Electric Vehicle Council

Powered by Fuels Institute

EV Charger Deployment Optimization

An Analysis of U.S. State-level Electric Vehicle Supply Equipment Demand Forecast and Supporting Infrastructure Considerations

AUGUST 2022

S&P Global Mobility

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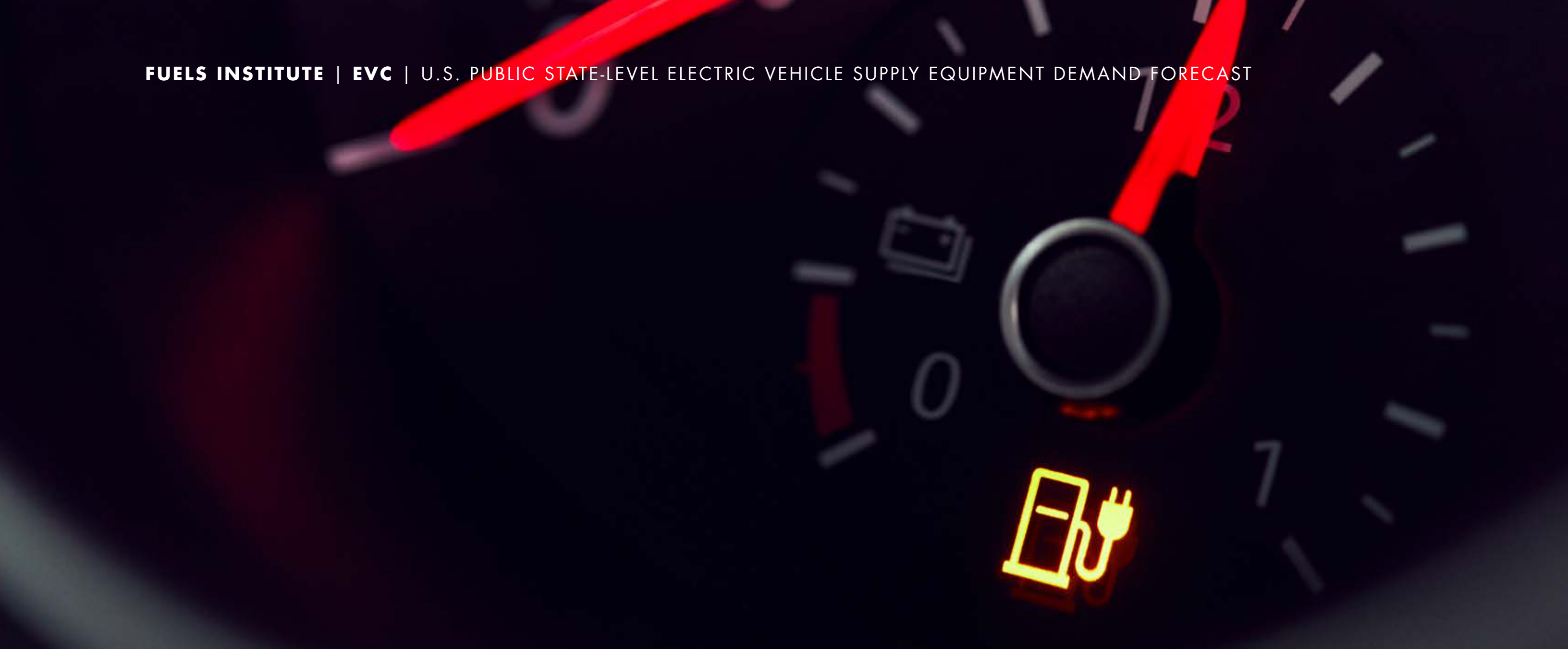


STUDY OBJECTIVES

In summer 2021, the Fuels Institute commissioned S&P Global Mobility to conduct a project evaluating the electric vehicle (EV) charging infrastructure deployment forecast in the U.S. While nationwide electric vehicle supply equipment (EVSE) forecasts are useful, a deeper state-level (and even local-level) analysis is required to understand the gravity of the challenge ahead of the industry and government to deploy a sustainable and equitable public EV charging network.

The underlying issue is timing and efficiency of EVSE deployment. As consumers begin to purchase EVs in greater volumes, the need for in-market charging facilities will increase. There are many models projecting how many chargers will be needed and where, yet there remains uncertainty among many stakeholders regarding which will be the most effective deployment strategies. Furthermore, a one-size-fits-all deployment strategy will not satisfy all needs or economic considerations. Determining the optimum charging solutions for specific use cases will help instill confidence in end users while providing businesses investing in charger deployment greater confidence in their potential return on investment (ROI).

