near other facilities, such as restaurants, shopping, bathrooms, etc. Such placement would make choosing and using an EV charging station an easier decision, especially if the time to charge is lengthy. Moreover, the placement of EV charging stations with respect to transportation corridors should be considered. Charging stations should be no more than a half mile from the highway or near preferred hot spots or corridors with a significant amount of truck traffic.
- **EV Charging Development Incentives.** The implementation of interregional connectivity will likely be demand-driven in Texas, which highlights the need for incentives to build out the interregional EV charging network.

- **EV Charging Accessibility for Medium- and Heavy-Duty Vehicles.** Providing accessibility for MHDVs includes configuring charging stations to allow for pull-through (or drive-through) maneuvers. Standard EV charging pull-in stations will not suffice due to the size and limited maneuverability of an MHDV. Planning for an MHDV-friendly charging station should include the following considerations: additional land requirements, entry/exit lane configurations, stacking configurations (two charging spots in a row is not ideal), and time to charge.
- **EV Charging Owner/Business Model.** An important consideration for EV charging station owners is the infrastructure cost. If the cost of building the infrastructure is included in the cost to construct the charging station, it will probably be cost prohibitive to build the charging station. It is also sensible to consider the proximity to electrical and other utility facilities when deciding to build a charging station.
- **Include Medium- and Heavy-Duty Vehicle in NEVI Planning.** NEVI funds should be leveraged to support MHDVs and be considered in current NEVI planning. This action will allow utility infrastructure to be adequately built to handle the expected load from MHDV charging stations. Including these considerations in current planning activities will ensure that the network will not need to be upgraded to manage additional loads from MHDV chargers.

Customer Experience

This breakout session focused on issues surrounding the customer experience during the implementation of EV charging infrastructure in Texas. *Customer experience* refers to how stakeholders external to TxDOT view or experience TxDOT's EV charging infrastructure implementation efforts. Customer experience also addresses the reliability and accessibility of EV charging infrastructure (e.g., access to charging, different payment methods, and transparent and consistent pricing).

- **EV Charging Infrastructure.** Two primary areas most concern EV charging users: charging speed and reliability. Questions that should be asked to improve the customer experience include the following:
    - What is the impression of stakeholders with the overall customer experience of the EV charging infrastructure implementation so far?
    - What has worked well and where are improvements needed?
    - What support could TxDOT provide to stakeholders to address some of the issues mentioned or to support stakeholder activities?
- **EV Charging Power.** Stakeholders discussed a recent poll from Volvo that asked EV users what their number one complaint about EVs was. The response was that they need faster charging options; specifically, customers want EVs to charge in half the time. The NEVI minimum is 150 kW, which is much slower and might be too slow for some customers. Electrify America (EA) builds out infrastructure with a focus on developing ultra-fast-charging stations (350 kW). The company recognizes that few EVs on the market can currently charge at that level (for example, the Lucid Air). Hyundai and Kia EVs can charge at 250 kW, which is faster than the NEVI minimum. If TxDOT builds out EV infrastructure at 150 kW, it will be only half of what many EVs can handle now and less than half of what more EVs will be able to handle in the near future. This result will lead to slower charge times and hurt EV adoption. As a stakeholder, EA would like

to encourage states to consider higher charge speeds in their scoring. The average charging speed has quadrupled since 2016, when standard chargers were around 50–55 kW. In 2016, 50 kW was the standard, so everyone funded the build-out at that level. Manufacturers understand that their customers want faster charging, so they invested in research and engineering to make charging quicker. The average vehicle charger in 2022 is just under 200 kW.

- **Minimum EV Charger Power Ratings.** Charging times depend on the state of charge, the charger, and the vehicle's charging capabilities. For example, the Hyundai Ionic 5 charges at 225 kW, so using a 150-kW charger will take 25 minutes, while at 225 kW, that time will be reduced to 18 minutes. However, charging slows down significantly after 80 percent, and most users do not charge past that level. The range that most users charge at is the 10–80 percent range. EVgo, a company that builds EV fast chargers around the United States, announced a partnership with General Motors to build out the U.S. fast-charging network. EVgo built lower kW chargers in the past but has now moved to building 350-kW chargers. Other companies are not interested in going above the NEVI minimum and advocate that 150 kW is sufficient, possibly because not all companies have the ability to build beyond 150 kW. The Auto Alliance (vehicle trade industry) submitted comments on the original NEVI plan as well as on the minimum standards indicating that all highway chargers should be 350 kW.
- **Future-Proofing EV Charger Power Ratings.** Increasing the power rating of EV chargers to 350 kW is one strategy since most vehicles currently cannot charge at 350 kW, and those EVs that are close have enough headroom to grow into 350-kW charging. A second strategy is to design the charging stations so that they are easy to upgrade. For example, some EA chargers have one dispenser that is capable of 350 kW but can also charge at 150 kW through the same dispenser as needed. To upgrade the charger, the company replaces the transformer but does not have to trench to replace any other hardware, which minimizes upgrade costs. A third strategy involves a station design that allows every cabinet to split the total wattage that is powering the cabinet. Thus, if only one car is using the charger, the car can use the full 350 kW, but if two vehicles are charging, each charges at 175 kW.
- **Power Ratings of EV Chargers in the Near Future.** Companies implementing EV chargers often use a standard 600-kW installation, and some use a standard 1-MW installation assuming four 250-kW chargers. Several stakeholders thought that 350 kW should be sufficient for many years into the future, in particular with regard to charge management that increases the speed of the last 20 percent of the charge. There might be 500-kW units in the future, although stakeholders thought there would be diminishing returns in terms of demand charge exposure, the cost of the equipment, and the electric grid impact. For example, four 350-kW chargers would require a 1.4-MW connection, which would require significant electric grid upgrades. However, 350 kW will not be sufficient in the long term for MHDVs. A coalition called Charging Interface Initiative is promoting the interoperability of MW charging standards and initiated the MCS.
- **EV Charging Infrastructure Reliability.** Stakeholders discussed approaches to monitoring the reliability of charging infrastructure. The primary indicator is uptime, which is also the focus of NEVI rules. Uptime may not be a good proxy for whether somebody can charge their EV. A stakeholder recently charged his car while shopping and found out afterward that the car never charged, even though it was plugged in, the

charger was on, the lights were on, and the car next to his was charging. He realized there was a communication error and had to spend 20 minutes with tech support to get it to work. Although he could not charge, this charger appeared as "up" on the charging infrastructure company's backend. While uptime is a main metric with NEVI, EV charging companies are encouraging states to think more broadly than uptime and consider a wholistic approach to operations and maintenance. If uptime is the only metric, the technology might not deliver as planned, the charging infrastructure might not meet demand, and EV adoption might suffer. To combat reliability issues, some companies have built complex diagnostic tools, including a vehicle interoperability testing center, to make sure that new cars and their chargers are compatible with their version of the CCS. Other companies have test vehicles that are roaming to test chargers. These vehicles might also check the condition of the chargers.

- **EV Charger Maintenance Issues.** One of the most prevalent operations and maintenance issues is vehicle interoperability. New vehicles come to market and have issues charging, even though compatibility falls within the CCS standard. Unfortunately, CCS standards are somewhat lax, so many times a new vehicle will not be able to charge. Despite other maintenance issues, manufacturers are getting better at producing EVs that can stand the wear and tear of real-world conditions.

WORKSHOP 2—IN PERSON IN AUSTIN, TEXAS

Workshop Activities

Researchers conducted the second workshop in person only on December 9, 2022, from 9 a.m. to noon (CST), at the Texas Department of Transportation, 6230 E. Stassney Lane, Austin, Texas 78744. Researchers coordinated with TxDOT staff to reserve five rooms at the Stassney Campus to conduct five breakout sessions.

Fifty-three stakeholders from 34 organizations registered for the event. The workshop began with a short introduction from the Research and Technology Implementation Division project manager on the TxDOT research program. The research team then provided some project background, discussed the objectives and purpose of the workshop, and provided a short summary of the previous virtual workshop. TxDOT then gave a brief overview of the agency's plan for the NEVI program, including background on the federal formula for funding provided through the IIJA and how it applies to Texas, an overview of existing and planned charging station distributions in Texas, timelines for planning and implementation, and how to find more information through TxDOT resources. Following TxDOT's overview, a panel of three representatives from transportation agencies discussed their plans and preparations for increased adoption of EVs in Texas. The panel consisted of the following participants:

- Lisa Lin, Harris County.
- Jason McLemore, Harris County Toll Road Authority.
- Andrew DeCandis, Houston-Galveston Area Council.

Ms. Lin, in her new role as director of sustainability, talked about initiatives at the Harris County Office of County Administration, including the county-wide emissions reduction plan. Ms. Lin shared activities to prepare for EV charging implementation, questions that remain to be

answered, and issues that are currently being discussed. Mr. McLemore provided a presentation of the initiatives at the Harris County Toll Road Authority in regard to EV charging and how the agency prepares for upcoming EV charging implementation activities. Mr. DeCandis talked about the Clean Cities perspective of EVs and EV readiness from the viewpoint of H-GAC. He focused on air quality problems, the Clean Cities program, and problems in regard to EV charging for fleet vehicles, office charging, and charging at multifamily homes. Some of the discussion with the panel included questions about commercial activity restrictions for toll roads in Texas, how EV charging implementation activities are coordinated among agencies, and how to deal with accessibility rules for EV chargers. Following the presentations, researchers facilitated a discussion between stakeholders and the presenting panel.

After a short break, participants were asked to join one of the five breakout groups listed below, each headed by a facilitator of the research team:

- Funding and Finance.
- Equity and Inclusion.
- Energy Supply and Demand.
- Interagency Coordination.
- EV Grant Programs (USDOT and others).

A TTI facilitator led the discussion, ensured that all participants had an opportunity to contribute, and took notes for a summary of the discussion. Following the discussions, all participants reconvened in the main virtual room, and facilitators shared a brief summary of the topics that were discussed in each breakout session.

Follow-Up Survey Results

A follow-up survey was sent to workshop participants on December 14, 2022, less than 1 week after the workshop. Three participants responded to the survey. All of the respondents expressed satisfaction with the workshop presentations, opportunities to contribute, and breakout discussions.

Workshop Findings

The topics that were discussed and are summarized here reflect the opinions, needs, concerns, and biases of the stakeholders who attended the workshops.

Funding and Finance

This breakout group discussed issues related to the funding and financing of EV charging infrastructure. Stakeholders noted that EV charging stations have similar implications as commercial real estate development in that they are subject to sales tax and other implications for a retail site. Specifically, breakout participants discussed the following:

- **EV Charging Site Considerations.** Discussion of site locations included questions about amenities, restrooms, restaurants, and security available at the site. For example, do restrooms and other amenities need to be open and accessible 24 hours a day, or can

availability be limited? A lot of data go into determining site locations for EV charging stations. Scoring of available amenities may help with site selection. Stakeholders also discussed the value of retail opportunities through EV charging.

- **EV Growth Projections.** It is important to track the projected growth of EVs in Texas. Trucks are popular in Texas, and so far, few electric trucks are available. It is also unclear how popular electric trucks are going to be in Texas. The current lack of options for light-duty pickup trucks may result in lower adoption of EVs in the near term.
- **EV Charger Investment in Disadvantaged Communities.** It is unclear how investments for EV charging infrastructure in disadvantaged areas—for example, under the IRA—will work in practice. It is unclear which disadvantaged areas will get credit under the IRA and how the areas will be selected. Potentially, the Justice40 Initiative map could be used to identify disadvantaged areas. In addition, there were questions around what happens if site owners do not want EV charging infrastructure on their property.
- **EV Charging Performance Specifications.** It is unclear whether EV charging stations need to be operational by the end of 2023 to meet performance requirements. It is estimated to take 6 to 18 months to complete the installation of a charging station. There is no guaranteed delivery date due to supply chain disruptions for the EV charging equipment, which affects partnering with equipment providers and manufacturers.
- **EV Charger Operations and Maintenance.** Stakeholders were interested in the cost coverage for operation and maintenance of EV chargers. TxDOT will provide funding for operation and maintenance only when the site requires it. Funding will need to be reallocated if there are few areas with sites that require additional maintenance. In addition, there seem to be no penalties in Texas regarding the uptime requirements for the EV charging stations. Some states, like Ohio, have penalties related to EV charging uptime. This lack of penalties could turn into an incentive.
- **Combining Solar with EV Charging Stations.** The installation of solar infrastructure at EV charging stations is reimbursable but reduces the competitiveness of the bid.
- **EV Charger Ownership Requirement.** A 10-year ownership expectation may reduce the willingness of the private sector to invest in EV charging in low-demand areas.
- **EV Charger Competition.** Stakeholders discussed implications of competing charging infrastructure that opens after operations and maintenance funding is no longer available.

Equity and Inclusion

This breakout group discussed EV charging issues related to equity and inclusion. Issues discussed by the group are summarized as follows:

- **Accessibility for EV Chargers.** San Antonio, Texas, is required to make EV charging stations accessible per the ADA. It is not known if any other city requires ADA accessibility for EV charging stations. Accessibility requirements include curb cuts, increased parking stall size, grading, and clear pathway requirements, which may impact parking structure pillars. San Antonio identified 20 potential sites for the installation of EV chargers. Due to the cost increase because of ADA accessibility requirements, the city can build only five EV charger sites within the same budget.
- **EV Charger Siting.** There is a need to estimate the expected walking distance from an EV charger to the person's destination, such as home, office, shopping center, etc. It

would be beneficial to have some numbers available when situating EV chargers in dense urban environments. Better cost revenue model estimates for EV charging stations are also needed.

- **V2G Considerations.** When needed, EV charging stations in parking garages could be used to supply the grid with electricity through V2G technology.
- **Planning for EV Charging Needs Beyond NEVI.** Since NEVI only covers 8 to 10 percent of the charging demand up to 2033, stakeholders should be looking beyond that to see how to plan for continued EV uptake. Otherwise, the grid may become overloaded.
- **EV Charging Equity Considerations.** The benefits of EV chargers may include considerations other than their location—for example, workforce considerations and the underutilized adversity quotient. The adversity quotient can be used as an indicator for equity of EV charger placement. Other states are prioritizing equity and inclusion in different ways. In Louisiana, locations in disadvantaged communities are being prioritized. Therefore, locations are not being selected based on current EV ownership/needs. Kentucky seems to be taking the opposite route regarding EV charger sites. It may be helpful to know how other states are planning to address communities with low EV utilization rates.
- **Community Engagement.** A program to provide outreach to communities on the benefits of EVs and to involve the community in assisting with EV charger site selection may be helpful. Job training programs can be key to community engagement.

Energy Supply and Demand

Discussions in this breakout group started with the question of whether the state will have enough electricity supply for about 1 million EVs in 2030 and extended to related concerns that stakeholders might have. Brief summaries of issues discussed by the group appear below:

- **Alternative Energy Sources for EV Charging.** Stakeholders discussed the range of alternative energy sources for electricity generation, including wind and solar, and the importance to plan for the efficient use of all types of energy sources.
- **Maintenance and Operations Costs for Fleet Vehicles.** Due to supply and demand considerations, the structure of electricity pricing will change during the day and over the weekends in the future. This shift might impact decision-makers responsible for fleet EV acquisition because decision-makers require clear and factual information about anticipated costs and other consequences in order to make defensible decisions. Maintenance costs for fleet ICE vehicles, including fuel prices, have a level of certainty that EVs do not have at the moment, so government agencies are hesitant to acquire more fleet EVs.
- **Cost of EV Acquisition.** A transportation agency representative mentioned that, from the agency's perspective, space for batteries and cost are the most challenging variables in decision-making. The representative discussed the idea of having fleet vehicles equipped with solar panels for charging, but costs are high, at $15,000–$20,000 per vehicle. Currently, due to a lack of cost-effective options, some agencies elect to not engage in major electrification initiatives.

- **DC Fast Charging for Fleet Vehicles.** For a fleet vehicle that is in use 12–14 hours a day and has a large battery on board, the only option is to use DCFCs. Level 2 charging simply takes too long. An agency representative mentioned that some of the electric buses that were acquired are currently not operational due to a lack of available chargers. A concern is that relying on DC fast charging alone will decrease battery life over time. Some DCFC technology for fleet vehicles exists but is still expensive, difficult to implement, and not yet widely available. More capable DCFC technology for fleets is currently being developed.
- **Affordable EV Charging.** Many people live in older houses without chargers, and they may need to go to work or other places to charge their vehicles if they buy an EV.

Interagency Coordination

Stakeholders in this breakout session started the discussion by talking about best practices for interagency coordination with respect to the implementation of EV infrastructure. In general, MPOs are focused on public locations for EV chargers, while municipalities are also looking at fleet transition. Several agencies are hiring staff to address the need for EV charging implementation. Overall, stakeholders mentioned that there are many best practices available for various types of infrastructure, but—with respect to EV charging infrastructure—policy, technology, and funding programs are rapidly evolving yet do not seem to be aligned. For example, while government agencies want to move forward with the implementation of EV charging infrastructure, agencies charged with implementation do not seem to have all the necessary information to be successful. Stakeholders were also not sure if there are agencies or agents that represent EV users outside of MPO areas (e.g., in rural areas). The following summaries cover issues discussed by the group:

- **Coordination between TxDOT and MPOs Regarding NEVI.** MPOs are looking for best practices and guidelines to coordinate, but they do not appear to exist. For example, MPOs have had a lot of interaction with TxDOT about the NEVI plan, but there are no details about what MPOs are going to do when MPOs start to implement EV charging infrastructure. Specifically, minimum charging infrastructure requirements are not yet defined. It is difficult for just one person to start and develop an implementation process. Some participants from local public agencies indicated that they are not clear about their role in the implementation of public EV charging infrastructure. In addition, uptime may not be the best way to measure how well an EV charger is functioning because a unit can be on and showing uptime but not functioning.
- **Coordination between MPOs and Cities.** Coordination between MPOs and cities varies throughout the state. Dallas is heavily involved with NCTCOG and local municipalities to advance permitting of DC fast-charging infrastructure.
- **Coordination between TxDOT and Cities.** There are many EV charging pilots from smaller companies that can provide useful data. Some jurisdictions are looking at small corridor programs to understand problems that occurred within the city regarding charging supply and demand. In hindsight, better coordination with TxDOT might have avoided several issues.
- **Support for Economic Development.** For some stakeholders, it is paramount that the EV charging infrastructure is made in the United States to support American economic

development. Except for new jobs for technicians, the economic impact of EV charging infrastructure appears to be limited.

- **EV Charging Location Process.** To some stakeholders, the process of identifying EV charger locations is unclear, as is determining whether TxDOT, the county, or the city has any say about what locations are permissible. For example, is the process for EV charger construction permitting similar to that of gas stations?
- **Profitability of EV Chargers.** Stakeholders expressed concern that currently no EV chargers appear to operate profitably, even chargers in areas with high demand. Chargers that do not operate with a load factor in the 30–35 percent range typically do not generate sufficient funds to pay for the property on which they are located. If the load factor is less than 30 percent, profits will be lower than the cost of conducting business. Companies owning EV chargers might currently be less concerned about profit and more focused on the development of market share. Once EV demand increases, sites that are highlighted in the NEVI plan should not be a problem since there will be enough EVs on those corridors. However, charging locations in areas with less demand or non-NEVI corridors might operate at a loss. There should be a discussion on how interagency cooperation can help small business owners avoid EV charger deployments that are not profitable.
- **Tools for EV Charger Location Planning.** Stakeholders wanted to know how agencies conduct long-range planning to determine the location of EV chargers. Stakeholders wanted to know if there are tools, models, or methodologies available to help avoid unprofitable EV chargers. One of the major concerns is that tools and sources that provide charging locations are often inaccurate. Maps have many errors and will show EV chargers are present when in fact they are not. There are crowdsourced platforms that provide a better idea of where chargers are.
- **Definition of Public Charging Infrastructure.** MPOs have discussed the definition of *public charging infrastructure*. It might be acceptable to call EV chargers public charging infrastructure if they are available during reasonable work hours (e.g., 8:00 a.m. to 7 p.m.). In that case, chargers could be located on private property as long as they are available during those hours. Additional legal analysis would be required to confirm if that option is viable.
- **Medium- and Heavy-Duty EV Charging.** There will be public charging depots for charging MHD EVs. In the short term, stakeholders are conducting planning activities and are using that planning to drive the funding. A lot of this activity is guesswork since no one knows what technology will be available in 10 years and what requirements will be in place for MHD EVs. However, it appears certain that these depots will need substations' worth of power to charge. One fleet charging substation could be similar to servicing a skyscraper. Getting the power to these depots might pose a serious challenge.
- **EV Charging at Multifamily Housing Units.** From a planning perspective, stakeholders are concerned about renters who cannot install a charger in their home. Due to the lack of sufficient charging options, there are a lot of unsatisfactory trade-offs for EV owners who are renting. From a public charging perspective, apartment complexes and offices will need at minimum Level 2 if not Level 3 chargers. One solution can be on-street charging. Using a Level 2 charger, the EV will take several hours to charge.

EV Grant Programs (USDOT and Others)

Many municipalities were interested in accessing local grant opportunities dealing with EVs. Specifically, breakout participants discussed the following:

- **Accessibility Requirements for EV Chargers.** The City of San Antonio successfully applied for a charging grant from TCEQ for installation of EV chargers on public property. Potential sites included libraries, community centers, parks, and downtown parking garages. A lot of planning was necessary for the installation of the chargers. During implementation, the municipality ran into several issues. The TCEQ grant was $2,500 per Level 2 charging dual port station, but due to new requirements, the city is now required to make at least one station at each site ADA accessible. As a result, originally negotiated project costs are 25 percent of the current estimated cost. The city is hesitant to pay the additional cost to install the chargers since there are no additional funds available.
- **Interpretation of ADA Requirements for EV Charging.** Complaints regarding the City of San Antonio's lack of ADA accessibility for EV chargers were filed with TDLR. Now that federal guidelines have been released, the city must adhere to TDLR rules at the state level. It seems that TDLR and TxDOT interpret the guidelines differently. There was also discussion regarding how legislation at the state level may solve some of the challenges the city and others are facing when looking to install EV chargers and infrastructure.
- **Incentives for EV Charging.** In San Antonio, City Public Services, an electric utility, is incentivizing EV charging through rate structures for home chargers. Austin Energy is also incentivizing home charging. However, a two-sided approach for EV charging infrastructure could be beneficial since not everyone has a place to charge their EV at home. In San Antonio, 44 percent of residents do not have garages or a convenient EV charging location near them. San Antonio wants to incentivize multifamily EV charging and support EV chargers at city facilities, but not at a cost to the city.
- **EV Fast-Charging Installation Costs.** The main items that have increased the EV fast charger installation cost include the electrical grid interconnection to make the site ready and the ADA accessibility requirement. The interconnection cost is very location-specific and will vary depending on where chargers are situated. Although TxDOT cannot help with the make-ready cost, TxDOT may be able to bring awareness to the issues around the make-ready cost. NEVI plan costs do not include the cost for the make-ready electrical interconnection. When the make-ready infrastructure is not already available, the cost to install the interconnection can be great. As installation of DCFCs and higher kW chargers expands, the make-ready cost will increase.
- **Covered Costs in NEVI Grants.** TxDOT should review grants to see what costs will be covered. Stakeholders preferred a more comprehensive cost coverage. Uncovered costs may be a barrier to applying for grants.

WORKSHOP 3—IN PERSON WITH VIRTUAL OPTION IN ARLINGTON, TEXAS

Workshop Activities

Researchers conducted the third workshop in person with a virtual option for the morning portion on February 22, 2023, from 9 a.m. to 4 p.m. (CST), at the NCTCOG main office in Arlington,

Texas. Researchers coordinated with NCTCOG staff to reserve four rooms to conduct presentations and panel discussions in the morning, followed by four breakout sessions in the afternoon, with an opportunity to rotate to two separate breakouts.

A total of 145 stakeholders from 108 organizations registered for the event. The research team provided the project background, discussed the objectives and purpose of the workshop, and provided a short summary of the previous two workshops. TxDOT then gave a brief overview of the agency's plan for the NEVI program, including a background on the federal formula funding provided through the IIJA and how it applies to Texas, an overview of existing and planned charging station distributions in Texas, timelines for planning and implementation, and methods to find more information through TxDOT resources. Following TxDOT's overview, a panel comprised of the following three representatives from NCTCOG and MPOs discussed their plans and preparations for increased adoption of EVs in Texas:

- Lori Clark, NCTCOG.
- Mukesh Kumar, Waco MPO.
- Martin Lucero, Lubbock MPO.

Ms. Clark talked about regional planning activities for EV charging infrastructure that are ongoing at NCTCOG. Ms. Clark also highlighted three key focus areas and goals of the agency—fleet/driver guidance and planning, infrastructure planning and readiness, and energy integration. Ms. Clark further discussed EV data and trends, including EV registrations in Texas and the Texas EV Registration Tool available at the NCTCOG website. Ms. Clark then talked about the proposed NEVI allocation for EV construction in the NCTCOG region and the MPO's role in collaborating with TxDOT. Ms. Clark also expressed interest for a Clean Cities initiative focused on rural areas and rural partners that would be interested in a collaboration.

Mr. Kumar talked about regional planning for NEVI activities that impact the Waco MPO region. Mr. Kumar highlighted equity concerns resulting in winners and losers from the transition to clean energy, zoning and land use concerns, parking regulations, and a process for incorporating NEVI activities into the metropolitan transportation plan process. Mr. Kumar also expressed concern about the cost of charging equipment, the capacity to deliver sufficient electricity, and the ongoing need for coordination and cooperation among cities. Mr. Lucero talked about EV planning activities in Lubbock and how those activities are supported by existing policy, policy agenda, and regional planning. Mr. Lucero also emphasized the need for a public-facing view of EV planning issues and activities that is easily understood by the public rather than relying on the planner's technical view of issues.

Following the presentations, researchers facilitated a discussion between stakeholders and the presenting panel. After a short break, the research team facilitated a second panel discussion focusing on issues related to EV charging for freight, fleet, and MFH. Pharr Andrews, with the City of Dallas, talked about multifamily EV charging initiatives in Dallas. Ms. Andrews presented the findings of an analysis of EV charging infrastructure in Dallas to assess resident proximity to public-access EV charging stations, identify charging gaps to guide equitable and strategic EV charging investments, and promote funding opportunities for charging stations. The analysis involved comparing charging station locations with EV registrations by zip code and NCTCOG environmental justice index areas. The analysis showed that few EV charging stations

are currently located in environmental justice areas in Dallas. It also showed that in Dallas, 54 percent of MFH units do not have access to a public charger within half a mile, compared to 67 percent of MFH units without access in environmental justice areas. Ms. Andrews further highlighted the activities of a targeted initiative to engage with MFH owners and residents to discuss EV charging opportunities.

Following her presentation, researchers facilitated a discussion with all presenters of the morning session. The morning session was recorded via Zoom and distributed to all registered workshop attendees along with slides from all morning presentations. In the afternoon, workshop participants attending in person were asked to join one of the following four breakout groups, each led by a facilitator of the research team:

- Equity and Inclusion.
- Energy Supply and Demand.
- Interagency Coordination.
- EV Grant Programs (USDOT and others).

A TTI facilitator led the discussion, ensured that all participants had an opportunity to contribute, and took notes for a summary of the discussion. The first breakout session was followed by a short break and a second round of the same breakout sessions, allowing workshop participants to join in a discussion of more than one breakout topic. Following the discussions, all participants reconvened in the main virtual room, and facilitators shared a brief summary of the topics that were discussed in each breakout session. The workshop concluded with brief remarks by the research team at 4:00 p.m. The following paragraphs summarize the workshop findings of the topics discussed during the breakout sessions.

Workshop Findings

The topics that were discussed and are summarized here reflect the opinions, needs, concerns, and biases of the stakeholders who attended the workshops.

Equity and Inclusion

This breakout group discussed EV charging issues related to equity and inclusion. Summaries of the issues discussed by the group are provided below:

- **Equity Considerations.** Workshop participants discussed several dimensions of equity. For example, geographic equity distributes EV chargers equitably over a region. Price equity takes into consideration the time cost to access EV chargers. This issue can be addressed by co-locating chargers at locations where people are already going, such as grocery stores or main areas of employment. A third dimension is land use equity, which includes considerations of rural, suburban, and urban land use patterns.
- **Opportunities for Minority Businesses.** Opportunities exist for businesses to install and maintain EV chargers or the facilities/amenities surrounding the EV chargers. Stakeholders were looking for more information about these opportunities and were also interested in training and certification requirements to get involved in these activities. There were also questions about DBE inclusion programs and matching goals.

- **Multifamily Housing Needs.** Stakeholders pointed out that the needs of MFH residents are unclear. On-street chargers close to MFH units might be a way to address some of the needs, but it is unclear how these units will meet equity goals. Maybe mobile charging companies that have charging trucks that come to the customer could help fill some of that need.
- **Accessibility/Need for User Education.** Stakeholders pointed out that charging systems should be as simple to use as possible to ensure that a less techno-savvy or less knowledgeable population is not excluded from the use of EV chargers. The technological hurdles to using EV chargers should be as low as possible. User education will be useful to improve understanding of the technologies. In addition, there are other gaps, such as differences in access to technology, the internet, or mobile data. As a result, use of certain technologies, such as the use of smartphones or apps, should not be mandatory. Use of credit cards or bank transfers should not be required since that would limit access of the unbanked population to EV chargers. Further, how would EV drivers find chargers without using smartphones? What are plans for signage—for example, on interstates? Ideally, charging an EV should be as easy as filling up a vehicle at a gas station. Good examples of community engagement and education include the Get Connected Dallas initiative that uses digital ambassadors to inform and educate.
- **EV Charger Location Safety.** Stakeholders discussed the need for guidelines to improve safety at EV charger locations, especially for women and vulnerable groups. For example, what should be the safety requirements under the NEVI program with regard to lighting at EV charger locations or use of camera monitoring?
- **EV Charger Accessibility.** Stakeholders discussed the need to make EV chargers accessible to the disabled population.
- **Benefits of EV Fast Charger Ownership.** Stakeholders talked about the economic benefits of owning EV fast chargers. It is unclear how much revenue can be expected from an EV fast charger since it will be highly dependent on its location. However, there might be other opportunities related to the higher dwell time at EV charging locations compared to the time to fill a vehicle at a gas station. There were also questions about what will happen to the EV chargers after federal oversight ends after 5 years. For example, what will happen to current uptime and maintenance requirements?
- **Needs of Rideshare EVs.** Stakeholders discussed the needs of rideshare drivers using EVs who might need to charge their vehicle during their shift. Rideshare drivers tend to be lower income and would need EV fast-charging options in the areas where they live.
- **EV Charger Maintenance.** There should be a way to notify EV charger companies when their system is not working. Priorities to fix broken EV chargers will be set by the charging companies, but how should that maintenance be prioritized? There should also be a requirement to maintain the area around EV chargers to keep them free of trash and debris.
- **EV Charger Use.** What are plans to avoid queuing problems at EV chargers? Even a short queue at an EV charger might mean exceedingly long wait times. Is there a way to schedule appointments at EV chargers?
- **EV Charger Locations for Fleet Vehicles.** EV charger locations can be centralized so that fleet vehicles go to a centralized location for charging. Alternatively, there might be a subscription model wherein mobile chargers come to a location to charge multiple vehicles at once.

- **Guidance for Justice40 Initiative.** Stakeholders mentioned that there does not seem to be much guidance available to implement the Justice40 Initiative. There also seems to be an overall lack of discussion or thought leadership. One issue is that there are so many potential options to address the requirements in the Justice40 Initiative. For example, job opportunities, charger placement, air quality improvements, or direct health outcomes could be included, but some benefits will be difficult to prove. There was interest expressed in approaching equity issues correctly right from the beginning so that there will not be a need to correct mistakes later.
- **MPO Coordination.** Coordination is needed among MPOs to share best practices and approaches with regard to EV charging infrastructure planning. Smaller MPOs might not currently have a platform to engage. However, collaboration might be limited by federal discretionary funding programs if MPOs compete for funding against each other.
- **Workforce Development.** There is a need to engage with community college technician programs to develop a workforce that supports EV charging infrastructure. Training might need to start at the high school level.
- **EV Charger Rentals.** Stakeholders talked about other opportunities involving EV chargers—for example, renting out chargers. This process could be similar to popular apps and businesses such as Airbnb for rental properties or Turo for personal vehicle rentals. At this point, it is not clear if individuals would be willing to rent out their charger, how they would get paid, and what liability questions need to be addressed.
- **Partnership with TxDOT.** Stakeholders discussed how TxDOT could support activities of local public transportation agencies. Although TxDOT has a large amount of data, it is not always clear how the data can be used. However, once performance measures are developed, data needs will be clearer. Under the NEVI program, utilization data at individual charging stations will be reported quarterly, which will be useful. The level of needed data aggregation, however, is not clear at this point.
- **Small Business Support Programs.** Stakeholders discussed ideas to support the goals of DBE programs. TxDOT is in a good position to support these goals by making sure that contractors follow these programs. Ideas include the use of DBE lists that could be published by TxDOT, new DBE goals for lead contractors and not just subcontractors, and requirements for DBE outreach.

Energy Supply and Demand

Discussions in this breakout group focused on questions related to estimates of energy supply and demand for EVs and impacts on the electric grid in Texas. Following are the key topics that were discussed in the breakout sessions:

- **EV Charging during Peak Demand Hours.** To deal with the issue of sufficient energy supply for various EV charging scenarios, batteries can help offset the peak consumption requirement, and charging during nonpeak hours should be encouraged. A potential challenge with the power supply might be how much energy can be delivered and where. The availability of power during the peak hour can be managed with the current unused generation capacity. The availability of transmission stations and substations might be related to infrastructure issues in the future.

- **Electric Generating Capacity and Electric Load.** Electric generating capacity and load are never equal in the current scenario. EVs can benefit utility companies since they already have extra generating capacity and low nonpeak load. Storing the nonpeak energy to complement the peak-hour load demand will address many issues with distributed generation demand. All EV charging stations should have automatic demand response to throttle power back or turn it off when demand exceeds capacity.
- **EV Electric Demand Modeling.** The demand modeling based on existing EV data may not be accurate for future events. It will be critical to consider who will install EV chargers and where. EV fleet charging stations (e.g., school buses, emergency vehicles, and delivery vans) may significantly impact the energy supply. TxDOT should work with MPOs to provide sufficient infrastructure and energy for charging station hubs to support EV fleet charging.
- **Electric Infrastructure Support for EVs.** Most EVs are only used for short trips within the city limits. The current electricity infrastructure can support the existing EVs; however, it may not be sufficient as their market share increases.
- **EV Charger Resiliency.** TxDOT should focus on the sustainability and resiliency of the infrastructure and charging stations. For example, during a hurricane, many gas stations have gas but no electricity to pump the gas into vehicles. Emergency evacuation routes have an infrastructure shortage to support existing EVs during an emergency. TxDOT should focus on resiliency and redundancy for evacuation routes and consider using mobile charging trucks during emergencies. Some private companies have started using mobile trucks for roadside assistance, but they may not be able to support future demand during emergencies.
- **EV Charger On-Site Energy Storage.** The NEVI plan for EV charging stations does not include sufficient funds for on-site energy storage, which can be critical during peak hours. In some cases, regulations might not allow EV charging stations to generate energy on-site and store it in batteries to sell during peak-hour demand. TxDOT can help with the infrastructure to store energy on-site and use it as needed.
- **EV Charger Education.** TxDOT is leading the EV charging infrastructure readiness in Texas, but education is vital to its success. TxDOT should focus on delivering a clear message to the public on existing and future plans for EV charging infrastructure. Installing signage posts indicating the distance and availability of charging stations on the highways will be critical. Training or guidance on how to use the charging stations and on how to get in and out will also be helpful, as will providing essential amenities in and around the charging stations.
- **TxDOT Considerations for Temporary Supply Chain Delays.** Supply chain delays and material shortages impact the construction of EV charging stations. The availability of switchgears is uncertain at this point. TxDOT should consider these hardships while working with contractors to build EV charging stations. It is also critical for utility companies to be involved in planning new EV charging stations so they can coordinate scheduled or planned upgrades to their infrastructure accordingly.
- **EV Charging Hub Charger Types and Locations.** Building a charging hub near MFH units, universities, and shopping complexes can allow residents, students, and taxi drivers to charge their EVs. These EVs do not always need DCFCs in the charging hubs, but Level 2 chargers can sufficiently meet the demand.

Interagency Coordination

This breakout session focused on topics related to interagency coordination in the context of vehicle electrification and the needs of Texas stakeholders. The intent was to go beyond TxDOT's plan for the NEVI Formula Program and to address topics related to EV infrastructure, for fleets, freight, MFH, and more. The discussion on interagency coordination touched on several subjects covered by other breakout sessions, such as equity, federal programs, etc. Below is a summary of key highlights and consensus items from the breakout discussions:

- **Need for Interagency Coordination.** Interagency coordination is needed for timely decision-making. For example, agencies must coordinate to ensure that EV charging facilities are available to meet demand. Coordination is also needed to ensure equitable decision-making—for example, ensuring that EV charging facilities are accessible to all income levels.
- **Coordination Leadership.** Stakeholders in general perceived TxDOT as the clear leader or convenor for ensuring interagency coordination statewide. This leadership is supported by TxDOT's role in the NEVI program and its role in coordinating other transportation-related initiatives statewide. Stakeholders mentioned that a bill introduced in the current legislative session will, if passed, require the establishment of a Texas Transportation Electrification Council, made up of senior representatives from a range of public entities and administratively located at TxDOT (*183*). Regardless of the outcome of the bill, it was noted that TxDOT will be expected to play a lead role in coordination efforts, whether mandated by state law or otherwise.
- **Focus of Coordination Activities.** Stakeholders discussed several items that can be addressed through interagency coordination. For example, resources for smaller entities across the state, such as grant writing support, job posting examples to help agencies hire for EV planning, templates for scope of work/specifications to contract out EV infrastructure development, and examples of best practices and success stories in deploying EVs and obtaining funding can all be addressed through interagency coordination. Other examples include help for public fleets in the procurement of EVs through cooperative models and capacity building for workforce development to support the transition to EVs. However, simple information sharing and just bringing stakeholders together can also be helpful.
- **Interagency Coordination Challenges.** Agencies are working with accelerated timelines to address EV charging issues, which in itself makes effective interagency coordination challenging. Another challenge that may have to be overcome for successful interagency coordination is the need to balance inclusivity with stakeholder fatigue; involving a diverse group of stakeholders sometimes results in too many meetings. If possible, meetings or events should be combined with other stakeholder engagement processes. It is also a challenge to find the right organizations to include in meetings, as well as the right people within the organization.
- **Balancing Coordination Goals.** Interagency coordination should balance state-level goals with local goals. A model of interagency coordination mentioned by participants was the VW mitigation settlement funding allocation process. Another example was the improvement of traffic safety in a process coordinated by NHTSA that required each state to establish a high-level safety office as part of the governor's office or similar level.

EV Grant Programs (USDOT and Others)

Stakeholders in this breakout group offered the following suggestions and comments:

- **Overview of Funding Programs.** It would be helpful to have a matrix/spreadsheet of funding opportunities, matching requirements, and other important information. There are many programs available to fund EV infrastructure, but not everyone knows about them, and it is difficult to keep up with changes and updates to programs.
- **Central Information Repository.** Having a central location for information related to the EC charging infrastructure development would be beneficial. For example, a website could list contacts for those interested in working within the state. Municipalities could list information, certification, or registration requirements to conduct local business. Other states—for example, Colorado and Louisiana—use simple tools such as Google forms to build similar databases.
- **Guidance for Implementation of Justice40 and Other Equity Considerations.** TxDOT could provide additional guidance on how disadvantaged communities will be prioritized and how Justice40 will be implemented.
- **TxDOT's NEVI Grant Application Guidance.** There were several questions regarding criteria for requests for grant applications under NEVI. More questions will arise once TxDOT releases the criteria and guidance. A sample or template grant application would be very useful. Further, a checklist for grant applications might be beneficial and could be similar to TCEQ's VW grants for EV charging. Efforts to build uniformity for EV supply equipment and electrification needs of the electric utility would be valuable as well.
- **Support for Grant Applications.** Many smaller cities or rural areas do not have staff or funding to develop grant applications. A support program—possibly administered through TxDOT—that would provide funding or support to ensure smaller cities can apply for the grants is needed. Microgrants currently available for planning or feasibility studies might be an option to support these efforts. There were also discussions about technical assistance after grants are received, such as reporting requirements, responsibilities, and timelines for the field implementation. A template was requested that summarizes how awarded funds should be spent.
- **TxDOT Coordination with MPOs.** Stakeholders suggested that TxDOT coordinate more with MPOs on how to generate the MPO plan for EV charging infrastructure. It would also help if MPOs could learn in advance about TxDOT's plans for the state NEVI plan update that is due every August to FHWA.
- **Grant Preparedness Workshops.** Future workshops that bring private and public stakeholders together to prepare for and discuss strategies for upcoming grants would be beneficial. This could be done regionally, leveraging stakeholder engagement in the NEVI program. Meetings should include the MPO's local planning partners.
- **Database of Grant Applications.** A database of grant applications, including applications that did not get approved, would be very useful. Even if they were not successful for the NEVI program, they might be useful for other programs.
- **EV Charging Implementation Competition.** Providers and manufacturers would like to match up with local partners to avoid competition among cities. Private companies want to sell charging stations, but municipalities must be competing for these grants. TxDOT might be able to provide guidance in this area.

- **Database of DBEs and Technicians.** Local technicians will be needed to maintain the 97 percent uptime of EV chargers. A database of technicians would be useful. An Electric Vehicle Infrastructure Training Program website provides a listing of certified electricians in the state (*193*). TxDOT can link to that site on its EV planning website.
- **EV Teaming Dashboard.** Several states have created a central website to provide information about EVs, including adoption rates, charging information, and other related information; one example is Oregon DOT (*188*). TxDOT could expand its current NEVI website to add more information that stakeholders are looking for.
- **EV Charging Infrastructure Workforce Development.** Stakeholders talked about apprenticeship programs for electricians. Some local/municipal programs are focused on that topic, such as the City of Dallas Green Job Skills initiative, but it is uncertain whether there will be funding available to build new or maintain existing programs. Texas State Technical College and the Texas Workforce Commission could be great resources in this area.
- **EV Charging Infrastructure Operations and Maintenance.** It is unclear what EV stations will be profitable in the future, but it is likely that some stations with low demand will not be profitable for many years. Those locations will likely fall behind in maintenance expenditures. To help with maintenance after NEVI funding ends, a new program to help maintain EV infrastructure would be useful.
- **EV Charging Infrastructure Implementation—Local Regulations and Ordinances.** Stakeholders pointed out that local regulations, such as parking regulations and zoning ordinances, may need to be modified to accommodate EV charging infrastructure. It would be useful to have model ordinances as a starting point.
- **Utility Considerations for EV Charging Implementation.** Utility considerations can be the largest cost of EV charging implementation. Current rules and policies—for example, line extension policies—should be evaluated to determine if they can be modified to reduce that cost. There are equity considerations on how the utility costs are included in the EV charger implementation. Other concerns are the need for grid capacity and making sure that grid capacity does not limit EV adoption, especially when heavier-duty trucks start to electrify. There is also a need to consider the requirements of electrified trucks for investments that are made now into the electric infrastructure. Moreover, determining which complementary policies and programs need to be in place to ensure that these investments move forward will be necessary.
- **Outreach and Education.** What should MPOs do to improve outreach and education about EVs, especially in disadvantaged communities? Disadvantaged communities might not have high EV adoption and therefore might not understand long-term goals of EV charging implementation, might not have a high interest in EV charging infrastructure, and might have other community priorities. How should local public agencies engage and communicate with these communities?
- **New EV Grant Programs.** Stakeholders discussed what new grant programs might be useful to address current equity problems and support EV adoption. For example, a program to support neighborhood EVs in disadvantaged and low-income communities would be beneficial. Programs could also support micromobility options, such as partnerships with rideshare companies. Grants are also necessary to support the needs of transit agencies. Finally, stakeholders noted that current efforts are focused on

electrifying the status quo of mobility and vehicle ownership but should be focused on improving mobility overall.