This study investigates how many charging stations and outlets may be required at various stages of EV market development in different regions to satisfy actual demand and to instill within end users the confidence that availability will be sufficient. In addition, the study aims to better understand what types of chargers (Level 2 and DC fast chargers of varying capacity) will be required at different locations to optimize deployment to satisfy consumer needs while reducing overall infrastructure costs and accelerating the business case for charger installation.

METHODOLOGY

S&P Global Mobility's approach to the micro-level EVSE forecasting involved many different types of data, inputted into a model that incorporates forecasting, indexing, and geo-location insights to ascertain the optimal volume, variety, and timing for EVSE across the U.S. More specifically, the S&P Global Mobility model leveraged the data inputs shown in Figure 1-A and 1-B.

FIGURE 1-A: S&P GLOBAL MOBILITY ELECTRIC VEHICLE SUPPLY EQUIPMENT FORECAST MODEL INPUTS

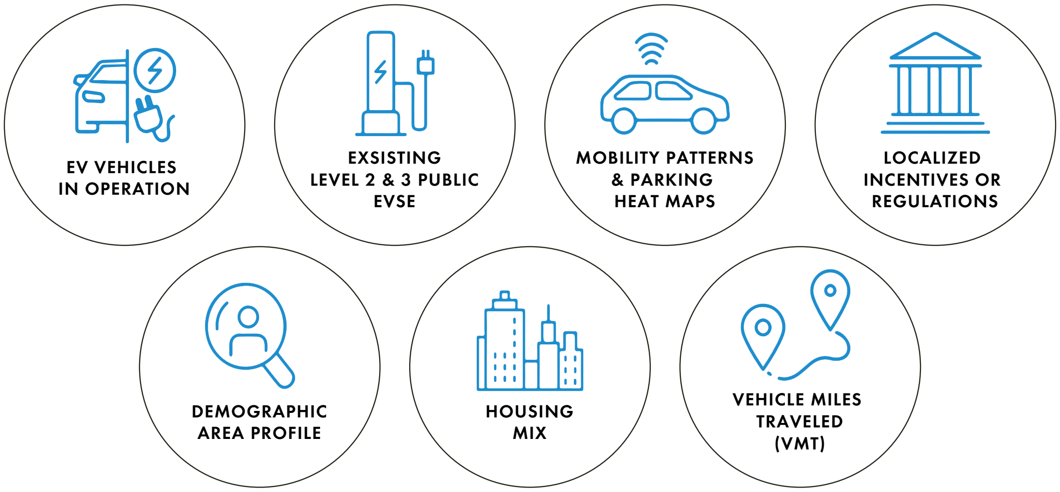


FIGURE 1-B: S&P GLOBAL MOBILITY'S DATA INPUTS FOR MICRO-LEVEL ELECTRIC VEHICLE SUPPLY EQUIPMENT DEMAND FORECASTING

DATA CATEGORY	DATA TYPE	SOURCE AND DATE
Current U.S. market electric vehicles in operation	Unit volumes	S&P Global Mobility (July 2021)
Forecasted U.S. market electric vehicles in operation (VIO)	Unit volumes	S&P Global Mobility (based on the second half 2020 EV sales forecast)
Current U.S. market Level 2 and 3 electric vehicle supply equipment infrastructure	Station and port types, locations, and volumes	PlugShare (September 2021)
Consumer mobility patterns – vehicle miles traveled	Indexed travel metrics	U.S. Dept. of Transportation (July 2021)
Consumer mobility patterns – parking hotspots	Daytime parking hotspots	MBI GmbH (2021)
Demographic area consumer profiles	Indexed data and ratios	MBI GmbH (2021)
Localized housing mix	Indexed data and ratios	Claritas PopFacts (2021)
Localized incentive and regulatory frame-work	State-level considerations	S&P Global Mobility (2021)

The state EVSE forecast and associated investment prioritization was developed at a census tract (CT) level with the above data inputs shown in Figure 1. The S&P Global Mobility national public EVSE infrastructure forecast was used as a starting point for determining top-line EVSE volumes and EV:EVSE ratios for Level 2 (AC) and Level 3 (DC) charging. These baseline ratios were applied to the light consumer EV vehicles in operation (VIO) forecast, which was calculated at a CT level using the S&P Global Mobility new vehicle sales forecast, historical VIO, and consumer demographics to predict future EV VIO at a granular level. The above factors of vehicle miles traveled, housing type mix, and parking hotspots were subsequently implemented down to the CT level to align the number and locations of public EVSE infrastructure in accordance with local market conditions.

For the purposes of this report, S&P Global Mobility defines EV as battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV). Where appropriate, the two powertrain system designs are broken out in the report. We do not include mild-hybrid electric vehicles, hybrid electric vehicles, or fuel cell electric vehicles into our analysis for this report.

This report also references three different count categories for EVSE. Charging locations represent the location on the map wherein a single or multiple charging station(s) are installed. Charging stations represent the individual stack installed in the ground, on the wall, or in a similar placement with one or more charging outlets. A charging outlet is the plug itself that connects to the EV or outlet to plug in to a user-owned charging cable. Charging stations is the count-type most often used throughout the report.

EXECUTIVE SUMMARY

In the U.S., there were 1.87 million EVs (plug-in hybrid and battery-powered) in operation as of July 2021. This follows over 300,000 new EVs registered per year from 2018 to 2021. California is home to 40.9% of all EVs and PHEVs in the U.S. and the top 15 states are home to 81.7% of EVs registered in the U.S. as of July 2021. Washington, D.C., is treated as a state in this report.

The year 2020 was challenging for many industries, and the automotive sector was no exception. Despite this, several states, including Florida, New Jersey, Pennsylvania, and Texas, showed strong growth in EVs last year. California new registrations have declined year-over-year from 2018 to 2020, but strong 2006–2021 numbers point to a reversal of the trend this year for the state, and the nation.

By 2030, California is expected to contribute 17.4% of new plug-in EV registrations with the top 15 states contributing a combined 73.4% (versus 38% and 81% in 2006–2021, respectively). New EV registrations per year are expected to hit 1.75 million in 2025 and 2.75 million by 2030. By this 2030 timeframe, S&P Global Mobility estimates EVs will make up 5.9% of the U.S. registered vehicles.

According to S&P Global Mobility data, while EVs were often purchased as additions to the garage historically, the first quarter of 2021 marked the first in which greater than 25% of BEVs where purchased as a replacement, likely making it the primary vehicle.

The top 15 states currently make up approximately 73% of the 115,197 public EVSE stations nationally. California is home to 28% of all charging locations and 30% of charging stations in the U.S., although only 19% of Tesla-networked stations are found in California.

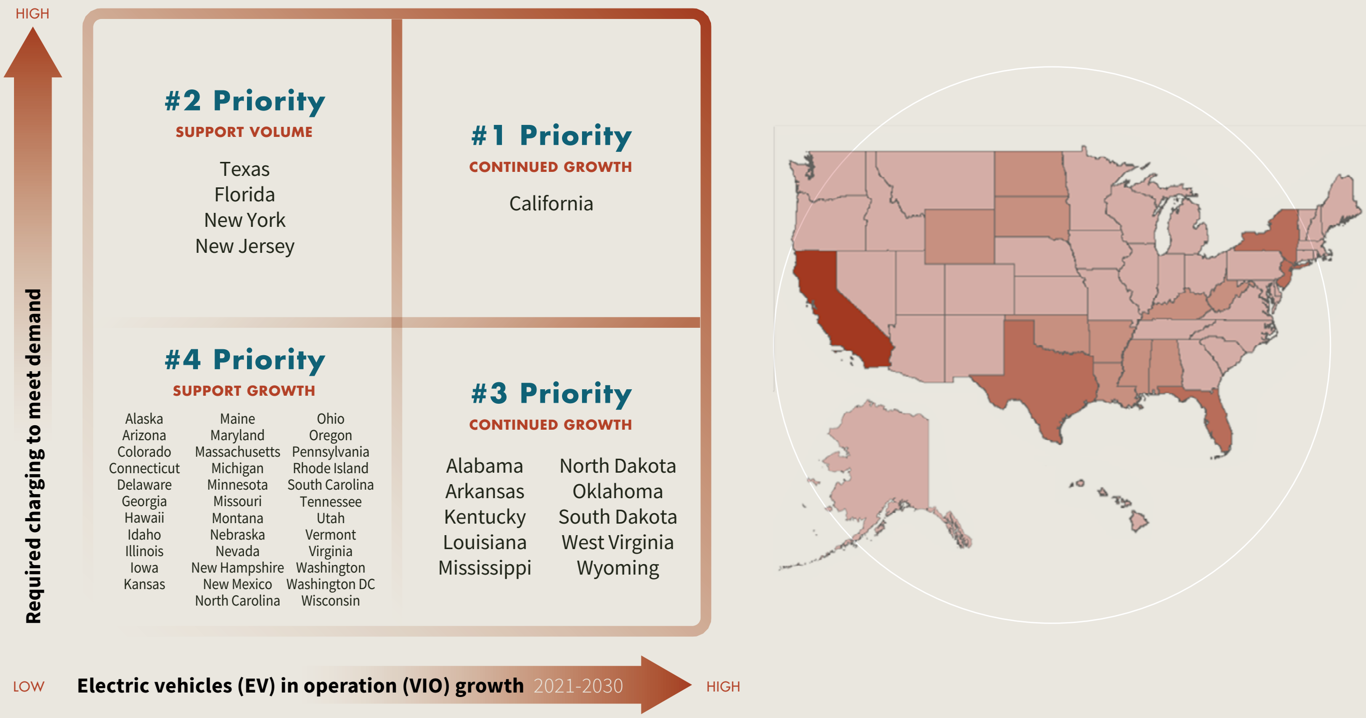
The highest EV-to-EVSE ratios are visible along the West Coast as well as Illinois, New Jersey, and Texas. According to several internationally recognized industry and academic sources, a ratio of greater than 10 to 15 vehicles to public charging stations represents a congested infrastructure (Hall, Dale and Nic Lutsey, 2017). Nationally, there are 19.7 vehicles for every one charging station.