CHAPTER 4. ASSESSMENT OF TOOLS AND ANALYSIS OF EV CHARGING DEMAND

INTRODUCTION

This chapter documents the research team's assessment of available data and tools to guide statewide EV planning analysis and develop a projected EV charging demand based on adoption trends and predictions. To meet these objectives, researchers considered methodologies to analyze and forecast state EV charging supply and demand and evaluated both freely available and proprietary/commercially available datasets and analysis tools.

Researchers divided this task into two subtasks: (a) assessment and selection of analysis tools, and (b) analysis of state EV charging demand based on that assessment. Specifically, researchers conducted the following activities as part of the assessment and selection of tools:

1. Mapped primary data and modeling needs for the analysis of EV charging demand.
2. Conducted a gap analysis evaluating the capability of the current state-of-the-art tools to project EV charging demand.
3. From the results of the gap analysis, selected the tools that were included in the assessment.
4. Conducted the assessment of datasets and tools.

Researchers included a variety of considerations, such as tool components and algorithms for vehicle adoption, traffic modeling, and EV charging load modeling, and discussed findings with the project monitoring committee before starting the second subtask. Based on the consensus findings, researchers conducted the following activities to complete the analysis of state EV charging demand:

1. Developed analysis scenarios.
2. Analyzed current EV charging demand.
    a. Acquired data.
    b. Conducted a gap analysis.
    c. Developed data transformation methods.
3. Used tools and data to forecast future EV charging demand and to estimate its regional energy and GHG impacts.

The following sections provide details on the available datasets and tools, the tool assessment process and findings, the tool selection process and methodology, and the state EV charging demand analysis.

OVERVIEW OF DATASETS AND TOOLS

The research team reviewed datasets and tools as part of the literature review and provided brief summaries of these tools in Chapter 2. The following provides information on these datasets that expands on the information provided in Chapter 2 as appropriate for the objectives of the assessment of tools and analysis of EV charging demand.

U.S. EIA's *Annual Energy Outlook*

The AEO projects that the sales of ICE LDVs (including gasoline, diesel, flex-fuel, natural gas, and propane powertrains) will decrease from 92 percent in 2021 to 79 percent in 2050 because of growth in sales of BEVs, HEVs, and PHEVs (*22*). The report estimates that through the projection period, sales of BEVs with a 200- and 300-mile range will grow, increasing from 0.34 million in 2021 to 1.52 million in 2050, while sales of PHEVs will increase from 144,000 in 2021 to 521,000 in 2050. Its analysis of PHEVs demonstrates fast growth and market penetration between 2021 and 2024. Growth in PHEV sales will slow after 2024 due to declining battery prices, which pushes BEVs into the highest electric LDV market share. The AEO projects BEVs and PHEVs combined will account for 13 percent of total LDV sales in 2050. It projects that the total electric vehicle share (both BEVs and PHEVs) of on-road LDV stock will grow from less than 1 percent in 2021 to 9 percent in 2050, based on the laws and regulations as of November 2021. This shift will occur even as the on-road LDV stock likely grows from 260 million to 288 million vehicles over that timeframe. Increased electrification of the on-road LDV fleet will increase electricity consumption from less than 0.5 percent to more than 2 percent of total consumption of energy in the transportation sector between 2019 and 2050.

The AEO report projects that demand for electricity will grow fastest in the transportation sector, even as consumption in that sector remains less than 3 percent of the economy-wide electricity consumption. Fully electric vehicles will grow from less than 1 percent of the on-road LDV fleet in 2021 to a little over 7 percent in 2050. The increase in demand will primarily follow evolutionary EV technology and market developments, as well as current fuel economy regulations. Both vehicle sales and utilization (miles driven) would need to increase substantially for EVs to raise electric power demand growth rates by more than a fraction of a percentage point per year. The transportation sector's share of electricity consumption is greatest in the high oil price case, where it reaches 5 percent of the total in 2050.

The AEO report is a valuable source to obtain an overview of the nationwide transportation sector and energy. It provides a reliable estimate of EVs' long-term growth and their electricity demand. Although its statistics and growth rates are nationwide (not state level), they can be used to build future baseline scenarios to forecast EV charging demand at the state level. The annual report with the updated statistics reflects the most recent changes in estimations.

USDOE's *National Plug-In Electric Vehicle Infrastructure Analysis*

National Plug-In Electric Vehicle Infrastructure Analysis is a comprehensive report on a study conducted by USDOE in 2017. As noted earlier, this study investigated how much PEV charging infrastructure will be needed in the United States in 2030 to support both PHEVs and BEVs (*26*). This study established a central scenario with PEV market conditions and used a parametric sensitivity analysis for the key variables of the PEV infrastructure modeling framework. The variables explored are listed in Table 1. The goal of the scenario development was to estimate the magnitude of PEV infrastructure requirements (relative to a growing national fleet of PEVs) and to highlight dependencies with consumer preferences and technology development.

The analysis made technical considerations for the spatial density of PEVs concentrated in cities and towns, ambient temperature effects on electric driving range, and frequency of long-distance

driving days requiring nonresidential charging infrastructure. The analysis applied a series of assumptions across all scenarios in this study. For example, consumers were simulated as preferring to perform most charging at their home location. This resulted in 88 percent of PEV charging taking place at home locations due to the large amount of time vehicles were parked there and relatively short typical daily driving distances. It was assumed that future PEVs would be driven in a manner consistent with present-day gasoline vehicles (e.g., 70 percent of daily driving under 40 miles and 95 percent under 100 miles). The study predicted the total PEVs, percentage of BEVs, and plug counts for all states in 2030. The analysis results for the central scenario are summarized in Table 3. Results are reported as numbers of DCFC stations required to provide an acceptable level of coverage and the number of plugs required to satisfy PEV charging demand. The station count estimates for providing a minimum level of coverage have been omitted for community Level 2 (L2) charging stations. The assumption was that nonresidential L2 would be primarily used for charging within walking distance of a destination due to the low charge power and long charge time of L2 stations. Coverage for every destination was considered unrealistic for the early PEV market; however, demand estimates for L2 plug counts are included. Similarly, coverage estimates are omitted for DCFC stations in rural areas since coverage provided by stations in cities/towns and along interstate corridors was deemed sufficient.

Table 3. Summary of Station and Plug Count Estimates for the Central Scenario (15 Million PEVs in 2030).

Charging Station	Scenarios	Cities	Towns	Rural Areas	Interstate Corridors
PEVs		12,411,000	1,848,000	642,000	—
DCFC	Stations (to provide coverage)	4,900	3,200	—	400
	Plugs (to meet demand)	19,000	4,000	2,000	2,500
	Plugs per station	3.9	1.3	—	6.3
	Plugs per 1,000 PEVs	1.5	2.2	3.1	—
Nonresidential L2	Plugs (to meet demand)	451,000	99,000	51,000	—
	Plugs per 1,000 PEVs	36	54	79	—

Note: — represents that coverage estimates are omitted since coverage provided by stations in cities/towns and along interstate corridors was deemed sufficient.

For Texas, the study estimated that there would be 835,000 PEVs, with 57 percent BEVs (among all EVs). It predicted the need for 18,300 “Work Level 2 Plugs,” 12,400 “Public Level 2 Plugs,” and 1,720 “Public DCFC Plugs” by 2030. This study is an example of a top-down approach to estimating future required EV infrastructure.

While this work did not intend to forecast future PEV markets, different scenarios were developed to exercise the infrastructure estimation methodology and highlight sensitivities. The estimation methodology developed in this study is highly useful to define different scenarios to estimate the future charging demand considering none of the scenarios as most likely at the state level. Considering a lack of historical data of EVs, this methodology provides reasonable assumptions for the forecast of EV charging infrastructure at the planning level.

ExxonMobil's *Outlook for Energy*

ExxonMobil's annual *Outlook for Energy* is a report on long-term energy demand and global trends for supply. The latest report update expects that personal vehicle energy demand will peak and decline by 2025 due to growing electrification and fuel efficiency, while commercial transportation will offset that reduction as increased economic activity and personal buying power raise the demand for more goods and infrastructure (*27*). The report predicts that the global transportation-related energy demand is expected to grow by 30 percent from 2021 to 2050. The report explains policy, technology, and consumer preferences as the three main drivers of energy demand in the future. The report provides the latest understanding and trends in the global energy market and can be used to reflect the effect of the global energy market and general trends in state-level forecasts.

McKinsey's *Building the Electric-Vehicle Charging Infrastructure America Needs*

The McKinsey Center for Future Mobility collaborated with the McKinsey Public and Social Sector Practice on the evaluation of different aspects of EV charging station needs (*28*). According to the report, the nation's limited charging station network probably discourages many prospective buyers. Although EV sales in the United States have climbed by more than 40 percent each year on average, since 2016, nearly half of U.S. consumers state that battery or charging issues are their top concerns about buying EVs. A goal stated in the BIL is to install 500,000 public chargers (i.e., publicly accessible charging stations compatible with all vehicles and technologies) nationwide by 2030. However, the report states that even the addition of half a million public chargers could be far from enough.

In a scenario in which half of all vehicles sold are ZEVs by 2030, in line with federal targets, the report estimates that the United States would require 1.2 million public EV chargers and 28 million private EV chargers by 2030. In other words, the country would need almost 20 times more chargers than it had in 2022. While the BIL highlights equity as a specific priority, electricity purchased at a public charger can cost 5 to 10 times more than electricity at a private one. To keep EVs powered up, public charging stations will probably need to be economical, equitably distributed, appealing to use, and wired to a robust power grid.

The report estimates that the country's fleet of EVs would grow from about 3 million to more than 48 million in 2030, amounting to about 15 percent of all vehicles in the United States, in a scenario in which the nation reaches the federal PEV sales target. The report also estimates that the annual demand for electricity to charge EVs would increase from 11 billion kWh to 230 billion kWh in 2030, which represents approximately 5 percent of the current total electricity demand in the United States. Nearly 30 million chargers would be needed to deliver so much electricity. While most of these chargers would be installed at residences, 1.2 million would be public chargers, installed at on-the-go locations and at destinations where vehicles are parked for long periods. The cost of hardware, planning, and installation for this amount of public charging infrastructure was estimated to be more than $35 billion over the period to 2030.

The report states that current charger installations tend to be located in higher-income areas, following the location of early EV sales. Future charger installations could be planned for areas of all income levels to make ownership of EVs as practical as ownership of ICE vehicles. The

report authors stated that broader geographic accessibility to chargers will likely be pivotal to improving visibility and viability. Their analysis shows that considerably less charging would occur at home by 2030, and the amount of charging in fleet depots would nearly double by then. The researchers estimated that public charging would deliver more than 20 percent of the electricity EVs would use in 2030. Determining how much public charging demand a state's infrastructure must serve, and how much demand there will be in particular locations, is a consideration not only in building an equitable infrastructure but also in helping businesses that operate public charging stations to be profitable. The potential locations for providing chargers in public settings are curbsides, parking lots, and highway rest stops. According to the report, guiding principles for building EV charging infrastructure are:

- Equity.
- Availability (of chargers where owners need them).
- Matching charging speed (to customers' needs).
- Making public charging affordable.
- Enhancing the public charging experience.
- Integrating chargers with the power grid.
- Creating viable opportunities (for charging businesses).

The report shows national trends in the United States and analyzes different EV growth rates. These growth rates, the required charging infrastructure and the influential variables, as well as the associated economic discussions in this report can be used in building what-if scenarios.

EEI's *Electric Vehicle Sales and the Charging Infrastructure Required through 2030*

In the report *Electric Vehicle Sales and Charging Infrastructure Required through 2030,* EEI estimates 26.4 million EVs on U.S. roads in 2030, more than 10 percent of the 259 million vehicles (cars and light trucks) expected to be on U.S. roads in 2030 (*29*). It predicts that the annual sales of EVs will be nearly 5.6 million in 2030, about 32 percent of annual LDVs in 2030. Figure 15 shows the comparison of the authors' annual EV sales forecast with the predictions in four other studies. It emphasizes the importance of the availability of EV charging infrastructure in the growth of EVs and estimates that 12.9 million charge ports will be needed in 2030. It predicts that approximately 140,000 DCFC ports will be needed to support the predicted level of EVs on the road in 2030.

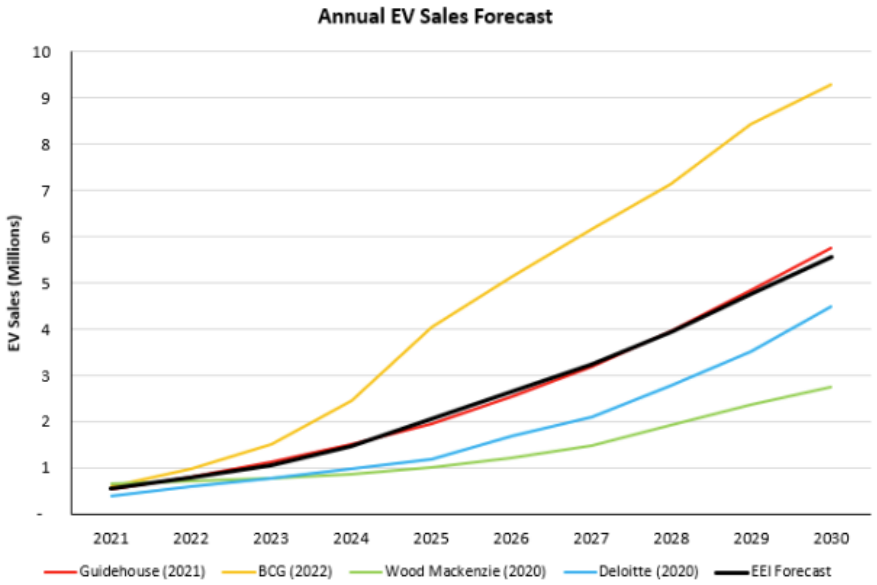


Figure 15. Comparison of the EEI Annual EV Sales Forecast with Four Other Studies (*29*).

The report lists three major factors to forecast EVs and their charging demand: customer preference models that determine interest in EVs, declining battery costs that influence EV cost competitiveness with ICE vehicles and manufacturer profitability, and fuel efficiency standards and environmental regulations. The report discusses the ambitious goals for ZEV sales announced by many major automakers following the executive order from the Biden Administration setting a goal for half of all vehicle sales to be zero emission in 2030 (*118*). Based on these announcements, potential EV sales in 2030 could be more than 8.3 million, well exceeding the consensus forecast of 5.6 million. Table 4 shows an estimate of total LDV sales by automakers in 2030, the percent of EV sales expected in 2030 based on automaker announcements, and the likely number of EV sales in 2030 based on those announcements.

Table 4. Projected EV Sales in 2030 by Vehicle Manufacturers.

Manufacturer	EEI Estimated LDV Sales in U.S. in 2030	Manufacturer Announced EV Sales in U.S. in 2030	Estimated EV Sales in 2030
BMW	420,000	50%	210,000
Ford	2,150,000	40%	860,000
General Motors	2,580,000	50%	1,290,000
Honda	1,660,000	40%	664,000
Hyundai-Kia	1,650,000	50%	825,000
Jaguar Land Rover	120,000	100%	120,000
Mazda	370,000	25%	92,500
Mercedes	370,000	100%	370,000
Nissan	1,230,000	40%	492,000
Stellantis	2,010,000	50%	1,005,000
Subaru	680,000	40%	272,000
Tesla	880,000	100%	880,000

Toyota	2,540,000	30%	762,000
Volkswagen	720,000	55%	396,000
Volvo	140,000	100%	140,000
Total	**17,520,000**	**48%**	**8,378,500**

This report highlights the evolving policy landscape in the United States and continued technological advancement as two key considerations for the development of the EV market. The report lists the following policy developments at the federal level that could impact the U.S. EV market between now and 2030:

- Vehicle Fuel Economy Standards.
- Greenhouse Gas Standards.
- Qualified Plug-In Electric Drive Motor Vehicle Credit (Internal Revenue Code 30D).
- Infrastructure Investment and Jobs Act.
- Federal Fleet Electrification.

The report discusses the importance of the availability of EV charging infrastructure to the growth of EVs. Unlike conventional vehicles, which typically refuel only at gas stations, EVs may charge at many different locations, such as while parked at home, at work, or in public spaces. Charging equipment is needed to deliver electricity from the energy grid to an EV, comes in a variety of types and configurations, and generally is categorized by power level. The report assumes that half of all EVs with access to home charging—including both single-family homes and MFDs—will use Level 1 (L1) charging, while the other half will use L2 (*29*).

The report provides a national-level analysis for EV infrastructure needed in 2030. Its methodology of using the manufacturers' estimated LDV sales and their announced EV sales in 2030 can be used for future analysis. Moreover, its discussions on the influential variables on the U.S. EV market are helpful for the scenario development.

ERCOT Reports and Statistics

ERCOT developed a process to produce EV load forecasts, with the expectation to begin using the forecasts in transmission planning studies in 2023 (*30*). ERCOT estimates between 4 and 6 million EVs, including 0.8 to 1.3 million pickup trucks, for an increase of 77 percent of miles driven by heavy electric trucks by 2035 (*31*). ERCOT used estimates from the annual Bloomberg *Electric Vehicle Outlook 2022*, which evaluated the global fleet size and estimations for the future (*32*). Figure 16 shows the global-long term EV share of new passenger vehicle sales.

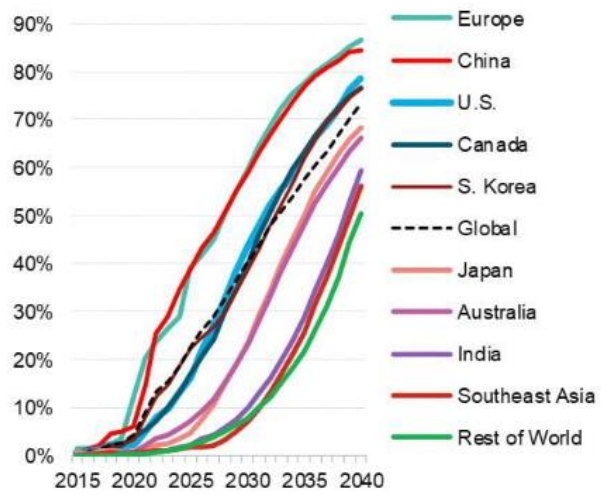


Figure 16. Global Long-Term EV Share of New Passenger Vehicle Sales (*32*).

The report provides two estimates, an economic transition scenario and a net zero scenario, which assumes adoption rates to reach net zero emissions in road transport by 2050. The report estimates that by 2030, between 34 and 58 percent of cars and between 12 and 20 percent of heavy-duty commercial vehicles will be EVs. It expects that assuming no new policies or regulations that impact the market (economic transition scenario), EV sales growth will slow down slightly in the 2030s after increasing rapidly over the next 10–15 years in the main EV markets (North America, Europe, and China). One of the findings of this annual report is that despite the relatively rapid growth of EV sales, it takes time to flow through to the fleet.

Considering the importance of EVs in the statewide grid load, ERCOT predicted the growth of EVs over the next several years. ERCOT estimates 1 million EVs on Texas roads by 2028. Using current EV growth trends, the Texas DMV estimates Texas will reach 1 million EVs by 2031. ERCOT expects a significant increase in the adoption of EVs in the near future, according to the December 2021 *ERCOT Report on Existing and Potential Electric System Constraints and Needs* (*30*). In this report, the impact of EV growth on load forecasts depends on the adoption rates and charging patterns associated with different types of EVs (e.g., passenger vehicles, trucks, buses, etc.).

ERCOT has developed a repeatable process for forecasting EV load impacts at the substation level out to 2029 for use in the system planning assessment (*42*). As such, the representative 24-hour load profiles at each substation for 8 years, four seasons, and two day types were generated using Texas-specific and publicly accessible data. In this process, the EV forecasts for 2022–2029 were allocated to zip codes, and then the load impacts at the substation level were calculated. The total forecast for 2029 was 770,000 light-duty and 160,000 MHDVs (4 percent of all vehicles). The total predicted EV charging load for 2029 was 6 TWh, adding 1.25 percent of load to ERCOT's electric load forecast (Figure 17).

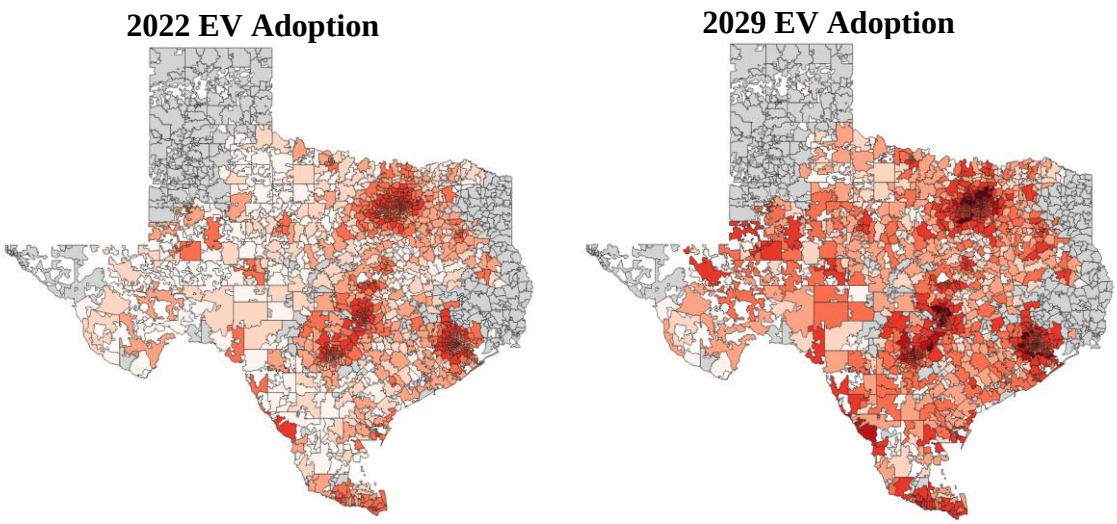


Figure 17. ERCOT Forecast for EVs in Texas (2022–2029).

Power allocation was established by multiple bottom-up models for key use cases. Analyses showed that a refresh of ERCOT's existing assumption was needed to ensure that the resulting allocations to substations were accurate. The improvement to the MHDV model were more substantial than the LDVs, and more granular MHDV use cases were developed for forecasts. Delivery vehicles and regional and long-haul trucks added load to substations in the city outskirts and major highways. It was shown that buses, pickup trucks, and certain regional trucks will increase load in urban and suburban areas. The allocation was concentrated primarily in urban and suburban zip codes surrounding major cities such as Austin, Houston, DFW, and San Antonio. The lack of historical adoption rates and a high level of uncertainty about the development of advanced technologies were identified as challenges for forecasting the adoption and allocation of vehicles. Some studies suggest ERCOT's future case should assume between 2.5 and 12.5 million EVs on roads in Texas in 2033 (*43*).

The estimations provided by ERCOT on EV counts and electricity loads, as well as the grid capacity and the related considerations, are critical parts of EV data analysis in Texas. In particular, the estimations of EV percentages of cars and heavy-duty commercial vehicles (between 34 and 58 percent of cars and between 12 and 20 percent of heavy-duty commercial vehicles) as well as the total count of EVs in Texas are helpful in the scenario building definition for future EV analysis in Texas.

USDOT's Rural EV Toolkit

USDOT's Office of the Under Secretary for Policy has developed the Rural EV Toolkit, which includes EV infrastructure planning resources potentially useful for research, such as tools to analyze charging and energy needs, cost analysis, equitable planning, and environmental and social impacts (*68*). The Rural EV Toolkit is a valuable source of information about EVs. It explains the EV charging speed for different charger types for LDVs, as summarized in Table 5.

Table 5. Overview of EV Chargers: Power Output, Plug Type, and Charge Time for LDVs.

	Level 1	Level 2	DCFC
Connector Type	J1772 connector 	J1772 connector 	CCS connector  CHAdeMO connector  Tesla connector/North American Charging Standard SAE J3400 
Typical Power Output	1 kW	7 kW–19 kW	50–350 kW
Estimated PHEV Charge Time from Empty	5–6 hours	1–2 hours	N/A
Estimated BEV Charge Time from Empty	40–50 hours	4–10 hours	20 minutes–1 hour (to 80 percent charge)
Estimated Electric Range per Hour of Charging	2–5 miles	10–20 miles	180–240 miles
Typical Locations	Home	Home, Workplace, and Public	Public

Note: N/A = not applicable.

As shown in Table 5, different vehicles have different charge ports. For DCFC, the CCS connector is based on an open international standard and is common on vehicles manufactured in North America and Europe; the CHAdeMO connector is most common for Japanese manufactured vehicles. Tesla vehicles have a unique connector that works for all charging speeds, including at Tesla's supercharger DCFC stations, while non-Tesla vehicles require adapters at these stations. In Table 5, the plug-in hybrids (PHEVs) are assumed to have an 8-kWh battery (thus, they do not work with fast chargers), and the BEVs are assumed to have a 60-kWh battery.

In November 2022, Tesla opened its proprietary charging connector to make specifications available to other EV manufacturers, called the North American Charging System (NACS). The

new standard uses the same ISO 15118 communication protocol as CSS, which makes it compatible with NACS by using a simple adapter. Teslas built before 2021 are not compatible with CSS, but Tesla's supercharger network remains backward compatible with the proprietary standard. Since NACS is a nonproprietary standard, NACS connectors can be installed on EV charging stations under the NEVI program as long as certain requirements are met, including that each DCFC charging port has at least one permanently attached CCS Type 1 connector.

The toolkit refers to USDOE's AFDC for explanation of the infrastructure readiness planning (*194*). As such, planners can use EVI-Pro to estimate how much EV charging infrastructure a city or state might need and what the electric load of EVs might be. This source compares the average annual transportation expenditures of urban and rural households for urban and rural areas ($9,822 versus $9,866, respectively) in 2020. It discusses that the transportation share of all annual household expenditures are 15.7 percent and 20.0 percent in urban and rural areas, respectively. The results of previous analyses are provided and conclude that more than 80 percent of EV drivers rely on home charging. Detached single-family residences with off-street parking and readily available standard power outlet access are common in rural areas and can easily accommodate EV charging. The rate of EV adoption in rural areas is roughly 40 percent lower than in urban areas, and EV charging infrastructure expansion has mostly been concentrated in cities and along major highways. Closing this gap will help rural communities more quickly realize the significant benefits from EVs, including economic development opportunities from offering people a place to charge their vehicles, health benefits from improved air quality, and lower GHG emissions. Upfront vehicle and charging infrastructure costs, limited infrastructure availability and geographic distribution, utility upgrades and electricity rates, charging station planning and permitting coordination, and public awareness and exposure to EVs are discussed as the EV challenges for rural communities.

The cost of purchasing or leasing an EV is expected to continue to fall due to increased EV production volumes, innovations in battery storage, declining battery pack costs, wider availability of mid-priced EV models, and increased competition among automakers producing non-luxury EVs. For example, USDOE is investing in reducing battery costs through public-private partnerships that aim to reduce battery costs from more than $120/kWh today to $60/kWh by 2030. This would bring EVs to near cost parity with ICE vehicles. The upfront costs in rural areas can be higher, especially for DCFC stations since installations in rural areas are more likely to require expensive electrical-service upgrades. Accurately assessing the total cost of ownership of such investments will lead to better long-term decisions and may make investments in charging infrastructure more appealing. While home-, business-, and fleet-based charging are expected to remain the primary ways EV drivers charge their vehicles, the need for expanded public fast charging continues to rise with the growth of EVs—especially for rural drivers, who typically drive longer distances than urban drivers and for whom existing DCFC stations are spaced much farther apart. Consumers are also concerned about the length of time it takes to charge an EV, the user-friendliness of chargers, the need to plan charging stops on long trips, and the relative convenience and safety of charging locations. Reduced battery performance and EV range during winter months are further concerns for rural communities in cold climates. The upgrade of the electrical-service wiring running to a facility, or even the upgrade of certain components of the local power distribution infrastructure, is more likely to be needed in rural areas, where the grid infrastructure may be less robust to begin with.

EV infrastructure planning in rural areas can be different from planning in urban areas. For example, many EV drivers in rural areas will likely have access to home charging to meet their day-to-day charging needs. Therefore, enhancing public charging infrastructure to support longer trips, such as through DCFC stations along highways, may be a higher priority among rural communities.

The Rural EV Toolkit is a useful source of basic and fundamental information for EV infrastructure planning. It provides a list of considerations for appropriate planning and also USDOT's view on EV charging infrastructure at different levels. However, it does not provide the quantitative measures for state-level EV planning. This toolkit is valuable to define the structure of planning and future scenario development.

NCTCOG's EV Registration Data Portal

The most up-to-date source of EVs registered in Texas is the DFW Clean Cities program, a USDOE program of NCTCOG and the Regional Transportation Council (*37*). As mentioned previously, the program collects and provides the monthly count of EVs registered in zip codes in Texas since September 2021.

The analysis of registration data in Texas shows that about 65 percent of EVs had the model year of 2021 or later as of September 2023. Moreover, Tesla vehicles (Models 3, Y, X, and S) account for about 59 percent of EVs in Texas. The Texas EV data classified by age and model provided by the DFW Clean Cities program can be used to characterize EVs and evaluate trends within Texas. The EV registration data can be used to understand the current scatteredness of EVs in Texas. However, it does not provide an overview of EV distribution as a subset of all registered vehicles.

USDOE's EV Registration Data

As mentioned in the literature review, registration data can be a useful source of information to characterize and predict EV counts. According to USDOE, Texas had the third-highest number of EVs registered by the end of 2021. USDOE EV registration data can be used to compare EVs in Texas with those of other states. Considering the lack of historical EV data, the EV data of states like California can be helpful to define different scenarios to forecast EV counts and their requirements in Texas.

TxDOT's EV Charging in Texas Data

TxDOT's Texas Electric Vehicle Mapping Tool lists EV charging stations by type and designated electric corridors by status (*195*). The most up-to-date statistics of EV chargers and their locations, along with valuable information such as the estimated costs in Texas, can be found on TxDOT portals (*40, 41*). The TxDOT EV charging dataset can be used to develop an accurate understanding of currently available EV infrastructure in Texas. The utilization data of these charging stations can be helpful to develop an understanding of EV charger efficiency and how available public chargers can facilitate the operation of EVs.

Wejo's Mobility Data

Vehicle telematics datasets are more readily available now and are a valuable source to better understand on-road transportation mobility. One mobility data provider, Wejo, can provide access to data curated from multiple motor manufacturers and a sample of the diverse range of connected vehicles and demographic types (*44*). The probe data are a resource to meet the federal requirements of monitoring and reporting congestion and freight performance enacted in MAP-21 (*47*). To assist agencies with meeting MAP-21 regulations, FHWA provides free access to the NPMRDS, a national database of probe-vehicle-based speed and travel time data (*48*). The travel time on Texas roadways can be used to develop location-specific profiles of vehicles on different trips.

Census Demographic Data

Census data indicating the spatial distribution of the population and demographic indicators can be used along with transportation activity for EV infrastructure analysis (*46*). These datasets can be used to determine trends in population and forecast needs for future EVs based on a variety of assumptions. The temporal and spatial distribution of population can be used as an indicator of potential growth in EV counts for different scenarios.

Atlas Public Policy's EV Hub

Atlas EV Hub is an online platform designed to provide information about the EV market (*69*). It developed the Highway Revenue Assessment Tool, built in Microsoft Excel, to provide insights on how the road network is funded by motor fuel taxes and how that revenue will change with new market conditions. This tool forecasts the annual revenue changes due to different oil price scenarios between 2019 and 2030 for different states. While this model can be used to predict the tax revenue of motor vehicles, the scenario development and assumptions in each scenario can be used for EV charging infrastructure requirements in Texas.

Pecan Street's Electricity Consumption Data

Pecan Street Dataport claims to be the world's largest resource for residential energy use data and collects data on energy usage from volunteer participants in residential and commercial buildings and EV charging stations (*49*). These data consist of EV usage, including charging behavior, driving patterns, and the impact of EV charging on the grid. Data on the electricity consumption of HVAC, pool pump, and EV chargers can be obtained from Pecan Street. Residential EV charger real-world data can give valuable insight into charging trends and characteristics. Pecan Street data can be useful for estimating the trends and characteristics of residential chargers. These data can help with planning the peak-hour demand for residential EV charger electric consumption.

NREL EVI-Pro

NREL has developed one of the primary tools in predicting EV infrastructure in the United States. NREL's EVI modeling suite informs the development of large-scale EV charging infrastructure deployment at different levels, from the regional and state level to site and facility operations (*61*). This suite includes three groups of modules and tools: network planning, site

design, and financial analysis. These tools are updated regularly, and some new models are also under development. One example is the EVI-Pro tool, which estimates the required EV charging stations in a designated area for a given EV fleet size. EVI-Pro can be used to analyze the typical daily travel patterns of LDVs, estimate related charging demand, and design infrastructure capable of meeting the demand. It can also be used to include the variations and uncertainty in vehicle and charger technologies, user demographics, market adoption conditions, shared use of chargers, and EV travel and charging preferences (*20*).

NREL EVI-Pro Lite

A simplified, web-based version of this tool, called EVI-Pro Lite, is geared for use by U.S. cities and states to estimate their charging infrastructure needs and the associated power demands on the electric grid (*63*). EVI-Pro Lite can provide a count of different types of chargers needed in a state or an urban area for a given count of EVs. It also provides the hourly profile of electric load for a given scenario that can be defined by the fleet size, average daily miles traveled per vehicle, average ambient temperature, percentage of PEVs, percentage of sedan PEVs, percentage of L1 and L2 chargers, percentage of access to home charging, and charging strategy.

NREL's EVI-Pro Lite is one the most comprehensive tools currently available for the prediction of future EV infrastructure needs. However, it provides limited options for defining scenarios. For example, there are just three options for average daily mile traveled per vehicle (25, 35, and 45 miles), which could constrain the scenarios for location-specific data analysis. Using the datasets behind EVI-Pro, TTI researchers developed a tool to overcome this limitation and enable more flexibility in defining future scenarios. Using this application, the required count of chargers and hourly electric load for a given fleet size can be estimated for any target area. The location-specific indicators of EV activities can be obtained from mobility data (e.g., Wejo) analysis. These indicators can be used to predict location-specific electric demand of EVs for different scenarios.

StreetLight

StreetLight is a data provider and analysis company that has built a commercial dashboard tool to guide planning for EV charging infrastructure. The data-driven tool is designed to help evaluate different scenarios for choosing EV charging locations (*64*). StreetLight uses cell phone, vehicle navigation device, commercial fleet, and other mobility data in conjunction with safety, land use, weather, and demographic data to predict travel behavior and charging demand. StreetLight also has information on existing L1, L2, and L3 EV chargers through available NREL data. The interactive dashboard provides visualized geospatial data with dynamic buttons for the user to adjust priorities based on utilization, equity, air quality goals, freight, and economic benefits of travel and tourism. The tool recommends locations, generally at a neighborhood or census tract level, for new EV chargers. StreetLight's calculations consider existing EV registrations available from states, driving patterns of current and future EV owners, freight routes, low-income and disadvantaged community locations, and air pollution levels. Figure 18 shows the custom dashboard equipped with slider inputs for each metric built by a consultant using the StreetLight data to prioritize EV charging station locations.

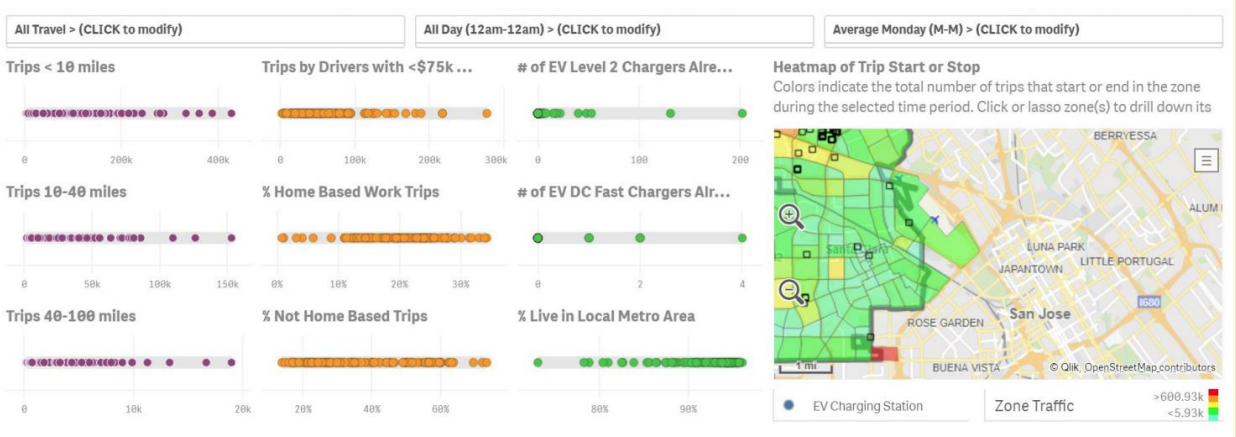


Figure 18. Dashboard Built Using StreetLight Data to Prioritize EV Charging Station Locations (*64*).

ElectroTempo

ElectroTempo is an analytics-as-a-service company that was founded in 2020 to specifically provide data insights to support the deployment of EV charging infrastructure. ElectroTempo's software is based on modeling tools developed by TTI that have since been spun into a commercial venture. The software unifies data and simulation infrastructure by integrating transportation demand, grid assets, land use, demographics, and emissions to accelerate EV infrastructure deployment. The software provides shared views, aims to maximize return to all stakeholders, and measures impacts on climate and equity.

AFLEET

The AFLEET tool, available from ANL, allows estimates of environmental and economic costs and benefits of AFVs (*65*). The AFLEET tool uses a life-cycle analysis approach to evaluate the environmental impacts of alternative fuels and vehicles. The tool takes into account the entire life cycle of the vehicle, including fuel production, vehicle manufacturing, vehicle use, and end-of-life disposal to provide estimates of environmental and economic costs and benefits. The AFLEET tool can analyze a wide range of alternative fuels, including electricity, hydrogen, natural gas, propane, and biofuels.

The AFLEET tool requires the user to provide fleet data, including vehicle types and usage patterns, to estimate fuel consumption and emissions for the fleet under various scenarios, such as using different types of alternative fuels or implementing several types of vehicle technologies. The AFLEET tool uses a variety of data sources, including vehicle performance data, fuel life-cycle data, and economic data. The tool also incorporates emission factors from the EPA and other sources. The AFLEET tool also provides economic analysis, including estimates of the cost savings associated with using alternative fuels and vehicles.

ANL also created the EV Charging Justice40 Map Tool to help EV charging planning efforts align with the Biden Administration's Justice40 goal of 40 percent of the benefits of federal investments in clean transportation going to disadvantaged communities (*66*). Further, ANL

provides a tool called Energy Zones Mapping Tool that allows the identification of energy zones that may be suitable for power generation and energy corridors (*67*).

EVALUATION OF TOOL CAPABILITIES AND GAP ANALYSIS

The purpose of this effort was to evaluate the tools described in the previous section to determine potential analysis gaps when using the available tools separately, and how to overcome these gaps by utilizing a combination of tools, available reports, and studies. The tools and studies are mainly designed to deal with the uncertainty of the future EV population due to the lack of historical data in this area. Each tool reviewed has strengths and weaknesses when used for charging demand forecast in Texas. This section summarizes the strengths and weaknesses of the tools and discusses their applicability for the analysis of EV charging demand.

Table 6 provides a list of the studies and tools, an assessment of their best use cases, and a description of potential weaknesses. The studies listed in Table 6 generally focus on a series of parameters that influence future EV charging demand. The studies use a series of assumptions and a top-down approach to predict national- and/or state-level EV charging demand for future years. The assumptions for the scenario development at national-scale analysis do not necessarily reflect the location-specific characteristics of future EV charging demand. In other words, the analyses based on a top-down approach are mainly developed by average criteria and are not capable of reflecting the details of location-specific needs and demands. These studies use statistics and growth rates for high-level, long-term, and nationwide predictions. While their methodology and statistics are useful to obtain a big picture of overall trends in the EV environment, their findings are not necessarily useful for short- and mid-term statewide planning. These types of studies do not use location-specific datasets with a bottom-up approach in the prediction of future EV charging demand in Texas.

Table 6 provides a list of datasets that can potentially be used in EV studies in Texas. Many previous studies have listed the lack of historical EV data as a challenging fact in the prediction of future EV charging demand. The location-specific datasets (e.g., registration data) can be helpful to build different scenarios and explore potential cases for future EVs in Texas. However, these datasets cannot be used individually for these studies; they need to be used as one component of EV studies. The analysis of mobility data in Texas counties would give an opportunity to better understand the variety of needs and be able to include those needs in a comprehensive plan tailored for EVs in Texas.

The tools listed in Table 6 provide different options to improve the prediction of future EV charging demand but are not generally developed based on location-specific mobility data. These models use the indicators of EV total activities (e.g., population) and predict the EV charging demand for different scenarios. However, they are limited in terms of the variety of scenarios, and they can cover general scenarios that can be used for national-level studies. Utilizing the high-resolution location-specific mobility data with these tools can improve the prediction of EV charging demand and the efficient planning for charging infrastructures.

Based on the reviewed and listed literature (Table 6), it can be concluded that using a combination of the influential variables employed in national-level studies with location-specific datasets and currently developed tools can provide a framework to build reasonable scenarios for

EV population growth to predict the temporal and spatial distribution of EV charging demand in Texas. While using the individual studies and tools will be associated with involving their weaknesses, using a combination of these studies and tools can significantly improve the prediction of EV charging demand. Using a solid framework gives the opportunity of updating the EV analysis while learning more about EV trends over time using future EV datasets.

Table 6. Tools, Datasets, and Other Sources Included in the Assessment.

Data/Tool/Source	Category	Description	Applicability/Best Use Cases	Weaknesses/Limitations
U.S. EIA, *Annual Energy Outlook*	Report	Projection of U.S. energy markets for the future three decades.	Includes projections of population, VMT, and energy use of different vehicle categories, including various types of BEVs. It gives a big picture of the nationwide transportation sector, and its growth rates can be used in scenario building.	Statistics and growth rates are high level, long term, and nationwide, not short term and state level.
USDOE, *National Plug-In Electric Vehicle Infrastructure Analysis*	Research Study	Comprehensive study on the charging infrastructure needed in the United States in 2030.	Provides a useful methodology that includes the sensitivity of the influential variables. It can be used in scenario building.	Lack of location-specific data and use of the nationwide average inputs as the activity indicators.
ExxonMobil, *Outlook for Energy*	Report	Annual report on long-term energy demand and global supply trends.	Provides the global transportation-related energy demand for the next three decades. It can be used to reflect the effect of the global energy market and general trends in state-level forecasts.	Statistics and growth rates are high level, long term, and nationwide, not short term and state level.
McKinsey, *Building the Electric-Vehicle Charging Infrastructure America Needs*	Report	Evaluation of different aspects of EV charging station needs in the United States.	Provides historical EV sales data, qualitative evaluation of changes in the EV future market, and principles for building EV charging infrastructure. It can be used in scenario building.	Focuses more on national trends and qualitative evaluations than location-specific quantitative terms.
EEI, *Electric Vehicle Sales and the Charging Infrastructure Required through 2030*	Research Study	Evaluation of different aspects of EV charging station needs in the United States.	Provides projected EV sales in 2030 by manufacturers and lists the policy development at the federal level that could impact the U.S. EV market. Discusses the importance of the availability of EV charging infrastructure to the growth of EVs.	Focuses more on national trends and qualitative evaluations than location-specific quantitative terms.