S&P Global Mobility forecasts more than 18 million EVs to be on the road in 2030 in the U.S. To support this volume of vehicles, 1.8 million charging stations will be required by that same 2030 milestone. As much as 95% could be Level 2 AC chargers, built alongside points of interest (POIs) with the intent of servicing many vehicles concurrently. Level 3 DC fast charge (DCFC) EVSE should then be deployed strategically to support instances where fast charging and high throughput is required.

The U.S. state prioritization in this report can help planners and investors understand the level of EVSE development that is required to support the growth and adoption of plug-in EVs in each state.

Figure 2 illustrates how all 50 states are categorized. The quadrant dividing line for the X-axis (electric vehicles in operation) is growth at 20 times or more, whereas the Y-axis (required charging to meet demand) is a weighted average between AC and DC charging needs, at or above 60,000 or 3,000 public chargers, respectively.

FIGURE 2: U.S. STATE-LEVEL ELECTRIC VEHICLE SUPPLY EQUIPMENT GROWTH PRIORITIZATION



California stands alone as the top priority simply due to the huge volume expectations. The infrastructure in California is already among the densest in the nation, but the forecasted continuous growth of EVs in the state will need commensurate continued growth in the charging infrastructure.

The next priority 2 level is dominated by the high-population states of Florida, New Jersey, New York, and Texas. These states will have lower growth rates of EV VIO compared to California, yet due to sheer population size, a smaller increase in EV VIO will have a profound effect on the demands for a public charging network.

Priority 3 states are lower volume in 2030 and have minimal EV adoption today but stand to see astronomical percentage growth rates in EV VIO over 2021–2030. Given the minimal adoption today, the current infrastructure is lacking, thus creating a need for additional EVSE to support the growth these states will see. Additionally, Priority 3 states, especially in the South, will provide crucial charging corridor support for highway transportation between states with higher EV VIO (such as Florida and Texas). So, building out infrastructure in Priority 3 states will not only benefit the local growth in EV VIO but also for those passing through.

Finally, Priority 4 states are those where expected volume is low to moderate but the growth rate is not astronomically higher than the national average. Some of these states already have strong adoption of EVs. As such, the growth in EV VIO should be met with equally steady growth in EVSE. Fortunately, this accounts for most states, including many of those with higher populations (such as Illinois, Pennsylvania, and Ohio).

Fundamentally, deployment happens on the local and municipal level, and this report introduces these details. However, the state-level analysis is an important and vital step to organizing the EVSE infrastructure strategies from a federal to state and, ultimately, local level of deployment.

LITERATURE REVIEW

Key Findings

To provide a baseline for this study, S&P Global Mobility began with a thorough review of published works on EVSE planning and development topics.[1] Academic-, industry-, and utility-sourced insights were gathered to build a foundation for both the quantitative and qualitative analysis of the study.

- A ratio of 10 to 15 EVs to one charging station will provide a sustainable infrastructure when the housing mix largely offers home-charging access, as it does in the U.S.
- The financial considerations for developing EVSE infrastructure can include land acquisition, hardware costs, installation labor, permitting and zoning fees, among other expenses.
- Service providers must also structure usage fees that cover these costs while meeting an acceptable price point for the end consumer.
- Three of the top five major factors that deter consumers from buying a hybrid or an EV are related to charging.
- simply put, the coordination of all the stakeholders creates the biggest barrier to bringing EV charging to the market, because SO SO many players are involved from banks, to cities, to utilities, to charging station network operators, to engineers, to electricians, and more.

RATIO OF ELECTRIC VEHICLES TO ELECTRIC VEHICLE SUPPLY EQUIPMENT

The first and most important topic to preview pertained to the ratio of EVs to charging stations because it establishes the level of congestion for the EVSE infrastructure.

According to a research report published in August 2021 by Mobilyze.ai and the Toyota Mobility Foundation, international benchmarks suggest one public charging station is needed for every 10 to 15 EVs, even when the housing mix enables easy access to home charging.[2] This ratio varies widely, especially when focusing on only AC or DC public charging. However, in international markets, the housing mix can also vary widely, requiring a different ratio. According to a report from October 2017 from the International Council for Clean Transportation, some metro areas in California can have upward of 25 to 30 EVs per charger where the housing mix supports more home charging versus parts of Europe and China where charger ratios are much lower with no more than three to five EVs per public charging station on average.[3]

For the U.S.—in general—S&P Global Mobility presumed a ratio of one EVSE to 10–15 EVs to analyze the nation on a state level. This ratio assumption was used as a baseline to develop insights on where today's EVSE infrastructure is congested and where it is under-utilized.

1 Mobilyze.ai, *Access to Electric Vehicle Charging in the United States*, eds. D. Keith, J. Long, & B. Gaiarin, August 2021, https://www.mobilyze.ai/research-report-download.

2 Mobilyze.ai, *Access to Electric Vehicle Charging in the United States*, eds. D. Keith, J. Long, & B. Gaiarin, August 2021, https://www.mobilyze.ai/research-report-download.

3 Dale Hall and Nic Lutsey, *Emerging Best Practices for Electric Vehicle Infrastructure* (International Council on Clean Transportation, October 2017), https://theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf.

ELECTRIC VEHICLE SUPPLY EQUIPMENT BUSINESS AND DEVELOPMENT CONSIDERATIONS

Initial investment and ROI highlight much of the concern for business owners, retail centers, parking facilities, and other stakeholders when considering the installation of either Level 2 or Level 3 DCFCs. Questions of funding, tax credits or grants, and permitting all factor into the equation for landowners and developers.

According to a whitepaper from Eaton in February 2021, the factors vary widely from housing stock and throughput to subsidized charging fees and installation costs.[4] Figure 3 visualizes some of the various advantages and disadvantages of each type.

Putting AC Level 2 stations in the ground is generally less expensive to purchase, install and operate than DCFC stations since high voltage lines are not as easily accessible around certain public parking facilities, such as older parking garages, retail complexes, and existing workplace parking lots.

FIGURE 3: PUBLIC CHARGING CONSIDERATIONS

DC FAST CHARGING	CHARGING CONSIDERATIONS	AC CHARGING
Faster	Charging	Slower
Fewer	Units needed per site for same throughput	More
Smaller	Site footprint needed	Larger
Larger	Individual station footprint needed	Smaller
More	Complicated site electrical install process	Less
Multiple DC	Required connector stadard	One AC
Neutral	Commonly drives indirect revenues from charging	Neutral

The difference here is a site is equivalent to a charging location - you need more space with multiple AC chargers than you need with DC chargers to serve the same number of vehicles, because of throughput. However, the individual station footprint is smaller with AC charging, so they don't take up as much individual space, versus a large DC fast charging cabinet.

Source: S&P Global Mobility

4 Eaton, *Education & Cooperation Will Deliver eMobility Expansion*, February 2021, prepared by HIS Markit, https://www.eaton.com/content/dam/eaton/company/news-insights/emobility-report/IHSMarkit_Eaton-eMobilityInfrastructure-Whitepaper_Feb2021_Final_v07_LowRes.pdf.

Furthermore, the AC stations will generally offer the end user a less expensive charge since the current is delivered at a slower rate. This then provides the station host with a chance to maximize other revenue opportunities for the duration of charging, which may include more time in the host's store or restaurant or simply a competitive edge for an urban parking facility.

The negatives for AC stations include the need for a larger footprint with more physical stations and outlets per site to meet demand, which can become an issue for smaller EV charging sites where fewer vehicle parking spots are available. It is also less likely for AC units to generate direct charging revenues, and they obviously provide a slower charge to the end user. AC stations are more likely to be free or very inexpensive to the end user, depending on level and potential incentives from other sources.