Data/Tool/Source	Category	Description	Applicability/Best Use Cases	Weaknesses/Limitations
ERCOT, constraint and needs assessment reports and statistics	Report	Estimation of EV count and charging demand in Texas for future years.	Provides methodology with assumptions that seemed reasonable to ERCOT as well as the forecast of EV count and charging demand based on national trends.	Does not provide the details of the estimation and does not cover different scenarios.
USDOT, Rural EV Toolkit	Report	Statistics and guidelines for planning level analysis.	Provides valuable information on EVs, high-level statistics, and considerations for charging infrastructures.	Does not have location-specific statistics and overall results for different scenarios.
NCTCOG, EV registration data	Data	The most recent count of EVs in Texas by county.	Provides the most location-specific of all EVs by county.	Does not provide the total registration data, which can be useful for future predictions.
USDOE, EV registration data	Data	A recent count of EVs in the United States by state.	Provides the most recent statistics to compare EVs in Texas with other states.	Does not provide the ratio of EVs to total vehicles in different states to compare.
TxDOT, electric vehicle charging in Texas data	Data	The most recent count of different types of public chargers.	Shows the availability of public chargers in different locations with a big picture of public chargers in Texas.	Does not provide private charger data, which are expected to be the majority of EV chargers.
Wejo, mobility data	Data	Real-world data of vehicles with their characteristics.	Provides location-specific data of sample vehicles.	The mobility data processing is computationally intense, and its validity depends on how representative the sample is. These datasets are expensive and may not be available for the long term. One major data provider (Wejo) recently filed for bankruptcy, casting doubt on the availability of future mobility data.

Data/Tool/Source	Category	Description	Applicability/Best Use Cases	Weaknesses/Limitations
Census, demographic data	Data	Population and demographic data by census block.	Provides the spatial distribution of the population and its characteristics in different areas, which can be used to estimate charging demand distribution.	The estimation of EV count and charging demand based on the population requires some assumptions, which can affect the accuracy of the analysis.
Atlas Public Policy, EV Hub	Data/Tool	Excel-based tool that provides insights into how the road network is funded by motor fuel taxes and how that revenue will change with new market conditions.	Provides the predicted count of vehicles with different types of fuels and their growth rates.	Does not use location-specific indicators of activity and uses national-level averages for estimations.
Pecan Street, electricity consumption data	Data	Real-world electricity consumption data of residential EV chargers.	Can be useful for estimating the trends and characteristics of residential chargers. Can also help in planning the peak-hour demand of residential EV charger electric consumption. Possible use cases of these data include understanding the charging patterns of residential and commercial chargers, identifying high-demand areas, optimizing the commercial charging infrastructure, and evaluating the impact of EVs on the existing electric grids.	The data are currently only available for certain regions of the United States, so not all homeowners and businesses can benefit from these data. The data may also have limitations in terms of sample size and geographic coverage, and they may not be fully representative of all energy users since data are collected from volunteer participants.

Data/Tool/Source	Category	Description	Applicability/Best Use Cases	Weaknesses/Limitations
NREL, EVI-Pro (EVI-Pro Lite)	Tool	Tool that estimates the required EV charging stations for a given EV fleet size in a designated area.	Uses a bottom-up approach to estimate charging infrastructure needs with the fundamental element of 24-hour daily driving schedules from real-world vehicles.	Tool provides limited options for the EV population. In other words, it is not flexible in building different scenarios. Only the simplified web-based version of EVI-Pro, called EVI-Pro Lite, is freely available.
StreetLight	Tool	Software-as-a-service-based platform that uses big data analytics to measure travel patterns of vehicles, bicycles, and pedestrians.	Travel patterns can be used to reduce congestion, improve safe and equitable transportation, and maximize the positive impact of infrastructure investment.	The accuracy of StreetLight data depends on the source and how they were collected. The platform does not allow customization of the pre-packaged reports and analysis needed for different use cases.
ElectroTempo	Tool	Tool that provides data insights to support the deployment of EV charging infrastructure.	Unifies data and simulation infrastructure by integrating transportation demand, grid assets, land use, demographics, and emissions to accelerate EV infrastructure deployment.	Tool is based on the travel demand model and other models and does not use the characteristics of location-specific mobility based on real-world data.
Argonne National Lab, AFLEET	Tool	Spreadsheet-based tool that provides detailed data and web-based tool that calculates the environmental and economic impacts of AFVs. Also has a web-based tool for heavy-duty vehicle emissions calculator.	Spreadsheet tool allows the user to calculate the energy and emissions for a gasoline vehicle driving the same mileage as dispensed by EV chargers. The EV charging benefit is defined as the EV emissions subtracted from gasoline emissions.	Tool is mainly designed for fleet managers and may not be useful for individual EV charging station planning. The user needs to provide input data for various scenarios.

SELECTION OF TOOLS AND METHODOLOGY

Considerations for Tool Selection

As discussed in the previous section, each study and tool has its strengths and weaknesses. Certain general high-level criteria for selecting one or more tools (or studies) for the prediction of future EV charging demand should be considered in the building of the overall analysis framework. These criteria are:

- **Capability of dealing with a series of different scenarios.** Different studies have shown variable prediction of EVs in the future based on different input sets. Defining and using a series of scenarios will be helpful to incorporate potential variations in future EV charging demand.
- **Ability to reflect temporal and spatial variations/distributions of EV charging demand.** While it is common to use average measures for future predictions at the state and national levels, it will be useful to have a variety of EV charging demand levels over a 24-hour period at different locations. It is important to build a framework for future EV charging demand that can incorporate these variations and reflect them in future planning for EVs in Texas.
- **Use of a methodology that can be updated in the future as the understanding of EV demand evolves.** Vehicle electrification is still in its early stages and will continue to evolve. Moreover, making viable assumptions will be part of current EV studies due to a lack of historical data. It is important to build a framework that can be updated in the future to reflect an improved understanding of EV mobility using evolving datasets. It is also important to define different pieces of analysis in a way that can be updated in the future to reflect potential changes (e.g., battery life and EV range).

The research team used these criteria for the selection of a tool and methodology to analyze and estimate EV charging demand.

Description of Selected Tool and Methodology

Based on the results of the literature review and assessment of datasets and tools, a three-step framework seems to be a reasonable approach to predict future EV charging demand. These three steps are:

1. Build a variety of appropriate scenarios based on previous studies.
2. Use mobility datasets with location-specific data available in Texas.
3. Predict charging demand using NREL's EVI-Pro Lite.

This framework benefits from three main components, which are the main influential variables on the future EV population identified by researchers nationwide and addressed in the latest reports; the location-specific mobility data, which reflect the temporal and spatial distribution of EVs in Texas; and the latest charging profiles developed by NREL.

ANALYSIS OF ELECTRIC VEHICLE CHARGING DEMAND

A variety of statistics can be used in the high-level prediction of EV charging demand for different scenarios. The comparison of different EVs shows that EV average energy consumption varies between 142 watt-hour (Wh) per kilometer (km) for a Tesla Model 3 and more than 290 Wh/km for a Mercedes eVito (*196*). According to USDOT, Americans drive on average 13,476 miles per year, or 36.92 miles per day (*197*). Using the average EV's energy consumption, a home EV charger would use around 11.81 kWh per day to charge the car to replenish the range driven. However, these values are general nationwide averages and do not reflect the variation of charging demand based on location-specific variables.

This section discusses the scenarios the researchers developed to estimate the future EV population. Researchers then discuss the base model using EVI-Pro Lite data and its influential variables. Finally, researchers discuss the future EV charging demand forecast at the state level for different scenarios, followed by the spatial distribution of charging demand around Texas.

EV Population

The DFW Clean Cities portal provides the latest registration data of EVs and total vehicles in Texas. This website shows there are about 23 million total vehicles and about 205,000 EVs registered in Texas as of July 2023. Many studies have discussed that the EV count in Texas will hit 1 million sometime between 2028 and 2035. As such, a model was developed to forecast the EV charging demand for the cases in which the EV population in Texas is 0.6, 0.8, 1.0, 1.2, and 1.4 million. Moreover, a scenario was developed for the current count of approximately 220,000 EVs. This model is flexible and can be easily modified to obtain future charging demand for any other population scenarios.

EV Charging Demand Model

The base data behind the EVI-Pro Lite model was obtained from the application programming interface provided by NREL. This dataset was used to develop a model that provides the charging demand for different counts of EVs for Texas. This dataset provides the hourly charging demands for a series of parameters, as discussed next.

Temperature

This parameter defines the average daily temperature in Celsius for the day on which the load profile shape is desired. Available options are −20, −10, 0, 10, 20, 30, and 40°C (equivalent to 4, 14, 32, 50, 68, 86, and 104°F).

Mean Daily Vehicle Miles Traveled

This parameter defines the average fleet daily VMT (per vehicle). Considering previous studies in Texas, 25 miles per electric vehicle was used.

Plug-In Electric Vehicle Distribution

This parameter defines the distribution of PHEVs and BEVs in the EV fleet. There are three options:

- PHEV dominant scenario (75 percent PHEV and 25 percent BEV).
- BEV dominant scenario (25 percent PHEV and 75 percent BEV).
- Equal shares scenario (50 percent PHEV and 50 percent BEV).

Class Distribution

This parameter defines the vehicle class distribution. There are three options:

- Sedan dominant scenario (80 percent sedan and 20 percent SUV).
- SUV dominant scenario (20 percent sedan and 80 percent SUV).
- Equal shares scenario (50 percent sedan and 50 percent SUV).

Preference Distribution

This parameter defines the preference for the primary charging location, at home or at other locations (including work), assuming the vehicle owner has access to both. There are three options:

- 60 percent prefer charging at home and 40 percent prefer charging at other locations.
- 80 percent prefer charging at home and 20 percent prefer charging at other locations.
- 100 percent prefer charging at home.

Home Access Distribution

This parameter defines access to home charging, where the number represents the percent of EV drivers in a fleet with access to home charging. There are three options:

- 50 percent of EV drivers have access to home charging.
- 75 percent of EV drivers have access to home charging.
- 100 percent of EV drivers have access to home charging.

Home Power Distribution

This parameter defines the distribution of access to L1 and L2 home chargers in residential areas. There are three options:

- Most L1 scenario (80 percent L1 and 20 percent L2).
- Most L2 scenario (20 percent L1 and 80 percent L2).
- Equal distribution of L1 and L2 scenario (50 percent L1 and 50 percent L2).

Residential Charging Strategy

There are four strategies for home charging:

- **Immediate—As Fast as Possible.** In this strategy, EVs begin charging immediately upon arriving at a charging location and charge at full power/speed until fully charged or the vehicle departs.
- **Immediate—As Slow as Possible (Even Spread).** In this strategy, EVs begin charging immediately upon arriving at a charging location, but the charging speed/power is controlled to be as slow/low as possible to spread the charge evenly over the time the vehicle is parked.
- **Delayed—Start at Midnight.** In this strategy, EV owners elect to program their vehicles to begin charging at a specific time overnight (often midnight local time).
- **Delayed—Finish by Departure.** In this strategy, EVs wait as long as possible to begin charging so they can still receive a full charge. This strategy uses arrival and departure times from the travel data referenced in the assumptions to shift load during simulations.

Day Type

This parameter defines the charging profiles that are provided for 24 hours of two day types: weekdays and weekends.

Other Parameters

There were other parameters and assumptions in using the NREL EVI-Pro Lite model in this current study. It was assumed that charging at work would be done using 80 percent L2 chargers with minimum delay.

Forecast of EV Charging Demand in Texas

The EV charging data were used along with different scenarios to predict the charging load for six charger types: Home L1, Home L2, Work L1, Work L2, Public L2, and Public L3. This modeling procedure resulted in the development of 489,888 hourly charging profiles for different scenarios. These profiles can be used for the prediction of EV charging in different situations. Table 7 shows the total daily load, the sum of all six types of chargers' demand, for one scenario with 1 million EVs in a day with an average temperature of 68°F.

Table 7. Charging Demand Predicted for 1 Million EVs.

Variable	Value
Population	1.0 M
Temperature	68°F (20°C)
Access to Home Charger	100%
Home Power Distribution	80% L1–20% L2
Preference for Home Charging	80%
Vehicle Class Distribution	50% Sedan–50% SUV
Distribution of PHEV and BEV	50% PHEV–50% BEV
Total Daily Load	9.56 GWh

Results show a significant effect of temperature on charging demand (Figure 19). Based on the NREL-provided profiles, the total daily charging demand for a population of 220,000 EVs, which is 2.15 GWh in a day with an average temperature of 68°F, can increase up to 3.27 and 3.4 GWh at −4 and 104°F, respectively. Figure 19 shows that the optimum charging demand for different populations occurs at 68°F. In other words, the same EV population demands higher charging levels at temperatures below and above 68°F (more than 50 percent, as shown in Table 8).

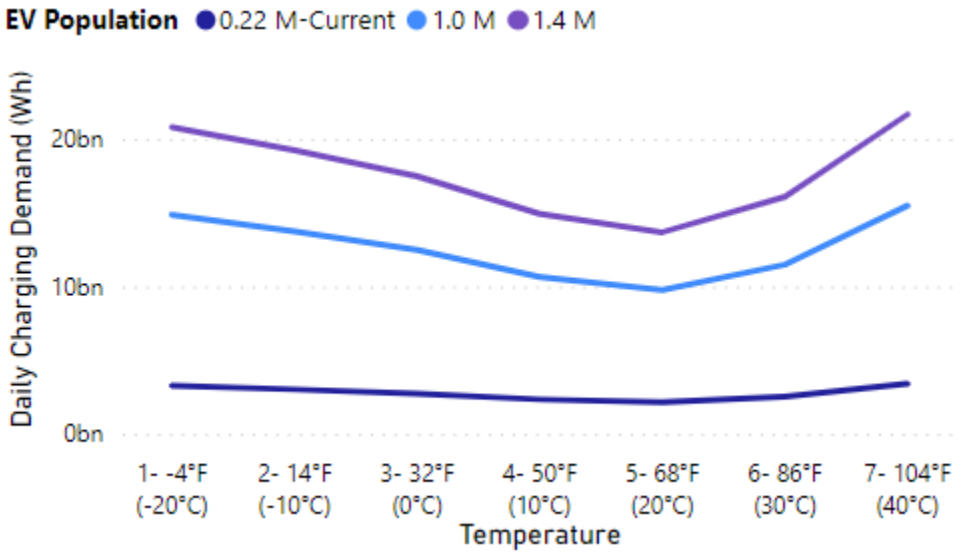


Figure 19. Total Daily Charging Demand in Different Daily Average Temperatures.

Table 8. Increase in Charging Demand Relative to the Demand at 68°F.

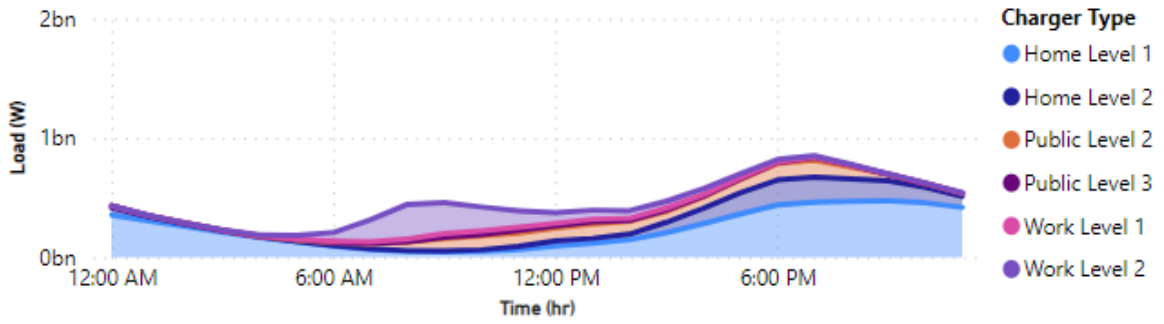
Temperature	Increase in Charging Demand
−4°F (−20°C)	52%
14°F (−10°C)	41%
32°F (0°C)	28%
50°F (10°C)	9%
68°F (20°C)	0%
86°F (30°C)	18%
104°F (40°C)	58%

The hourly variation of charging demand is one of the important topics discussed by various stakeholders in workshops held for this project in late 2022 and early 2023. Researchers investigated the effect of different residential charging strategies on the statewide hourly charging demand using four residential charging strategies: Immediate—As Fast as Possible, Immediate—As Slow as Possible (even spread), Delayed—Start at Midnight, and Delayed—Finish by Departure. Figure 20 shows the hourly variation of charging demand for 1 million EVs at 86°F. Figure 21 shows the same information as a bar chart with the hourly demand generated by each scenario. The total charging demand in all scenarios is about 11.15 GWh. However, the spread of this demand is different in different scenarios. The comparison of the peak hourly load of the network in these scenarios can be highly useful in grid management.

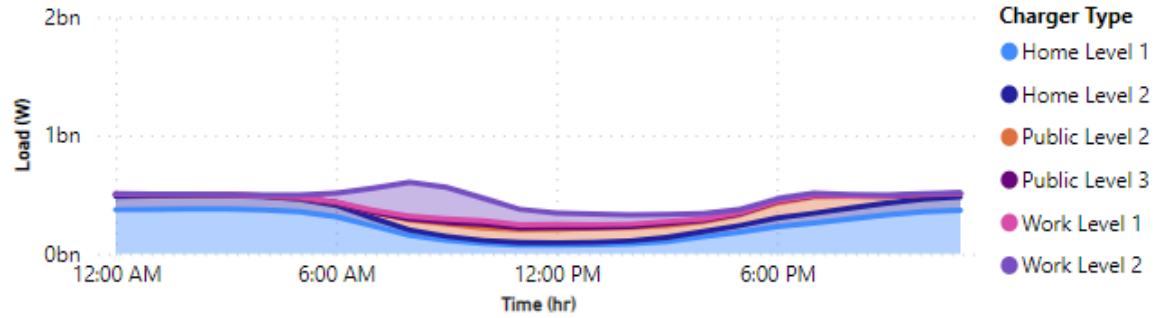
The Immediate—As Fast as Possible strategy represents a situation where there is no effective planning and time management for charging EVs, and drivers use chargers immediately upon arrival. This scenario causes one evening peak in using residential chargers and one morning peak because of using public DCFCs. The Immediate—As Slow as Possible strategy predicts the hourly demand for a situation where drivers use chargers immediately upon their arrival, but the charging rate is adjusted in a way that vehicles are fully charged over the time the vehicle is parked. As shown in Figure 20, this strategy results in an even distribution of hourly charging demand over 24 hours and does not cause the evening peak.

There are two strategies with a delayed charging approach. The Delayed—Finish by Departure strategy assumes vehicles wait as long as possible to begin charging so they can receive a full charge. This strategy causes a peak charging load at early morning, right before the morning traffic peak. The Delayed—Start at Midnight strategy assumes vehicles begin home charging at midnight. This strategy causes a peak charging load at midnight, and then it decreases until morning. The delayed strategies aim at maximum reduction of load at the evening energy demand peak. A combination of these strategies can be used to minimize the charging demand in peak hours and maximize contribution of green energies, such as wind and solar, in EV charging.

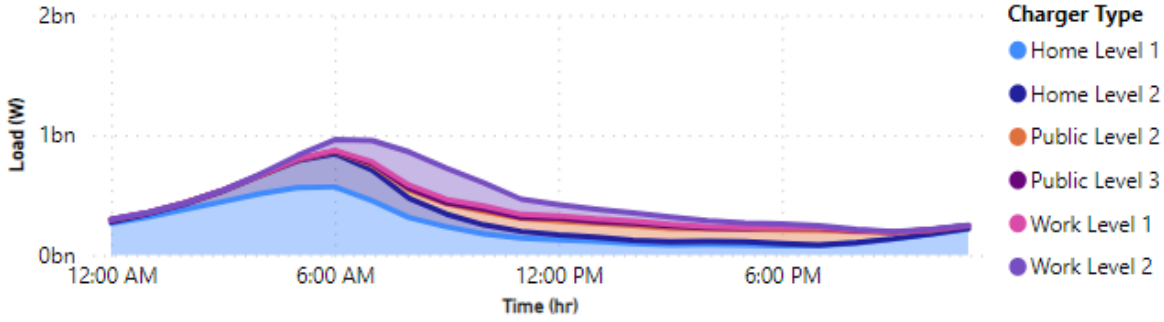
Immediate—As Fast as Possible



Immediate—As Slow as Possible



Delayed—Finish by Departure



Delayed—Start at Midnight

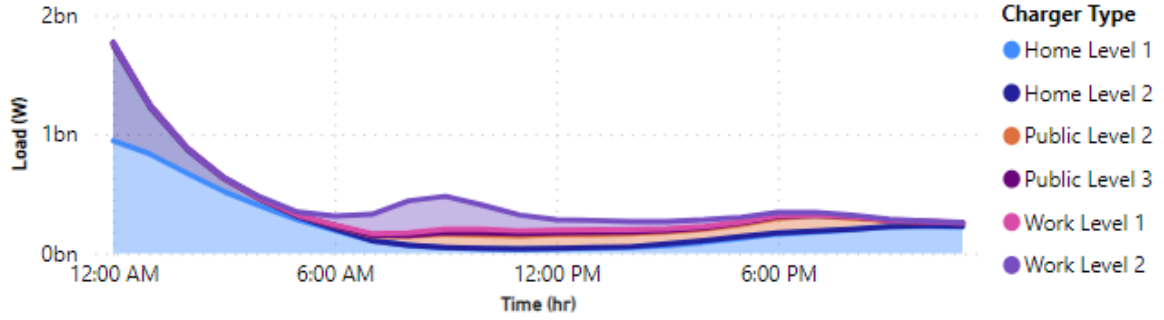
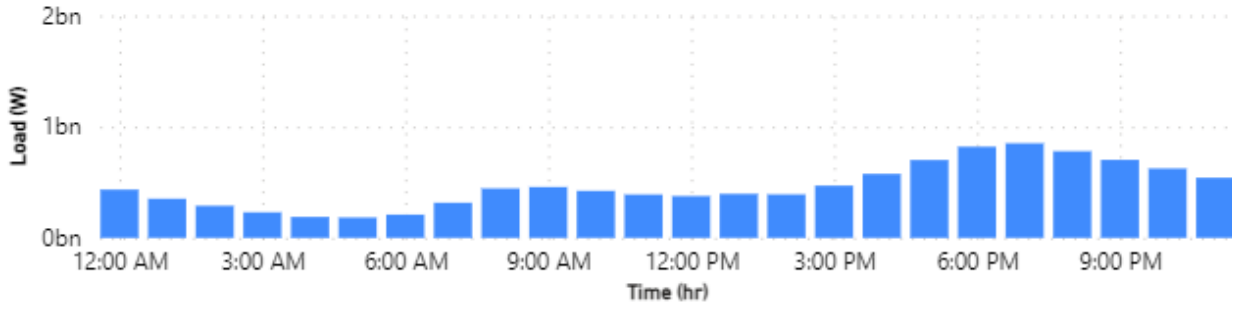
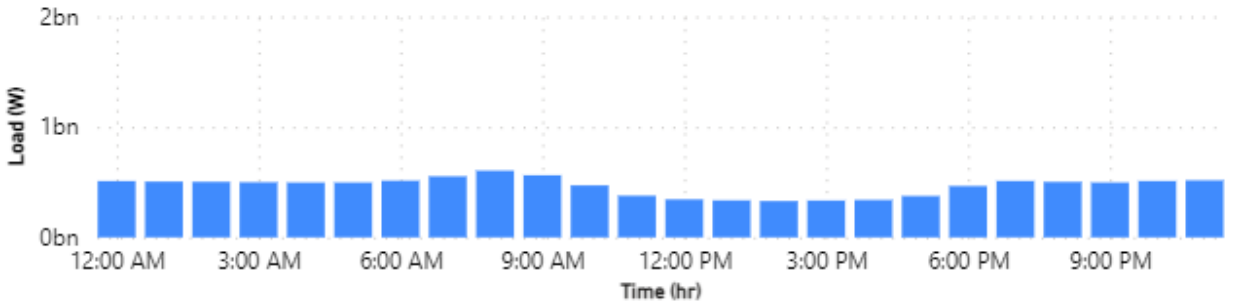


Figure 20. Hourly Profile of Charging Demand for 1 Million EVs at Daily Average Temperature of 86°F by Different Charging Strategy (~11.15 GWh Daily Demand).

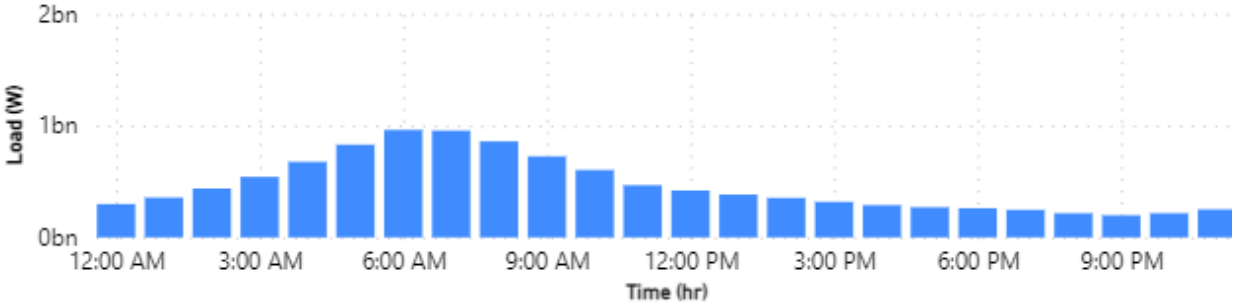
Immediate—As Fast as Possible



Immediate—As Slow as Possible



Delayed—Finish by Departure



Delayed—Start at Midnight

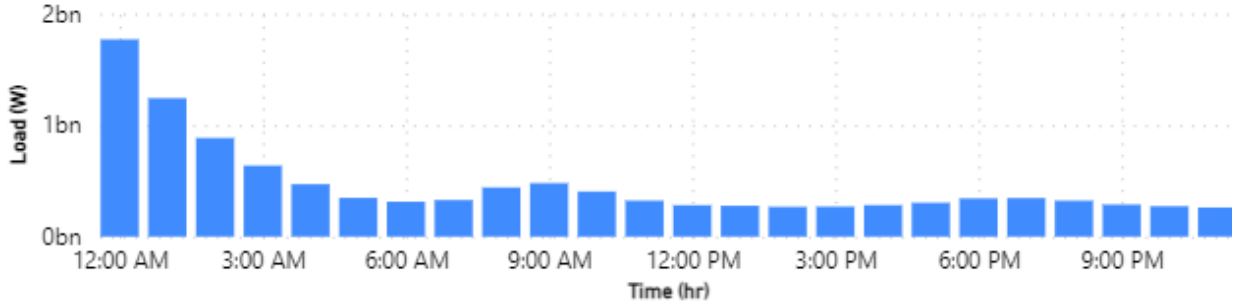


Figure 21. Hourly Charging Demand for 1 Million EVs at Daily Average Temperature of 86°F by Different Charging Strategy (~11.15 GWh Daily Demand).

Spatial Distribution of EVs and Charging Demand

Vehicle registration data were used to investigate the spatial distribution of EV charging demand in Texas. The assumption behind using registration data is that EVs will be available for

charging overnight in proximity of their registration address. Researchers obtained registration data of all vehicles and EVs in Texas in July 2023 from the DFW Clean Cities portal by zip codes. Figure 22 and Figure 23 show the distribution of registered vehicles in Texas, and as an example, with a focus on the Houston area. The figures show that there are still many zip codes without any registered EVs. While distribution at the zip code level can be helpful to have a high-resolution distribution of charging demand that is important from an operation standpoint, it is not particularly helpful to understand EV charging demand at the planning level. Thus, county-level registration data were used for this current study.

The county-level EV registration data include many counties with very small EV populations that are prone to drastic changes (Appendix E). As such, total registration data were used to obtain EV charging demand distribution. The assumption here is that a prediction is being done for the time that the spatial distribution of EVs is comparable with distribution of all vehicles at the county level in Texas. The provided methodology can be easily modified to apply any other spatial distribution to the EV charging demand forecast in this current study.

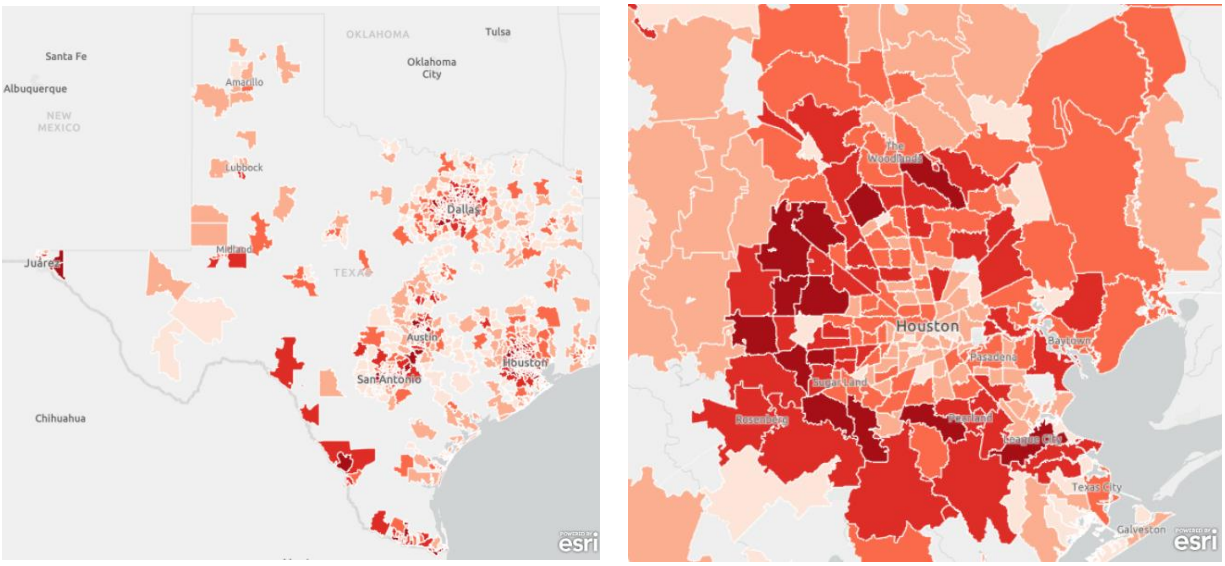


Figure 22. Distribution of All Vehicles Registered in Texas by Zip Code.

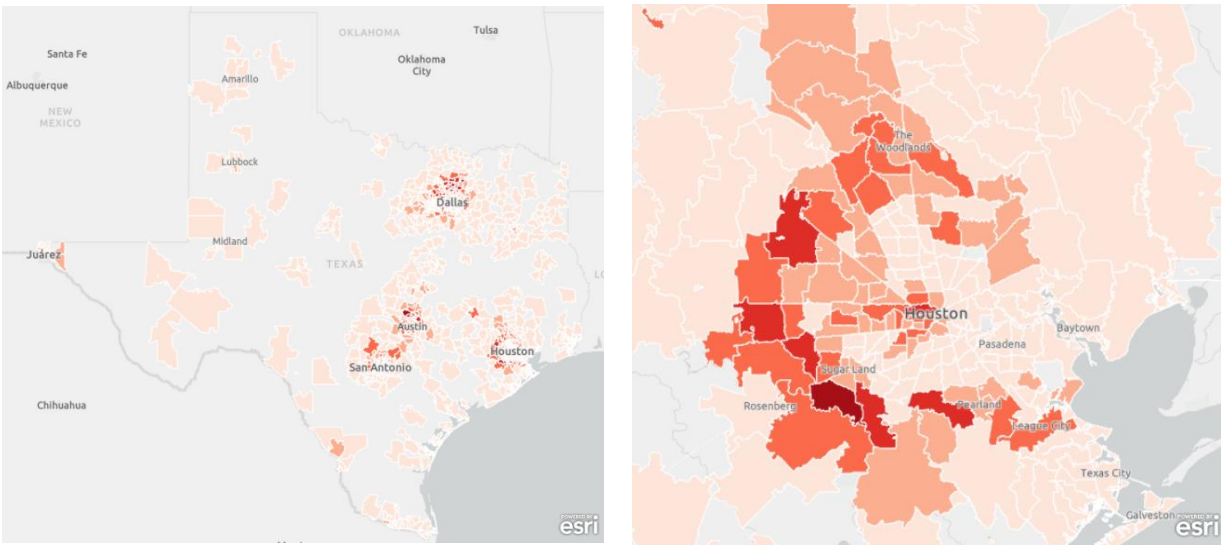


Figure 23. Distribution of Electric Vehicles Registered in Texas by Zip Code.

The spatial distribution of county-level total registration data was used to distribute the EV charging demand forecast around Texas. Figure 24 is an example that shows the spatial distribution of the charging demand of 1 million EVs at 68°F by county. The daily EV charging demand (for the total of 1 million EVs) was predicted to be 9.6 GWh, and the county-level charging demand (for 254 counties) in Texas is provided in Appendix F. Appendix F shows that Harris, Dallas, Tarrant, and Bexar Counties will have the highest daily charging demand in Texas at 68°F, with 1,382, 841, 681, and 655 MWh, respectively.

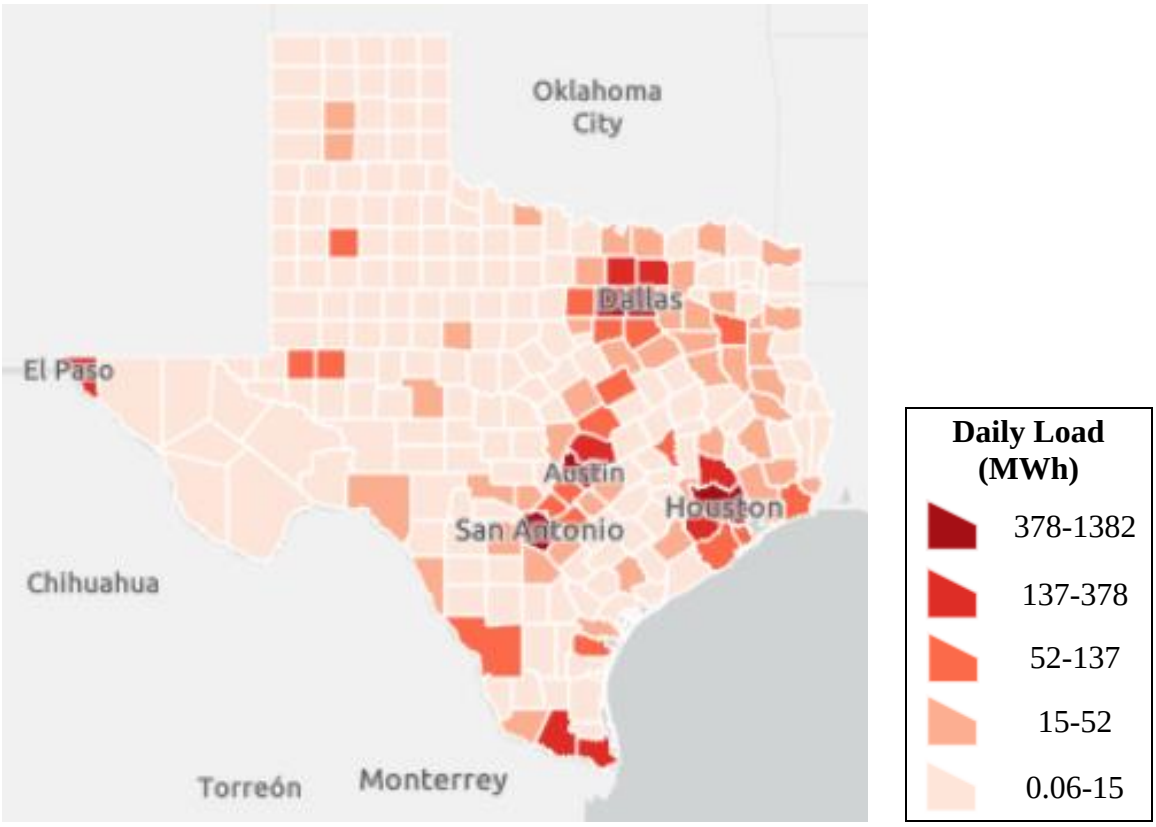


Figure 24. Distribution of Daily Charging Demand of 1 Million Electric Vehicles (9.56 GWh) in Texas (68°F) by County.

The predictions in this study are based on EVI-Pro Lite data provided by NREL and cover light-duty EVs. The research team investigated the charging demand of heavy-duty vehicles as well. The major finding was that the current total population of heavy-duty EVs is a few hundred nationwide, and its market is immature and still evolving. Potential exists for the heavy-duty market to be more focused on alternative fuels rather than EVs. The research team's understanding is that it is too early to predict heavy-duty EV demand since technological advancement can significantly change the market and related analysis.

CHAPTER 5. ANALYSIS OF POLICIES AND FUNDING OPPORTUNITIES

INTRODUCTION

TxDOT is leading planning efforts to support electrified mobility throughout the Texas transportation system. Ensuring effective charging coverage for EVs across a statewide network requires consideration of EV charging needs as well as investments required to meet those needs. Questions surrounding effective policies, regulations, and funding options should be addressed when developing a strategy for transportation electrification. Strategic planning for charging infrastructure is impacted by the policy and regulatory environment in a state as well as the availability of plans and programs to support electrification.

This chapter documents the research team's efforts to review EV legislation and policies in selected peer states and cities as well as funding models and opportunities for EV charging infrastructure to develop a policy analysis and funding framework for Texas. Researchers developed the framework based on a review of legislation, regulations, and policies at the federal level, in peer states, and in selected metropolitan regions and cities in those states. Researchers considered potential funding models and opportunities for EV charging infrastructure as well as revenue opportunities in the EV purchasing, charging, and operating markets. Researchers focused on potential policy options and legislative and regulatory barriers related to EV charging as well as potential funding and revenue options. To meet the objectives of the project, researchers performed the following activities:

- Conducted a state-of-the-practice review of existing policies, plans, legislation, and regulations at the federal level and across selected peer states and cities.
- Assessed funding models used in peer states as well as novel and innovative funding and finance options.
- Developed a policy analysis framework that identifies the options available for Texas with respect to legislation, policies, and funding and highlights potential implications of implementation.

The research team conducted a thorough review of statutes, policies, regulations, and funding and financing programs across the federal government and in 14 peer states. The peer state review also considered potential local and regional issues, such as zoning and permitting. Interviews were conducted with the following seven states: Arizona, California, Colorado, Ohio, Pennsylvania, Tennessee, and Oklahoma. Interviews were also conducted with the following five MPOs: Maricopa Association of Governments (MAG) in Arizona, Chicago Metropolitan Agency for Planning (CMAP) in Illinois, Region 1 Planning Council in Illinois, Capital Region Transportation Council (CRTC) in New York, and Delaware Valley Regional Planning Council (DVRPC) in Pennsylvania. Interview narratives are included in Appendix G, and the discussions informed the state and regional policy review.

This chapter summarizes the activities that led to the development of the policy analysis framework. The framework itself—Product 2 of this research project—is available as a separate document. As such, this chapter provides an overview of policies, legislation, and regulations at the state and federal level that impact EV infrastructure planning and decision-making. Topics of

interest included freight, fleets, and MFH, as well as workforce, education, and economic development. Policies impacting funding and financing—ranging from providing grants and tax credits to generating revenue to offset foregone fuel tax revenue—were also reviewed. Revenue and financing models for EV charging developed by the private sector were also explored. Finally, the challenges and opportunities for Texas with respect to EV infrastructure policy and funding were analyzed to understand Texas's needs moving forward.

FEDERAL EV LEGISLATION AND POLICIES

With the passage of the IIJA in 2021, the federal government and the current administration signaled a strong interest in promoting electrification across transportation to meet climate and equity goals. Subsequent legislation continued that interest in developing a robust electric mobility landscape in the United States through advancements in battery technology as well as improvements to the supply chain. In addition, executive orders and federal initiatives have emphasized the focus on the climate and the environment as well as on equity and justice in transportation. Federal EV legislation and policies provide a broad framework for transportation investments that are determined and finalized at the state and local levels. These policies—through their dedicated funding levels and the requirements associated with this funding—have implications for EVs and charging infrastructure in Texas. Finally, after the IIJA and the NEVI program expire, Texas decision-makers will need to consider how to maintain EV infrastructure capacity throughout the state, beyond the scope of these initial programs and funding.

The Infrastructure Investment and Jobs Act

The IIJA represents a significant investment in U.S. infrastructure, especially in electrifying transportation and providing clean energy to support that electrification. The legislation includes efforts across all modes of transportation, often with a focus on climate change or reducing emissions (*198*). A key component of reducing emissions, as well as the overall environmental footprint from transportation, is promoting the use of alternative fuels (e.g., through the use of EVs). To that end, the IIJA intends to build out a national network of EV chargers that would enable greater adoption of EVs by providing access to long-distance travel and filling in the gaps in communities across the United States. In addition to charging infrastructure funding, the IIJA also provides additional support for clean school buses and other transit.

The investment provided through the IIJA highlights the new federal priorities in terms of transportation—a transportation system focused on cleaner vehicles such as EVs. The IIJA also establishes the need for minimum standards regarding new infrastructure, such as EV chargers. FHWA made its final rule regarding standards for the NEVI program effective on March 30, 2023 (*199*). The IIJA mandates that minimum standards and requirements be developed in the following six areas:

- Installation, operation, and maintenance.
- Interoperability.
- Traffic control devices and on-premises signs.
- Data.

- Network connectivity.
- Information on location, pricing, real-time availability, and accessibility through mapping applications.

These requirements include a minimum of four charging ports per station, each with CCS Type 1 connectors; DCFCs that provide 150 kW of power; and Level 2 chargers that provide at least 6 kW per port. These regulations are intended as a minimum, so states can include additional ports, higher power requirements, or additional connector types as desired. Chargers located along AFCs have an uptime requirement of 100 percent (i.e., 24 hours a day, 7 days a week), while chargers located outside designated AFCs must maintain accessibility for use during their regular business hours. Additional requirements relate to accessible methods of payment, equipment certification, cybersecurity, long-term stewardship, and use of qualified personnel such as technicians. All electricians must be certified by the Electric Vehicle Infrastructure Training Program (EVITP) (*193*). In terms of customer or consumer protection, mechanisms must exist to report issues and safeguard data privacy. This rule also establishes compliance with the *Manual of Uniform Traffic Control Devices* and federal outdoor advertising rules for on-premises signs (*200, 201*). While these requirements are defined for the conditional use of federal funds, they also present a baseline for EV charging infrastructure and charging station development across the United States. These requirements may become the industry standard depending on state adoption of alternative requirements or feasibility.

The Inflation Reduction Act

The IRA, while not focused on transportation, includes a number of provisions that will impact the number of EVs on the road and the subsequent need for charging infrastructure (*123*). The light-duty EV tax credit was extended through 2032 with modifications to eligibility. Manufacturer caps were replaced with caps on purchaser incomes, vehicle manufacturer suggested retail prices, and additional requirements for assembly and sourcing of EV materials. The credit can also be transferred to the dealer at the point of sale, enabling a reduction in the overall purchase price for the consumer. The IRA also provides a tax credit for used EVs of up to $4,000 or 30 percent of the sales price as well as a commercial EV tax credit. These tax incentives are intended to promote the growth of EV sales within the United States alongside the investment in charging infrastructure. Regarding charging infrastructure, the IRA also extended the tax credit for charging equipment. Other provisions related to EVs and charging infrastructure include incentives to electrify the U.S. Postal Service fleet and funds for clean heavy-duty vehicles.