In contrast, DCFC offers end users a "rapid" charging experience, especially compared to users' experiences with home charging. Strategically placed DCFCs can help make or break the usability of EVs for lengthy commutes or road trips. DCFCs will match more of the traditional vehicle fueling user-experience model, wherein the user must go to a station to refuel. In particular areas and scenarios, this is the optimal solution.

Another aspect to consider is the tariffs utilities assess at each charging station and how this impacts the ultimate cost to the end-user. This can vary based on location, charger power levels, and time-of-day, all of which impact how a charging station operator's profitability may be calculated.

Given these considerations, and the overall benefits to AC charging solutions, S&P Global Mobility used a prioritization toward AC charging in its forecast modeling, especially in urban markets where space is in limited supply and driving distances are shorter overall. DCFC makes a bigger impact along highway

interchanges and in suburban and rural areas where the opposite factors are at play: longer driving distances and more real estate to work with.

Regardless of location or charger type, the specific site plan details can actually provide the biggest impediment toward EVSE deployment, as utilities, landowners, operators, and other stakeholders will weigh in on each specific installation.

With this in mind, officials with the Florida Department of Transportation put together a comprehensive master plan for the adoption of EVs and infrastructure in the state.

Their report, updated in April 2021 from an earlier version, identified power supplies, space requirements, and future EV and EVSE sales and installations as the key considerations that every location plan should have prior to start. Specifically, the space requirements highlighted how electrical utilities require easements for power supplies and that transformers often need three feet of space available to the sides and rear for fire safety, and up to 10 feet in front for operational safety.[5]

The plan goes on to list requirements from the Americans with Disabilities Act (ADA) for users with accessibility issues as well as ensuring the proper options for vehicle queue management, in the event of a high-demand scenario with EVs waiting to charge.

5 "Electric Vehicle Infrastructure Master Plan (EVMP)," Florida Department of Transportation, April 2021, https://www.fdot.gov/planning/fto/ev/default.

UTILITY AND GRID IMPACTS

One of the biggest challenges to EVSE deployment is the stakeholder alignment. Many of the articles and reports we reviewed highlighted aspects of this—from utility involvement on rate plans and equipment rebates to the impact on the grid and technologies to reduce grid strain.

In a Fuels Institute report from August 2021, the utilities and other Authority Having Jurisdictions (AHJs) can either empower or ensnare developers trying to get EVSE in the ground. Utilities may engage by developing make-ready infrastructure, providing documentation in interconnect and inspection processes, organizing development zones with other utilities, and providing aid in obtaining environmental credits after installation is complete.[6]

Meanwhile, AHJs might have ordinances and codes applied to a particular site, such as permits and permit requirements that vary from site to site. AHJs might require a long lead-time on the installation site plans and may offer other requirements related to the parking, building codes, or operation of the EVSE itself.[7]

This process of stakeholder coordination is comically complicated in the U.S. today. For example, across the nation, there are 49 individual jurisdictional commissions whose mission is to ensure cost prudence and be gatekeepers over this type of infrastructure development. On top of that, there are often watchdog organizations who overlook the commissioners. All this puts pressure on the utilities, and if the utilities do not have approvals from the regulators, then development programs will stall.[8]

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6 Fuels Institute, *Installing and Operating Public Electric Vehicle Charging Infrastructure*, August 6, 2021, https://www.fuelsinstitute.org/Research/Reports/Installing-and-Operating-Public-Electric-Vehicle-C.

7 Fuels Institute, *Installing and Operating Public Electric Vehicle Charging Infrastructure*.

8 Eaton, E*ducation & Cooperation Will Deliver eMobility Expansion*.

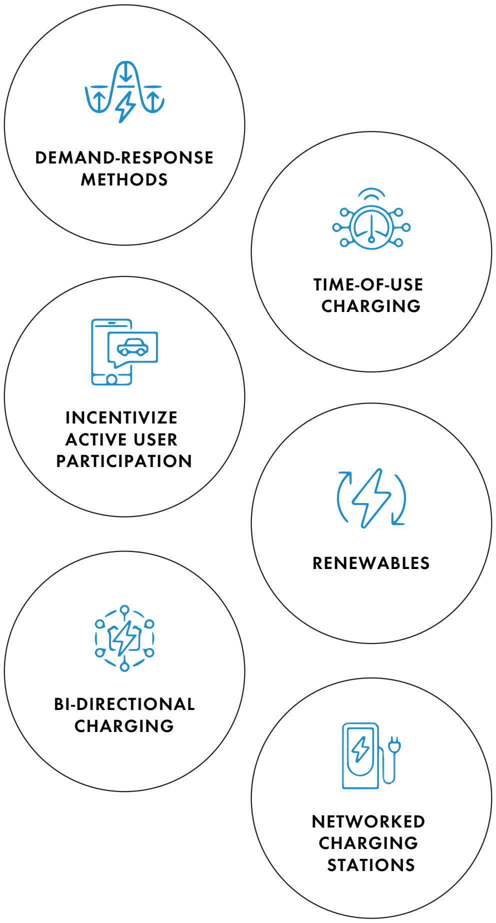
As cities big and small begin to transform their infrastructure to a more connected, digital footprint, the incentives and development projects will help to drive further EV charging infrastructure. In the public domain, the key factors at play are electrical provisioning at the site, adequate incentives, uniform building codes, and significant planning.

The Eaton paper addresses another key topic—the impact to the electrical grid. Much is claimed in the media about the potential for EVs to have a detrimental impact on the nation's electrical grid, but this is misguided. As we have experienced 100 years of growth in need for electricity, a careful balance between supply and demand has mostly met the needs of modern society. However, the stable operation and functioning of the grid has recently come into question due to widespread blackouts, including the 2003 Northeast Blackout, 2011 Southwest Blackout, Hurricane Sandy, and most recent the 2021 Texas Power Crisis.

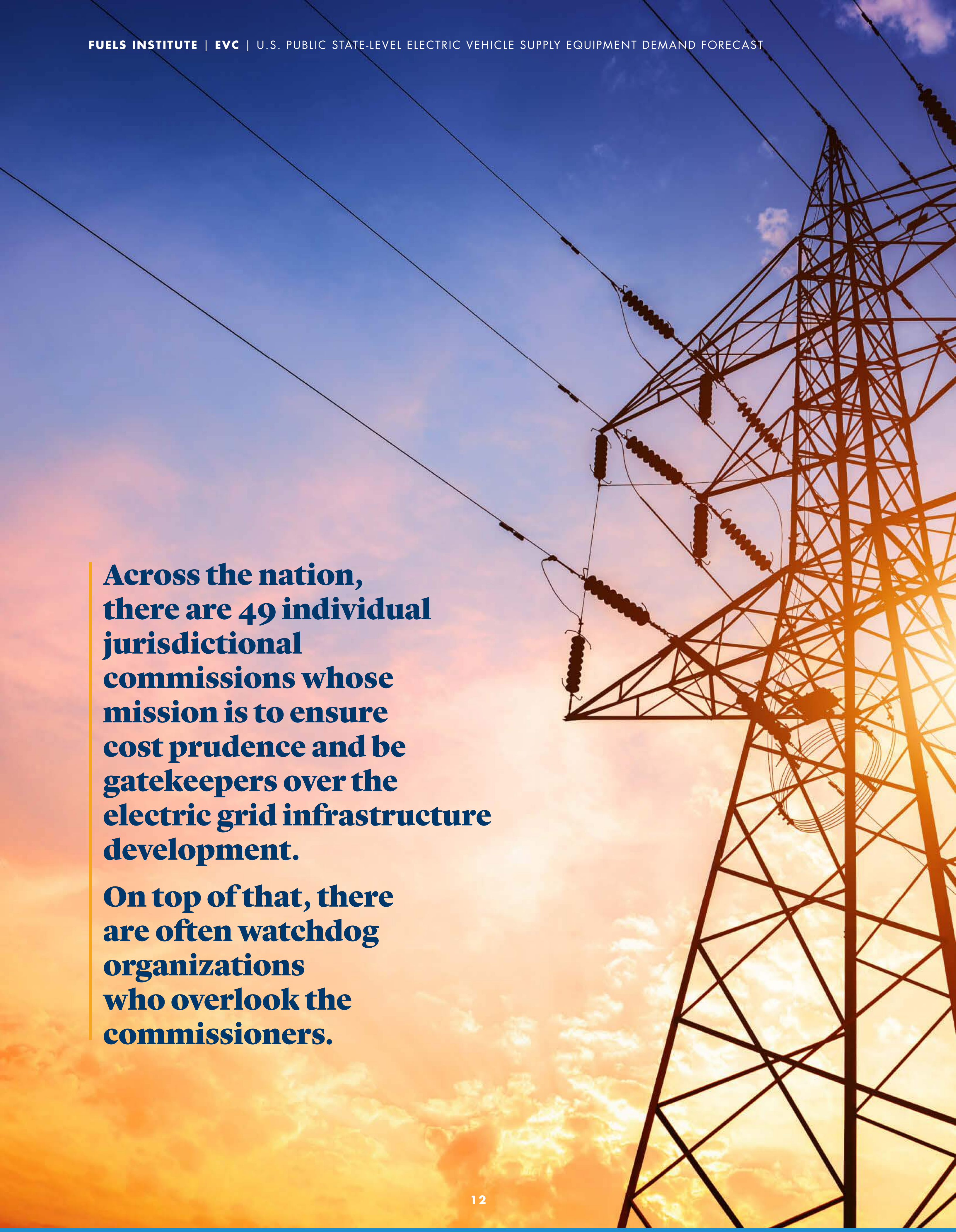
In one scenario, the growth of EVs could impact the grid and have detrimental effects on power transmission to other electricity destinations such as housing, public works, industry, and more. Furthermore, the increased load from EVs is coming while an increase in renewable generation is changing the load and source characteristics of the grid. However, this scenario implies that the build-out of charging stations goes unchecked and is unregulated. Based on the sheer complexity of organizing the various stakeholders, we can conclude there is too much oversight for this to become an issue.