Executive Orders and Federal Requirements Related to EV Infrastructure

Recent initiatives and EOs at the federal level highlight the federal funding and programming priorities over the next 4 years. Equity in transportation is playing a greater role in decision-making and priorities than it has previously. The renewed focus on transportation equity is highlighted by the Justice40 Initiative as well as EO 13985, Advancing Racial Equity and Support for Underserved Communities through the Federal Government (*104*). Existing and new federal formula and grant programs also include updated guidance that places a larger emphasis on equity in practices, processes, and decision-making. Any strategy for developing EVI should understand the importance of equity when leveraging federal funding. Federal initiatives and

programs also focus on environmental goals, such as emissions reduction and increased use of non-single-occupant vehicle modes of transportation.

The Justice40 Initiative began in January 2021 with EO 14008, Tackling the Climate Crisis at Home and Abroad (*98*). This initiative directs certain programs and projects that receive federal funding to provide 40 percent of the benefits to disadvantaged communities. The CEJST was developed and released in 2022 to provide guidance on communities that are considered disadvantaged based on the following categories and their criteria (*99*):

- Climate change.
- Clean energy and energy efficiency.
- Clean transit.
- Affordable and sustainable housing.
- Reduction and remediation of legacy pollution.
- Critical clean water and wastewater infrastructure.
- Health burdens.
- Training and workforce development.

These categories also guide the programs that the Justice40 Initiative covers across the federal government. For USDOT, this initiative includes 39 programs across five modes (*202*). The related tool utilizes publicly available and nationally consistent databases to measure the relevant criteria under each category, such as projected flood risk or energy costs. This tool is intended to assist both eligible grant applicants and funding recipients as well as the federal government in locating disadvantaged communities in the United States. USDOT developed a complementary tool—the Equitable Transportation Community (ETC) Explorer—that provides greater insight into transportation disadvantages (*203*). The ETC Explorer provides additional data on the following:

- Transportation access.
- Environmental burden.
- Social vulnerability.
- Health vulnerability.
- Climate and disaster risk burden.

The ETC Explorer does not identify areas as disadvantaged or not disadvantaged but instead aims to provide information on the cumulative impacts that result from a lack of access to transportation (*204*). USDOT is in the process of developing a method for calculating the benefits and burdens of its programs as well as incorporating the Justice40 Initiative requirements into its notice of funding opportunities.

Through procurement authorities, EO 14008, Federal Clean Electricity and Vehicle Procurement Strategy, aims to promote the use of clean and zero-emission vehicles by all public fleets, including at the state and local level.

In addition to EO 14008, EO 13985 was signed in January 2021 to address racial equity and support to underserved communities (*104*). This EO recognizes the past and existing disparities in laws, institutions, and policies that have denied equal opportunity to individuals and

communities. The order establishes a policy moving forward to advance equity for all, especially in those communities that have suffered harm and been adversely affected by poverty and inequality. The EO calls for the fair allocation of federal resources and the equitable delivery of government benefits and opportunities. USDOT responded to the EO with an equity and access policy statement that affirmed the agency's support for the EO, emphasizing the importance of removing language barriers and ensuring environmental justice to comply with the EO (*105*). These policies are now included in criteria and guidance for the use of both grant and formula-based funding. Any proposed policy and funding framework should acknowledge these policy inclusions because federal funding remains the key source for EV infrastructure.

Other federal requirements that apply to EV charging infrastructure will include the ADA and the DBE program. While no specific ADA design standards have been released for EV charging stations, the U.S. Access Board provides guidance in its *Design Recommendations for Accessible Electric Vehicle Charging Stations*, and USDOE provides guidance on complying with the ADA for workplace charging installations (*109, 205*). This guidance includes the recommended number of accessible charging spaces per lot (if charging stations are in a parking lot) as well as spacing and access standards. The ADA requirements apply to public charging stations and thus must be considered when developing EV infrastructure plans and policies. Any use of federal funds will also require consideration of DBEs. This consideration should again be reflected in policies that relate to EV infrastructure, where necessary, to ensure compliance. The NEVI program formula funds are not currently subjected to DBE requirements, but future federal funding may differ in its requirements. Similarly, the Build America, Buy America (BABA) requirements can be waived for EV charging infrastructure to allow time for domestic markets to mature. Looking beyond the NEVI program, these two programs may apply when leveraging federal funds for an EV infrastructure project.

Importance to Texas EV Planning

Policies and regulations at the federal level play a role in Texas's EV infrastructure planning by providing funding and also establishing requirements for EV charging infrastructure that is likely to be maintained after the end of the NEVI program. Texas is set to receive $407.8 million over the 2022–2026 fiscal years from the NEVI program. This funding will be leveraged to support private investment in an EV charging network across Texas. Texas's NEVI plan follows the program guidelines by building out infrastructure on the AFCs before expanding the network across the state in later years. Year 1 of Texas's NEVI program funding will focus on those AFCs, ensuring spacing of no more than 50 miles between charging stations. Years 2 and 3 will focus on rural counties and small urban areas, as well as MPO needs in large urban areas. However, a state the size of Texas will require continued planning, monitoring, and investment in the EV charging network to ensure accessibility that enables widespread adoption of EVs.

Specific needs beyond the NEVI program include charging infrastructure for freight and fleet applications, as well as for supporting MFH. Although a smaller number of vehicles require access to charging, freight and fleet applications may require additional investment due to increased power needs relative to LDVs. Utility coordination is necessary to ensure adequate available infrastructure for these types of vehicles. In addition, MFH poses a unique challenge; individuals living in MFH may not have easy access to at-home charging. While these EV owners will benefit from a robust public charging network, MFH may also require an in-

neighborhood solution to ensure the necessary range. Post-NEVI charging needs will be influenced by the current federal regulations to a certain extent because the uptime, charging capability, power, data, and customer service standards may become the norm.

When developing a policy and funding framework for Texas, it is important to consider the impacts of federal requirements on industry standards as well as the impacts of policies and regulations in other states on those standards. These impacts may include the types of infrastructure developed (DCFC or Level 2), specific components available (plugs or adapters), and payment options. On a broader level, states may have to consider pricing and revenue models for both the EV charging infrastructure and the transportation system. In addition, state-level policies, legislation, and regulations may provide best practices or lessons learned that can be considered when developing a guide for Texas's EV charging infrastructure.

STATE-LEVEL EV LEGISLATION AND POLICIES

State-level policies, regulations, and legislation vary greatly by state in terms of their breadth and depth. For example, California has a number of regulations intended to increase electric or zero-emission vehicle use with a particular focus on MHDVs and fleets, while states such as Iowa are currently focused on incentivizing the purchase of EVSE or low- to zero-emission vehicles. Policies, regulations, and legislation from 14 peer states were analyzed to help establish a policy and funding framework for Texas. The states were selected based on criteria relevant to funding and finance, such as lane miles per capita, as well as technological progress and goals. Table 9 shows the peer states and their selection criteria.

Table 9. Peer States.

Peer State	Lead Area
Arizona	EV planning and development
California	Funding and finance
Colorado	EV planning and development
Florida	Funding and finance
Georgia	Funding and finance
Illinois	Funding and finance
Iowa	EV planning and development
Michigan	Funding and finance
New York	Funding and finance
North Carolina	Funding and finance
Ohio	Funding and finance
Oklahoma	EV planning and development
Pennsylvania	Funding and finance
Tennessee	EV planning and development

The policy and funding framework will consider the current infrastructure, goals, and funding and finance mechanisms available in Texas as well as the needs based on existing EV-related goals. During the review, researchers identified policies and regulations related to utilities, accommodations, air quality and the environmental, funding and financing, freight and MHDVs, fleets, MFH, and zoning and land use. In addition to the policy and legal review, plans and programs related to EVI were considered. Planning efforts have been conducted by multistate coalitions as well as individual states and regions beyond the NEVI program. These efforts related to equity, economic development, workforce and education, and energy and utilities. Certain states and multistate coalitions also focused on freight and fleet considerations for EVI.

Utility-Related Policies and Regulations

Electric vehicle charging station locations and types may interact with utilities based on their right-of-way or surrounding interconnection requirements. In the dynamic landscape of EV infrastructure development, the interaction between EV charging stations and utilities is a critical aspect governed by various state regulations and codes.

Updates to Rate Schedules

In California, the state is actively involved in shaping the integration of EVs into the grid. California Public Utilities Code §740.16 mandates the development of strategies and metrics for

feasible and cost-effective EV grid integration by January 1, 2030 (*206*). This mandate includes consideration of demand, time-of-use rates, and adherence to National Institute of Standards and Technology standards for cybersecurity. Simultaneously, the California Vehicle Code permits utility owners to request data on the addresses of EV owners but not their names (*207*).

Another significant California statute aims to facilitate the development of technologies for grid integration, consistent with §740.16 (*208*). It addresses policies supporting rate strategies to mitigate the impacts of demand charges and establishes a tariff for MHDVs. In 2022, California passed AB 2700, requiring the collection of fleet data by the California Public Utilities Commission (CPUC) in collaboration with CARB and the Energy Commission (*209*).

Colorado allows utilities to establish rates and charge schedules to facilitate the return on investments in EV programs (*210*). Electric utilities must submit specific rate proposals to the commission that encourage vehicle charging and support the electric grid.

Recent legislation in New York establishes a commercial tariff on EVs that may urge utilities to explore alternative demand-based rate structures or provide other operating cost-relief mechanisms to facilitate faster charging (*211*).

Iowa requires an electricity dealer license to sell or dispense electricity as a vehicle fuel outside of a residence (*212*). Pennsylvania Code mandates that each electric distribution company address third-party owned and operated EV charging stations in its tariff (*213*). Oklahoma restricts municipal utilities from using revenue from the sale of electric power to fund the maintenance or construction of EV chargers (*214*).

Regulations Relating to Utility EV Infrastructure and Resources

The California Public Resources Code tasks the CPUC with creating a website that provides consumer resources, including residential utility service upgrade requirements, basic charging circuit requirements, utility rate options, and load management techniques (*215*).

AB 841 mandates the CPUC's approval or modification of utility transportation electrification programs (*216*). These programs, including EV charging stations, are to be deployed through a reasonable cost recovery mechanism that does not unfairly compete with nonutility enterprises. At least 35 percent of investments must be directed toward underserved communities. Utilities must file a new tariff to design and deploy all electrical distribution infrastructure within the utility's right-of-way for all customers installing separate meters, which is to be recovered as other distribution infrastructure authorized on an ongoing basis in the utility's general rate case for EV charging stations.

EV Charging Station Definitions under State Law

Policies and regulations related to EVSE range from infrastructure classification as a utility (due to the provision of electricity) to building code updates to ease of installation. EVSE or charging stations provide electricity to refuel a vehicle; in some states, definitions of a utility or public utility may apply to charging stations or equipment owners. The rules and regulations for public utilities are extensive and can be prohibitive for installing, operating, and maintaining charging equipment. To address these issues, 43 states and the District of Columbia have specified that

their definition of a public utility does not include owners of EV charging stations (*146*). Depending on the state, the language in the regulation can broadly exclude EV charging facilities from the definition of a public utility, or it can specify that charging facilities owned by non-utilities will not be regulated as a public utility. Table 10 lists the states that exempt EV chargers from public utility regulations (*148, 149*).

Table 10. Exemptions for EV Chargers from Public Utility Regulations.

State	Enacted Date	References
Arizona	04-06-2022	Docket No. RU-00000A-18-0284
California	10-06-2011	AB 631 Public Utility Code §216(i)
Colorado	05-03-2012	HB 12-1258 Colorado Revised Statutes 40 §101-104
Florida	2012	Florida Revised Statutes §27-366.94
Iowa	11-27-2019	Docket No. RMU-2018-0100
Illinois	08-28-2012	220 Illinois Compiled Statutes 5/3-105 1112/3 §3-104
Michigan		Case No. U-17990 and U-20162
New York		PSC Case No. 13-E-0199
North Carolina	07-17-2019	House Bill 329
Ohio	07-01-2020	Public Utilities Commission of Ohio Case No. 20-434-EL-COI
Oklahoma	01-31-2019	Oklahoma Administrative Code 165:35-13-l(c)
Pennsylvania		Final Policy Statement Order M-2017- 2604382

As vehicle manufacturers move toward fully electric models, states are also limiting the sales of ICE vehicles. In August 2022, CARB adopted a regulation that would ban the sale of new gasoline-powered cars and light trucks by 2035 (*150*). This regulation follows a similar measure by New York State, where SB 7788 stipulates that all in-state sales of new passenger vehicles and trucks will be zero emission by 2035 (*152*).

Air Quality and the Environment

EV markets and charging networks are developing partly in response to air quality and emissions-related regulations in certain states. California has the most aggressive targets and often sets the standard for other states through CARB standards. Environmental goals are increasingly focused on low- to zero-emission vehicles to reduce the overall emissions accounted

for by transportation. With 28 percent of U.S. GHG emissions attributable to the transportation sector, EVs, and therefore EV charging, will be part of the overall solution (*217*).

Zero-Emission Vehicle Promotion

CARB adopted a regulation in 2022 that bans the sale of new gasoline-powered cars and light trucks by 2035 (*150, 218*). Other peer states have adopted similar targets, including New York's ZEV sales requirement under SB 7788 and Colorado's low-emission automobile regulation that added a ZEV program in 2019 (*152, 219*). Establishing these targets often requires additional planning or rules and regulations to help enable the transition to 100 percent ZEV sales by a set date. For example, California developed a ZEV promotion plan—the ZEV Market Development Strategy—to provide specific directives to agencies that can influence ZEV adoption and incentivize state fleets to make the transition. Specific tasks in the plan include the following:

- Establish infrastructure to support 1 million ZEVs.
- Update the 2016 ZEV Action Plan with a focus on low-income and disadvantaged communities.
- Support and recommend policies that will facilitate the installation of EV infrastructure in homes and businesses (*220*).

To support these tasks, the California Energy Commission (CEC) partnered with the California DMV to develop a dashboard that tracks sales and the total number of light-duty ZEVs in the state (*221*). The dashboard has expanded to provide a variety of information on ZEVs including information for medium-duty vehicles and buses. This type of information can help regions and local governments effectively plan infrastructure investments and make decisions regarding their EV charging networks.

Emissions Standards and Targets

Reducing emissions from transportation supports overall environmental goals but can also increase cooperation among state agencies and between states. California has the highest number of air quality and environmental policies and regulations that relate to EVs and EV infrastructure; 19 different policies and programs, including funding programs, aim to reduce emissions or the use of gasoline and diesel fuels. California has mobile source emission reduction requirements, CARB standards for conversions and retrofits, and low carbon fuel use requirements for its state agencies (*222, 223*). Select other states, such as New York, have adopted California's emission standards (*224*). California's Clean Miles Standard Program, which attempts to address the annual emissions of transportation network companies by establishing emissions reduction targets, is also being considered by other states. Both California and New York also have several funding programs in place to help incentivize emissions reductions, which are discussed later in this report.

Colorado, Illinois, and North Carolina have all developed roadmaps, plans, or targets that incorporate EVs and charging infrastructure. Colorado developed its GHG Pollution Reduction Roadmap 2.0, which includes eight near-term actions related to transportation. One of those actions is to streamline EV charger deployment (*225*). The Illinois Beneficial Electrification Plan includes similar strategies and goals with the intent of reducing pollution from transportation and

ensuring that EV adoption does not place significant additional burdens on the electric system while creating benefits for Illinois residents (*226*). North Carolina's targets, from 2018, included reducing GHG emissions to 40 percent below 2005 levels, in part by increasing the number of registered ZEVs to at least 800,000 (*227*). Attaining this target will require the development or incentivization of EV charging as well.

States have also developed broader policies and programs focused on clean transportation that help to incentivize or promote the installation of EV infrastructure. Colorado developed a Clean Fleet Enterprise that offers incentives to governments and fleets for AFVs but also allows the enterprise to assess a clean fleet retail delivery fee (*228*). In New York, the Port Authority of New York and New Jersey prohibits trucks older than model year 1998 to operate at their marine terminals; this prohibition is in part to address the environmental challenges associated with ports (*229*).

Although each state has different targets and strategies related to air quality and emissions, all states are considering the impact from transportation to a greater extent. These plans, programs, and goals not only set standards, regulations, or incentives but also promote cooperation between different state agencies. While the implementation of EV charging infrastructure and the distribution of NEVI program funds places DOTs in a unique and unprecedented position, it also offers the opportunity to collaborate with other state agencies and provide a transportation-specific perspective to those targets and goals.

Funding and Finance for EV Charging Infrastructure

State-level policies and legislation around funding and finance can reduce the regulatory burden for the installation and development of EV charging infrastructure. Tax incentives reduce the burden on private developers, while regulations on financing and investment can enable local governments to safely invest in infrastructure or partner with private charging providers. Other policies or initiatives provide streamlined processes for fleet procurement or provide financing options for local governments.

Tax Incentives

Tax credits, exemptions, and deferrals help to spur investment and reduce barriers to investment for private entities. Table 11 details the tax incentives provided in the peer states.

Table 11. Tax Incentives for EV Infrastructure.

State	Statute/Legislation	Description
California	Cal. Rev. & Tax. Code §6377 (2022)	Extends the sunset of the sales tax exemption from the state's General Fund portion (3.9375%) for the purchase of zero-emission buses eligible under the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project from January 1, 2024, to January 1, 2026.
	Cal. Rev. & Tax. Code §7284.3 (2022)	Utility user tax exemption for electric public transit bus.
Colorado	Colo. Rev. Stat. §39-22-516.7 (2022)	Tax credit for qualified EVs.
	Colo. Rev. Stat. §39-22-516.8 (2022)	Tax credit for innovative trucks. The credit amount for any qualifying truck is limited to the difference in manufacturer's suggested retail price between the qualifying truck and a comparable truck that operates on either gasoline or diesel fuel.
	Colo. Rev. Stat. §39-26-719 (2022)	Conversion parts are exempt from sales and use tax.
	HB 1272, 74th Gen. Assem., Reg. Sess. (Colo. 2023)	Extends tax credit and creates a temporary specific ownership tax rate reduction on a portion of the sale of electric MHD trucks.
Georgia	Ga. Code Ann. §48-7-40 (2023) Alternative Fuel and Advanced Vehicle Job Creation Tax Credit	Annual tax credit (available for 5 years) for businesses that manufacture alternative energy products for use in battery, biofuel, and EV enterprises. Credit amounts differ by county and are based on the number of employees.
	Ga. Code Ann. §48-7-40.16 (2023)	Clean vehicle tax credits of 10% of the cost of the charger and installation (up to $2,500). Only available to businesses. Charger must be greater than 130V and designed for on-road vehicles.
Illinois	35 Ill. Comp. Stat. 200/10-390 (2023) Reimagining Energy and Vehicles Tax Credit	Tax credit for eligible EV, EV component parts, and EV charging station manufacturers. Credits are available in two tiers. Tier 1 credits are available to EV, EV component, and EV charging station manufacturers that invest a minimum of $20 million and create at least 50 new jobs within 4 years in Illinois. Tier 2 has several criteria, such as investing $1.5 million and creating at least 500 jobs within 5 years.

State	Statute/Legislation	Description
Iowa	Iowa Admin. Code r. 701—42.42 (2023)	The High-Quality Jobs Program offers state-level tax incentives to business projects for the production of biomass or alternative fuels. Incentives may include an investment tax credit; a refund of state sales, service, or use taxes paid to contractors; and a local property tax exemption based on the value added to the property.
Michigan	Mich. Comp. Laws §207.803-809 (2022)	Industrial property that is used for high-technology activities or the creation or synthesis of biodiesel fuel may be eligible for a tax exemption. High-technology activities include those related to advanced vehicle technologies such as electric, hybrid electric, or alternative fuel vehicles and their components. To qualify for the tax exemption, an industrial facility must obtain an exemption certificate for the property from the Michigan State Tax Commission.
North Carolina	N.C. Gen. Stat. §105-164.13 (2023)	No retail sales and use tax for alternative fuels.
Oklahoma	Okla. Stat. tit. 68, §2357.22 (2023)	Alternative Fuel Vehicle Tax Credit—Tax credit varies by the weight of the vehicle, ranging from $5,500 to $100,000.
	Okla. Stat. tit. 68, §2357.22	Alternative Fuel Infrastructure Tax Credit—Tax credit for up to 45% of the cost of installing alternative fuel or EVI.

As the light-duty market develops, states are ending tax exemptions or credits for those vehicles and focusing their efforts on MHDVs. California, Colorado, and Oklahoma all have tax credits aimed at supporting alternative fuel or electric trucks. States such as Oklahoma, Illinois, and Georgia are also providing tax credits or exemptions to support infrastructure. These tax credits or exemptions allow states to spur investment without providing grant funds. Programs can also support workforce development and draw jobs to the state.

Regulations, Policies, and Programs Related to Financing and Revenue

Broad policies on financing and revenue relate to both operational issues with charging infrastructure as well as programs that enable cost savings from AFVs. California's SB 123 requires that charging stations accept both credit and mobile forms of payment (*230*), providing consumers with additional options when paying for charging. Florida has also protected consumers by prohibiting insurance companies from assessing a surcharge to insure EVs. The restriction applies to surcharges that would be based on factors such as new technology, weight-to-horsepower ratio, types of materials, or passenger payload (*231*).

Colorado enacted rules around vehicle fleet maintenance and cost-savings contracts as well as utility rates and schedules (*232*). Utilities are required to submit a report to the utility commission on the cost of providing electricity to support EV charging at commercial and industrial sites (*233*). Illinois has also offered to provide reimbursements to qualifying school districts for the cost to convert gasoline buses to alternative fuel buses (*234*). Iowa has authorized the purchase of AFVs for research and testing needs if funds are available. Eligible funding is for alternative fuel demonstration grants (*235*).

North Carolina and Illinois have developed programs to support or require EV charging infrastructure. North Carolina has an Alternative Fuel Revolving Fund that uses credits to support projects. The North Carolina Department of Transportation (NCDOT) is eligible to receive the proceeds from this fund and use them to purchase alternative fuels, to develop alternative fuel infrastructure, or to purchase AFVs (*236*). Illinois required the Illinois State Toll Highway Authority to construct and maintain at least one EV charging station at any location where fuel, garages, stores, or restaurants are provided by 2016 (*237*). The authority assessed a fee for charging to offset the costs.

Florida has several statutes aimed at enabling local governments to finance, or help finance, the installation of charging stations and charging equipment. The EV Charging Station Financing Authorization Act allows local governments to offer funding to property owners to support charging stations (*238*). In addition, local governments can use income from the infrastructure surtax to support alternative fuel infrastructure (*239*).

Policies Relating to Freight and Fleets

Freight and fleet electrification are in various stages of development depending on the vehicle classification. Light-duty fleets are easier overall to transition but still require a different set of policies and procedures than traditional fuels regarding maintenance and end of life. MHD trucks are in the earlier stages of development, but manufacturers are ordering electric trucks and piloting their potential capacity (*240, 241*). Most states and state DOTs are in the initial planning stages regarding freight and fleet charging infrastructure needs, but an expectation exists that greater charging capacity will be required. Most of the peer states are not setting specific targets for MHD trucks but are regulating or incentivizing their government fleets to switch to alternative fuels.

Freight Plans and Assessments

During interviews, most states noted that their efforts are focused on developing a light-duty charging network while encouraging freight operators to coordinate and communicate their electrification needs with both state agencies and utility providers. However, both California and Colorado are developing plans or assessments that will prepare the transportation system for further freight electrification. California is conducting a zero-emission freight assessment—codified under California Government Code as the Clean Freight Corridor Assessment Program—that will identify the needs for charging across key freight corridors in the state (*242, 243*). This assessment requires consultation with local governments, regional agencies, and key community stakeholders. Colorado is about to complete a freight electrification study that assesses the need for freight-specific charging infrastructure within the state.

Multistate efforts are also attempting to address the issues surrounding MHDVs. The Northeast States for Coordinated Air Use Management convened a ZEV taskforce that developed an action plan. Development of the plan was supported by 17 states and the District of Columbia (*244*).

Permissive Rules for Alternative Fuel Trucks

A key concern in the short term for EVs is the weight of the battery and therefore the overall weight of the vehicle. In terms of freight, the additional battery capacity required may reduce the payload potential for trucks. Several states have adopted policies that allow for alternatively fueled trucks, including electric trucks, to exceed the maximum weight allowances by up to 2,000 lb. Table 12 provides an overview of these statutes.

Table 12. Weight Exemptions.

State	Statute	Description
Arizona	Ariz. Rev. Stat. §28-1100 (2023)	EVs may exceed limit by 2,000 lb.
California	Cal. Veh. Code §35551 (2022)	ZEVs or near-ZEVs may exceed 80,000 lb (by 2,000 lb).
Colorado	Colo. Rev. Stat. §42-4-508 & §24-30-1104 (2023)	AFVs may exceed weight limit by 2,000 lb.
Oklahoma	Okla. Stat. tit. 14 §109.4 (2023)	EVs may exceed gross vehicle weight limits by 2,000 lb.
Pennsylvania	75 Pa. Cons. Stat. §4941 (2023)	EVs may exceed weight limit by 2,000 lb.

Clean Truck Regulations

Similar to ZEV requirements for LDVs, states are also developing clean truck regulations to spur the transition to alternative fuels for MHDVs. California introduced its Advanced Clean Truck Regulation in 2019 that requires all new MHDVs sold in the state to be a ZEV by 2045 (*245*). Required sales percentages were developed by CARB and included within the regulation. New York adopted the same clean trucks requirement as California, with increasing sales percentage requirements starting in 2025 (*224*). This requirement is in addition to the clean truck requirements at the Port Authority of New York and New Jersey.

Fleet Transition Requirements

States are taking varying approaches—using either regulations or incentives—to transition fleets away from gasoline-powered vehicles. Certain states have requirements that extend beyond traditional light-duty government fleets to include buses or shuttles. Table 13 provides an overview of the statutory requirements relating to fleets.

Table 13. Government Fleet Requirements.

State	Statute/Policy	Description
Arizona	Ariz. Rev. Stat. §9-500.04 (2023)	Requires certain cities and towns to develop a vehicle fleet plan to encourage use of AFVs.
	Ariz. Rev. Stat. §49-474.01 (2023)	Requires use of AFVs where possible in air quality control areas.
	Ariz. Rev. Stat. §49-573 (2023)	Encourages progressive use of AFVs for federal fleets operating within the state.
	Ariz. Rev. Stat. §15-923 (2023)	Eases the process to buy electric school buses.
California	Regulation under development: Zero-Emission Airport Shuttle	Requires all airport fixed-route shuttle fleets to be 100% ZEVs by 2035.
	Cal. Code Regs. tit. 17, §95480-95486 (2023)	Requires low carbon fuel use by state agency fleets.
	Cal. Code Regs. tit. 13, §2023.3 (2023)	Zero-Emission Bus Bonus Credit—Provides bonus credit system for buses that utilize alternative fuels.
	Cal. Pub. Res. Code §25726 (2023)	Requires 75% of vehicles within a procurement contract (for city, county, special districts) to be energy efficient.
	Cal. Pub. Res. Code §25722.5 (2023)	Includes vehicle acquisitions and petroleum reduction requirements and data requirements for Department of General Services to determine compliance.
	Cal. Health & Safety Code §39719.2 (2023)	Established the California Clean Truck, Bus, and Off-Road Vehicle and Equipment Technology Program.
Colorado	Colo. Rev. Stat. §43-1-125 (2023)	The statute aims to address the impact of changing travel trends due to new technologies on Colorado roads.
	Colo. Rev. Stat. 2 §4-30-1104 (2023)	Requires Department of Personnel and Administration to purchase AFVs where possible.
	Colo. Rev. Stat. §43-4-1203 (2023)	Allows an enterprise to impose a clean transit retail delivery fee to fund its operations, and issues grants, loans, or rebates to support electrification of public transit.

State	Statute/Policy	Description
	SB 21-260, 72nd Gen. Assem., Reg. Sess. (Colo. 2021)	Title: Sustainability of the Transportation System—Created the Clean Fleet Enterprise that aims to incentivize fleet transitions.
Florida	Fla. Stat. §286.29 (2023)	Requires vehicles described in paragraphs (a)–(h), when being processed for purchase or leasing agreements, to be selected for the greatest fuel efficiency available for a given use class when fuel economy data are available.
Illinois	105 Ill. Comp. Stat. 5/29-5 (2023)	Requires the Illinois Department of Education to reimburse any qualifying school district for the cost of converting gasoline buses to more fuel-efficient engines or to engines using alternative fuels (restrictions may apply).
Iowa	HF 2128, 89th Gen. Assem., Reg. Sess. (Iowa 2022)	Alternative Fuel Vehicle Acquisition Requirements—Requires at least 10% of new vehicles purchased for the state to be AFVs.
North Carolina	N.C. Gen. Stat. §143-341d (2023)	States preference for energy-efficient vehicles when purchasing fleet vehicles.
	N.C. Gen. Stat. §143-215.107c (2023)	Sets goal that 75% of new LDVs purchased will be alternative fuel or low-emission vehicles.
	2013 N.C. Sess. Laws page 265	Requires petroleum displacement plans for state agencies, universities, and community colleges, further encouraging the use of AFVs in their fleets.
New York	EO 22, 2022 (*246*) SB 2838, 2021–2022 Gen. Assem., Reg. Sess. (N.Y. 2022)	Defines fleet transition and state fleet procurement plan requirements per the Department of Environmental Conservation and New York State Energy Research and Development Authority (NYSERDA). Requires 100% ZEVs by 2035 for LDVs and by 2040 for MHDVs.
Ohio	Ohio Rev. Code Ann. §125.834 (2023)	Establishes certain requirements related to AFVs within state fleets.
Oklahoma	Okla. Stat. tit. 74 §130.3 (2023)	Defines AFV acquisition requirements.
	Okla. Stat. tit. 74 §78 & §130.2 (2023)	Defines access requirements for state alternative fueling stations (access is discontinued if privately owned alternative fueling station opens within 5 miles).

State	Statute/Policy	Description
Pennsylvania	EO 2019-01 (*247*)	Requires all agencies under the governor's jurisdiction to replace 25% of the state passenger car fleet with battery electric and plug-in electric hybrid cars by 2025 and evaluate opportunities for the reduction of VMT and incorporation of new technology where appropriate.
Tennessee	Tenn. Code Ann. §4-3-1109 (2023)	Requires that agencies attempt to purchase 100% AFVs. Requires that at least 25% of new vehicle purchases be energy efficient/alternative fuel in nonattainment areas.

In addition to establishing targets for AFVs, these statutes also provide relief from certain procurement rules to enable the purchase of EVs (e.g., in Arizona) and make fleet charging infrastructure available to the public to support the state's charging network (e.g., in Oklahoma). Reducing the regulatory burden is often key to incentivizing AFV purchases, especially when these vehicles can be more expensive or require additional training for maintenance workers. Pennsylvania is developing demonstration projects to understand the needs of electric freight and EV charging; these projects allow both the state and businesses to test the viability of electric trucks within the state. As states develop their charging networks, ensuring efficient utilization of all assets can reduce the amount of public funding required to support EV charging needs.

Planning, Zoning, and Land Use

Planning, zoning, and land use are important considerations with publicly accessible EV charging stations. Locating charging equipment within existing parking facilities has required additional regulations. Codes and ordinances have also been developed to help ease the process of installing charging at a variety of locations. Local and regional entities must regulate zoning and land use, as well as provide permitting procedures. Certain states have played a leading role by providing model codes and ordinances and streamlining permitting procedures to reduce the number of different processes across the state.

Parking Regulations

State statutes work to reduce the patchwork of rules across a state. Regarding EV parking regulations, these statutes define the use of and prohibitions on EV parking spaces for charging. Table 14 provides an overview of the statutes across six states.

Table 14. EV Parking Regulations.

State	Statute or Legislation	Description
Arizona	Ariz. Rev. Stat. §28-876 (2023)	Prohibits non-EVs from parking in EV charging spaces.
	Ariz. Rev. Stat. §28-877 (2023)	Allows AFVs to park in carpool spaces when not meeting typical requirements.
California	Cal. Veh. Code §22511 (2023)	Allows a local authority (by ordinance or resolution) and a person in lawful possession of an off-street parking facility to designate stalls or spaces in an off-street parking facility owned or operated by that local authority or person for the exclusive purpose of charging and parking a vehicle that is connected for electric charging purposes. Allows a local authority (by ordinance or resolution) to designate stalls or spaces on a public street within its jurisdiction for the exclusive purpose of charging and parking a vehicle that is connected for electric charging purposes (*248*).
Colorado	Colo. Rev. Stat. §42-4-1213 (2023)	Electric Vehicle Parking Regulations—Prohibits any vehicle that is not actively charging from parking in designated EV charging parking spaces. An EV is presumed to not be charging if it is parked at a charging station and is not connected to the charger for longer than 30 minutes. Some exclusions apply, including EVs parked at lodging or airports, and between the hours of 11 p.m. and 5 a.m. The penalty for violation is $182.
Florida	Fla. Stat. §366.94 (2023)	Prohibits non-EVs from occupying EV charging spaces.
Illinois	625 Ill. Comp. Stat. 511-1308	Prohibits a non-electric vehicle from parking in an EV charging station designated for use by EVs, including an EV charging station on any private or public off-street parking facility. A person may park only an EV in an EV charging station space designated for use by EVs.
New York	N.Y. Veh. & Traf. Laws: §1202 (2022)	Prohibits stopping, standing, or parking in EV charging spaces unless actively charging an EV. Allows a 30-minute grace period.

Codes, Ordinances, and Permitting

Although EV charging infrastructure is expanding, many local governments do not have the appropriate codes and ordinances to meet the use case, especially for charging outside traditional

parking facilities and for larger stations. To ease the process at the local level, California and Colorado statutorily required the development of permissive local ordinances or model codes. AB 1236 (passed in 2015) set standards for the local permitting process and required the adoption of an ordinance to expedite and streamline the permitting process for EV charging stations (*249*). Colorado HB 1362 (passed in 2022) required the Colorado Energy Office (CEO) and Department of Local Affairs to appoint an energy code board to develop two sets of model codes for counties, municipalities, and state agencies. The codes address electric and solar ready requirements as well as low energy and low carbon requirements (*250*).

Updates to codes and ordinances have typically related to the permitting process. Due to the limited standards and procedures applicable to EV charging infrastructure, the permitting process can range from months to over a year, according to interviewees. These difficulties with permitting can deter private-sector investment and reduce the incentive to switch to an EV. To date, California is the only state to legislate a streamlined permitting process under AB 1236 and AB 970. AB 970 relates to streamlining the permitting process for charging at buildings (*251*). The California Governor's Office of Business and Economic Development has developed a variety of model language, checklists, and materials to support local governments wanting to streamline their procedures (*252*). A guide to planning and zoning for EV charger deployment was also created by the Sustainable Energy Action Committee, in coordination with Rocky Mountain Institute, and Interstate Renewable Energy Council to support local code officials (*253*).

Prohibitions on Rules and Regulations

States have also used prohibitions and exemptions to enable the installation of EV charging. California prohibits the execution of leases on commercial property that restrict the installation or use of charging equipment (*254*). Colorado passed HB 1233 in 2023, forbidding prohibitions on EV charging and parking by private entities as well as local governments. The bill also required local governments to count EV charging spaces toward parking minimums (*255*). These statutes help ensure reliable business practices across a state.

EV Charging at Residential Properties

Charging availability at home remains a challenge with current EV ownership levels, but it is crucial to developing a robust network. Policies and regulations within peer states are aimed at ensuring access to home charging and reducing the barriers to installation for homeowners. The term *right-to-charge* is emerging, which helps define legislation that supports the installation of charging at residential properties and regulates community groups (e.g., homeowners' associations) such that they cannot prevent the installation of charging equipment. In addition, states have developed additional rules and regulations on EV charging equipment to protect renters and lessors of buildings.

Right-to-Charge Laws

Several peer states have updated their statutes to provide either renters, homeowners, or commercial tenants with the right to install an EV charging station within the bounds of their property. California's Civil Code includes provisions for renters, commercial tenancies, and

restricted covenant communities (*254, 256, 257*). Colorado has similar provisions under its state statutes to allow for installation of Level 1 or 2 charging stations on leased premises as well as within common interest communities (*258, 259*). Both Florida and New York have statutes that prohibit condominium associations or restrictive covenants from disallowing the installation of charging equipment (*260-262*).

Rules and Regulations Relating to EV Charging Equipment at Residential Properties

Rules and regulations relating to housing can also reduce the burden of installing charging equipment by updating building codes to provide make-ready or EV-ready buildings as the standard. California has developed mandatory EV charging station building standards that require either EV charging stations or capabilities for EV charging in new builds and has established requirements for charging stations in parking facilities (*263*). Colorado passed HB 1233 in 2023, directing the state electrical board to adopt rules that will facilitate the installation of EV charging in multifamily buildings. In addition, the state limited the ability of the electrical board to restrict the installation of EV charging stations (*255*).

EV Charging and Multifamily Housing

During interviews with state DOTs, MPOs, and other stakeholders, additional challenges associated with EV charging at MFH or dwellings were discussed. Due to the structure and location of these residential properties, it can be difficult to determine the appropriate location and number of chargers required to support all residents. Interviewees mentioned offering EV charging at central locations within apartment complexes or in the general neighborhood to avoid the need for specific chargers at multifamily residences. Another challenge is funding for the installation of equipment; apartments, townhomes, or condominiums that restrict entry to residents may not be eligible for certain government funding. States noted difficulty in allocating all funding that is currently available for MFH. Existing residential buildings can be difficult and expensive to retrofit, while new builds that incorporate EV charging capabilities may not necessarily need the funding to justify their investment. Because EV charging is currently viewed as an amenity for residential properties, ensuring the correct incentives and allocation of public funding can be complex.

Equity

Specific policies and regulations that require equity to be included when installing EV charging stations are limited at the state level, but many states have programmatic guidance that focuses on equity or ensuring that the benefits of funding reach underserved communities. In recent years, states have shifted their grant funding programs to either focus on disadvantaged communities or provide a greater level of funding to those areas. Colorado, Illinois, and New York all either include additional incentives for specific communities or guarantee a certain amount of total funding for those communities (*264-266*).

California passed legislation that focuses on equity within alternative fuel planning. SB 1251 (passed in 2022) requires the Governor's Office of Business and Economic Development to develop a "shared, cross-agency definition of equity," and establish an equity agenda for the deployment of ZEVs, supporting infrastructure, and workforce development (*267*). The bill also

establishes an equity advocate for the department to serve as a point of contact for stakeholders with concerns or suggestions on equitably achieving ZEV goals. The state budget bill in 2023 updated the requirements to include recommendations on actionable steps to improve access to ZEVs, charging infrastructure, and ZEV transportation options, as well as metrics to measure progress (*268*). An assessment of progress is also required for the equity action plan that would include tracking state and federal subsidies and different ownership structures for ZEVs.

PLANS AND PROGRAMS RELATED TO EV INFRASTRUCTURE

Supporting vehicle electrification requires an understanding of the current system, forecasted needs, and different use cases and challenges that may hinder the transition. States and regions are developing plans and programs that address the remaining challenges or unanswered questions around electrification, including multistate coalitions, equity, freight and fleet requirements, economic and workforce development, and grid and power concerns.

Transportation Electrification Planning

Many of the peer states have either previously completed transportation electrification plans or been legislatively required to complete a study. California requires a biannual statewide assessment of EV charging infrastructure (*269*). The California Department of Transportation (Caltrans) is required to incorporate elements of the state's ZEV action plan and assessment into California's transportation plan, including addressing emissions reductions and forecasting the impacts of emerging technologies (*220, 270*). The plan should also include a review of progress made toward policies and goals. In addition, Caltrans must conduct a zero-emission freight assessment and incorporate the findings into its plan (*242*). In a similar manner, Colorado has developed an EV plan that separately considers equity and freight (*271, 272*). Colorado statutes require an annual report detailing progress toward both the EV plan and the Greenhouse Gas Pollution Roadmap (*273*). Florida, Georgia, Iowa, New York, and North Carolina have all completed transportation electrification plans (*274-278*). Statutes often direct coordination between relevant agencies, such as environmental protection and energy agencies and public service commissions that regulate utilities. New York's report analyzed the benefits of expanding the statewide inventory of EVs and EV charging stations, while considering access to charging, EV incentives, and the state vehicle fleet (*279*). North Carolina requires a performance dashboard to be maintained by NCDOT and include data on hybrid and electric vehicle registrations (*280*).

Regarding regional or multistate planning efforts, the REV West initiative and the Lake Michigan Electric Vehicle Circuit Tour have developed MOUs and plans to ensure a cohesive network in their regions. Other interstate planning and coordination efforts exist—often coinciding with the NEVI program efforts—but these efforts have not resulted in formal MOUs or plans at this stage. REV West is comprised of eight governors from Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming (*281*). The coalition was developed to enable those traveling across state lines to be able to access EV charging. The MOU called for a framework to develop the Intermountain West EV Corridor. These states share similar challenges with EV charging including high altitude, cold weather, and large distances between population centers. This agreement allows them to share best practices and present a unified voice when addressing rules and regulations that impact their states. The Lake Michigan Electric

Vehicle Circuit Tour is a multistate collaborative project between Illinois, Indiana, Michigan, and Wisconsin to ensure accessibility to EV charging in the region (*282*).

Equity

Equity is an important consideration to ensure fair access to charging and to meet the requirements of federal grant funding. Plans and programs across the peer states are incorporating equity considerations by requiring robust community engagement, providing priority to disadvantaged communities, and ensuring agencies have the data needed to assess the equity of their EV infrastructure plans. As noted in the federal policies and regulations discussion, several recent EOs have introduced equity requirements into transportation planning and projects. The Justice40 Initiative applies to all clean transportation funding programs, and USDOT, along with other agencies, has a stated commitment to equity. Incorporating equity into programs and projects can take a variety of forms. The following tools and programs offer data to analyze equity impacts as well as examples of programs that focus on equity for EVs and EV infrastructure:

- EVI-Equity by NREL: The Electric Vehicle Infrastructure for Equity Model (EVI-Equity) evaluates the environmental justice, energy justice, and energy equity impacts of the nationwide charging network (*283*). The tool aims to define equitable charging, assess equity in the current network, and guide thoughts about justice and equity in charging moving forward. The tool uses high-resolution spatial analysis based on individual households to inform these topics. EVI-Equity can create a visualization map that acts as the basis for further analysis and development of an equitable EV infrastructure plan.
- ETC Explorer by USDOT: A summary was provided previously in the Executive Orders and Federal Requirements Related to EV Infrastructure section.
- Climate and Economic Justice Screening Tool: A summary was provided previously in the Executive Orders and Federal Requirements Related to EV Infrastructure section.
- California Clean Mobility Options: California's Clean Mobility Options is a statewide program that empowers under-resourced communities to better understand their mobility options and overcome any obstacles. The program provides vouchers for funding community needs assessments and for clean, shared, zero-emission projects.

These tools can support TxDOT's efforts to engage with the traveling public on issues related to equity and ensure compliance with federal regulations.

Economic Development

Transportation electrification offers the opportunity to provide new, good-paying jobs across the United States. However, states often compete to attract these businesses and development opportunities. Existing positions within transit and fleet maintenance, as well as for consumer vehicles, will require training and new educational programs (discussed in the next section). States are developing tax incentives, business accelerators and incubators, and partnerships to attract investment and jobs in their state.

The Michigan Mobility Platform provides incentives to technology developers working within the state. Iowa and Colorado have a mix of tax incentives and programs that support business

development in clean technologies, including vehicle electrification, within the state. The Governor of Georgia established the Georgia Electric Mobility and Innovation Alliance, which is led by the Department of Economic Development (*284*). The initiative brings together government, industries, electric utilities, nonprofits, and other relevant stakeholders. This partnership intends to grow the electric mobility ecosystem within the state and strengthen Georgia's ability to attract electrification-related manufacturing and innovation.

Oklahoma and Arkansas have partnered to develop the Super Region for Advanced Mobility in the Heartland (*285*), with the intent of developing a national hub for advanced mobility with support from the Tulsa Innovation Labs and Runway Group. The effort will include drones, electric and autonomous vehicles, battery manufacturing, and transportation and logistics solutions. The effort includes new research and testing space, support for local advanced mobility startups, incentives to attract new companies, and partnerships with industry corporations to test and scale new technologies.

Workforce and Education

The expansion of an EV charging network across the United States will require new training programs and workforce development initiatives to ensure the correct knowledge, skills, and abilities are available to meet demand. The Bureau of Labor Statistics identified the following six industry sectors that would see an increase in employment due to EVs: (a) scientific research, (b) design and development, (c) manufacturing, (d) EV maintenance, (e) infrastructure development, and (f) sales and support (*286*). While new curriculums will be required in secondary and postsecondary education, states are starting to consider the need for on-the-job training and upskilling.

California passed legislation that required specific workforce training. AB 841 required that installation crews have at least 25 percent of their members certified under the EVITP (*287*). The EVITP provides training to qualified electricians on the unique needs of EV charging installations (*193*). While the EVITP is a common training requirement for EV charging installations, more formal standards and training requirements do not currently exist. Other training programs do exist, and many charging equipment providers provide their own training.

In Texas, Northeast Texas Community College has developed an EV automotive technician certification program—the first of its kind to be offered by an accredited college (*288*). This program allows students to work on EV systems, learn their unique maintenance needs, and gain firsthand experience in conversions.

ChargerHelp has developed a three-track system to provide workforce development opportunities: (1) the community track, (2) the reskill track, and (3) the EVSE technician track (*289*). The community track establishes a baseline understanding of charging operations and maintenance. The reskill track identifies charger maintenance workforce gaps that can be filled with existing community members through retraining or upskilling. The EVSE technician track identifies EVSE technicians in a community that would be able to maintain charging infrastructure. Organizations can also receive an assessment of their charging infrastructure and their hiring needs.

Energy

Energy and grid integration are critical issues for EV charging, which has led to the involvement of state energy offices in funding or providing resources for charging stations. In addition, the federal government created the Joint Office of Energy and Transportation that allows USDOE and USDOT to work together to provide technical assistance and support for transportation electrification and other energy issues. Energy issues are especially important in rural or remote areas that require utility infrastructure upgrades or potential off-grid solutions to avoid additional utility costs.

State energy offices have a key role to play in transportation electrification. The power requirements for a state will increase as more EVs are sold and the charging network is developed. Many state energy offices have taken a leading role by providing grants, guidance, and technical assistance for both EV owners and charging providers. In addition, these offices have provided assistance or led coordination for NEVI planning. California, Colorado, New York, and Tennessee all have highly engaged state energy offices that complete plans and/or collect data to support transportation electrification. California requires an integrated energy report that considers zero-emission impacts on state energy needs (*290*).

Joint Office guidance includes its public agency EV checklist, community guidance, and technical assistance help sheets. The public EV charging station site selection checklist provides information on the background research required, the site selection process, and the available resources to support next steps (*291*). The community engagement guidance describes how to ensure the process is equitable, how to develop meaningful and ongoing engagement, and how to document feedback from the community (*292*). The Joint Office provides assistance to states and local governments but also highlights the need for coordination between these two areas as transportation fuel use shifts away from gasoline and diesel.

Because grid integration can be challenging in rural and remote areas, off-grid charging solutions that co-locate solar or another renewable energy source for power are being considered. While this approach offers a unique opportunity for certain areas that will see an increased demand for charging, the upfront cost can be prohibitive for both public agencies and private charging providers. Understanding the current utility system and the need for upgrades is critical to meeting future charging network needs. Colorado representatives noted during their interview that their major utilities are now required to forecast energy needs. This requirement has led to greater coordination between businesses, fleets, and utilities to understand the expected demand.

FUNDING MODELS AND REVENUE CONSIDERATIONS

Funding for both electrification and transportation system needs must be determined as more vehicles transition to alternative fuels, including EVs. Recent legislation has provided or expanded the amount of funding available at the federal level. States are also providing funding opportunities, either to support federal programs or to advance state goals. Peer state funding programs were reviewed to highlight the different options and structures of those programs.

Federal Funding Landscape

Several key programs and funding opportunities have been introduced in response to the Biden-Harris Administration's goals to improve infrastructure and promote clean transportation. The IIJA is a significant piece of legislation that allocates approximately $1 trillion for transportation, broadband, and electric grid infrastructure funding. Within this act, $7.5 billion is designated for building a national network of EV chargers, and an additional $73 billion is invested in upgrading and expanding power infrastructure to support renewable energy expansion.

The IIJA also established the NEVI program, which provides $5 billion in formula funding to states and territories for strategic deployments of EV charging and other alternative fuel infrastructure to fill the gaps after the currently planned NEVI investments are installed. Ten percent of the NEVI program formula funding is set aside each fiscal year to provide discretionary grants to help fill gaps in the national network. Texas is expected to receive about $408 million over the next 5 years (beginning in FY 2022), with a federal cost share of 80 percent, to support the expansion of EV charging infrastructure (*117*).

At the end of 2021, the U.S. Secretary of Energy and the U.S. Secretary of Transportation signed an MOU to create the Joint Office of Energy and Transportation (*120*). By establishing two programs—a grant-based national EV charging program and a competitive CFI program—the Joint Office supports the deployment of $7.5 billion for a nationwide EV charging network.

The CHIPS and Science Act of 2022 provides critical investment in domestic semiconductor manufacturing that will support the growth of the EV industry (*124*). Passage of this act has helped stimulate private-sector investment in EV manufacturing, batteries, battery material processing, and charging infrastructure and networks.

The Discretionary Grant Program for Charging and Fueling Infrastructure is a competitive program to strategically deploy eligible infrastructure, including EV charging infrastructure. The program will allocate $2.5 billion over 5 years with a federal cost share of up to 80 percent. Funds will be distributed as part of two distinct initiatives: (a) the Corridor Charging Grant Program, which will deploy publicly accessible charging infrastructure along designated corridors; and (b) the Community Charging Grant Program, which will deploy publicly accessible charging infrastructure in communities (*38*). Community charging grants prioritize rural areas and low- to moderate-income neighborhoods that have low ratios of private parking and high ratios of multiunit dwellings. The first round of funding was announced in March 2023 and closed in June 2023.

To further support EV charging infrastructure development, the Biden-Harris Administration released the Electric Vehicle Charging Action Plan, which aims to gather stakeholder input, establish guidance and standards, and solicit applications for AFCs.

Other funding opportunities include the CMAQ Improvement Program, which provides funding for nonattainment areas to help meet the requirements of the Clean Air Act, and the RAISE program, which provides discretionary grant funding for roads, rail, transit, and port projects that will achieve national objectives (*130*). Potential projects would promote a modal shift away from GHG-emitting options, EV adoptions, and ZEV infrastructure implementation (*133*).

The IRA also introduced several new programs, including the Neighborhood Access and Equity grant program. The grant requirements cover investments in technologies, activities, and infrastructure to reduce surface transportation-related GHG emissions and other pollution (*135*). The IRA also changed the Alternative Fuel Infrastructure Tax Credit, which provides tax credits for alternative fueling equipment. This credit is available for both residential and commercial charging equipment. Additional requirements apply to commercial credits; the equipment must be placed in a low-income community or nonurban area. The tax credit for residential/individual use is up to $1,000 or 30 percent of the total cost. For commercial users, the tax credit is up to $100,000 per unit or 6 percent of the total cost.

These funding initiatives aim to accelerate the growth of EV charging infrastructure and clean transportation, supporting the goals of reducing GHG emissions and promoting sustainable energy solutions.

State Funding Landscape

Investments in EV charging infrastructure are supported through state-level grants, rebates, or incentives across the United States. Many states are still expending their VW emissions settlement funds; these funds have been used to invest in alternative fuel and air quality projects. California, North Carolina, Iowa, Michigan, Oklahoma, and Ohio are all still using VW funds to provide grants or programs that support EVs and charging stations. Outside of the VW settlement funds, states are also using the revenue generated through additional taxes and fees on EVs to support charging infrastructure. Colorado, for example, has developed the Electric Vehicle Grant Fund, where 40 percent of the revenue from its EV registration fee is deposited and used to support the Charge Ahead Colorado and other charging projects or programs (*255*). Other states are supporting their programs through traditional transportation funds or direct appropriations from the state.

In addition to using different funding sources, charging station funding programs at the state level differ with respect to the goal of the program, the overall needs within the state, and the structure of the program. Peer states have developed programs with a variety of different goals, although a common goal relates to improving air quality and protecting the environment. Many state offices of environmental quality or environmental protection will provide funding for AFVs or AFV infrastructure. California, Colorado, and to some extent New York have funding for vehicles covered by their environmental or health agencies and charging infrastructure supported by state energy offices. Business or economic development, as well as the efficient use of resources, can also guide funding programs. For example, Michigan's Mobility Funding Platform provides grants to mobility and electrification companies that intend to deploy their technologies within the state (*293*). The program eventually hopes to support those efforts from Michigan-based businesses, ensuring that economic growth and opportunities remain within the state while also providing investment in charging technologies.

As the light-duty market has expanded, the private sector has begun to play an increasing role in the provision of EV charging for passenger vehicles; states have switched their focus to freight and fleet electrification. Freight and fleet vehicles also contribute a greater proportion of GHG emissions, and these funding programs can therefore support other transportation goals. Similar to early light-duty EV incentives, freight and fleet incentives are largely focused on vehicles at

this stage. Interviewees also noted that providing public funds for non-publicly accessible charging infrastructure may not be politically popular and has led to some hesitation in providing such funding. Table 15 highlights the programs that support alternative fuel freight, fleets, and infrastructure.

Table 15. Freight- and Fleet-Related Funding Programs.

State	Program	Description	Funding Source/Program Administration
California	Zero-Emission Class 8 Freight and Port Drayage Trucks	Provides funding to replace Class 8 freight trucks with zero-emission technologies.	VW Settlement Funds/CARB
	Combustion Freight and Marine Projects	Provides funding to replace or repower Class 7 or 8 freight trucks with cleanest commercially available technology.	
	California Clean Truck, Bus, and Off-Road Vehicle and Equipment Technology Program	Provides support for pilots and demonstration projects and purchase incentives for ZEV trucks and buses. Priority is given to projects in disadvantaged communities.	CARB
	MHD Zero-Emission Vehicle Financing Program	Authorized under California Health and Safety Code 44272. Provides purchasing assistance for MHDVs.	CARB
Colorado	Clean Fleet Vehicle and Technology Grant Program	Clean Fleet Enterprise provides funding for businesses and governments to purchase AFVs for their fleets.	Colorado Department of Public Health and Environment
	Fleet Zero-Emission Resource Opportunity	Competitive grant program for zero-emission fleet transitions offers funding for EV charging to support the transition of light-, medium-, and heavy-duty fleets to EVs.	
	Energy/Mineral Impact Assistance Fund Grant	Public fleet assistance program offers funding for municipalities, counties, and special districts to cover AFV costs for public fleets.	Colorado Department of Local Affairs
Georgia	Georgia Diesel Emissions Reduction School Bus Program	Grants provide funding for alternative fuel school buses or retrofits.	Georgia Environmental Protection Division

State	Program	Description	Funding Source/Program Administration
Iowa	Iowa Energy Center Grant Program	Grants provide funding to eligible entities to benefit Iowa ratepayers. Projects can include AFVs, energy workforce development, carbon management, etc.	Gas and Electric Utilities/Iowa Economic Development Authority
North Carolina	Clean Fuel Advanced Technology Project	Provides funding for clean transportation technologies in eligible (nonattainment) counties. Eligible projects include AFVs, idle reduction technologies, and diesel retrofits.	CMAQ
New York	New York Truck Voucher Incentive Program	Incentive vouchers encourage replacing older trucks, transit buses, school buses, shuttle/paratransit buses, and port cargo handling equipment. CMAQ funds used for purchases require scrappage of pre-2009 vehicles.	NYSERDA
	Municipal Zero-Emission Vehicle Program	Provides rebates to local governments to encourage adoption of ZEVs for their fleets. Rebates are available for vehicles and charging installations.	New York Department of Environmental Conservation
Ohio	VW Mitigation Grants	Provides funding to replace diesel school buses and off-road equipment and install DCFC stations (the 2023 funding cycle only included funding for school buses and off-road equipment).	VW Settlement Funds
Oklahoma	Alternative Fuel School Bus Program	Provides funding for projects that reduce nitrogen oxide emissions from diesel vehicles and promote the use of alternative fuels in school buses for pre-Kindergarten through Grade 12.	VW Settlement Funds/Oklahoma Department of Environmental Quality
Pennsylvania	MHD Zero-Emissions Fleet Pilot Grant Program Initiative	Competitive grants offer funding to replace aging fleets of diesel-powered MHDVs with ZEVs. Priority is given to projects that serve environmental justice communities.	VW Settlement Funds (Partial)/ Pennsylvania Department of Environmental Protection

State	Program	Description	Funding Source/Program Administration
	Truck and Bus Fleet Grant Program	Competitive grants offer funding to replace or repower fleets of six or more Class 4–8 trucks, port drayage trucks, school buses, shuttle buses, and/or transit buses.	
	On-Road Rebate Program—Trucks and Buses	Provides funding to repower or replace single vehicles or fleets of five or less Class 4–8 trucks, port drayage trucks, school buses, shuttle buses, and/or transit buses.	
Tennessee	Vehicle Emissions Reduction and Electric Vehicle Charging Station Project Funding	Project solicitations will be released for (a) Class 4–8 school buses; (b) Class 4–8 shuttle and transit buses; (c) Class 4–7 local freight trucks, Class 8 local freight trucks, and port drayage trucks; and (d) light-duty ZEV supply equipment.	VW Settlement Funds/Tennessee Department of Environment and Conservation

Within each program, further considerations exist related to structure and management. Programs often now consider the need for state support in terms of location as well as community. If EV charging is saturated in one area, the state program may establish an eligibility threshold or specific eligible locations. Program structure often accounts for equity considerations by providing priority to disadvantaged communities or additional funding to support those projects. Regarding program management, states use a variety of different agencies to administer the different funding programs; the selection of agencies is often goal dependent. State DOTs are more often partners in funding programs rather than managers or operators.

Revenue Generation Options

States are also exploring revenue generation options from EVs to recover foregone fuel tax revenues; these revenues either partially support charging investments or broadly support the transportation system. As the number of EVs increases, states must consider the foregone revenue from fuel taxes. States are utilizing additional registration fees, a tax per kilowatt-hour, or a mileage-based system to address AFVs as well as general declines in transportation revenue. Illinois commissioned a study conducted by the Illinois DOT to assess the impacts of lost infrastructure funds and explore replacement options from EVs (*226*). Figure 25 highlights the different revenue options used by the states.

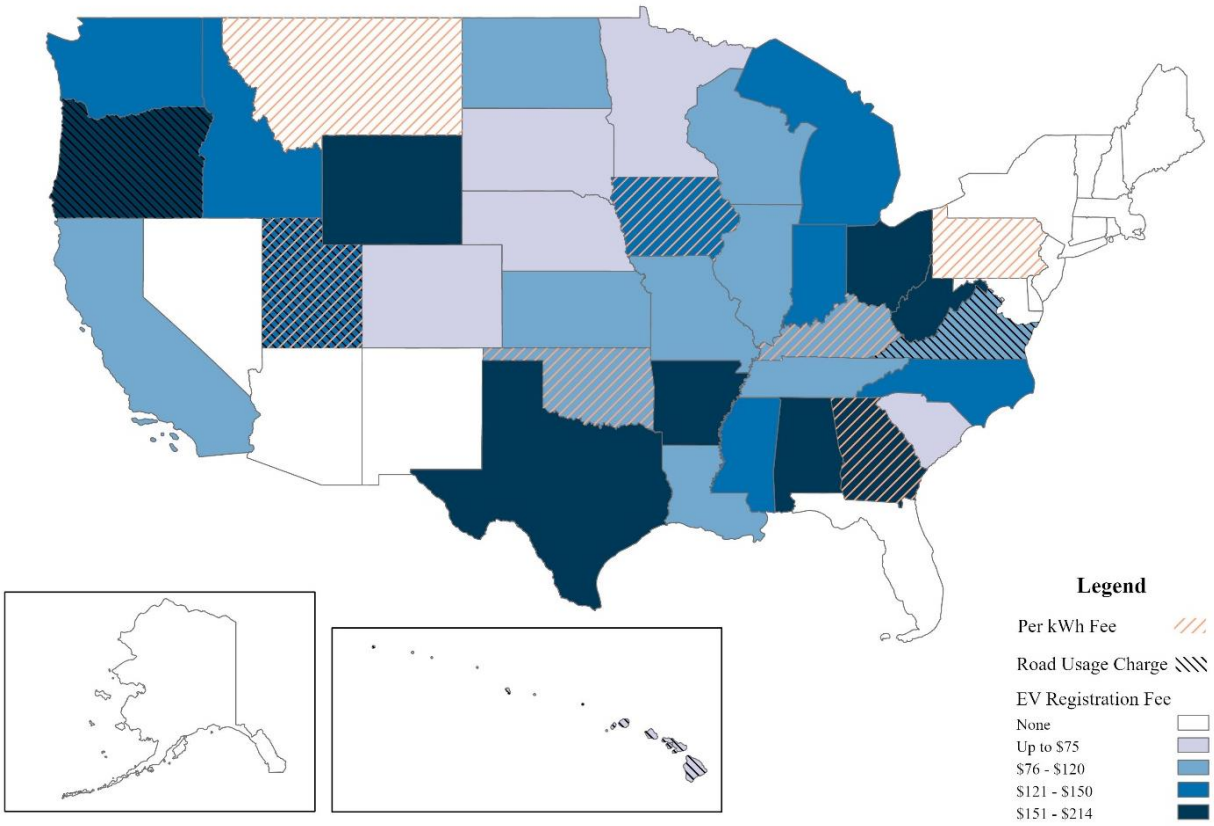


Figure 25. Transportation Revenue Generation from EVs and EV Charging.

Two-thirds of all states (33 states) currently assess an additional registration fee on EVs that ranges from $50 to over $200. In Oregon, the registration fee for EVs is only $86 if the vehicle owner also joins the RUC program (*294*). Utah now limits the eligibility for its RUC program to only EVs, and Virginia's RUC is an alternative to its highway use tax that assesses an additional fee on fuel-efficient vehicles (*295, 296*). States such as Georgia, Oklahoma, and Michigan have tiered fees by weight and commercial versus noncommercial vehicle categories. Ensuring that the revenue keeps up with inflation has led states to index their fee to inflation (e.g., California) or provide increases over time (e.g., Tennessee) to address the issue (*223, 297*). Another method for recouping foregone fuel tax revenue is a per kilowatt-hour fee assessed mostly on public charging. A fee assessed on charging provides a similar revenue generation mechanism to existing fuel taxes. However, these fees are often only assessed for public charging; most EV owners will charge at home when possible, reducing the overall revenue that can be collected. The similarity to the fuel tax is also seen as a challenge because it does not effectively tie the revenue collected to the usage of the roadways. These revenue generation options do not necessarily provide funding for EV charging infrastructure but do provide support for transportation system maintenance. Colorado, however, has tied its registration fee to a fund that supports EV charging to ensure drivers see the benefit from their payment.

Existing and Emerging Funding Models for EV Charging

Funding for EV charging infrastructure can come from several sources and can fall into categories ranging from all public to all private. Most public EV charging infrastructure still has

a private component or is supported through a public-private partnership because the majority of EV charging equipment is privately developed, owned, and operated.

Public-Private Partnerships

Depending on the nature of the partnership, a public entity can decide to own and operate an asset while a private company designs, constructs, and installs the infrastructure, or a public entity can develop an arrangement to maintain ownership in a lease or hybrid structure.

Electrify America operates an extensive public charging network in the United States, with its Electrify Commercial arm providing a turnkey solution to businesses, utilities, and government entities. Electrify Commercial has recently partnered with both APS and NYPA through Mirabito convenience stores to provide EV charging equipment (*79, 80*). APS will own the charging stations, with Electrify Commercial providing support in site acquisition, design and development, charging equipment and networking, and ongoing operations and maintenance. NYPA will construct, own, and operate its charging stations in cooperation with the site hosts (*79*).

EVgo operates one of the largest networks of fast-charging stations in the United Sates, including solutions for governments and utilities (*81*). EVgo has developed a Connect the Watts initiative to guide best practices, planning considerations, and permitting issues for states and utilities (*82*). EVgo partnered with the Washington State DOT, the Port of Seattle, and Forth (a nonprofit organization in Washington State) to develop Washington's part of the West Coast Electric Highway (*83*). EVgo also has partnerships with PSE&G, Green Mountain Power, and the City of Sacramento. EVgo has developed the Communities Charging for Change program to support EV charging in certain California communities disproportionately impacted by pollution.

Blink Charging utilizes Sourcewell to manage contracts for its EV charging equipment with public entities. Contracts can include AC Level 2 chargers, DC Level 3 chargers, and residential chargers through either a hybrid ownership agreement or a Blink-owned agreement (*86*). Blink partners with cities like Portland and San Diego, public agencies, and business owners (*87, 88*). Blink Charging has partnered with the City of San Antonio in Texas to build Level 2 charging facilities. Blink Charging and CPS Energy collaborated to develop strategic locations for the chargers. The public-private partnership leverages the Texas Volkswagen Environmental Mitigation Program funds and splits the revenue generated from charging between Blink Charging and the city (*89*).

ChargePoint has one of the largest networks of EV charging stations in the United States, with an integrated portfolio of hardware, cloud services, and support (*298*). ChargePoint offers AC and DC charging infrastructure, with options specifically designed for fleets and an all-purpose charging unit (*91*). ChargePoint partners with a variety of different public entities, including cities such as Denver and New York, as well as MPOs and federal and state agencies (*90, 92*). ChargePoint offers its partners the ability to track key sustainability metrics to aid in the justification of investments and provides them with the data to understand the impact of this equipment in their area. Public partners have noted that familiarity with the ChargePoint network and brand is helpful in their purchasing decision for EV charging equipment (*93, 94*).

Volta Charging provides EV charging and a media solution through marketing and advertising opportunities built into its EVSE (*95*). Volta also owns a proprietary EV network planning tool—PredictEV—that uses behavioral science and machine learning to determine appropriate locations, as well as the requirements for these locations, for its charging solutions. The revenue considerations with Volta differ slightly due to the focus on branding partnerships and advertising. This revenue can be a cost-saving measure for drivers or their partners. Volta and the City of Hoboken in New Jersey recently announced a partnership to develop an initial network of 25 charging stations at no cost to the city (*96, 97*). The costs incurred by Volta will be covered by advertising revenue from its media displays.

Private Funding

Key investors in EV charging infrastructure include electric utilities and vehicle manufacturers.

Electric Utilities

Some electric utilities have worked to develop their charging infrastructure investments and plans. Their connection to the grid and their understanding of the components required enable them to scale EV charging efficiently and effectively within their regions.

An example is the NEHC—a collaboration of more than 60 investor-owned and municipal electric companies across the United States (*77*). Utilities under the NEHC are developing fast-charging infrastructure to meet the needs of their customers and region. This collaborative effort ensures careful planning regarding location, load capacity, and equipment needs across major corridors and transportation facilities while sharing expertise and best practices. The NEHC has also stressed the importance of reliability and has set standards to ensure a smooth customer experience state to state (*78*).

Utilities may also partner with key private providers to deliver the hardware, software, or maintenance services for EV charging infrastructure. This arrangement is similar to public-private partnerships.

Vehicle Manufacturer

An example of a vehicle manufacturer in the EV charging infrastructure space is Tesla, which owns and operates standalone charging solutions across the United States. Tesla provides the equipment and software for the charging solution, but the commercial partner is the owner of the asset and responsible for maintenance costs (*84*). Examples of commercial partners include hotels, restaurants, shopping centers, and service stations. Tesla recently entered into agreements with Ford and General Motors to allow their vehicles to use the supercharger network (*299*). In addition, Tesla has agreed to provide adapters for CCS connectors to access NEVI program funding (*300*).

Residential, Workplace, and Retail Property Owners

Business models for charging at private properties differ depending on the use case; residential (including MFH) charging provisions are increasing, but barriers remain related to cost. Workplace and retail property owners must consider the level of charger to provide and whether to partner with a charging provider to avoid the cost of maintenance and operation. Despite these differences, common cost components often exist. For residential charging, the potential exists to

cluster charging near existing electrical capacity and offer slower charging speeds because drivers are often parked for anywhere from 8 to 24 hours. Emerging business models for residential charging could also provide options for workplace and retail property owners.

Residential charging is often provided as an attractive amenity at higher-end apartment, condominium, and townhome complexes, but it may soon be viewed as critical infrastructure. Key considerations for residential charging are the availability of electrical capacity, projected demand, and type of parking available. Emerging business models to support residential charging include peer-to-peer, multiuse, and mobile solutions (*301*).

Peer-to-peer charging utilizes an Airbnb model for curbside pedestal charging using a 240V connection (*302*). The connection runs from the building fronting the curb. This type of charging offers residents or property owners a passive income stream and can circumvent some issues with long utility lead times. No cable is provided; the model operates on a bring-your-own-cable premise.

Multiuse refers to battery enabled DCFC based on low power, grid services, and backup power. One example of this is FreeWire (*303*). The battery provides the potential for fast charging and the grid services reduce costs and avoid the need for utility upgrades and demand charges. This model also provides the property owner with a potential passive revenue stream through utility demand management incentive programs. The charging equipment can also provide backup power to buildings in a power outage.

Mobile solutions can be driven in a van or trailer to different neighborhood locations or wheeled across a garage or lot to a specific vehicle. This mobile application can allow for more effective use of charging without the driver having to relocate their vehicle at the end of their charging session. Similar to the multiuse business model, mobile solutions use low power, provide backup power, and avoid utility coordination. A few examples of this are Sparkcharge and Ziggy from EV Safe Charge (*304, 305*).

Utility Incentives

Utility providers are intertwined with the electric mobility space because charging stations often must connect to the grid for their power. Utility providers also establish rate schedules that ultimately impact the cost of ownership for EVs—fleet or passenger vehicles. Therefore, utilities have a critical role to play in transportation electrification; this role has led to several efforts by both utility commissions within states and utilities themselves to support the growth of EVs and charging. For example, the New York State PSC authorized the Make-Ready Program, which provides incentives to electric utilities for installing Level 2 and DCFC stations. The PSC also required that utilities establish a MHD make-ready pilot program and a fleet assessment service. Select utilities are also required to establish a transit authority make-ready program (*306*). These directives ensure that both utilities and fleets are prepared for the investment and infrastructure requirements of electrifying vehicles.

Utility incentives can include the following programs: time-of-use rates, preferential rate schedules, rebates, pilot programs, incentive assessments, and make-ready programs. Time-of-use rates incentivize individuals to charge at home either overnight or during off-peak hours,

reducing the demand on the grid by staggering electricity use. All the peer states have utilities that are offering time-of-use rates. Preferential rate schedules are similar to time-of-use rates but instead provide a specific rate for EV charging to reduce the impact of demand charges and ensure charging at home remains affordable. Rebates and pilot programs often provide funding to support the installation of charging stations at either residential or commercial properties. Depending on the utility, they can provide support for both types of property as well as transit fleets and other high-use customers. For example, Duke Energy in North Carolina has a park-and-plug program to support electric school buses (*307*). In Pennsylvania, PECO, an electric and natural gas utility, offers a commercial charger rebate as well as a pilot discount on its distribution charges for commercial customers that choose to install fast-charging infrastructure (*308*). Because distribution can be a key cost factor with more intensive charging, this discount can help fleets make the switch. Incentive assessments allow a company to understand the different programs available to them. Finally, make-ready programs are incentives focused on make-ready updates and upgrades to ensure the easy installation of charging equipment. New York, North Carolina, Michigan, and Georgia utilities have make-ready incentives or programs.

CHALLENGES AND OPPORTUNITIES FOR TEXAS

Ensuring a robust charging network across Texas requires an understanding of the unique challenges associated with the state, including its size, large rural population, and reliance on freight movement. Reducing anxiety regarding the availability of charging will require strategic public chargers across Texas, even in rural locations. Providing the number of charging ports necessary to support demand while also ensuring accessibility in remote areas will be complex. Off-grid solutions or Level 2 charging may be the most cost-effective in areas with low current demand. However, freight electrification may raise additional challenges due to the capacity and space requirements. While NEVI charging stations may provide options for certain MHDVs, these stations will not be enough to meet the needs of most heavy-duty use cases. In addition, ports of entry could be key freight charging centers due to the wait times during processing and inspection; however, truck parking may need to be upgraded to provide access to charging. Conducting freight plans and electrification assessments, as well as providing policies and regulations to support efficient charging, will be necessary. The policy and funding framework will provide potential policy and planning options to address the remaining challenges for Texas.

Developing a stable and effective charging network across Texas will require policies, plans, and programs that support the development of EV infrastructure from a variety of different entities. Texas's business-friendly environment offers an opportunity for greater private investment in EV charging equipment that will ultimately provide additional employment. Leveraging existing EV-related businesses in the state to develop further electrified mobility workforce development and education options is a key opportunity. Engagement of utilities in the EV charging space provides an opportunity for additional investments to ensure grid capacity and support the growth in transportation electrification. Ensuring that the required capacity is available during unpredictable weather events will remain a challenge, but utility providers are working to reduce EV-related costs and provide support for EV-related infrastructure. Finally, while charging for MFH is a challenge, most existing housing is single-family homes. This allows for the easy installation of at-home charging, reducing the burden on neighborhood and public charging needs. Texas can focus on ensuring a smooth process for installing charging equipment within existing properties as well as supporting make-ready policies for new developments.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

This chapter presents is a summary of conclusions of the research project based on stakeholder feedback, policy and funding opportunities, and EV charging demand estimation tool development. Following the conclusions are recommendations by the research team for actions, new programs, pilot projects, and additional research.

CONCLUSIONS

EV Charging Infrastructure Implementation

The following bullet list provides a summary of the conclusions based on the research project for EV charging infrastructure implementation:

- **Challenges with Identification of EV Charging Infrastructure Locations.** Having the right tools and expertise to use the tools to identify EV charger locations is a challenge for many stakeholders. In addition, the process of identifying EV charger locations is unclear to some stakeholders, as is knowing whether TxDOT, the county, or the city has any say about what locations are permissible. Parking regulations and zoning ordinances may need to be modified to accommodate EV charging infrastructure. It would be useful to have model ordinances as a starting point.
- **Concerns about EV Charging Site Environment.** Stakeholders had questions about amenities, restrooms, restaurants, and security that should be available at an EV charging location. For example, do restrooms and other amenities need to be open and accessible 24 hours a day, or can availability be limited? Scoring of available amenities may help with site selection.
- **Understanding of Local EV Adoption and Demand.** Stakeholders were concerned about how to determine or estimate current and future numbers of EVs in order to determine current and future demand for EV charging infrastructure.
- **Concerns about Rural EV Charging Infrastructure Needs.** In rural areas, where there may not be a clear financial incentive for the private sector to provide EV charging services, an approach modeled on utility cooperatives may be needed to ensure access and service to customers and EV users.
- **Need for EV Charging Infrastructure Guidance.** During planning, it is important to note that installing chargers may involve more work than simply placing a charger. Electrical infrastructure may need to be updated, and the location may need to be approved and permitted.
- **Challenges with Blocking of EV Charger Parking Spots.** There was concern on how to enforce the misuse of EV charging parking spots by ICE vehicles. A related issue is EVs parked in quick-charging spots overnight. Since they are not charging the entire time they are parked there, another EV could be charging at that location. One possible solution is to have a sensor to track if the EV is still there. Then, a gross amount could be charged for parking over the allotted amount of time needed to charge the EV.
- **Need for EV Charger Accessibility.** Stakeholders discussed the need to make EV chargers accessible for the disabled population. In addition, charging should be as simple as possible and not include unnecessary technological hurdles, such as requirements for certain applications or payment systems.

- **Interpretation of ADA Requirements for EV Charging.** Complaints regarding a municipality's lack of ADA accessibility for EV chargers were filed with TDLR. Now that federal guidelines have been released, cities must adhere to TDLR rules at the state level, but there were questions about the interpretation of the rules. There was discussion regarding how legislation at the state level may solve some of the challenges cities and others are facing when looking to install EV chargers and infrastructure. The technical memorandum issued by TDLR on EV charging stations in 2012 was withdrawn in July 2023, and TDLR started working with the Elimination of Architectural Barriers Advisory Committee to develop new rules that will become part of Texas Administrative Code Chapter 68. TDLR has also formed an EVSE stakeholder work group that is developing a regulatory framework for EV charging stations. Working draft rules were published on May 16, 2024.
- **Concerns about EV Fast-Charging Installation Costs.** The main items that have increased the EV fast charger installation cost include the electrical grid interconnection to make the site ready and the ADA accessibility requirement. The interconnection cost is very location-specific and will vary depending on where chargers are located. Although TxDOT cannot help with the make-ready cost, TxDOT may be able to bring awareness to the issues involved in the make-ready cost.
- **Concerns about Return on Investment for EV Charging Infrastructure Investments.** Many stakeholders agreed that it is currently challenging to determine the estimated return on investment for EV charging infrastructure.

Support for Grant Programs/Maximizing Grant Program Results for Texas

The following bullet list provides a summary of conclusions based on the research project for support for grant programs for Texas:

- **Need for Grant Program Guidance.** Many stakeholders were concerned with the number of potential grant programs in the EV space, along with understanding what government programs are available and how to apply.
- **Need for Grant Writing Expertise and Support.** Many stakeholders were concerned about having sufficient staff, expertise, and necessary data to support applications for funding programs.
- **Need to Provide Guidance for Justice40 Initiative.** Stakeholders mentioned that there does not seem to be much guidance available to implement the Justice40 Initiative. There also seems to be an overall lack of discussion or thought leadership. One issue is that there are so many options to address the requirements. For example, job opportunities, charger placement, air quality improvements, or direct health outcomes could be included, but some benefits will be difficult to prove.

Stakeholder Coordination

The following bullet list provides a summary of conclusions based on the research project for stakeholder coordination:

- **Consensus for TxDOT Leadership in Coordination Efforts.** Stakeholders in general perceived TxDOT as the clear leader or convenor for ensuring interagency coordination

statewide. This leadership is supported by TxDOT's role in the NEVI program and its role in coordinating other transportation-related initiatives statewide. A bill introduced in the current legislative session would have required establishment of the Texas Transportation Electrification Council made up of senior representatives from a range of public entities and administratively located at TxDOT, but it did not pass (*183*). Regardless of this outcome, stakeholders saw TxDOT as the leader for future coordination efforts, whether mandated by state law or otherwise.

- **Challenges with Interagency Coordination.** Agencies are working with accelerated timelines to address EV charging issues, which in itself makes effective interagency coordination challenging. Another challenge that may have to be overcome for successful interagency coordination is the need to balance inclusivity with stakeholder fatigue; involving a diverse group of stakeholders sometimes results in too many meetings. If possible, meetings or events should be combined with other stakeholder engagement processes. It is also a challenge to find the right organizations to include in meetings, as well as the right people within the organizations.
- **Need for Balancing Coordination Goals.** Interagency coordination should balance state-level goals with local goals. A model of interagency coordination mentioned by participants was the VW mitigation settlement funding allocation process (*184*). Another example was the improvement of traffic safety in a process coordinated by NHTSA that required each state to establish a high-level safety office as part of the governor's office or at a similar level (*185*).
- **Need for Partnership with TxDOT.** Stakeholders discussed how TxDOT could support activities of local public transportation agencies. Although TxDOT has a large amount of data, it is not always clear how the data can be used. However, once performance measures are developed, data needs will be clearer. Under the NEVI program, utilization data at individual charging stations will be reported quarterly, which will be useful. The level of needed data aggregation, however, is not clear at this point.
- **Need for Coordination among MPOs.** Coordination is needed among MPOs to share best practices and approaches with regard to EV charging infrastructure planning. Smaller MPOs might not currently have a platform to engage. However, collaboration might be limited by federal discretionary funding programs if MPOs are competing for funding against each other.
- **Need for Non-Metro Coordination Coalitions.** The Clean Cities Coalition Network has greatly promoted EVs and provided resources, but it is geared toward more urban areas. A coalition-type approach would be beneficial in supporting currently underserved areas, similar to the Clean Cities Coalition Network model. This approach would be a creative way to help stakeholders and promote equity across Texas. Similar types of organizations for the non-metro areas of the state would also be helpful. Since the needs are different in less populous areas of the state, there may be a need for a different perspective for the coalitions, which may include more infrastructure facilitation than an emphasis on clean air/clean cities.
- **Need for Coordination among Fleet Transition Stakeholders.** Depending on the type of fleet, some attendees are engaging with fire, EMS, sustainability, and parking organizations. The internal communication is still being worked out for most organizations who want to electrify their fleets. There are a lot of internal groups to consider and include in the conversation. Some of the outside stakeholders to engage with

include the local electrical utility companies. Collaborative programs between stakeholders are also being established. A partnership called Resilient Now, between the City of Houston and CenterPoint Energy, was established to develop a regional master energy plan (*187*). This action should help the city prioritize its investment in transitioning its fleet.

Information Dissemination

The following bullet list provides a summary of conclusions based on the research project for information dissemination:

- **Importance of Central Information Repository or Clearinghouse.** It would be beneficial to have a central location for information related to the EC charging infrastructure development. For example, a website can list contacts for those interested in working within the state. Municipalities can list information, certification, or registration requirements to conduct local business. Other states—for example, Colorado and Louisiana—use simple tools such as Google forms to build this database (*186*).
- **Need for a Central Database of Grant Applications.** It would be very useful to have a database of grant applications, including grants that did not get approved. Even if they were not successful for the NEVI program, they might be useful for other programs.

Equity Considerations

The following bullet list provides a summary of conclusions based on the research project for equity considerations:

- **Need to Evaluate and Support Equity Considerations.** Equity can have many dimensions, such as geographic equity that distributes EV chargers equitably over a region. There is also price equity, which takes into consideration the time cost to access EV chargers, and land use equity, which considers equitable use of available public space.
- **Need for Small Business Support Programs.** Stakeholders discussed ideas to support the goals of DBE programs. TxDOT will be in a good position to support these goals and can make sure that contractors follow these programs. Ideas included the use of DBE lists that could be published by TxDOT, new DBE goals for lead contractors and not just subcontractors, and requirements for DBE outreach.

Medium- and Heavy-Duty Vehicle Electrification

The following bullet list provides a summary of conclusions based on the research project for medium and heavy duty vehicles electrification:

- **Need for Medium- and Heavy-Duty Vehicle Electrification.** Electric trucks and MHDVs are still more expensive than vehicles using ICEs. Programs and funding are needed to bring electric MHDVs closer to cost parity with ICE vehicles.
- **Need for DC Fast Charging for Fleet Vehicles.** For a fleet vehicle that is in use 12–14 hours a day and has a large battery on board, the only option is using DCFCs. A

concern is that relying on DC fast charging alone will decrease battery life over time. Some DCFC technology for fleet vehicles exists, but it is still expensive, difficult to implement, and not yet widely available.

Workforce Development

The following bullet list provides a summary of conclusions based on the research project for workforce development:

- **EV Charging Infrastructure Workforce Development.** Stakeholders talked about apprenticeship programs for electricians. Some local/municipal programs are focused on that topic—such as the City of Dallas Green Job Skills initiative—but it is uncertain whether there will be funding available to build new or maintain existing programs (*189*). Texas State Technical College and the Texas Workforce Commission could be great resources in this area.

Policies and Funding Opportunities

The following bullet list provides a summary of conclusions based on the research project for policies and funding opportunities:

- **EV Charging Equipment Legislation Is in Progress.** SB 1732 and SB 1001, both passed during the 2023 legislative session, address charging equipment standards and the rules surrounding utility investment and provision of charging. This legislation helps to establish a baseline expectation of the charging network as well as a cooperative and collaborative partnership with TxDOT and its EV infrastructure planning efforts.
- **Electrification Assessments Are Useful to Develop Implementation Timelines.** Understanding the infrastructure needs for freight and fleets is one of the key challenges when switching to EVs or electric trucks. The electrical capacity requirements can present an issue in terms of both cost and time for managers hoping to transition. Utilities need advanced notice of freight and fleet electrification plans to manage and upgrade capacity when necessary. Electrification assessments for freight and fleets are a way for both utilities and fleet managers to understand load requirements and develop a realistic transition timeline. Expanding the use of these assessments and developing forecasts of demand based on current and planned investment in EVs will allow for effective infrastructure planning. While many fleets will use depot charging, those traveling longer distances may use public charging; freight electrification planning can determine the appropriate need and location of these charging stations.
- **Freight Electrification Plans Are Useful for Freight Electrification Planning.** Based on the peer state review, California and Colorado conduct or have conducted freight electrification plans to determine needs and corridors of interest. Key to understanding freight needs will be identifying fleets within the state that intend to electrify and the use cases of those trucks. This will enable TxDOT to identify potential corridors or charging locations that should be accessible to MHDVs. Combining existing data, fleet electrification data, and freight planning into an internal dashboard can support both the state and MPOs in their planning efforts.

- **EV Infrastructure Workforce Development Is Needed.** As the charging network expands, workforce development to ensure reliable charging and accessible charging at home or in residential locations will be critical to meeting consumer demand for charging. Texas can leverage existing training programs and can require certification by the EVITP. However, ensuring economic benefits to the state may be best supported through accelerators or platforms that support business within or relocating to the state. Michigan and Oklahoma have developed programs to support the electrified mobility industry within their states, and Oklahoma has statutorily required an alternative fuels technician certification. In terms of residential charging, policies that support the inclusion of make-ready infrastructure or that preclude prohibitions on installing charging equipment help to ensure access to at-home charging. Local governments may require support in developing codes and ordinances that require a certain number of charging ports in parking facilities or that require developers to ensure charging can be easily installed. Laws and policies that support the installation of charging equipment at residential properties are in effect in California, Colorado, and New York.
- **Updated Policies Are Needed.** Improving the availability and access to charging will require new policies and legislative actions to support the growth of transportation electrification. These include updated policies on data and private installation of charging as well as plans and programs to support freight, fleet, and economic development needs. Policies and legislative actions could include the following:
    - **Infrastructure data sharing.** Data sharing is key to EV preparedness, especially in terms of the MHDV space. Establishing a data-sharing policy between utilities, fleet managers, and key public agencies will support transportation electrification by streamlining utility planning efforts, ensuring adequate capacity, and providing all parties with accurate timelines to support EVs.
    - **Freight and fleet planning coordination.** Freight and fleet electrification needs are unique and vary greatly from existing light-duty needs and assumptions. Coordinating with freight planning efforts to identify key corridors, areas that require additional capacity, or places where fleet charging depots can be shared will be critical to developing a charging network that supports freight and fleet applications.
    - **Economic and workforce development.** Electrification can spur economic development within the state and already has with the increase in battery manufacturing in Texas. However, there is still a need to develop connections to ensure Texas remains competitive, especially in terms of the existing and future workforce. Accelerator or mobility platforms connect businesses to Texas. These efforts could be supported by existing TxDOT task forces. Ensuring continued growth will require a focus on workforce development; establishing training programs and requirements and supporting new curriculums in schools can better position Texas for the increase in jobs related to EV infrastructure.
    - **Home and residential charging installation support for private property owners.** Smoothing the process for residential charging ensures a robust charging network. State-level policies that limit prohibitions on installing charging equipment reduce barriers across jurisdictions. Model codes and ordinances for local governments can help to establish a standardized process that protects all parties and reduces the overall planning and permitting timeline.

EV Charging Demand Estimation Tool

Researchers developed a methodology to forecast EV charging demand in Texas based on a review of available datasets and tools. The research team presented the findings of the literature review to the project management committee, which resulted in a decision to use NREL's EVI-Pro Lite. The research team developed the methodology with a bottom-up approach to predict EV charging demand in Texas for different scenarios. This methodology is capable of predicting EV charging demand at different hours of the day in each zip code and county in Texas.

Among different factors, researchers identified temperature as an influential factor critical in planning for EVs in Texas. Results showed the optimum charging demand occurs at an average daily temperature of 68°F. The total daily EV charging demands at the state level for 220,000 and 1 million EVs were predicted to be 2.15 and 9.56 GWh, respectively. Results showed that charging at extreme temperatures, such as −4°F or 104°F, can cause an increase of more than 50 percent in EV charging demand compared to charging at 68°F.

Results further showed the significance of different charging strategies on magnitude and time of peak EV charging. Adding an extra load on the grid in peak hours due to EV charging demand can potentially be a concern from a reliability point of view. Findings revealed that charging strategies that schedule charging during nonpeak hours are critical components of planning for EV charging demand.

The methodology developed in this study was used to create a prototype EV charging demand estimation tool that allows users to quickly evaluate different EV charging scenarios. The tool's data architecture allows for updates of the underlying data as new datasets become available. Similarly, new modules and scenarios can be added based on future research. The tool also allows for application of various temporal and spatial distributions that allocate EV charging demand to different areas. Moreover, this model can be expanded to investigate EV charging demand along with other factors (e.g., demographic data) targeting specific groups and populations.

Other Findings from Stakeholder Workshops

The following bullet list provides a summary of conclusions based on the research project for other findings from stakeholder workshops:

Stakeholders provided feedback on several issues related to EV charging infrastructure that are unlikely to be addressed by TxDOT. These are included here to complete and supplement the overview of stakeholder concerns.

- **Interest in Direct Pay Programs.** A direct pay program implemented by the state in lieu of a tax credit will benefit not-for-profit agencies that do not have a tax liability.
- **Investigation of Electric Rate Incentives.** Electric companies can set rates that are advantageous to the adoption of EVs. For example, they can allow charging at night at low or no cost. This strategy should be accompanied by education and outreach to EV owners.

- **Capturing of Sales Tax Revenue for EV Charging.** In some areas, such as malls and other commercial areas, EV charging could induce revenue that could be captured by a sales tax. This option could become part of the discussion to replace the declining gas tax revenue.
- **Incentives for Electric Grid Infrastructure Expansion.** Incentives may be important to ensure more electrical generation infrastructure is built in a timely manner to support EVs.

RECOMMENDATIONS

The following are recommendations for actions and programs that would improve EV charging readiness and deployment of EV charging infrastructure. These actions or programs could be developed by TxDOT as a lead agency or jointly with other stakeholder groups. Recommendations are based on the review of applicable literature, discussions and feedback from EV stakeholders, and analysis of policies and funding opportunities.

EV Charging Infrastructure Implementation

The following bullet list provides a summary of recommendations based on the research project for EV charging infrastructure implementation:

- **Consider the development of support tools for the determination of EV charging location infrastructure.** Provide support to identify potential locations for EV charging infrastructure based on local priorities and requirements, including equity considerations.
- **Evaluate EV charger on-site energy storage opportunities.** The NEVI plan for EV charging stations does not include sufficient funds for on-site energy storage, which can be critical during peak hours. In some cases, regulations might not allow EV charging stations to generate energy on-site and store it in batteries to sell during peak-hour demand. TxDOT might be able to help with the infrastructure to store energy on-site and use it as needed.
- **Evaluate alternative energy sources for EV charging.** A range of alternative energy sources for electricity generation, including wind and solar, could be combined with EV charging infrastructure. However, the installation of solar infrastructure at EV charging stations might reduce the competitiveness of a bid under federal grant programs. In addition, TxDOT could evaluate alternative uses of its right-of-way for renewable energy generation.
- **Research options for alternative uses of right-of-way.** TxDOT could investigate alternative uses of right-of-way that do not interfere with the primary purpose of transportation and can support a combination of DCFC implementation and renewable energy generation.
- **Evaluate EV charging at multifamily housing units.** Some renters cannot install EV chargers in their rented domicile. Due to the lack of sufficient charging options, there are unsatisfactory trade-offs for EV owners who are renting. From a public charging perspective, apartment complexes and offices will need at minimum Level 2 if not Level 3 chargers. This issue could be addressed from various perspectives, including guidance for rental unit owners to support EV charging, local policies that require EV charger access, or local on-street charging solutions.

- **Address issues with EV charging station maintenance.** Addressing EV charging station maintenance in areas with lower use and lower or no profitability will become increasingly important. Charging locations in areas with less demand or non-NEVI corridors might operate at a loss and receive less maintenance than needed. There should be a discussion on what can be done to address this issue. To ensure that all EV chargers are functional, TxDOT could analyze data received from DCFC owners. TxDOT could further analyze how well the 5 percent holdback of federal reimbursement funds is working and could consider a company's maintenance record in future applications.
- **Adapt EV charging implementation process as needed.** Uncertainty exists with the current predictions of EV adoption, so the EV charging implementation process should be flexible and adaptable. Continual feedback and updates to the EV implementation model are important to ensure that the growth expected is in line with the capacity of the electric infrastructure in the time period needed. The number of chargers in the NEVI plan are only 8 to 10 percent of the number of chargers that will ultimately be needed in Texas.
- **Assess EV charging technology improvements.** NEVI and other programs are intended to provide funding for several years, during which technology will likely change and improve. For example, a minimum of 150-kW charging capacity might not be sufficient in a few years.
- **Expand on the analysis of EV charging demand.** Texas needs an analysis of EV charging demand that includes local, regional, and interstate demand. This analysis should be regularly updated and widely shared with EV charging stakeholders. This analysis could build on the tool that was developed by this research team.
- **Review EV charging performance specifications.** There are some questions regarding performance requirements for EV charging implementation under the NEVI program—for example, with regard to installation dates. Completing the installation of a DCFC station might take 6 to 18 months, depending on the location and other factors. There is no guaranteed delivery date due to supply chain disruptions for the EV charging equipment. This issue affects partnering with equipment providers and manufacturers.
- **Consider development of new EV grant programs.** New grant programs would be useful to address current equity problems and support EV adoption. For example, a program could support neighborhood EVs in disadvantaged and low-income communities. Programs could also support micromobility options, such as partnerships with rideshare companies. Grants are also needed to support the needs of transit agencies.
- **Evaluate EV charging during emergency events.** Uncertainty exists regarding EV infrastructure and vehicles in areas that are prone to flood and areas prone to weather events, like hurricanes. It is not clear what safety measures need to be in place for the vehicles and infrastructure. For example, during a hurricane, many gas stations have gas but no electricity to pump the gas into vehicles. Emergency evacuation routes have an infrastructure shortage to support existing EVs during an emergency. TxDOT should focus on resiliency and redundancy for evacuation routes and consider mobile charging trucks to be used during emergencies. Some private companies have started using mobile trucks for roadside assistance, but they may not be able to support future demand during emergencies.

Support for Grant Programs/Maximizing Grant Program Results for Texas

The following bullet list provides a summary of recommendations based on the research project for support for grant programs for Texas:

- **Consider development of resources and training opportunities for EV grant programs.** Stakeholders voiced interest in how to communicate benefits and use of EVs; receiving more information about case studies, success stories, and general implementation best practices; and implementation of best practices in rural areas with predominantly heavy-duty and farm vehicles. A program could be established to create resources to support this need. This program could also investigate needed data products specifically geared toward the data needs of federal EV funding programs.
- **Develop grant preparedness workshops.** It would be beneficial to have future workshops that bring private and public stakeholders together to prepare for and discuss strategies for upcoming grants. These events could be held regionally, leveraging stakeholder engagement in the NEVI program. Meetings should include the MPO's local planning partners. These events could also support grants under the federal CFI program.
- **Develop an EV teaming dashboard.** Several states have created central websites to provide information about EVs, including adoption rates, charging information, and other related information; one example is Oregon DOT. TxDOT could expand its current NEVI website to add more information that stakeholders are looking for.

Stakeholder Coordination

The following bullet list provides a summary of recommendations based on the research project for stakeholder coordination:

- **Develop the Texas Transportation Electrification Council.** A diverse group of EV charging stakeholders could address ongoing and future challenges with EV infrastructure through communication, collaboration, and coordination. This effort could expand on an existing group that TxDOT recently formed to address EV charging infrastructure concerns.
- **Consider developing a community engagement and education program.** A program to provide outreach to communities on the benefits of EVs and to involve the community in assisting with EV charger site selection may be helpful. Job training programs could be key for community engagement.
- **Continue sharing EV charging data.** TxDOT will receive data from EV charging infrastructure every quarter and will share it with others. These data will be an important source of information for ongoing EV charging infrastructure development.

Medium- and Heavy-Duty Vehicle Electrification

The following bullet list provides a summary of recommendations based on the research project for medium and heavy-duty vehicles electrification:

- **Evaluate electric grid infrastructure for fleet charging.** Upgrading electric networks to enable fleet charging may be a challenge since fleets may want to charge quickly, will

have a high electricity demand, and will have many vehicles. That combination could be a challenge from an electric grid perspective. As of today, fleets are expected to take a minimum of 6 years to electrify, while electrification of school buses may take 12 to 14 years. Although it remains to be seen how quickly fleet charging will be adopted in Texas, it is expected to be a gradual process and therefore should be manageable from an electric grid infrastructure planning perspective. Fleet charging is seen as a point problem since a great amount of electricity is needed at a particular location. Point problems may be addressed by providing charging at multiple locations since EVs can drive to a location where the grid has power. Thus, fleet EVs may need to be flexible in terms of charging locations. The availability of suitable fleet charging locations could affect actual versus planned operation of fleet EVs and fleet EV charging infrastructure.

- **Develop fleet EV transition guidance.** More in-depth guidance on how fleets can transition to EVs is needed. The Transportation Research Board and National Cooperative Highway Research Program may have some guides and information. There may be some information on how to determine locations for EV charging infrastructure, if not for fleets. Partnering or talking with EMS for fleet EV transition might be useful.
- **Consider developing a program to support commercial vehicle electrification.** Many EV programs currently focus on passenger vehicles. There is a need for federal and/or state programs that focus on electrification of MHDVs or commercial vehicles. A pilot project that involves the commercial vehicle industry could provide insight and lead to topics that could be addressed by future research. For example, a pilot project could involve commercial drayage operations in Laredo, where trucks conduct multiple short-range trips daily using heavy commercial trucks across the U.S.-Mexico border.
- **Consider participating in federal pilot programs for MHDV corridor infrastructure plans.** USDOE has started funding several projects to develop innovative MHD EV charging and hydrogen corridor infrastructure plans. Future rounds of funding could involve pilot research studies in Texas, such as research planning for MHDV depots using the MW charging standard, and options for mobile charging including in-ground and overhead charging. These types of projects might lead to a future federal program for MHDVs similar to the NEVI program for LDVs. Getting involved in this type of program would benefit Texas by ensuring that research topics are relevant to TxDOT infrastructure.
- **Develop a research roadmap for MHDV electrification.** Although MHDV electrification is still in its infancy, standards are being developed, relevant regulations are under review to determine necessary updates, and development is occurring at a high speed. TxDOT would greatly benefit from the development of a research roadmap for MHDVs that defines TxDOT's priorities for research in this area in the following years.

Policy and Funding

The following bullet list provides a summary of recommendations based on the research project for policy and funding:

- **Ensure ongoing compliance with changing BABA regulations.** EV chargers must comply with BABA, but EV chargers assembled domestically are covered by a BABA waiver. The waiver limits the amount of steel and iron that must be domestically sourced to the EV charger enclosures and housing if they are predominantly made of steel or iron.

Domestic manufacturing of those components must occur in the United States, including all processes—from melting to pouring to final application of coatings. Starting July 1, 2024, the cost of domestic content for EV charger components must be at least 55 percent of component cost. EV charger components that do not meet the standard must be installed no later than October 1, 2024.

- **Create a dedicated fund to support transportation electrification efforts that support demonstration and pilot projects as well as planning efforts.** Through recent legislation, such as SB 1002, the state is working to ensure a competitive marketplace for EV charging. Ensuring that private EV supply equipment providers can operate cost-effectively within the state should ensure both broad network coverage and options for EV drivers when charging in denser areas. Establishing dedicated revenue to support electrification would enable public agencies to develop broader plans and programs to support electrification. Colorado and Oklahoma direct a portion of their EV registration fee revenue to a specific fund that supports EV infrastructure. While this would require a legislative change because SB 505 directs Texas's EV registration revenue to the state highway fund, it presents an option to help address the charging investment needs within the state.
- **Develop demonstration or pilot project programs to test freight and fleet applications.** While investing in charging equipment will largely be accomplished through local, regional, and private investments, TxDOT and state-level programs can support those investments. Demonstration and pilot projects that highlight the capabilities of different charging equipment to support freight, fleets, or housing applications can reduce the perceived risk for the private sector. A similar model to NEVI funding could be created, with a private partner providing the matching funds. States such as Pennsylvania, California, and New York have programs that provide data for companies to assess the cost of investment.
- **Explore options to stabilize revenue from AFVs to better position Texas to meet future transportation system needs.** The increase in both EVs and other AFVs will reduce transportation revenues in the long term. While EV registration fees help to address the current deficit, increased fuel efficiency and increased use of other fuels will continue to erode revenue. In addition, rising construction costs, partly due to inflation, reduce the purchasing power of those revenues. Some of the peer states are addressing this by indexing the registration fee to the consumer price index, while other states are assessing alternatives. Alternative revenue options, such as a per-mile fee, an RUC, or a per-kWh fee for vehicle charging, could be explored to test their feasibility and potential implementation challenges.

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APPENDIX A. WORKSHOP AGENDA

WORKSHOP 1 AGENDA

November 9, 2022
8:00am – 12:00pm Central Time
Location: Virtual
Attendee link: [insert link]

8:00-8:20 Introduction
8:20-8:45 Overview of TxDOT EV Planning

- Ryan Granger, TxDOT

8:45-9:00 Q&A for TxDOT
9:00-9:45 Panel on Texas Energy and Utilities

- Randy Boys, Oncor
- Chantelle Barretto, LCRA
- Jeff Billo, ERCOT

9:45-10:00 Q&A for panel
10:00-10:10 Break
10:10- 11:00 Breakout Groups

- Group 1: Funding and Finance
- Group 2: Equity and Inclusion – focus on rural considerations
- Group 3: Energy Supply and Demand – include V2X considerations
- Group 4: Jobs and Workforce Development
- Group 5: Public Agency Fleet Transitions
- Group 6: Interregional Connectivity
- Group 7: Customer Experience

11:00-11:45—Full group report back
11:45-12:00—Wrap-up

WORKSHOP 2 AGENDA

December 9, 2022
9:00am – 12:00pm Central Time
Location: Texas Department of Transportation, 6230 E Stassney Ln, Austin, TX 78744

8:30-9:00 Arrival and check-in
9:00-9:10 Introduction and virtual workshop recap

- Joanne Steele and Edgar Kraus

9:10-10:00 Panel presentations and Q&A: Alice Grossman

- Ryan Granger, TxDOT
- Lisa Lin, Harris County
- Jason McLemore, Harris County Toll Road Authority
- Andrew DeCandis, Houston-Galveston Area Council

10:00-11:15 Breakout group discussions

- Funding and Finance
- Equity and Inclusion
- Energy Supply and Demand
- Interagency Coordination
- EV Grant Programs (USDOT and others)

11:15-11:55 Group report on breakout discussions
11:55-12:00 Wrap-up

WORKSHOP 3 AGENDA

February 22, 2023
9:00am – 4:00pm Central Time
North Central Texas Council of Governments Main Office,
Centerpoint II, 616 Six Flags Drive, Arlington, Texas 76011

8:30-9:00 Arrival and Check-in
9:00-9:15 Introduction and Previous Workshop Recap

- Edgar Kraus

9:15-10:30 TxDOT/MPO panel presentations and Q&A

- Ryan Granger, TxDOT
- Lori Clark, NCTCOG
- Mukesh Kumar, Waco MPO
- Martin Lucero, Lubbock MPO

10:30-10:45 Break
10:45-12:00 Freight, Fleet, Multi-housing panel presentations and Q&A

- Pharr Andrews, City of Dallas

12:00-1:00 Networking lunch
1:00-2:00 Breakout group session I

- Equity and Inclusion
- Energy Supply and Demand
- Interagency Coordination
- EV Grant Programs (USDOT and others)

2:00-2:15 Break
2:15-3:15 Breakout group session II

- Equity and Inclusion
- Energy Supply and Demand
- Interagency Coordination
- EV Grant Programs (USDOT and others)

3:15-3:50 Group report on breakout discussions
3:50-4:00 Wrap-up

APPENDIX B. WORKSHOP INVITATIONS

INVITATION FOR WORKSHOP 1

Hi,

Texas A&M Transportation Institute (TTI) is pleased to invite you to our Long-Term Plan for Electric Vehicles in Texas Stakeholder Workshop on Wednesday, November 9, 2022, from 8am to noon Central Time and to be held virtually. This event is part of an information gathering effort by TTI to support a research project for the Texas Department of Transportation (TxDOT) to develop a Texas Electric Vehicle Charging Infrastructure Readiness Plan. This effort ties into, but is distinct from, TxDOT's development of a National Electric Vehicle Infrastructure (NEVI) plan in that it expands beyond the scope of NEVI defined by the Federal Government in content and timespan.

Register for the virtual workshop here: [registration link]

This virtual event is the first of three workshops, the second and third of which will be held in-person and build off information gathered in November. The workshop will include an overview of the TTI research project, presentations from transportation and energy leaders in Texas with ample time for subsequent discussion, and breakout group conversations on specific topics related to infrastructure supporting transportation electrification. A draft agenda for the workshop is attached to this email.

The workshop attendees will include transportation and energy subject matter experts relevant to mobility electrification. You are invited to the workshop because you or your agency has been identified as a valuable and knowledgeable stakeholder. We hope you are able to attend one or more of the workshops to provide feedback, insights, and experience.

Best Regards,

Edgar Kraus

INVITATION FOR WORKSHOP 2

Hi,

The Texas A&M Transportation Institute (TTI) is pleased to invite you to our Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop. The workshop will be held in-person only on December 9, from 9 am to noon Central Time, at the Texas Department of Transportation, 6230 E Stassney Lane, Austin, TX 78744. The event is part of an information gathering effort by TTI to support research for the Texas Department of Transportation to develop a Long-Term Texas Electric Vehicle Charging Infrastructure Readiness Plan. This effort builds upon TxDOT's development of a National Electric Vehicle Infrastructure (NEVI) plan.

The workshop is free to attend, but registration is required, please register here:

[registration link]

The workshop will include an overview of TxDOT plans and activities, presentations from transportation and energy leaders in Texas, and breakout group conversations on specific topics related to infrastructure supporting transportation electrification and of interest to workshop participants.

The workshop is targeting transportation and energy subject matter experts relevant to mobility electrification. We hope you are able to attend the workshop to provide feedback, insights, and experience. Please forward the above link to other members of your organization that would be interested in attending this workshop.

For further information, or if you have any questions, please contact me or Alice Grossman (a-grossman@tti.tamu.edu). We look forward to your participation in the workshop!

Best Regards,

Edgar Kraus

INVITATION FOR WORKSHOP 3

Hi,

The Texas A&M Transportation Institute (TTI) is pleased to invite you to the rescheduled Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop (agenda attached). The workshop will be held in-person on February 22, from 9:00 am to 4:00 pm Central Time, at the North Central Texas Council of Governments Main Office, Centerpoint II, 616 Six Flags Drive, Arlington, Texas 76011. The event is part of an information gathering effort by TTI to support research for the Texas Department of Transportation to develop a Long-Term Texas Electric Vehicle Charging Infrastructure Readiness Plan. This effort builds upon TxDOT's development of a National Electric Vehicle Infrastructure (NEVI) plan.

The workshop is free to attend, but registration is required, please register here:

[registration link]

The morning portion of the workshop will include an overview of TxDOT plans and activities and presentations from transportation and energy leaders in Texas. The afternoon portion will include breakout group conversations on specific topics related to infrastructure supporting transportation electrification. Attendance of the morning portion will be in-person or remotely (via zoom link sent out at a later time), while the afternoon portion of the workshop will be in-person only. We will provide a box lunch for those planning to attend in person.

The workshop is targeting transportation and energy subject matter experts relevant to mobility electrification. We hope you are able to attend the workshop to provide feedback, insights, and experience. Please forward the above link to other members of your organization that would be interested in attending this workshop.

For further information, or if you have any questions, please contact me or Alice Grossman (a-grossman@tti.tamu.edu). We look forward to your participation in the workshop!

Best Regards,

Edgar Kraus

APPENDIX C. WORKSHOP ATTENDEES

WORKSHOP 1

7-Eleven
American Electric Power
Anrol Investment
Austin Transportation Department
Bluebonnet Electric Cooperative
Capital Area Metropolitan Planning Organization
ChargeNet Stations
Chargepoint
City of Austin
City of Fort Worth
City of Houston
City of Houston Fleet Management Department
City of Plainview
CoServ Electric
Daimler Truck North America
Electrify America
Encore Energy Group
Enel X Way
ERCOT
EV TECH Inc.
Evolve Houston
Farmers Electric Cooperative
Grayson County MPO
Green Water and Power
Heart of Texas Electric Vehicle Association
HiON Charging
Houston METRO
Intel Corporation
Laredo & Webb County Area MPO
Livingston Energy Group
Longview MPO
Lower Colorado River Authority
Lubbock MPO
Magic Valley Electric Cooperative
Medina Electric Cooperative
Metropolitan Transit Authority of Harris County Texas
Navistar
New Braunfels Utilities
NRG
Nueces Electric Cooperative
Oncor Electric Delivery
Pedernales Electric Cooperative
Petroleum Wholesale LP

Power Midwest
Red e Charging
Rio Grande Electric Cooperative Inc.
Rivian Automotive Inc.
San Bernard Electric Cooperative
Schneider Electric
Shell Recharge Solutions
South Plains Electric Coop
Texas A&M Transportation Institute
Texas Commission on Environmental Quality
Texas Department of Agriculture
Texas Department of Agriculture Metrology Lab
Texas Department of Licensing and Regulation
Texas Department of Motor Vehicles
Texas Department of Parks and Wildlife
Texas Department of Transportation
Tri-County Electric Cooperative Inc.
Trinity Valley Electric Cooperative
Tritium Charging
TxETRA Education Fund

WORKSHOP 2

ABB E-mobility Inc.
Alamo Area MPO
ChargeNet Stations
ChargePoint Inc.
City of Austin
City of Dallas
City of San Antonio
City of San Antonio Office of Sustainability
El Paso MPO
EnviroSpark Energy Solutions
ERCOT
Federal Affairs
Gentrest
Harris County
Harris County Toll Road Authority
Intel
Killeen-Temple MPO
LTRA Engineers
NCTCOG/DFW Clean Cities
Office of the Governor
Oncor Electric Delivery
Pedernales Electric Cooperative
Public Utility Commission of Texas
SAM Companies

Shell Recharge Solutions
Tesla
Texas A&M Transportation Institute
Texas Department of Agriculture
Texas Electric Transportation Resources Alliance
Tritium Technologies LLC
TxDOT
TxETRA
Tyler Area MPO
Walmart US

WORKSHOP 3

A+EVC
AECOM
AGI
Air Products and Chemicals
AMEX Electric Services
Arrow Building Solutions
ATG
Avanti Engineering Group
Black & Veatch
Boost EV
Burns & McDonnell
Business Development Manager
Catapult Social Responsibility LLC
CenterPoint Energy
Chargenode
City of Allen
City of Dallas
City of Denton
City of Farmers Branch
City of Fort Worth
City of Irving
City of Lewisville
City of Plano
City of San Antonio
Cobb, Fendley and Associates Inc.
Dallas ISD
DAVACO LP
Denton Municipal Electric
DFW Airport
Dikita Enterprises Inc.
El Paso Electric Co.
El Paso MPO
Electric Utility
Environmental Defense Fund—Texas

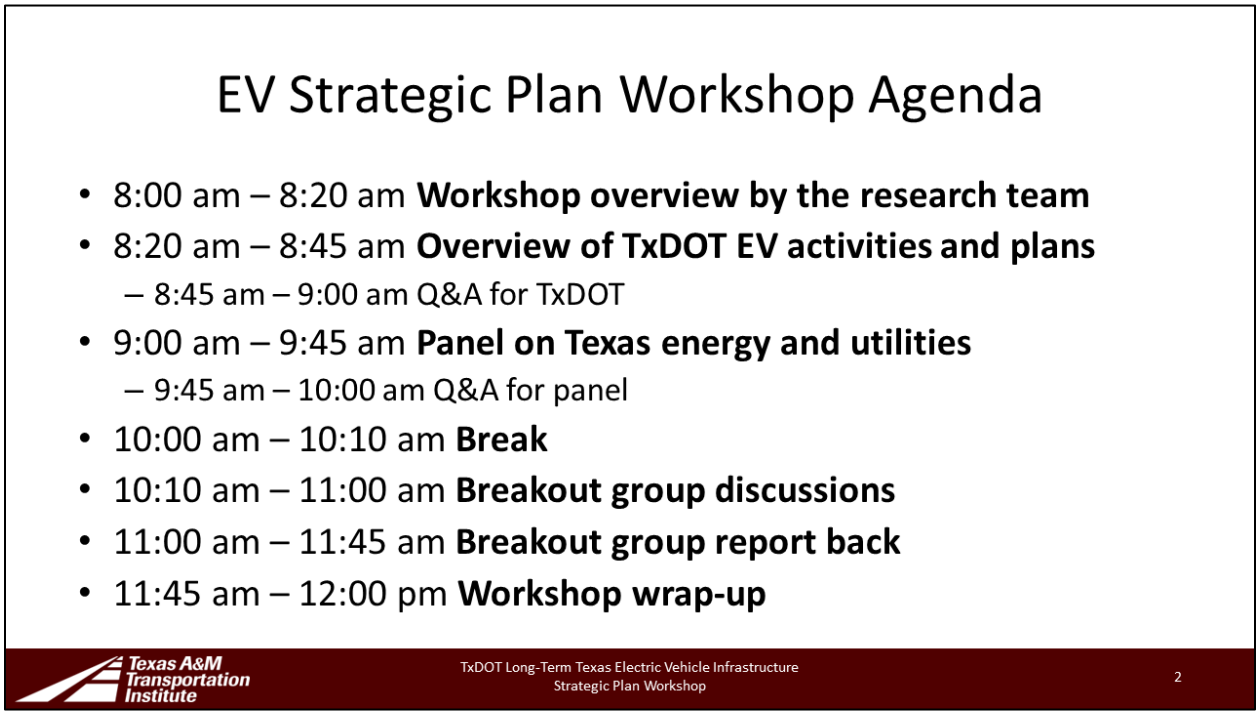
EnviroSpark Energy Solutions
EPRI
Eric Wright & Associates
EV Tech EV Charging Equipment
EY
Farmers Electric Cooperative
FHWA Texas Division
Francis Energy
GEUS
GNA
Graviti Energy
Greenville Electric Utility System
Hanson Professional Services
HDR Inc.
Hertz Corporation
HGP Mobility LLC
HNTB Corporation
Hood County Clean Air Coalition
Horrocks Engineers
IBEW
Impower Connection
Indigo Energy Partners LLC
JF Petrogroup
Kiewit
Kimley-Horn
KPMG
Louisiana Department of Transportation and Development
LTRA
Lubbock MPO
Mahuya Industries
Modus LLC
Moser Energy Systems
Multimodal Aircraft Charging Network
Municipal
NCTCOG/DFWCC
NEVIPRO
North Central Texas Council of Governments
North Texas Innovation Alliance
NRG Energy
NTEAA
Olsson
Oncor Electric Delivery
Parsons Corporation
Pedernales Electric Cooperative Inc.
RaceTrac Inc.
Revitalize Charging Solutions

RGVMPO
Rivian
RS&H Inc.
Schneider Electric
Shell Recharge Solutions
Southern Methodist University
Stantec Consulting
Tarrant County
Tata
TDA
Texas A&M Transportation Institute
Texas Department of Agriculture
Texas Department of Transportation
Texas Research Alliance
Town of Flower Mound
Town of Prosper
Toyota Motor North America
Tri-County Electric Cooperative Inc.
Trillium Energy
Tritium
TVEC
TxETRA
University of Texas at Austin
Volta Charging
Volvo Group North America
Waco MPO
Wallbox
ZamCo Directional Drilling LLC

APPENDIX D. WORKSHOP PRESENTATIONS AND HANDOUTS

WORKSHOP 1

TTI Overview Presentation



8:00 am – 8:20 am

WORKSHOP OVERVIEW

Research Project Overview

- Research project 0-7169
- Develop EV long-term strategic plan
  - Guide development of EV infrastructure in Texas
  - Meet needs of EV stakeholders
  - Maximize financial opportunities available to Texas
  - Guide effective and equitable distribution of infrastructure funding
- Goal: a stable and consistent EV charging network

What is TTI Doing?

- Review existing EV charging infrastructure state of practice
- Assess tools available to guide statewide EV planning analysis
- Develop analysis of projected EV charging demand based on adoption trends and projections
- Develop policy analysis of local, state, and federal statutory landscape
- Analyze funding opportunities and develop frameworks for funding models
- Develop strategies to improve EV charging infrastructure system in Texas over next 5 to 10 years

What are Expected Products of the Research?

- Assessment of EV planning analysis tools
- EV policy analysis framework
- Long-term statewide EV infrastructure strategies
  - Guidance for equitable deployment/densification of EV charging infrastructure in Texas
  - Guidance to maximize funding from federal formula and discretionary funding programs
  - Guidance to assist and engage regional/local transportation agencies to request funding from federal funding programs

Project Overview

- Task 1. Project Management
- Task 2. Review of Literature, Programs, and Regulations
- **Task 3. Regional Stakeholder Workshops**
- Task 4. Assessment of Available Data and Tools to Guide the Analysis
- Task 5. Analysis of Policies and Funding Opportunities
- Task 6. Develop Long-Term EV Infrastructure Strategic Plan

Workshop Objectives

- Discuss the research project and need to develop a Texas EV infrastructure strategic plan
- Discuss TxDOT's plans for a statewide EV charging plan
- Identify stakeholder needs, active initiatives, planned activities, and concerns
- Discuss EV policy considerations
- Gather feedback on potential implementation strategies, including financial strategies
- Identify opportunities to coordinate activities among stakeholders

Project Monitoring Committee

Research Project Manager: Joanne Steele, Research and Technology Implementation Division

Name	Title	Organization
Benjamin Cox	Transportation Engineer	Lubbock District
Brent Johnson	Roadside Facilities Section Director	Maintenance Division
Ernesto Jaimes	Engineering Assistant	Austin District
Harsh Doshy	Transportation Engineer	Maintenance Division
James Kuhr	Strategic Portfolio Project Manager	Strategy and Innovation Division
Lori Clark	Air Quality Management Program Manager & DFW Clean Cities Coordinator	North Central Texas Council of Governments (NCTCOG)
Patrick Hargrove	Engineering Assistant	Austin District
Ryan Granger	Strategic Research Analyst	Strategy and Innovation Division

Research Team Members

Name	Title	Organization
Edgar Kraus	Research Engineer (P.I.)	Texas A&M Transportation Institute
Joe Zietsman	Deputy Agency Director	Texas A&M Transportation Institute
Alice Grossman	Associate Research Scientist	Texas A&M Transportation Institute
Jacqueline Kuzio	Assistant Research Scientist	Texas A&M Transportation Institute
Harshit Shukla	Assistant Research Scientist	Texas A&M Transportation Institute
Mohammad Askariyeh	Assistant Research Scientist	Texas A&M Transportation Institute
Tara Ramani	Associate Research Engineer	Texas A&M Transportation Institute
Cesar Quiroga	Senior Research Engineer	Texas A&M Transportation Institute
Jolanda Prozzi	Senior Research Engineer	Texas A&M Transportation Institute
Thomas Overbye	Professor	TAMU Department of Electrical and Computer Engineering

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Director, Center for Advancing Research in Transportation Emissions, Energy, and Health (CARTEEH)
Texas A&M University System
j-zietsman@tti.tamu.edu
979-317-2796

TTI Breakout Presentation

Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop

Virtual Workshop
November 9, 2022
8:00 a.m. – 12:00 p.m.

10:00 am – 11:45 am

BREAKOUT DISCUSSIONS

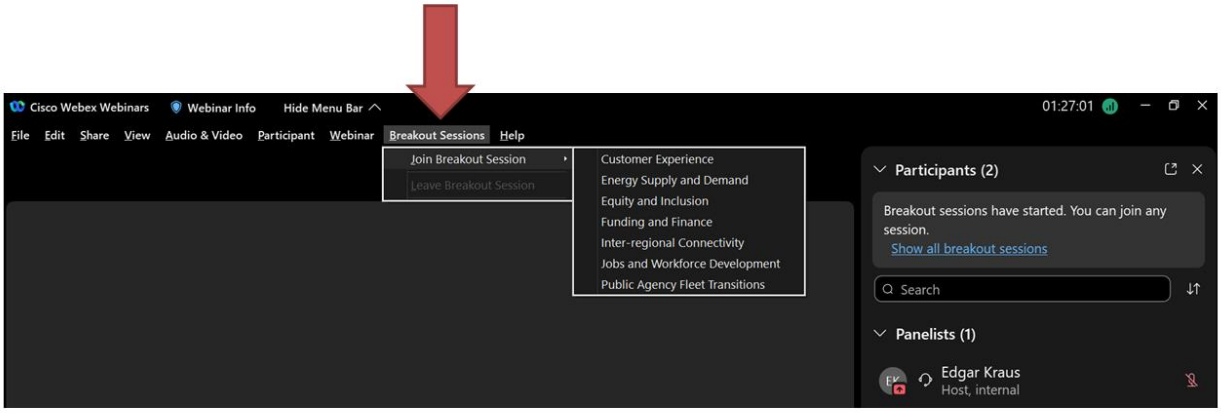
Breakout Goals and Expectations

- Conduct high-level discussion on breakout topic
- Provide feedback and insight on breakout topic
  - What are critical issues?
  - Should TxDOT be involved, and if yes, how?
- Develop list of comments, insight, and feedback
- Report back

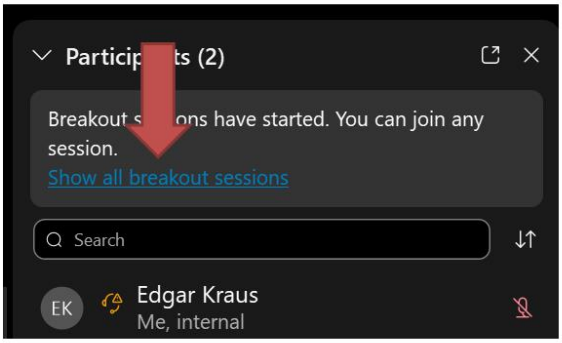
Breakout Groups

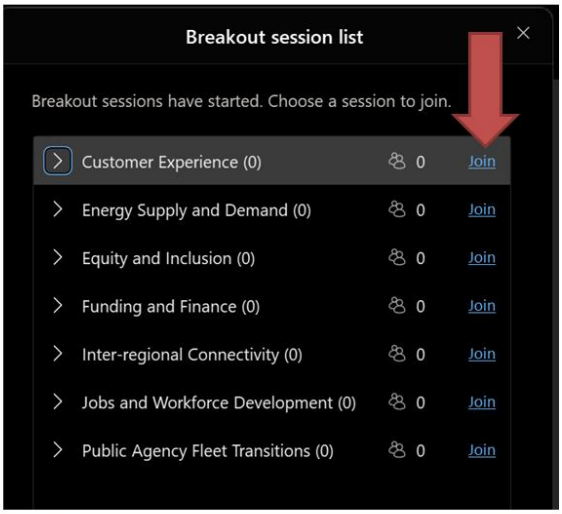
1. Funding and finance
2. Equity and inclusion – focus on rural considerations
3. Energy supply and demand – include V2X considerations
4. Jobs and workforce development
5. Public agency fleet transitions
6. Inter-regional connectivity
7. Customer experience

How to Join a Breakout in Webex

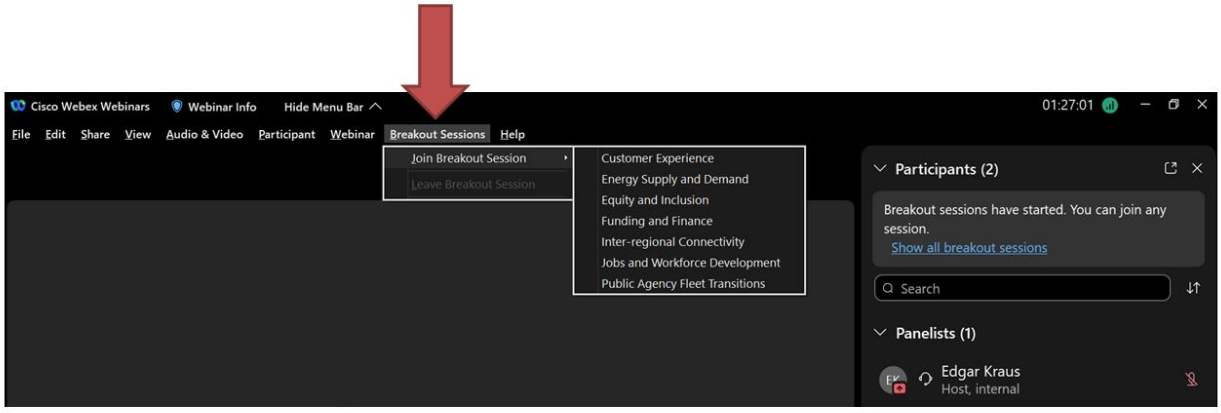


How to Join a Breakout in Webex: Option 2



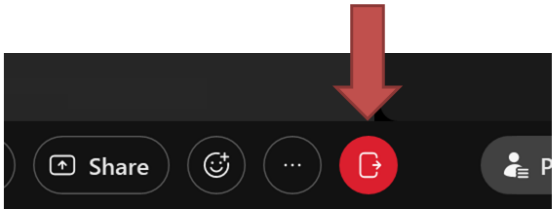


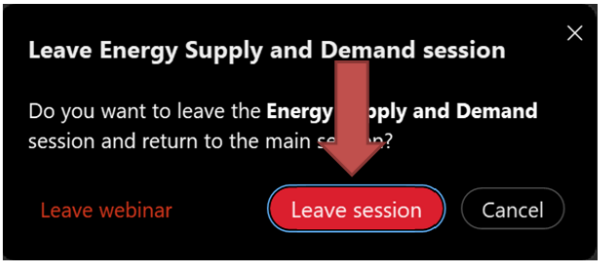
How to Move to a Different Breakout



How to Return to the Main Room

- Breakouts will close at 11:00 am central time
- You will automatically rejoin the main room





Breakout Ground Rules

- Be courteous and hear one another out
- Keep an open mind and consider all ideas
- Keep workshop goals in mind
- Disagreement is ok, but work constructively towards a solution
- Participate: share ideas/thoughts, ask questions, and listen

Breakout Guidance and Recommendations

- Panelist will help guide the discussion
- Select a note taker
- Review notes halfway through session
- Consider “structured round” of comments based on emerging themes
- Select a presenter for report back

Next Steps

- Select a breakout group to join
- Technical difficulties
  - Go back to the main room
  - Email Harshit h-shukla@tti.tamu.edu

TTI Wrap-Up Presentation

Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop

Virtual Workshop

November 9, 2022

8:00 a.m. – 12:00 p.m.

11:45 am – 12:00 pm

WORKSHOP WRAP-UP

Workshop Summary

- Learned about TxDOT EV research and other TxDOT EV activities
- Gained perspective from Texas energy stakeholders
- Conducted breakout discussions and provided feedback

Options to Provide Feedback

- Email comments to the research team
- Provide feedback in survey
- Participate in upcoming workshops
  - December 9, 2022, **in-person only**, TxDOT Stassney Campus, 6230 E Stassney Ln, Austin, TX 78744
  - January 19, 2023, **in-person only,** TBD

Research Team Contact Information

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Deputy Agency Director
Texas A&M Transportation Institute
Director, Center for Advancing Research in Transportation Emissions, Energy, and Health (CARTEEH)
Texas A&M University System
j-zietsman@tti.tamu.edu
979-317-2796

Texas A&M Transportation Institute

5

WORKSHOP 2

TTI Combined Presentation

Texas State Planning and Research (SPR) Program

Research

History

- Commission Minute Orders from 1948 to 1997
- Provides TxDOT the authority to contract with Texas colleges and universities for transportation-related research
- Legislative Appropriations Request (LAR) submitted to Governor identifies a strategy for Research

Value to TxDOT and State

Research:

- Develops application for advanced technologies
- Contributes to the high quality of Texas transportation facilities and services
- Assists the state in meeting needs created by growth and changing technologies
- Ensures that transportation research funds are available to Texas universities in order to assure high quality research results

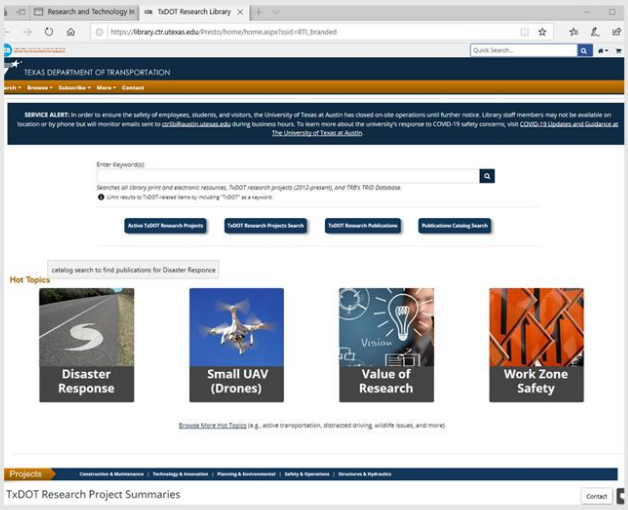
Aligns to TxDOT Goals and Objectives:

- Optimize System Performance
- Deliver the Right Projects
- Focus on the Customer
- Foster Stewardship
- Preserve our Assets
- Promote Safety
- Value our Employees

3

TxDOT Research Library Website

- https://library.ctr.utexas.edu/Presto/home/home.aspx?ssid=RTI_branded
- Includes on-line search engine for all TxDOT research projects from 2012 to the present (and TRID database)
- Includes highlighted **video summary reports (VSR)** for completed research activities
- TxDOT Research Program Reference Materials
- Research Digest publications (free subscription)
- Includes **Project Summary Reports (PSRs)** are 2-page leaflets describing the background, methodology, results, and recommendations from Research Projects.



Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop

Workshop

TxDOT, Austin, December 9, 2022

EV Strategic Plan Workshop Agenda

- 9:00 am – 9:10 am **Introduction and workshop overview**
- 9:10 am – 10:00 am **Panel discussion and Q&A**
- 10:00 am – 11:15 am **Breakout group discussions**
- 11:15 am – 11:55 am **Breakout group report back and discussion**
- 11:55 am – 12:00 pm **Workshop wrap-up**

Research Project Overview

- TxDOT research project 0-7169
- Develop EV long-term strategic plan
  - Guide development of EV infrastructure in Texas
  - Meet needs of EV stakeholders
  - Maximize financial opportunities available to Texas
  - Guide effective and equitable distribution of infrastructure funding
- Goal: a stable and consistent EV charging network

Project Monitoring Committee

Research Project Manager: Joanne Steele, Research and Technology Implementation Division

Name	Title	Organization
Benjamin Cox	Transportation Engineer	Lubbock District
Brent Johnson	Roadside Facilities Section Director	Maintenance Division
Ernesto Jaimes	Engineering Assistant	Austin District
Harsh Doshy	Transportation Engineer	Maintenance Division
James Kuhr	Strategic Portfolio Project Manager	Strategy and Innovation Division
Lori Clark	Air Quality Management Program Manager & DFW Clean Cities Coordinator	North Central Texas Council of Governments (NCTCOG)
Patrick Hargrove	Engineering Assistant	Austin District
Ryan Granger	Strategic Research Analyst	Strategy and Innovation Division

Research Team Members

Name	Title	Organization
Edgar Kraus	Research Engineer (P.I.)	Texas A&M Transportation Institute
Joe Zietsman	Deputy Agency Director	Texas A&M Transportation Institute
Alice Grossman	Associate Research Scientist	Texas A&M Transportation Institute
Jacqueline Kuzio	Assistant Research Scientist	Texas A&M Transportation Institute
Harshit Shukla	Assistant Research Scientist	Texas A&M Transportation Institute
Mohammad Askariyeh	Assistant Research Scientist	Texas A&M Transportation Institute
Tara Ramani	Associate Research Engineer	Texas A&M Transportation Institute
Cesar Quiroga	Senior Research Engineer	Texas A&M Transportation Institute
Jolanda Prozzi	Senior Research Engineer	Texas A&M Transportation Institute
Thomas Overbye	Professor	TAMU Department of Electrical and Computer Engineering

Project Overview

- Task 1. Project management
- Task 2. Review of literature, programs, and regulations
- **Task 3. Regional Stakeholder Workshops**
  - 11/09/2022 (virtual)
  - **12/09/2022 (Austin)**
  - 02/01/2023 (NCTCOG Arlington)
- Task 4. Assessment of available data and tools to guide the analysis
- Task 5. Analysis of policies and funding opportunities
- Task 6. Develop long-term EV infrastructure strategic plan

Workshop Objectives

- Discuss TxDOT's plans for a statewide EV charging plan
- Identify stakeholder needs, active initiatives, planned activities, and concerns
- Discuss EV policy considerations
- Gather feedback on potential implementation strategies, including financial strategies
- Identify opportunities to coordinate activities among stakeholders

Virtual Workshop Recap

- About 100 participants from diverse background
- Presentations from TxDOT, LCRA, ONCOR, and ERCOT
- Topics discussed in breakouts:
  - Funding and Finance
  - Equity and Inclusion
  - Energy Supply and Demand
  - Jobs and Workforce Development
  - Public Agency Fleet Transitions
  - Inter-Regional Connectivity
  - Customer Experience

Workshop 1 Summary: Discussion Points

- Details of TxDOT's NEVI plan, build out priority, funding for operations and maintenance
- Challenges to the electrical grid, electricity cost, reliability
- Charging infrastructure for fleet vehicles
- Lack of standardized communication infrastructure
- Electric cooperatives: forecasting revenues, planning info, TxDOT support
- Need for "clean cities" type coalition for areas outside big cities

Today's Workshop

- Expert Panel
  - Ryan Granger, TxDOT
  - Lisa Lin, Harris County
  - Jason McLemore, Harris County Toll Road Authority
  - Andrew DeCandis, Houston-Galveston Area Council
- Breakouts
  - Funding and Finance
  - Equity and Inclusion
  - Energy Supply and Demand
  - Interagency Coordination
  - EV Grant Programs (USDOT and others)

Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop

Workshop

December 9, 2022

Breakout Goals and Expectations

- Conduct high-level discussion on breakout topic
- Provide feedback and insight on breakout topic
  - What are critical issues?
  - Should TxDOT be involved, and if yes, how?
- Develop list of comments, insight, and feedback
- Report back

Breakout Groups

- Funding and Finance
- Equity and Inclusion
- Energy Supply and Demand
- Interagency Coordination
- EV Grant Programs (USDOT and others)

Breakout Ground Rules

- Be courteous and hear one another out
- Keep an open mind and consider all ideas
- Keep workshop goals in mind
- Disagreement is ok, but work constructively towards a solution
- Participate: share ideas/thoughts, ask questions, and listen
- Feel free to move around

Breakout Guidance and Recommendations

- Researcher will help guide the discussion
- Select a note taker
- Review notes halfway through session
- Consider “structured round” of comments based on emerging themes
- Select a presenter for report back

Long-Term Texas Electric Vehicle Infrastructure Strategic Plan Workshop

Workshop

December 9, 2022

Workshop Summary

- Learned about TxDOT EV research and other TxDOT EV activities
- Gained perspective from EV stakeholders
- Conducted breakout discussions and provided feedback

Options to Provide Feedback

- Email comments to the research team
- Provide feedback in survey
- Participate in next workshop
  - February 1, 2023, NCTCOG Arlington, Texas

Research Team Contact Information

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WORKSHOP 3

TTI Combined Presentation

Post-NEVI Electric Vehicle Infrastructure Research

Workshop
Arlington, February 22, 2023

EV Strategic Plan Workshop Agenda

- 9:00 am – 9:15 am **Introduction and previous workshop recap**
- 9:15 am – 10:30 am **TxDOT/MPO panel discussion and Q&A**
- 10:30 am – 10:45 am **Break**
- 10:45 am – 12:00 pm **Freight, Fleet, Multi-housing panel and Q&A**
- 12:00-1:00 pm **Networking lunch**

EV Strategic Plan Workshop Agenda

- 1:00- 2:00 pm **Breakout group session I**
  - Equity and Inclusion
  - Energy Supply and Demand
  - Interagency Coordination
  - EV Grant Programs (USDOT and others)
- 2:00-2:15 pm Break
- 2:15-3:15 pm **Breakout group session II**
- 3:15-3:50 pm **Group report on breakout discussions**
- 3:50-4:00 pm Wrap-up

Research Project Overview

- TxDOT research project 0-7169: Post-NEVI Electric Vehicle Infrastructure Research (Freight, Fleet, and Multi-family Housing)
- Develop EV long-term strategic plan
  - Guide development of EV infrastructure in Texas
  - Meet needs of EV stakeholders
  - Maximize financial opportunities available to Texas
  - Guide effective and equitable distribution of infrastructure funding
- Goal: a stable and consistent EV charging network

Project Monitoring Committee

Research Project Manager: Joanne Steele, Research and Technology Implementation Division

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Mohammad Askariyeh	Assistant Research Scientist	Texas A&M Transportation Institute
Tara Ramani	Associate Research Engineer	Texas A&M Transportation Institute
Cesar Quiroga	Senior Research Engineer	Texas A&M Transportation Institute
Jolanda Prozzi	Senior Research Engineer	Texas A&M Transportation Institute
Thomas Overbye	Professor	TAMU Department of Electrical and Computer Engineering

Expected Research Products

- Assessment of EV planning analysis tools
- EV policy analysis framework
- Long-term statewide EV infrastructure strategies
  - Guidance for equitable deployment/densification of EV charging infrastructure in Texas
  - Guidance to maximize funding from federal formula and discretionary funding programs
  - Guidance to assist and engage regional/local transportation agencies to request funding from federal funding programs

Project Overview

- Task 1. Project management
- Task 2. Review of literature, programs, and regulations
- **Task 3. Regional Stakeholder Workshops**
  - 11/09/2022 (virtual)
  - **12/09/2022 (Austin)**
  - 02/01/2023 (NCTCOG Arlington)
- Task 4. Assessment of available data and tools to guide the analysis
- Task 5. Analysis of policies and funding opportunities
- Task 6. Develop long-term EV infrastructure strategic plan

Workshop Objectives

- Discuss TxDOT's plans for a statewide EV charging plan
- Identify stakeholder needs, active initiatives, planned activities, and concerns
- Discuss EV policy considerations
- Gather feedback on potential implementation strategies, including financial strategies
- Identify opportunities to coordinate activities among stakeholders

Workshop 1 Recap

- Virtually, about 100 participants
- Presentations from TxDOT, LCRA, ONCOR, and ERCOT
- Topics discussed in breakouts:
  - Funding and Finance
  - Equity and Inclusion
  - Energy Supply and Demand
  - Jobs and Workforce Development
  - Public Agency Fleet Transitions
  - Inter-Regional Connectivity
  - Customer Experience

Workshop 2 Recap

- In-person, about 40 participants from diverse background
- Presentations from TxDOT, Harris County, Houston-Galveston Area Council, and Harris County Toll Road Authority
- Topics discussed in breakouts:
  - Funding and Finance
  - Equity and Inclusion
  - Energy Supply and Demand
  - Interagency Coordination
  - EV Grant Programs

Workshop Discussion Points

- Details of TxDOT's NEVI plan, build out priority, funding for operations and maintenance
- Challenges to the electrical grid, electricity cost, reliability
- Charging infrastructure for fleet vehicles
- Lack of standardized communication infrastructure
- Electric cooperatives: forecasting revenues, planning info, TxDOT support
- Need for "clean cities" type coalition for areas outside big cities

Questions?

Post-NEVI Electric Vehicle Infrastructure Research

Workshop

Arlington, February 22, 2023

EV Strategic Plan Workshop Agenda

- 1:00- 2:00 pm **Breakout group session I**
- 2:00-2:15 pm Break
- 2:15-3:15 pm **Breakout group session II**
- 3:15-3:50 pm **Group report on breakout discussions**
- 3:50-4:00 pm Wrap-up

Breakout Goals and Expectations

- Conduct high-level discussion on breakout topic
- Provide feedback and insight on breakout topic
  - What are critical issues?
  - Should TxDOT be involved, and if yes, how?
- **Bring back your top three items/concerns/issues that are most pressing and potential ways to address them**

Breakout Groups

- Equity and Inclusion (Alice Grossman)
- Energy Supply and Demand (Harshit Shukla)
- Interagency Coordination (Tara Ramani)
- EV Grant Programs (USDOT and others) (Jackie Kuzio)

Breakout Ground Rules

- Be courteous and hear one another out
- Keep an open mind and consider all ideas
- Keep workshop goals in mind
- Disagreement is ok, but work constructively towards a solution
- Participate: share ideas/thoughts, ask questions, and listen

Breakout Guidance and Recommendations

- Panelist will help guide the discussion
- Select a note taker
- Review notes halfway through session
- Consider “structured round” of comments based on emerging themes
- Select a presenter for report back

Post-NEVI Electric Vehicle Infrastructure Research

Workshop

Arlington, February 22, 2023

Workshop Summary

- Learned about TxDOT EV research and other TxDOT EV activities
- Gained perspective from EV stakeholders
- Conducted breakout discussions and provided feedback

Options to Provide Feedback

- Email comments to the research team
- Provide feedback in survey

Research Team Contact Information

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APPENDIX E. EV REGISTRATION DATA

In Texas by County (August 2023)

County	Registered EVs	County	Registered EVs	County	Registered EVs	County	Registered EVs	County	Registered EVs
Anderson	58	Crockett	3	Hartley	3	Madison	15	San Saba	8
Andrews	25	Crosby	4	Haskell	5	Marion	19	Scurry	20
Angelina	119	Culbertson	13	Hays	2,644	Martin	1	Shackelford	2
Aransas	59	Dallam	11	Hemphill	2	Mason	5	Shelby	16
Archer	8	Dallas	21,644	Henderson	162	Matagorda	35	Sherman	4
Armstrong	1	Dawson	8	Hidalgo	2,061	Maverick	61	Smith	684
Atascosa	69	Deaf Smith	20	Hill	71	McCulloch	6	Somervell	21
Austin	74	Delta	10	Hockley	18	McLennan	831	Starr	43
Bailey	1	Denton	14,661	Hood	305	Medina	193	Stephens	6
Bandera	78	Dewitt	16	Hopkins	72	Midland	319	Sterling	1
Bastrop	498	Dickens	2	Houston	20	Milam	45	Stonewall	1
Baylor	3	Dimmit	2	Howard	45	Mills	52	Swisher	9
Bee	25	Donley	3	Hudspeth	2	Mitchell	1	Tarrant	15,050
Bell	1,369	Duval	5	Hunt	269	Montague	26	Taylor	366
Bexar	16,446	Eastland	14	Hutchinson	15	Montgomery	4,916	Terry	7
Blanco	67	Ector	196	Jack	6	Moore	16	Throckmorton	1
Borden	1	Edwards	4	Jackson	11	Morris	15	Titus	43
Bosque	36	El Paso	3,298	Jasper	25	Motley	1	Tom Green	230
Bowie	142	Ellis	953	Jeff Davis	7	Nacogdoches	100	Travis	27,352
Brazoria	2,352	Erath	73	Jefferson	443	Navarro	81	Trinity	16
Brazos	880	Falls	14	Jim Hogg	1	Newton	5	Tyler	15
Brewster	19	Fannin	66	Jim Wells	41	Nolan	9	Upshur	47
Briscoe	2	Fayette	43	Johnson	658	Nueces	901	Upton	1
Brooks	3	Fisher	2	Jones	11	Ochiltree	7	Uvalde	28
Brown	35	Floyd	6	Karnes	15	Oldham	2	Val Verde	93
Burleson	25	Foard	2	Kaufman	839	Orange	106	Van Zandt	129
Burnet	254	Fort Bend	11,265	Kendall	662	Palo Pinto	40	Victoria	162
Caldwell	90	Franklin	18	Kent	1	Panola	25	Walker	95
Calhoun	24	Freestone	25	Kerr	171	Parker	852	Waller	331
Callahan	21	Frio	13	Kimble	2	Parmer	4	Ward	11
Cameron	1,032	Gains	20	King	1	Pecos	12	Washington	93
Camp	9	Galveston	1,786	Kinney	5	Polk	113	Webb	424
Carson	9	Garza	3	Kleberg	45	Potter	179	Wharton	53
Cass	34	Gillespie	161	Knox	2	Presidio	7	Wheeler	5
Castro	9	Goliad	3	Lamar	88	Rains	28	Wichita	280
Chambers	139	Gonzales	26	Lamb	10	Randall	411	Wilbarger	10
Cherokee	67	Gray	19	Lampasas	62	Real	5	Willacy	21
Childress	4	Grayson	503	Lasalle	3	Red River	9	Williamson	10,745
Clay	13	Gregg	271	Lavaca	27	Reeves	16	Wilson	143
Coke	1	Grimes	65	Lee	26	Refugio	2	Winkler	5
Coleman	4	Guadalupe	804	Leon	23	Roberts	1	Wise	192
Collin	21,274	Hale	30	Liberty	101	Robertson	15	Wood	82
Collingsworth	2	Hall	1	Limestone	20	Rockwall	1,133	Yoakum	3
Colorado	47	Hamilton	14	Lipscomb	2	Runnels	6	Young	33
Comal	1,577	Hansford	3	Live Oak	9	Rusk	67	Zapata	6
Comanche	12	Hardeman	2	Llano	104	Sabine	1	Zavala	2

County	Registered EVs	County	Registered EVs	County	Registered EVs	County	Registered EVs	County	Registered EVs
Concho	3	Hardin	95	Loving	1	San Augustine	5		
Cooke	109	Harris	29,788	Lubbock	787	San Jacinto	43		
Coryell	163	Harrison	125	Lynn	10	San Patricio	106	**Grand Total**	211,055

APPENDIX F. DAILY CHARGING DEMAND DATA FOR TEXAS

(MWh) for 1 Million EVs by County (68°F) in Texas

County	Daily Load (MWh)	County	Daily Load (MWh)	County	Daily Load (MWh)	County	Daily Load (MWh)	County	Daily Load (MWh)
Anderson	16.7	Crane	1.7	Hartley	2.3	Madison	4.7	San Patricio	24.2
Andrews	7.0	Crockett	1.6	Haskell	1.9	Marion	3.5	San Saba	2.3
Angelina	28.8	Crosby	1.9	Hays	80.5	Martin	2.1	Schleicher	1.2
Aransas	8.9	Culberson	0.8	Hemphill	1.6	Mason	1.9	Scurry	6.1
Archer	3.8	Dallam	2.8	Henderson	31.9	Matagorda	12.7	Shackelford	1.4
Armstrong	0.8	Dallas	841.5	Hidalgo	266.8	Maverick	20.2	Shelby	9.4
Atascosa	17.4	Dawson	3.9	Hill	15.1	McCulloch	3.0	Sherman	1.0
Austin	13.4	Deaf Smith	7.5	Hockley	8.2	McLennan	83.9	Smith	84.4
Bailey	2.3	Delta	2.1	Hood	25.7	McMullen	0.5	Somervell	3.7
Bandera	9.4	Denton	293.8	Hopkins	14.7	Medina	19.8	Starr	22.1
Bastrop	37.6	DeWitt	7.3	Houston	7.3	Menard	0.9	Stephens	3.2
Baylor	1.4	Dickens	0.8	Howard	10.0	Midland	68.8	Sterling	0.7
Bee	7.9	Dimmit	3.7	Hudspeth	1.4	Milam	9.7	Stonewall	0.5
Bell	124.2	Donley	1.1	Hunt	36.0	Mills	2.1	Sutton	1.6
Bexar	654.8	Duval	3.8	Hutchinson	8.1	Mitchell	2.3	Swisher	2.4
Blanco	6.4	Eastland	7.6	Irion	0.9	Montague	8.6	Tarrant	680.7
Borden	0.3	Ector	60.9	Jack	3.3	Montgomery	216.0	Taylor	47.0
Bosque	7.5	Edwards	0.9	Jackson	5.7	Moore	8.5	Terrell	0.4
Bowie	30.5	El Paso	281.5	Jasper	12.7	Morris	4.6	Terry	3.8
Brazoria	126.4	Ellis	71.2	Jeff Davis	0.9	Motley	0.5	Throckmorton	0.6
Brazos	61.2	Erath	14.0	Jefferson	77.3	Nacogdoches	20.8	Titus	11.2
Brewster	3.6	Falls	5.8	Jim Hogg	1.6	Navarro	18.1	Tom Green	40.9
Briscoe	0.6	Fannin	13.2	Jim Wells	13.0	Newton	4.3	Travis	378.7
Brooks	2.2	Fayette	10.9	Johnson	66.3	Nolan	4.9	Trinity	5.4
Brown	13.7	Fisher	1.4	Jones	5.5	Nueces	106.3	Tyler	7.1
Burleson	7.7	Floyd	2.3	Karnes	5.6	Ochiltree	3.9	Upshur	14.7
Burnet	20.5	Foard	0.5	Kaufman	52.2	Oldham	1.0	Upton	1.5
Caldwell	16.6	Fort Bend	270.2	Kendall	24.0	Orange	27.1	Uvalde	9.6
Calhoun	7.9	Franklin	4.2	Kenedy	0.3	Palo Pinto	10.7	Val Verde	18.3
Callahan	5.3	Freestone	7.4	Kent	0.3	Panola	8.7	Van Zandt	21.3
Cameron	137.2	Frio	5.2	Kerr	21.0	Parker	57.4	Victoria	31.0
Camp	5.7	Gaines	7.6	Kimble	1.9	Parmer	3.5	Walker	18.5
Carson	2.4	Galveston	113.3	King	0.1	Pecos	5.4	Waller	19.3
Cass	10.9	Garza	1.6	Kinney	1.2	Polk	19.3	Ward	4.8
Castro	3.0	Gillespie	12.2	Kleberg	9.3	Potter	38.3	Washington	14.2
Chambers	17.8	Glasscock	0.7	Knox	1.4	Presidio	2.9	Webb	89.3
Cherokee	17.6	Goliad	2.8	La Salle	2.4	Rains	4.9	Wharton	16.1
Childress	2.1	Gonzales	8.3	Lamar	18.2	Randall	51.3	Wheeler	2.2
Clay	4.1	Gray	7.6	Lamb	4.5	Reagan	1.6	Wichita	40.4
Cochran	1.0	Grayson	50.5	Lampasas	8.9	Real	1.5	Wilbarger	4.2
Coke	1.4	Gregg	46.3	Lavaca	8.8	Red River	4.6	Willacy	5.9
Coleman	3.3	Grimes	11.4	Lee	7.6	Reeves	5.0	Williamson	199.3
Collin	350.5	Guadalupe	61.5	Leon	7.1	Refugio	2.5	Wilson	19.8
Collingsworth	1.1	Hale	10.3	Liberty	32.1	Roberts	0.4	Winkler	3.3
Colorado	9.1	Hall	1.0	Limestone	8.4	Robertson	6.5	Wise	29.8
Comal	69.6	Hamilton	3.6	Lipscomb	1.3	Rockwall	39.2	Wood	18.0
Comanche	5.4	Hansford	2.2	Live Oak	4.2	Runnels	3.9	Yoakum	3.4
Concho	1.0	Hardeman	1.4	Llano	9.6	Rusk	17.6	Young	7.3

County	Daily Load (MWh)	County	Daily Load (MWh)	County	Daily Load (MWh)	County	Daily Load (MWh)	County	Daily Load (MWh)
Cooke	17.4	Hardin	20.3	Loving	0.1	Sabine	4.1	Zapata	4.3
Coryell	22.7	Harris	1,382.0	Lubbock	95.3	San Augustine	3.1	Zavala	3.5
Cottle	0.5	Harrison	24.1	Lynn	2.2	San Jacinto	9.9	Total	9,558.3

APPENDIX G. INTERVIEW NARRATIVES

This appendix includes the narratives of interviews the research team conducted with peer states and MPOs. Researchers submitted each interview summary to the corresponding state or MPO for review and comment. These interview narratives have been updated based on comments received from the interviewees.

ARIZONA DOT

Thor Anderson is the performance/asset manager for the Arizona Department of Transportation (ADOT), as well as the NEVI program manager. In this interview, the discussion focused on EV infrastructure planning efforts, the focus of ADOT's NEVI plan and investments, and relevant policies, regulations, and funding issues within Arizona.

EV Infrastructure Planning and NEVI Program

ADOT's focus is on designating new AFCs and building out the infrastructure to meet the requirements under the NEVI program. ADOT is taking a conservative approach to ensure requirements can be met with the funding available under the program. Arizona's NEVI funding will total $76.5 million over the program's 5 years. No plan currently exists to assess the unmet charging needs post-NEVI. The most recent budget for the state did include funding to help electrify the state fleet by providing charging infrastructure; ADOT oversees the state fleet, and planning efforts will begin shortly to utilize that funding. However, the focus with the funding for fleets will be on Level 2 charging infrastructure. The Department of Administration is the main coordinating partner for that effort. Since NEVI funding is subdivided into annual allocations, ADOT has adopted a conservative approach to ensure it does not plan more charging stations than the annual NEVI funding allocation can support. For this reason, it has mapped out several new AFCs but is applying for that designation using a piecemeal approach. Each year of the NEVI program, it plans to designate some additional corridors. The goal is to nominate most of the NHS corridors in the state in the coming years, so they are eligible for NEVI funding. Additionally, the data and information requirements of nominating new corridors are resource intensive, making the piecemeal approach to corridor nomination more manageable.

ADOT is presenting its plans at statewide meetings with MPOs, local governments, and special interest groups to facilitate coordination. These efforts help to determine locations at a high level rather than specific sites. In terms of NEVI charging station deployment, ADOT is using a private design-build-own-operate approach and will provide up to 5 years of funding for operations and maintenance support. The funding will be provided to the private entity to support installing and operating the charging infrastructure. It is currently in the procurement/contracting stage.

Funding

The state has applied for a CFI grant for the installation of publicly accessible Level 3 chargers at select state facilities. If the grant is received, state funding would be used to cover the federal match requirement. In terms of revenue generation from electric vehicles, the legislature recently repealed the license tax reduction that was in place for EVs. Arizona's elected officials are

responsible for initiating any additional legislation that can generate revenues from EVs for roadway preservation and maintenance. While EV registrations remain relatively low, they are steadily increasing. By the end of 2023, Arizona had about 80,000 registered EVs.

ADOT is acting as a partner by providing information and guidance for local governments that are applying for grant funding for charging stations.

Policies and Regulations

Arizona has been supportive of the business side of EV development, including supporting industries that are key to charging equipment. The policy focus is on supporting industry and private development. Outside of the federal formula and grant funding for EV infrastructure, Arizona is leaving the role of developing a charging network to the private sector.

There is also a move to introduce EVs into the state fleet. The recent funding through the state budget is focused on the state fleet as well as providing a federal match if ADOT's CFI grant request is awarded.

Utility rate structures may be a barrier to EV infrastructure deployment. Demand charges increase the overall cost of operating EV infrastructure, so the use of alternative rate plans will benefit the transition to electric. The impact of demand charges is particularly problematic in rural areas; coordination with co-ops is needed to reduce the burden of these charges to enable more rural charging infrastructure.

Freight, Fleet, and Multifamily Housing

Although Arizona has seen growth in light-duty EVs, MHDV options have lagged behind. Arizona is seeing some interest from freight EV charging infrastructure companies to partner with local governments in developing CFI grant applications for truck charging depots. The problem is the ability of local governments to support these applications, and it will be easier for large urban areas to participate since smaller rural communities are unlikely to have the capacity to support these grants.

The big challenge for freight is the limited range of MHD EVs, so Anderson does not believe that a full transition is possible right now. Increases in charger availability as well as vehicle range are required to support both freight and fleets.

MFH is not on ADOT's radar; that is an area that MPOs and local governments will be focusing on rather than the DOT.

CALIFORNIA TRANSPORTATION DEPARTMENT

The research team met with Jimmy O'Dea and Jelani Young from the Caltrans' Director's Office of Equity, Sustainability, and Tribal Affairs. Jimmy O'Dea is the assistant deputy director for electrification and Jelani Young is an associate transportation planner in the office. The interview focused on the current goals for California as well as their experience with different initiatives involving freight, fleets, and MFH.

Planning and Research

The current goal for Caltrans is to support the state's zero-emission policies, which aim for 100 percent of light-duty sales to be ZEVs by 2035. There are similar targets for MHDVs; 2036 for trucks and 2029 for buses. In regard to MFDs, Caltrans does not include those needs within its purview, but it is an area of EV infrastructure that needs addressing statewide. CEC offers incentives and includes MFDs under its needs. There is a greater potential for Caltrans to play a role with freight EV infrastructure needs. In terms of the NEVI program, CEC is leading implementation, with Caltrans having an oversight role. CEC is a partner on almost every EV infrastructure project that Caltrans leads.

Funding and research have focused on statewide emissions goals; so far, Caltrans has supported 37 public charging station projects. The stations do not currently assess a fee because it is against federal and state law, but that might change in the future.

Caltrans is also exploring a few different revenue options and models to support charging stations as well as airspace use-agreements under Caltrans-owned assets, such as bridges and highways. It is also supporting the build-out of charging infrastructure without its right-of-way. Current state-owned charging assets are maintained through service contracts. Caltrans's experience with the contractors has seen many challenges, including difficulty getting contractors on board.

Post-NEVI, Caltrans will continue pursuing funding opportunities for electrification through other programs; it will also remain involved regarding the right-of-way for charging and in providing technical support.

Funding and Revenue

The California Transportation Commission has one key program that provides a stable source of revenue for freight projects on a broad scale and can also be utilized for charging infrastructure: the Trade Corridors Enhancement Program. The program uses a combination of state fuel tax revenue and federal formula fundings.

CARB and the CEC also received funding from transportation sources for their programs, which mostly support new EV infrastructure projects across the state. This infrastructure has goals in terms of uptime and maintenance that need to be met.

One of the biggest questions in terms of funding is for fleets because California has some very aggressive targets with regard to fleet electrification. Historically, they have not had the budget available to replace all of the vehicles at the end of their useful life, even without factoring in the increased cost of EVs.

Another important funding source is the Low Carbon Fuel Standard (LCFS), which helps fund alternative fuel projects. This fee on carbon fuels offsets the cost of hydrogen, electricity, and biofuel. LCFS can offset electricity costs by roughly 10 cents per kilowatt-hour; the current electricity rate in California is roughly 25 cents a kWh, so it almost halves the cost. It works as a credit system that requires the use of a third-party broker. LCFS is undergoing an update that will affect the credit values. In addition, California's gas tax is indexed to inflation to reduce

some of the concerns over budget stability. In 2020, California introduced a registration fee for BEVs that was initially set at $100 but will increase according to the consumer price index.

Policies and Regulations

Policies that are driving the sale of electric vehicles have also spurred investment in infrastructure specifically for EV charging. Primarily in terms of funding, before NEVI, the investment in California was mostly provided by the CEC. The CEC provides funds for infrastructure, while CARB provides funding for vehicles. The CEC grants are funded through vehicle registration fees; the amount of funding is around $100 million per year.

There are a number of utility programs and legislation as well that intend to support EV charging infrastructure. SB350—a bill that directs the CPUC to require utilities to submit plans to use rate-payer funding for building out light- and medium-duty charging infrastructure—has recently been passed. This funding can be used for both utility side investments and rebates for customers. Current funding levels are over $1 billion, with programs having a 5-year timeline; utilities are on their second iteration. A program was approved to support 18,000 charging ports for trucks in the last iteration of the program. Due to COVID, there have been delays in building out the charging infrastructure. Since there are only 2,500 MHD EVs on the road in California to date, most of those charging stations are probably not built out. These stations will be behind the fence on private property, and there are no requirements on size or wattage.

Caltrans noted the importance of streamlining the permitting process, and the Governor's Office of Business and Economic Development (GO-Biz) has done a lot of work to improve it. GO-Biz developed a guidebook for local governments to help them navigate the process. Timing is still considered one of the biggest barriers to deploying charging infrastructure, and streamlining the permitting process is one way to reduce the time burden. Ultimately, everyone is new to the process, which can increase the complexity. This is a new use case for the utility industry, and more staff is required across the board to meet the needs of electrification.

Freight, Fleet, and Multifamily Housing

Investments in charging for freight are underway, but there are currently only four public charging stations designed for large trucks on the West Coast, with more behind the fence on private property that are privately owned and operated. This is not enough to support needs based on the expected growth in MHDVs. California expects to have 200,000 MHD EVs by 2030, which will need to be supported by charging infrastructure. Caltrans did submit a CFI proposal that will support ZEV trucks through a deployment 350kW chargers with the capacity to support more expanded charging in the future. Tesla, in coordination with a local government, also has a proposal for a CFI grant to install eight 750kW chargers at a site.

The challenges with charging for freight is the load required at each site. In order to support this dynamic, California is changing how the PUC and energy companies are planning for this infrastructure. In the past, these entities have not been future-focused, but now that California has a better understanding of the number of ZEVs that will be on the road, these forecasts are included in the load analysis. It has been a shift in the framework for planning since trucks that do not exist today must be considered and included in forecasts and estimates.

Although freight charging will require private investment, government investment is needed to lower the risk for the private sector. Hydrogen is viewed as an important technology to support alongside BEVs given the relative early stages of freight electrification. There is a need to understand how operations are conducted and what those refueling requirements will be to support the use of hydrogen. Hydrogen is also dependent on public investment, and California is pursuing projects for both technologies; questions remain on which technology suits long-distance trucking the best.

Fleet transition rates have tracked with available capital to invest in ZEVs as well as larger fleets that have the resources to apply for grants. Due to this process, larger fleets are in a better position than some of the smaller fleets in the state. For example, Pepsi is the first to receive and test Tesla trucks. There is a greater need for incentives at the point of purchase rather than as a credit or rebate that must be applied for after the fact.

In terms of MFH, Caltrans is supporting local agencies with off-highway projects. The state has also supported workforce development programs, such as EVITP, and is trying to staff up to support all its programs (at Caltrans and beyond).

COLORADO DOT

The research team met with Michael King, Colorado Department of Transportation (CDOT), Office of Innovative Mobility. CDOT, the CEO, and the Colorado Department of Public Health and Environment share responsibility for zero-emission transportation policy within Colorado. These three entities work together on policy and work with the governor's office to move zero emissions forward.

EV Infrastructure Planning

Colorado's approach to assessing unmet charging needs extends beyond the NEVI program. The state has conducted various analyses to identify these needs, including sanctioning a report from the International Council on Clean Transportation (ICCT) that was completed in 2021. The ICCT report looks at the level of charging needed to meet the state's pre-NEVI 2030 EV adoption goals. These analyses recur every few years, and the next one will incorporate NEVI funding.

Moreover, the CEO conducted a study on MHD charging needs, available here. That study assessed investment scale and geographic distribution but did not investigate specific locations. Instead, it analyzed electric utility providers to determine funding requirements in specific electrical utility areas.

CDOT actively collaborates with local governments to promote NEVI and state programs. It has worked with other state agencies to fund local government EV readiness planning, which provides local governments with a blueprint for available state and federal funding to support EV growth.

The state also cooperates with the REV West plan, a partnership initiated with seven other states to ensure that AFCs complement each other regionally across state lines. Some of the items that set apart the states in the REV West plan from others are high altitude, cold weather, and distance between population centers. This collaboration allows states to share best practices and

present a unified voice when addressing federal issues affecting the region. REV West is voluntary, and some states are more forward-leaning in EVs and AFCs.

Right-of-Way Charging

The federal prohibition for charging within the interstate right-of-way is a big challenge for some states in the REV West. The restrictions do not align with the realities of long-distance travel in western states. A solution needs to be identified if the federal government wants to have a national network. There needs to be flexibility on restrictions to help support the federal programs. Some stretches of interstate have no businesses or residential areas, so there is no place to locate the EV charging infrastructure. In these areas, it would make sense to place EV infrastructure within rest areas along the interstate since a 50-mile distance between chargers is required in NEVI.

MPO and Local Government Involvement

For larger EV efforts with a plan development process, such as NEVI and the Colorado EV plan, CDOT works to engage with local governments and government coalitions such as MPOs. MPOs seem less involved, possibly due to their lack of funding for EV infrastructure and the MPOs' limited role in EV planning. MPOs tend to defer to the state or local levels regarding EV infrastructure. CDOT is still interested in reaching out to MPOs on EVs since it makes sense to have a regional approach for implementation.

Electrical Utility Providers

Colorado faces challenges related to its 53 electrical utility companies, each of varying sizes and capabilities. Some of the very large companies have a presence in other states, and some are small municipal utility companies. Different elements, including politics, technology, electrical capacity, and personnel support, affect EV infrastructure uptake.

Some utility companies are making strides in EV adoption. Holy Cross Energy Co-op is at the forefront of EV preparedness and adoption. It has developed policies and worked with transit fleets. Xcel Energy, a major energy provider in the state, is actively investing in programs to support EV infrastructure. In contrast, charging program grantees have sometimes relocated some fast-charging EV projects in some parts of the state due to issues with the local electric utility. Some electric utilities are dealing with day-to-day issues and do not have the capacity to support EV infrastructure, or they don't believe that transportation electrification is part of their core business and mission.

Funding and Financial Sustainability

Colorado has developed several complementary grant programs that draw on multiple funding sources, including NEVI and Charge Ahead Colorado, and cater to EV infrastructure development aspects. NEVI aligns well with large national companies funding DCFC deployments, while Charge Ahead Colorado is better suited to community-oriented applications and can encompass Level 2 or DC fast charging.

The sustainability of Charge Ahead Colorado is not a major concern due to stable funding sources. There are a couple of different sources of funding for Charge Ahead Colorado. One source is a portion of the state EV registration fee. The remainder of the registration fee goes to offset the gas tax. A community access enterprise is funded by delivery fees from UPS, Amazon, and similar companies. A few tenths of a cent of the delivery fee goes to funding Charge Ahead Colorado.

NEVI is seen as a program with limited funding and time but will be sufficient to build out the corridors in the state. Colorado has 16 designated AFCs.[1]

Policies and Regulations

Colorado has instituted several policies and regulations to support EV charging infrastructure, including low-emission and zero-emission vehicle regulations. In 2022, legislation was passed to prevent local governments and homeowner associations from creating barriers to installing EV chargers. A law has been in place for several years making it illegal for ICE vehicles to park in EV charging spots. Colorado also provides some of the most substantial tax incentives for leasing and purchasing EVs—up to $5,000 that can be stacked on top of existing federal incentives.

Electrical Utility Companies

There are regulations that restrict electrical utility companies from overbuilding the grid. There are good reasons for these regulations, but there should also be planning for expected EV infrastructure needs because it affects the utility's ability to quickly respond to requests for new service.

Federal Requirements and Restrictions

The federal restriction on charging in the highway right-of-way may affect some areas in Colorado in which a rest area may make the most sense as a location for EVs to charge. The general public continually asks CDOT why it is not placing EV chargers at rest areas since it makes sense to the public location-wise.

Buy America requirements for NEVI are making implementation more difficult since the materials that meet the requirements are not readily available. Buy America requirements are good and are in place for a reason, but it would be good to weigh the balance of supporting EV infrastructure and the Buy America requirements.

Upcoming Policies and Updates

Over the last few years, the legislative sessions have been busy with legislation dealing with energy, utilities, transportation, and other related areas.

[1] As of January 2024; at the time of the interview (September 2023), Colorado had 13 designated corridors, with another four that had been nominated.

Advanced Clean Cars II is on the agenda for November 2023.[2] The Greening Government EO is typically updated every 2 to 4 years and is where updates to the state fleet requirements will be seen.

Xcel Energy is requesting that the Public Utilities Commission allow it to have a certain level of "no regrets" investments. These investments are viewed as safe bets on the network, where there will be an increased demand, but the user has not been specifically identified.

At the state level, there have been discussions on getting utility companies in the same room as fleet owners. This will help facilitate earlier coordination between fleet owners and utility companies. Typically when fleet owners plan to transition to EVs, they do not include the electrical utility until later in the process. CDOT wants fleet operators and utility companies to plan together to prepare for EV infrastructure needs.

Programs and Planning for Freight, Fleet, and Multifamily Housing

Multifamily Housing

For MFH, challenges include a lack of incentives, awareness, age of buildings, equity, and affordability. The state has the Charge Ahead Colorado grant program, which has been around for over a decade and encourages the inclusion of EV chargers in MFH projects. The program started funding Level 2 charging. It is for any applicant other than private homeowners, including businesses and MFH. The funding is usually seen being used for new construction—often in luxury developments that incorporate it as an added amenity. Some local municipalities are requiring that new builds be EV charger ready.

For existing MFH, the building owner bears the cost of the EV infrastructure but does not directly use the benefits of the infrastructure investment. The residents stand to gain from installation of the EV infrastructure because it allows them a wider choice of vehicles, but they will not realize that benefit without the building owner's capital and support. Thus, even with financial incentives, the building owner does not have a business incentive to install EV infrastructure unless the owner's goal is to have the chargers as an amenity that allows the owner to charge tenants more for rent. This scenario can negatively affect current MFH residents and lead to a form of green gentrification and displacement that is in no one's interests.

Fleet

All state agency fleet purchases are shifting toward EV unless there is justification for doing otherwise. The state is starting an MHD needs assessment to see how many vehicles are in the DOT and all other state agencies and determine the viability of converting the state fleet to zero emissions, which may include electric or other alternatives, such as hydrogen. A governor's EO was created to consider an EV a first option as a state vehicle, as appropriate. A bill in 2021 provided $5 million in funding for state agencies to build EV charging infrastructure at state facilities to support the transition to fleet EVs. The funding was provided as a first deployment

[2] Since the interview, the regulation has been adopted by the Colorado Air Quality Control Commission.

for EV infrastructure. State agencies are expected to budget for EV infrastructure in the future in the same way they budget for other fleet operation needs.

The big challenge with freight is the availability of vehicles and the extended timeline for the charging infrastructure. The culture of freight operators is another challenge since transitioning to EVs is not the freight operator's first priority. For other types of fleets, such as school districts or small fleet operators, the availability of vehicles and infrastructure timelines have a significant impact on EV adoption.

A concern of fleets is who will be maintaining the EV fleet vehicles since they differ from traditional fleet vehicle maintenance. Since no established pipeline of EV maintenance workers exists, the DOT is beginning to give out small grants to community colleges, technical schools, and other programs to develop curricula, purchase equipment, and deliver classes on EV maintenance. Clean Transit Enterprise started two small grant programs, with one focused on zero-emission workforce development.

Another program is E-Mobility Education and Awareness, which has programs for K–12 to support STEM and local community EV education programs. The goal is to provide financial support to peripheral industries since EVs encompass more than vehicles and chargers. There is an ecosystem in the transportation world, and if it is not all supported, there will be friction in the transition to EVs.

Freight

Hydrogen is an emerging technology that shows great potential but can also be used as a reason for fleet operators to wait and not adopt EVs in the near-term based on the belief that eventually hydrogen vehicles will meet all of their needs. Colorado is developing a state grant program focused on corridor MHD charging. It has not begun but should be set up by early 2024. The grant program will support the findings in the study, which is slated for publication soon, by funding projects within areas identified in the study.

COLORADO ENERGY OFFICE

The research team met with Matt Mines and Christian Williss from the CEO. Matt is a senior program manager on the Transportation Fuels And Technology unit and leads the infrastructure team. Christian is the managing director of the Transportation Fuels And Technology unit. CEO administers numerous grant programs and research to support vehicle electrification across the state. It has a longstanding partnership with CDOT and most of its funding in the EV space is directed toward infrastructure, while the Colorado Department of Public Health and Environment provides grant funding for zero-emission fleet vehicles and technologies.

Planning and Research

CEO recently completed a Medium- and Heavy-Duty (MHD) Charging Infrastructure Study with Atlas Public Policy that focused on required investment for charging in Colorado by 2030 for MHD vehicles. The study found that the total investment required to meet the electrification needs of the MHD sector in Colorado through 2030 is between $790 million and $1 billion. The study also uncovered the percentage of personally owned MHD vehicles in Colorado and the

importance of home charging to some of the smaller owner-operators. This interest may require investments in upgrading residential capacity as well as installing Level 2 chargers in homes. In addition to home charging, the study also identified depot, enroute, and long-haul MHD charging needs and created a visualization of the study results in a geographic information system map found here: https://experience.arcgis.com/experience/9f2da35d8f0a4d0aaec8db151f668696. There are current and new programs from CEO that will work to address these infrastructure gaps, which include Charge Ahead Colorado as well as the new Fleet-ZERO program CEO has just kicked off (https://energyoffice.colorado.gov/fleet-zero) and a future home charging program.

CEO's planning and research focus on statewide needs, especially in terms of charging infrastructure. Due to this focus, its coordination with MPOs is limited. Though CEO and CDOT partner on EV infrastructure, CDOT is more involved with local agencies, such as MPOs and cities.

Funding Programs

There are a variety of funding programs available at the state level in Colorado to support EV charging infrastructure, including Charge Ahead Colorado, Fleet-ZERO, and DCFC Plazas. This funding is supported in a few ways. Portions of the EV registration fee are directed toward EV charging infrastructure, as is much of the funding available through the Community Access Enterprise. The Community Access Enterprise receives a portion of a retail delivery fee that is levied on deliveries in the state; the full fee is $0.28, of which the enterprise receives approximately 7 cents per delivery. This fee is expected to generate approximately $310 million in revenue for the Community Access Enterprise over the next 10 years. Funding from EV registrations—of which $20 for each registration is deposited into a dedicated EV fund, with the remainder deposited into the highway users trust fund—is used to fund additional charging stations across the state. It is expected that about $100 million will be collected by 2030 to fund EV infrastructure. The state also leverages federal funding to support EV charging, including from the NEVI Program and the CMAQ Improvement Program.

Despite this available funding, it does not fully address the gap determined in the MHD Charging Infrastructure Study. Colorado expects investor-owned utilities and private investments to bridge the remaining gap in funding. All of their current funding programs require a minimum match, which is usually between 10 to 50 percent, depending on the program and recipient.

Colorado's first round of NEVI funding closed in May 2023, and CEO believes that will make significant progress in filling in existing gaps in the state charging network. In addition to CEO's other infrastructure programs, CEO made an award in 2018 to one entity to develop fast-charging stations at 34 locations across Colorado's major transportation corridors. Information on this award and build-out of those corridor locations can be found here: https://energyoffice.colorado.gov/transportation/grants-incentives/ev-fast-charging-corridors.

Grants are available through Charge Ahead Colorado to support charging installations throughout communities, workplaces, and MFH units as long as the charging spaces are not deeded or assigned and the charging will be available to all employees or residents. Utilities also offer financial support for charging—Xcel Energy is the major utility in the state, and it has been

an active partner in preparing for expanded vehicle electrification. There is also a strong mandate for the state to replace older vehicles with EVs, and this transition is occurring across the state.

Policies and Regulations

Supporting policies for vehicle electrification include the Advanced Clean Cars rule adopted in 2019 and the Advanced Clean Trucks rule adopted in April 2023. An update to the Advanced Clean Cars rule (Advanced Clean Car II) was also recently adopted in October 2023. Other legislation passed in 2023 requires that beginning in spring 2024, MFH must include EV-ready standards and installed EV charging in new developments and major renovations. Chargers are also exempt from increasing property taxes through January 1, 2030. Finally, parking spots that include charging or charging equipment count toward mandatory minimum parking spaces, and accessibly designed parking spaces served by EV charging stations count as two standard spaces.

Limiting factors have largely been focused on funding; there is always a need for increased funding to support the transition to EVs. There are also challenges with navigating home rule cities and the diverse utility landscape in the state. In total, Colorado has 52 electric utilities, including two investor-owned utilities. Some utilities have moved away from the high-demand charges by reducing the cost or eliminating them entirely, which helps to create a more positive business case, particularly in areas with low utilization.

In terms of policies needed or under review, Colorado is working to improve permitting EV charging stations to accelerate that installation of charging infrastructure. Experiences with permitting differ greatly across the state, and Colorado is trying to create a more standardized process across the board.

OHIO DOT

Santos Ramos is a project manager for DriveOhio, a division of the Ohio Department of Transportation (ODOT). His current focus is in managing the implementation of the NEVI Formula Program across the state.

EV Infrastructure Planning and NEVI Program

Ohio's main focus at this time is the implementation of the NEVI formula funds. ODOT is planning every year throughout the duration of the NEVI Formula Program to ensure it uses the funds to address existing charging needs. However, it is aware of some of the infrastructure gaps needed for freight that are not currently being met. Ohio completed a study on the state of readiness for freight electrification in 2021. The information is still relevant, but some areas might need updating. In terms of its current effort, ODOT is developing relationships with utilities and trying to facilitate conversations around more broad-scale vehicle electrification.

Although ODOT is not pursuing CFI grants, it is acting as a partner by providing letters of support on many grant applications. DriveOhio provides information on these grants and useful funding resources available through its website (https://drive.ohio.gov/programs/electric/funding/funding). It acts in a supporting role for local governments by providing data and information to support a successful application, as requested. In terms of data and analysis,

ODOT tracks and provides vehicle registration data, resources on siting considerations, grant training, and a process guide.

Funding

Currently, Ohio does not have plans to sustain funding for EV infrastructure post-NEVI. The NEVI Formula Program in Ohio was procured as a turnkey service; therefore, the projects funded through the NEVI Formula Program will be transferred to the private developer after the 5 years of operation and maintenance oversight, as outlined in the agreement. ODOT is utilizing public-private partnerships for the NEVI funding; ODOT's role in the partnership is to provide oversight, monitor compliance, and manage reimbursement. Based on federal requirements and as outlined in the agreement, ODOT will collect data and ensure the NEVI requirements are being met.

In terms of revenue generation from EVs, a registration fee exists for EVs and PHEVs, but ODOT is not aware of discussions about changing or increasing the fee. Ohio is in the middle of an alternative funding study to address the needs of the system. This study is assessing public opinion on the different options to address the funding gap in transportation, which is due to both inflationary factors and increased fuel efficiency, not just AFVs.

Policies and Regulations

Flexibility in federal legislation and policies would help the state in developing their charging network. The NEVI Formula Program was implemented quickly, and lack of technical and contracting details has caused problems for states during implementation. Design standards, specifications, and further guidance would help smooth the design and construction process and would help in terms of both light-duty and freight vehicles.

In terms of limitations from a policy and regulation perspective, the unknowns of the landscape and the fact this is not an area typically in the DOT's purview has made the process challenging. The lack of policy and regulatory landscape as it pertains to the DOT is seen as a limitation. While some of this occurs through large-scale peer exchanges, such as the EV Clearinghouse, it is not always possible to delve into the details that impact a specific state. Coordination between neighboring states has been a helpful and effective resource for sharing knowledge and lessons learned. The recent rule that the EV charging infrastructure must be within 25 miles of a state border has prompted greater engagement between neighboring states in making sure a national network is being built.

Freight, Fleet, and Multifamily Housing

The key challenges for Ohio in terms of deployment of EV charging infrastructure for freight, fleet, and MFH is the need for more policy and guidance at a local, regional, and state level.

DriveOhio is busy with the implementation of the NEVI program and making sure it meets the program requirements. As far as freight goes, it is monitoring development of hydrogen as a fuel for freight.

At this time, there are no state initiatives to support EV infrastructure development or deployment other than the NEVI Formula Program.

OKLAHOMA DOT

The research team met with Andreas Weber and Jared Schwennesen with the Oklahoma DOT. Jared Schwennesen is the multimodal division head, and Andreas Weber is the advanced mobility coordinator at the Oklahoma DOT. The Multimodal Division handles areas of the DOT that are not roads and bridges, such as transit, rail, waterway, and advanced mobility, including the NEVI program.

EV Infrastructure Planning

The Oklahoma DOT is considering MFH, fleet electrification, or other solutions as potential areas for the fifth year of funding post-NEVI, but no major plans have been established yet.

There are currently 18,000[3] EVs in Oklahoma out of approximately 4 million vehicles. It was noted that Oklahoma has more EV infrastructure planned than there are EVs currently, but the number of registered EVs has significantly increased in the last year and a half, from 4,000 to 18,000.

For unmet charging needs beyond the NEVI program, the Oklahoma DOT mentioned its reliance on the Clean Cities groups in Oklahoma. They collaborate with Clean Cities groups in Oklahoma City and Tulsa for activities outside of NEVI. This coordination includes shared planning efforts, and the Oklahoma DOT actively participates in the quarterly Oklahoma EV coalition meetings attended by the Clean Cities group.

Funding and Financial Sustainability

Regarding sustaining funding from state sources post-NEVI, the Oklahoma DOT indicated that there are currently no specific sources allocated for post-NEVI funding. It mentioned tax credits for infrastructure but noted that it has not been informed that state funds can be used to support EV charging infrastructure beyond the NEVI program. The legislature determines the funding available to the Oklahoma DOT, which is allocated based on the specific fund designated by the legislature.

Oklahoma has implemented an annual registration fee for EVs and a three-cent per kilowatt-hour fee at EV charging stations beginning in 2024. The state's extensive turnpike network may influence the EV/PHEV registration fee structure by vehicle class. It was noted that Oklahoma does not have a centralized DMV, with Service Oklahoma handling driver's license registration and the Tax Commission managing vehicle registration. The Oklahoma DOT collaborates closely with the Tax Commission to track the number of registered EVs in the state.

Oklahoma is conducting a 6-month pilot program to assess road user charges per mile. The pilot program has approximately 500 participants who can choose different reporting methods for

[3] As of December 2023.

miles traveled. The reporting methods include vehicle dongle, app reporting, and writing down or submitting pictures of the vehicle's odometer. Results from the pilot program are expected by the end of 2023. These funds will primarily contribute to road use and address the reduction in fuel tax revenue.

Policies and Regulations

It was highlighted that Oklahoma led the nation in the number of DC chargers per capita when it received its portion of the VW settlement. The state currently ranks seventh in per capita DC chargers.

Oklahoma has passed a tax credit for EVs and adjusted it to accommodate a 2,000-lb weight increase for EVs. The Oklahoma DOT primarily focuses on transportation infrastructure and leaves housing requirements to local municipalities.

Freight, Fleet, and Multifamily Housing

The key challenges in expanding electrification for freight in Oklahoma include potential limitations in electrical infrastructure to provide sufficient charging for freight vehicles.

The Oklahoma DOT emphasized the importance of addressing range anxiety and identifying appropriate fleets for electrification. It mentioned efforts to transition the Oklahoma DOT Multimodal Division to EVs as a test since the Multimodal Division does not drive as many miles as the Oklahoma DOT field units.

Clean Cities has financial support for fleet electrification. It also has funding to help install EV chargers to help support employee vehicle charging. Bulk orders of EVs are challenging to secure due to the limited availability of electric vehicles.

The Oklahoma DOT is discussing the possibility of supporting EV charging infrastructure after completing the NEVI build-out of utility corridors. However, deciding which MFH units are appropriate for EV infrastructure will depend on applications from cities. There is also a question of whether there will be sufficient EVs in MFH complexes to use the EV charging infrastructure.

PENNSYLVANIA DOT

The research team met with Colton Brown, an alternative fuels infrastructure coordinator for the Pennsylvania Department of Transportation (PennDOT). Colton previously worked on the Driving PA Forward EV charging program managed through the Pennsylvania Department of Environmental Protection (DEP).

EV Infrastructure Planning

Currently, no state funds have been allocated post-NEVI. However, Pennsylvania's current administration is interested in expanding resources for EV charging. The Pennsylvania DEP would like to continue supporting Level 2 charging until NEVI can help fund Level 2 charging projects, but the Level 2 rebate program exhausted all funds in fall of 2023 and no other funding source has been identified. Areas with higher concentrations of EV registrations are more likely

to attract private investment in charging stations. High EV registrations are currently seen in the suburbs surrounding major cities. There is also a need to ensure that existing stations are reliable.

PennDOT will seek community feedback to determine the best uses of NEVI funds after the alternative fuel corridor build-out is completed. PennDOT will continue to engage with communities and stakeholders to gather feedback and identify priorities, which may include addressing state roadways connecting rural communities, MFH, and freight charging. The freight and fleet charging infrastructure will focus on making charging infrastructure usable by multiple fleet operators so NEVI funds can be applied. PennDOT will consider the feasibility of extending this feature to accommodate truck depots serving multiple companies in the future. PennDOT is looking into EV workforce development to see where Pennsylvania can support training.

Funding and Financial Sustainability

There are no plans for continued financial support at NEVI stations beyond the initial 5 years. PennDOT mentioned that private companies have proposed stations in rural areas even without guaranteed operations and maintenance support and beyond networking and warranty costs.

While Pennsylvania would like to continue expanding its charging network until public financing is no longer needed, the specific plans post-NEVI are still under consideration. Potential uses for state funding, if funds become available, could include Level 2 charger support and investments in EV workforce development.

The Pennsylvania DEP also clarifies that Driving PA Forward, funded through the VW settlement, provided a one-time cash infusion. It was initially focused on DC fast charging and Level 2 charging, but after NEVI was announced, all remaining funds were used for L2 charging, and the program has now ended.

Regarding the state's tax on electricity as a transportation fuel, PennDOT stated that discussions are ongoing to explore more robust and sustainable revenue collection methods. Since the Alternative Fuels Tax was not initially founded with EVs in mind, it is not streamlined for them. The challenge lies in ensuring equity in the program, and various fee structures are being considered.

Flat fee registration has been considered, but that method does not consider the weight of the vehicle or miles traveled. The Senate passed a bill with a $290 flat fee earlier this year. The House is working on its own version. A mileage-based user fee would be difficult to use since there is no data source for miles traveled aside from self-reported data from annual inspections. PennDOT does not currently assess any financial fees based on self-reported data due to the potential for intentional and unintentional errors.

Policies and Regulations

PennDOT noted that Pennsylvania's utility support for EVs has been less than in some other states due to existing legislation and judicial interpretations. The state PUC released a draft policy statement on EV rate design in late 2023 that will likely encourage utility companies to

expand their EV rates and programs while also providing clear guidance that the PUC welcomes these policies.

Some utility policies and programs seen in other states are not feasible in Pennsylvania. For example, mandatory whole-home time-of-use rates are not allowed in Pennsylvania. Utilities are also restricted from using rate-payer funds on programs that would benefit specific customers or groups of customers.

Most investor-owned utilities in Pennsylvania are now working on expanded, or new, EV rates and programs. This process includes exploring options and policies for sub-metering so that EV charging can have its own rate without the need to purchase and install a separate utility grade meter.

Freight, Fleet, and Multifamily Housing

Freight

It may be helpful to separate freight into size categories to support electrification. Two types of freight are heavy- and medium-duty. Heavy-duty can be subcategorized into day cabs, while long-haul and medium-duty can be categorized into box trucks and light-medium-duty. Due to their size, light- and medium-duty freight vehicles can access NEVI chargers.

PennDOT acknowledged that there are significant challenges related to freight electrification, especially regarding the coordination between charging infrastructure and freight EVs. It suggested conducting pilot studies of infrastructure and vehicles to understand the dynamics better.

Fleet

Fleet electrification could be supported through education and case studies highlighting the cost-effectiveness of EVs. If the case studies show that EVs are more cost-effective, it may lead to an increase in EV fleets. The Pennsylvania DEP will soon announce awards through its MHD ZEV Pilot program. Funding recipients will be required to place at least three MHD ZEVs into service and the Pennsylvania DEP will have a consultant track the performance of those vehicles for 2 years. Each project will result in a published case study.

Multifamily Housing

Pennsylvania's Level 2 rebate program has supported charging infrastructure for MFH. However, there is a need to increase support for multifamily charging, especially when more affordable EVs become available and as current EVs enter the used market. Workplace, destination, and community charging can also help fill the need for multifamily charging.

TENNESSEE DOT

The research team met with Matt Meservy, director of long-range planning, Tennessee Department of Transportation (TDOT).

EV Infrastructure Planning

TDOT is considering unmet EV charging needs beyond the NEVI initiative. Once TDOT has completed the AFC build-out, it anticipates having remaining NEVI funds to expand the charging station network to additional corridors and/or invest in EV-related workforce development.

Freight

There may be ways to incorporate more freight into the EV plan; however, it is worth noting that the freight industry is not yet fully prepared to adopt EVs, possibly due to the larger vehicles and the need for a robust charging network. There is also research being done on other fuel types. The industry seems willing to embrace electrification, but the necessary technology is not yet fully developed.

Fleet

TDOT is working to incorporate fleet vehicles into its own fleet. There is some hesitancy due to the lack of charging infrastructure to support an electrified fleet. TDOT will continue to strive to demonstrate that it can operate well, given the resources available.

Multifamily Housing

TDOT agrees that EV infrastructure at multifamily sites is important, and it has received a lot of interest from cities and counties regarding EV infrastructure for residential areas. However, federal funds and the restrictions of NEVI's first round have limited TDOT's ability to provide such support. If the federal government offers funds for MFH, TDOT and its partners will develop opportunities to use the funds for MFH.

Funding and Financial Sustainability

TDOT has not contributed any state dollars to fund the NEVI program and does not plan to contribute funding from state sources post-NEVI. TDOT has always assumed EV charging infrastructure will be operated by private industry—similar to today's fuel stations.

Recent state legislation has changed the registration fees for electric and hybrid vehicles to create parity with combustion engine vehicles. The increased transition to EVs will result in less funding from state and federal gas tax, and EVs' additional weight decreases the lifespan of pavement conditions.

The University of Tennessee did a study that helped TDOT determine the increase needed to offset the loss of federal funding and gas tax funding. The legislation raised the EV registration fee to $200 (with a gradual increase to reach $274 for parity in the next 4 years), then increased to Chain-CPI annually (approximately 3%). It also proposed a $100 registration fee for hybrids, indexed alongside the EV fee. These fees will also be shared with local governments, just like the gas tax.

Policies and Regulations

TDOT has been implementing a carbon reduction strategy as part of its efforts to support EV charging infrastructure deployment. However, there are relatively few policies specifically tailored to support EV deployment in the state.

There are no immediate plans to review or update existing policies and regulations related to EV charging infrastructure. There have been discussions on the ineligibility of rest areas for revenue-producing infrastructure like EV charging stations.

Buy America Build America regulations have complicated deployment. Additionally, despite their necessity, the National Environmental Policy Act has delayed the implementation of EV charging stations.

Other

TDOT is a co-author on CFI grants for freight and commercial-type components. The role of TDOT is to provide information and coordination with local governments.

TDOT emphasized the need for additional staff and resources to support its interests in expanding alternative fuels, including EVs.

CAPITAL REGION TRANSPORTATION COUNCIL

CRTC is the MPO for Albany and the surrounding area in New York State. Jacob Beeman is a senior transportation planner for CRTC as well as the director for the Clean Cities Coalition for the area. The interview discussed current planning focuses, coordination efforts, available funding, and remaining challenges.

Planning

The region completed a zero-emission vehicle plan in 2016 and updated it in 2020; it was focused on Level 2 charging and meeting the growing needs of the region. However, due to the fast-paced nature of vehicle electrification, that plan does not accurately reflect the current landscape, including the impact of the NEVI program. The senior transportation planner for CRTC conducts meetings with their municipalities to help them address questions and concerns. In line with that, CRTC has a local technical assistance program wherein municipalities can request assistance with EV charging deployment. CRTC's member governments have requested information and assistance with fleet transitions as well as MHD vehicles. Fleets are attempting in varying degrees to transition across the state, but many of the capital region municipalities and townships are interested in making progress, especially since they are subject to aggressive emissions reduction requirements set in the state's Climate Leadership and Community Protection Act.

In terms of unmet needs, freight and fleet are clearly a concern, but in terms of freight, it is mostly a private-sector issue. There have been some success stories in New York, including a steel rebar company that is utilizing electric yard trucks. School and transit districts are also transitioning to differing extents; again, some local governments are being more aggressive in

their approach to electrification. One of the major concerns is the scalability of electrification and the charging infrastructure. For example, although megawatt charging standards are being developed, there is no guarantee that the plug and vehicle is capable of handling that power. Issues such as these can reduce the incentive for freight and fleets to switch. In addition, there are hydrogen stations being developed in New York State.

CRTC does coordinate with the DOT, but its existing, and stronger, relationship is with NYSERDA. NYSERDA manages the existing funding opportunities for the state and provides data to MPOs and their local governments. Previously, federal funding to the state DOT (from FHWA) was not the main source of funding for EV infrastructure, so discussion between the two agencies on that topic was limited. CRTC does feel that most of its data needs are met through current channels, and they do not require additional data from the DOT. However, the granularity of data could be improved.

Funding

There is current state funding available that will likely remain post-NEVI. For example, NYSERDA has the Truck Voucher Incentive Program; the New York State PSC established a make-ready incentive program for utilities; and municipal ZEV grants are available through the Department of Environmental Conservation. In addition, NYSERDA has the Cleaner Greener Communities program. Although the MPO is not heavily involved, the program requires participants (municipalities/local governments) to make progress toward sustainability goals to access funding, which allows for progress measurement and directly ties incentives to those making progress on a variety of "green items"; for example, installing solar power can help unlock funding to advance EV infrastructure if that is an area where the participant needs assistance.

CRTC did not directly apply for CFI grants at the federal level this cycle. Managing a program or project across its region while other local governments are also seeking funding was deemed too complex. NYSERDA did coordinate a statewide application, and the MPO provided support to their member agencies for that effort. This support entailed letters of support as well as providing any data and information the MPO has readily accessible.

Policies and Regulations

New York State passed the Climate and Community Protection Act, which includes aggressive emissions reduction targets as well as overarching guidance of transitioning the state to a greener future. This act is viewed as the most important piece of environmental policy because it sets targets and/or expectations, including some that specifically relate to transportation. Specific transportation-related targets include the number of school buses operating on alternative fuels as well as charging equipment requirements for parking lots and EV-ready guidance for new buildings. There are no penalties within the legislation, but communities are beginning to act.

In terms of policies and regulations that are needed to support vehicle electrification, Beeman mentioned zoning and development policies that ensure EV readiness and streamlining the permitting process. He also said that providing definitions of the levels in those zoning documents was needed as well. Current guidance/regulation requires 2 percent of parking spaces

be allocated for charging in new developments. This figure is viewed as a good starting point that will eventually be built upon to increase access. As people see more charging availability, the anxiety over range and charging accessibility will diminish and ultimately facilitate the switch.

Similar to the policies and regulations needed to support charging deployment, policies and regulations that act as a limiting factor tend to be in the permitting process. Cumbersome or unnecessary procedures hamper development. New York State also has limitations on direct-to-consumer car sales, which has hurt companies like Tesla that are pushing EVs onto the market. The inability to easily purchase popular or new EVs in a state will limit development.

There are several policies under review or being updated, including the state's carbon reduction strategy (update is due in October/November). This strategy will outline how federal carbon reduction funds will be spent, which can include support for vehicle electrification. In terms of the NEVI funding, New York State has not started spending those funds at this time.[4] The request for proposals has not been released by the DOT, but the hope is that will happen early next year. The DOT for New York State is very hands on and has essentially completed the NEVI planning for the entire state, including the areas served by an MPO. As the program completes their alternative fuel corridor build-out and shifts to other priorities, there may be more room for engagement with the DOT.

Freight, Fleet, and Multifamily Housing

Key challenges in the areas of freight, fleet, and MFH include effective stakeholder engagement, managing developers, and managing residential restrictions, including the difficulties with retrofitting, enabling on-street charging, and unforeseen costs. In terms of MFH, developers are starting to include chargers at their properties, but one area that presents more challenges are condominiums. There is a concern over who owns the chargers and who is therefore responsible for maintenance. CRTC tries to provide education and resources to support the deployment of chargers at residential sites. However, retrofitting can be costly in terms of older structures. One method has been to install chargers centrally at an apartment complex or MFD, but this often does not provide the best accessibility. In addition, if only, for example, two chargers are installed, residents will then have to move their vehicle once it is fully charged. This again limits the desirability of an EV when not in a single-family residence.

Another issue that the MPO has faced is the impact of network charges. Often a local government is not aware that the network fee is annual and continues throughout the life of the asset. This feature can become a problem if grant funding was used to install the charger and no funding is available to support that network fee in perpetuity. This issue has led to the MPO turning off the chargers because it cannot support the fee. The state requires that the chargers be networked if state incentives were used to install the charging equipment.

Although there are no additional initiatives that were not discussed elsewhere in the interview, CRTC does keep an eye on all applicable state, federal, and regional incentives. Beeman also

[4] The interview was conducted in September 2023; New York has begun spending their NEVI funds as of December 2023.

believes that education and connecting the right folks with each other is key to the success of EV charging infrastructure deployment and overall vehicle electrification.

CHICAGO METROPOLITAN AREA PLANNING COMMISSION

The research team met with Phoebe Downey and Brian Daily at CMAP. Phoebe is a principal in the Research and Analysis of Programming division, and Brian Daily is a senior planner on the research policy implementation team and works on a variety of climate-related issues.

CMAP is an MPO and has a research accelerator grant from USDOT that looks at accelerating and implementing more infrastructural projects and using alternative financing.

EV Infrastructure Planning

The MPO does not engage in specialized planning for the locations of EV infrastructure at a regional level. Instead, it focuses on data analysis, research, and consultations with stakeholders, such as local and state agencies and EV infrastructure providers.

One of the key challenges faced by the MPO is the need for in-depth knowledge of sites and transportation patterns for effective EV infrastructure implementation. Because zoning regulations differ across municipalities, providing comprehensive guidance can be complex. The MPO is currently conducting a plan and collaborates with partners to support local planning programs.

The MPO acknowledges the importance of understanding the grid and identifying suitable locations for EV charging to plan the EV network's growth effectively.

The MPO's coordination with the state regarding the NEVI program is affected by interagency challenges. The handling of EVs in Illinois has been under the jurisdiction of the EPA rather than the DOT, leading to some difficulties in interagency coordination.

Some of the NEVI and DOT programs are looking at other areas besides the Chicago region, which the MPO covers. Chicago is ahead of a lot of the other MPO partners.

Funding

Various sources of funding are available for EV infrastructure projects, including federal programs, VW settlement funds, and incentives and rebates through electrical companies. The MPO is not currently pursuing CFI grants, but some partner organizations are, and the MPO provides them with information to support their applications.

The MPO is working with a consultant to conduct market outreach and establish a pilot program. They plan to collaborate with the Illinois Finance Authority, which manages IRA funding. The hope is to fund a broader program based on the pilot once the Green Bank receives the IRA funding.

It would be good to show the public benefit of supporting private EV transition. There may be potential for public funds to support private fleet electrification, such as through a revolving fund that companies can use and repay like a loan.

Electrical Utilities

The Climate Equity and Jobs Act passed in Illinois included a requirement for all electrical utility companies in the state to develop an electrification plan. The Chicago Commonwealth Edison Company (ComEd) is the only electrical utility provider in the MPO region. ComEd is working on an EV capacity map.

Currently, there is no way of knowing if there is available capacity in a specific area to support EV charging. The map will hopefully be a resource for freight and fleet users to site larger demand EV charging stations.

The MPO faces difficulties in coordinating with electrical utility companies. While ComEd is developing an EV capacity map, there has not been substantial partnership outreach between the utility company and municipalities. The lack of clear points of contact at the utility company hinders effective coordination.

Policies and Regulations

Illinois has recently passed an EV charging act that requires new residential developments to incorporate EV charger-ready infrastructure. A beneficial rate plan for utilities to facilitate lower EV charging rates has been introduced. Some funding and support requirements for freight electrification have also been put in place.

The Buy American requirements have posed challenges to programs supporting EV implementation. Exemptions to Buy America can potentially accelerate projects since many have been delayed due to the difficulty of meeting those requirements.

There is a large freight community in the state. Comparing Illinois to California, another large freight state, illustrates how some factors can affect EV freight transition. In California, regulatory requirements and cooperation with electrical companies have supported fleet electrification. In Illinois, these factors seem to be less encouraging, resulting in slower fleet electrification.

Freight, Fleet, and Multifamily Housing Initiatives

Freight

When discussing unmet needs, MPOs primarily emphasize the importance of aiding the freight industry in acquiring public funding to offset the upfront costs of EV investments. They are eager to ensure equitable benefits for the region, which leads to faster progress.

Fleet

Regarding fleet electrification, the state fleet has a budget of $30 million to electrify a portion, approximately 10 percent, of its 15,000-vehicle fleet. New EV chargers were installed during the redevelopment of a state building to help support the fleet's transition. An EV fleet can serve a lot of operations at the state level since most fleet vehicles are used within a 50-mile range.

Challenges include EV supply issues for fleets. The City of Chicago made the first request for fleet EVs in Illinois. Chicago has been taking a more ad hoc approach to fleet electrification. It has overcome the fleet EV supply issues by acquiring EVs when they become available instead of waiting on bulk orders from EV manufacturers.

Since the city's fleet varies in type of EVs, it adds to the complexity of working with various electric vehicle types. It would benefit the maintenance staff if the fleet were more alike instead of varied.

Multifamily Housing

Chicago is developing a plan that will determine how to spend CFI grants if awarded. The plan is expected to include on-street charging and initiatives aimed at addressing areas with challenging charging access.

DELAWARE VALLEY REGIONAL PLANNING COMMISSION

The research team met with Sean Greene at DVRPC. DVRPC is the MPO for the greater Philadelphia area, encompassing four counties in southwest New Jersey and five in Pennsylvania, including Philadelphia and the surrounding counties. Mr. Greene manages the Freight and Clean Transportation Office at DVRPC.

EV Infrastructure Planning

The MPO actively collaborates with counties in Pennsylvania to prepare them for the NEVI program. This process involves identifying priority interchanges and accessing NEVI funds to deploy fast chargers strategically. Because it recognizes the dual purpose of interstates as commuter highways and interstate highways for long-distance travel, the MPO is eager to ensure chargers are placed at intersections to serve both long-distance travelers and commuters around Philadelphia.

To enhance community accessibility, the MPO is working with counties to pinpoint government-owned properties close to multifamily units and commercial districts. It aims to position public chargers in areas that encourage people to visit parks or nearby locations while charging. The MPO, acting as a regional data hub, emphasizes the importance of coordinating with utility companies and municipalities to gather and disseminate crucial data.

Partnerships with PennDOT and New Jersey's DEP have revealed different approaches to information sharing. While New Jersey readily shares electric vehicle registration data, Pennsylvania requires coordination with PennDOT to decode vehicle registration information. The MPO acts as an information arbiter, disseminating data to utility companies and

municipalities and serving as a data hub for the region. The data are available on the MPO's website.

Funding

In regard to CFI grants, the MPO has actively applied for them on behalf of municipalities in the Pennsylvania region. New Jersey DOT and Philadelphia have also submitted their CFI grant applications. The MPO's application spans 22 municipalities and 35 charging locations, with a mix of Level 2 and fast chargers. The prioritization of locations provides a coordinated approach that might be challenging at the county or local level.

New Jersey has funds available to support EV infrastructure projects. Conversely, there is one large electrical utility provider in the Pennsylvania region. That utility provider is trying to move a rate case through the state to allow them to support chargers financially. Pennsylvania has some funds to support EV chargers, but the MPO wants to use funds other than state funds to support EV infrastructure.

Policies and Regulations

New Jersey has a make-ready law requiring a percentage of parking spots in new developments to be designated for EV charging. Counties and municipalities are working on model ordinances to mandate planning for EV charging and establish standards for charging stations. The MPO sees its role as a bridge between the state and local entities and acting as a facilitator in the adoption of these policies.

There has been some interest in "adjacent charging," in which electricity is pulled from a light pole of some existing source to provide street-side charging. Because the EV charging space takes away from traditional community parking spots, in dense communities, parking spots in front of homes mean a lot to the adjacent homeowners. There was some pushback on this situation, which provided a lesson learned—EV charging cannot be separated from parking.

The MPO recognizes the need for extensive public outreach, especially when considering solutions like adjacent charging. There is a belief that fast charger hubs in the community do not take away existing street-side parking.

DVRPC supports equitable investment in EV charging, which can include prioritizing disadvantaged communities. However, the MPO wants to be cautious of unintended consequences from such an investment—for example, the potential for gentrification in a neighborhood that installs EV charging equipment.

The MPO sees the need for policy updates, particularly in the realm of first responder and accident and incident training related to EVs. The MPO sees that push as driven by the first responder community.

Freight, Fleet, and Multifamily Housing

In its address of the unique challenges in freight, the MPO highlights a shortage of truck parking spaces in the region and the lack of heavy-duty EVs indicate that responsible parties should plan

for EV infrastructure when designing industrial buildings. It is important to contact the electrical utility early and often when planning for EV infrastructure, especially at scale.

The MPO emphasizes the importance of strategic charger placement for fleet electrification to encourage sharing among local government fleets, particularly in municipal parking lots. Fleets can charge overnight when no one else uses the municipal lots. Most municipal fleet vehicles seem a natural place to deploy EVs.

MFH presents the challenge of providing EV charging options for residents without home or work charging access. If public-access EV chargers are placed near a multifamily unit, they can serve as an outlet for individuals who cannot charge at home or work. Thus, there are existing regulations mandating EV chargers or make-ready spots in new MFH units.

MARICOPA ASSOCIATION OF GOVERNMENTS

The research team met with Cara Nassar, transportation planner with the MAG, the MPO serving 32 member agencies in the greater Phoenix region, and Audra Koester Thomas, transportation planning program manager.

MAG Regional Electrification Readiness Strategic Plan

In August 2023, MAG concluded an extensive planning initiative that marked the first holistic examination of the region's preparedness for electrification. The plan was directed by elected officials recognizing the increase in EV adoption and the growing need for EV infrastructure. The plan centered on three critical goals: assessing the current and future states of electrification, formulating strategies for EV infrastructure deployment and identifying associated roles and responsibilities, and exploring strategic funding opportunities.

MAG recognized that implementing many strategies of the plan would require coordination with regional partners because the collective outcomes depend on them for implementation. While various efforts are ongoing in the region, intentional coordination is needed, and MAG has an opportunity to facilitate coordination as a regional convener.

The region has limited funding opportunities, and state funding to implement items in the study has not been identified. MAG has worked with ADOT to understand its strategies for EV infrastructure deployment across the state, which focuses on the interstate system and primarily rural areas. ADOT is responsible for the development of the federally mandated state electrification plan and continues to apply for different state routes to be recognized as AFCs to be eligible for funding.

MAG's plan addresses various priorities, including EV readiness, air quality, economy, and equity, and is in alignment with federal government objectives related to EV infrastructure deployment. The MAG Regional Electrification Readiness Strategic Plan was unanimously accepted by the MAG Regional Council in September 2023 and can be accessed on the MAG project website.

Funding and Financial Sustainability

MAG's study includes a high-level siting plan that identifies the need and gaps in the number of chargers and ports by census tract. One key outcome of the study was the identification of the region's allocation of Carbon Reduction Program funding—made available through the BIL—for advancing strategies in the plan in the near future, including the installation of chargers. MAG is currently working with member agencies to develop policies to program those funds.

Policies and Regulations

A section in the plan looks at partner agencies and outlines current efforts related to electrification and charging station locations. Several partner agencies are actively developing ordinances and regulatory language supportive of EV infrastructure, particularly for new construction. There is a recognized opportunity for MAG to serve as a clearinghouse of information to help advance electrification readiness, such as providing model language for local ordinances to support EV adoption.

The level of electrification readiness varies among partner agencies due to resource constraints, differences in development and growth patterns, and the varying priorities of elected officials.

Utilities

The plan development included interviews with utilities because of the vital role utilities play in electrification efforts. The region has two major electrical utility companies—APS and Salt River Project. MAG provided the utilities opportunities to be involved in the strategies process. Certain strategies will rely heavily on the utilities in order to be carried out, such as updating policies related to charging rate structures to manage demand.

The utilities reported that the increased adoption rates of EVs will place increased demand on the current electric system, and they are approaching it as a time-demand issue. Utilities are actively considering the balance between increasing capacity and managing demand while aligning electricity generation with consumption patterns. The availability and demand of electricity do not necessarily align. An opportunity that has been identified in the MAG region is the abundance of daytime solar power that can be leveraged to help satisfy the increased charging needs.

Utilities also noted that addressing the lead time for adding electrical capacity to the grid is crucial for EV infrastructure projects since that can be a substantial hurdle. This element was a big lesson learned for people approaching electric utility companies requesting to add capacity to the system to support an EV charging project. The region's growth has been tremendous over the last decade, and the region as a whole is adopting EVs at a faster rate than the national average.

Freight, Fleet, and Multifamily Housing Electrification

MFH typically faces additional challenges when it comes to having access to EV chargers, so a focus on workplace charging can address these charging needs while also encouraging daytime charging when solar power generation creates excess electrical capacity.

One strategy in the plan is to transition fleets toward zero-emission technologies to improve air quality. Member agencies and stakeholders can develop and implement zero-emission fleet transition plans, and MAG, as the air quality planning agency, can model the impacts of fleet transitions on air quality. Although MAG is aware that other vehicle classes—not just light-duty fleets—can benefit from EV transition, the strategic plan does not address freight.

General Insights

In the near term, MAG is developing a strategy to program its share of federal funds from the Carbon Reduction Program. ADOT is responsible for programming the federal NEVI funding to ensure a continuous EV network on the interstate system, with no more than 50 miles between charging stations. ADOT is looking at public-private partnerships for the EV network build-out.

MAG takes a regional approach and collaborates with local agencies to support community grants. MAG's goal is not to own EV infrastructure but to provide information and support for others who have the ability to build and implement infrastructure within their own jurisdictions. The region recognizes Arizona's higher EV adoption rate and growing status as an EV manufacturing hub.

NORTHERN ILLINOIS REGION 1 PLANNING COUNCIL

The research team met with Sydney Turner, director of transportation planning for the Region One Planning Council. The interview focused on planning efforts undertaken by the MPO as well as on where the council is focusing its efforts to support member agencies.

EV Planning

In 2021, the MPO completed its first EV infrastructure plan, which was mostly focused on LDVs, but did acknowledge freight applications and some of the additional considerations for freight. The plan did an assessment of the current status of EV infrastructure as well as specific siting considerations that can help its member agencies set criteria or determine locations.

Through the planning efforts, the MPO determined that the region needed an increase in the number of charging stations to support future EV charging needs. There are enough charging stations right now to support EVs on the road today, but with targets and increasing EV sales, there is always room for added capacity. One example of this is the Tesla superchargers in the region, which are often full on the weekends as people travel outside of major metropolitan areas. This situation highlights that unmet needs are often at specific times and locations.

The plan also identified equity considerations by defining the different groups of consumers or users. Early adopters require infrastructure, but so will MFH. The plan tried to incorporate siting considerations for these use cases, including where public charging could be placed to support broader residential locations. These areas included downtowns, which include low-income residential areas for the region. The MPO has not coordinated with MFH owners at this stage, however. Instead, its plan focuses on EV readiness and what types of charging are best for specific locations, such as Level 2 in places where people spend more time and Level 3 near interstates.

The MPO has coordinated with the state on the NEVI plan and other state-level efforts. The MPO is a stakeholder on the NEVI/EV Planning Committee at the state level. Region One's plan was published prior to the state conducting their own planning data, but they did not provide data to support state efforts. Illinois collects its own data to support EV planning. The MPO does coordinate with other entities as well and considers a variety of programs for grant funding. Region One has a grant writing team that assists with those applications. The MPO does provide data to its local governments to support those grant applications.

Funding

Region One feels that there is a continued need for funding for EV infrastructure. The MPO is working with the state to stretch the available funding as far as it will go. For example, it is still working on project criteria for funding to ensure needs can be met.

Policies and Regulations

The state is very proactive in terms of policies and regulations to support EV charging, but the MPO's focus is more on the local level. For example, as part of its EV readiness plan, Region One created model ordinance language for developing EV infrastructure. It then works with local government to implement it. The permitting process is an area that the MPO has discussed but does not get directly involved in; it provides technical assistance when needed. Since it has been a few years since the plan was completed, it has not undertaken another review yet.

Freight, Fleet, and Multifamily Housing

Although the MPO does not specifically address freight electrification, it is a key challenge for the area. The region has two major interstates as well as another interstate that converges with those two. This leads to a significant amount of freight movement in the area. The challenge, or concern, is the amount of energy/electricity that will be required to support freight electrification. Questions still remain on whether the grid can currently handle this additional load.

Fleets have similar issues, but the key challenge is understanding the demand upfront. For example, the local mass transit fleet is converting its fixed-route buses to hybrid and electric. The transit agency has several hybrid vehicles and two all-electric vehicles with another two on order. Converting the fleet is a slow process because the agency is waiting for vehicles to age out before purchasing hybrids or EVs. That being said, Turner did note that they have a timeframe for the conversion, so they have to put the necessary infrastructure in place to support the fleet. Other fleets have discussed the conversion to electric; both the school district and municipal partners are focusing on their LDVs initially. The MPO is most heavily involved with the transit fleet and is coordinating with them to support the transition to electric.

The major challenge for MFH is being able to place chargers in proximity to housing. The region is not seeing a significant amount of growth, so requiring EV readiness in new development will not solve the problem. There are inherent challenges with retrofitting, but it may be necessary to ensure that everyone has access to charging. Ultimately, for personal vehicle owners, the challenge is ensuring everyone has access to charging even if they live in MFH.

Outside of these three areas, Turner noted that education is key for both the public and elected officials to understand the importance of and issues surrounding EVs. Public concerns over range anxiety as well as some of the basic questions on how to charge and operate the vehicle are commonly heard by the MPO. In order to address these, the MPO has an FAQ page, and it hosts pop-up events to try and dispel some of these concerns. The MPO has hosted Drive Electric for the last 3 years, and it has seen how attitudes have changed as more vehicles enter the market and charging is installed.

Finally, the MPO is working with its local utility as it pursue grants and determines charging station locations. This is a new relationship and a coordinated effort will be key to transportation electrification.

APPENDIX H. VALUE OF RESEARCH

This appendix summarizes the procedure to estimate the value of research associated with this research. The research team considered two types of benefits for inclusion in the analysis: economic (or quantitative) and qualitative. However, due to a lack of available data to conduct a quantitative analysis of research benefits, researchers limited the value of research analysis to qualitative benefits, as summarized below.

SELECTION OF BENEFIT AREAS

TxDOT provided a list of 19 potential benefit areas that might be affected by the products of this research. Of these benefit areas, researchers recommended and the project panel approved five benefit areas to develop the value of research for this project. The following provides the selected benefit areas along with a definition in the context of the project statement:

- **Level of Knowledge.** The project will provide information and understanding about issues and concerns of EV infrastructure stakeholders, tools that can be used for EV planning, which tool and methodology would be most suitable to forecast EV charging demand, and policies and funding opportunities related to EV charging infrastructure.

- **Management and Policy.** The project will develop an EV infrastructure strategic plan that will guide and inform TxDOT decisions for long-term EV infrastructure planning. The plan will provide critical information to guide TxDOT management decisions and to support the development of policies that maximize economic and environmental benefits to Texans.

- **Quality of Life.** The project will develop an EV infrastructure strategic plan that will guide and inform TxDOT decisions for long-term EV infrastructure planning. Strategic efforts to guide EV infrastructure investments will improve the quality of life for Texans.

- **Customer Satisfaction.** The project will identify opportunities to engage and coordinate with EV infrastructure stakeholders and will identify specific needs of stakeholders where TxDOT could provide assistance. The project will engage with EV infrastructure stakeholders and receive feedback about how TxDOT could improve EV infrastructure planning activities.

- **Environmental Sustainability.** The project will develop an EV infrastructure strategic plan that will guide and inform TxDOT decisions for long-term EV infrastructure planning. Strategic efforts to guide EV infrastructure investments will maximize the impact of EVs, minimize production of greenhouse gases by vehicles, and improve environmental sustainability in Texas.

QUALITATIVE BENEFITS

The research team expects that an implementation of the research products will have the following qualitative benefits:

- **Level of Knowledge.** Research products will increase TxDOT's understanding of the issues and concerns related to EV infrastructure stakeholders, including MPOs, cities, local public agencies, utilities, regulators, manufacturers, fleet owners, developers, and EV station operators. It offers recommendations to address these issues and concerns, summarized from workshops where various stakeholders expressed their expectations and concerns, viewing TxDOT as a leader in this field. Research products will also broaden TxDOT's understanding of the diverse tools available for EV planning, and identifies the most suitable tool and methodology for forecasting EV charging demand. A prototype EV charging demand estimation tool has been developed within the project to predict hourly demand across different scenarios. Furthermore, the policy framework will expand TxDOT's knowledge of policies and funding opportunities pertaining to EV charging infrastructure. The framework provides a summary of the funding and resources currently in use by other stakeholders or those that may become available in the future through various federal grants.

- **Management and Policy.** The research team has developed a methodology using a bottom-up approach to forecast EV charging demand in Texas under various scenarios. This methodology is capable of predicting EV charging demand at different hours of the day for each zip code and county in Texas. The prototype EV charging demand estimation tool, developed in this study, enables users to swiftly evaluate different EV charging scenarios. The data architecture of the tool allows for updates as new datasets become available. Similarly, the architecture supports the addition of new modules and scenarios based on future research. The methodology permits the application of various temporal and spatial distributions that allocate EV charging demand to different areas. Furthermore, this model could be expanded to investigate EV charging demand in conjunction with other factors (e.g., demographic data), targeting specific groups and populations. This project also offers a detailed analysis of policies that impact the EV infrastructure and provides recommendations to update policies on data and private installation of charging, as well as plans and programs to support freight, fleet, and economic development needs.

- **Quality of Life.** The project developed an EV infrastructure strategic plan that will guide and inform TxDOT decisions for long-term EV infrastructure planning. Strategic efforts to guide EV infrastructure investments will improve the quality of life for Texans.

- **Customer Satisfaction.** This project identified opportunities to engage and coordinate with EV infrastructure stakeholders and specific needs of stakeholders where TxDOT could provide assistance. The project presents the findings of EV infrastructure stakeholders engagement and feedback about how TxDOT could improve EV infrastructure planning activities. The EV users can access the EV charging stations reliably and plan their trips without worrying about range anxiety. Carefully designed and

targeted EV charging station infrastructure will help with increased EV adoption in the future.

- **Environmental Sustainability.** The project developed an EV infrastructure strategic plan that will guide and inform TxDOT decisions for long-term EV infrastructure planning. Strategic efforts to guide EV infrastructure investments will maximize the impact of EVs, minimize production of greenhouse gases by vehicles, and improve environmental sustainability in Texas.