Furthermore, there are many novel solutions to this problem (Figure 4). Such solutions include time-of-use charging schemes, demand-response methods, renewable energy and Energy Storage System (ESS), bi-directional charging technologies, integrated charging networks, and incentivizing consumer and fleet management to be active in sharing their charging status. These technical and non-technical solutions will enable EVs to become a living, dynamic part of the electrical grid, versus an endpoint that simply consumes energy.[9]

FIGURE 4: FOUNDATIONS OF A SMART ELECTRIC VEHICLE GRID



9 Eaton, *Education & Cooperation Will Deliver eMobility Expansion*.



Across the nation, there are 49 individual jurisdictional commissions whose mission is to ensure cost prudence and be gatekeepers over the electric grid infrastructure development.

On top of that, there are often watchdog organizations who overlook the commissioners.

CONSUMER PERSPECTIVES

Education is a key requirement for the ongoing growth of EV adoption among mainstream consumers. This element must not be lessened among the long list of other EVSE deployment considerations, as consumer demand will be a catalyst to a heavily used infrastructure.

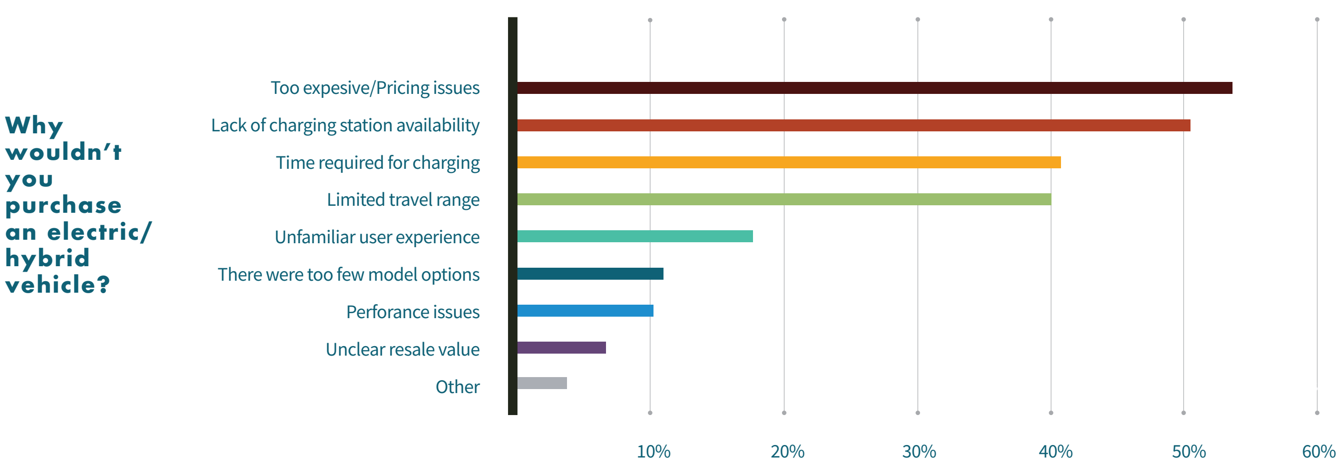
Therefore, this study aims to uncover some high-level perspectives of consumers as it pertains to infrastructure availability, convenience, and charging preferences. According to S&P Global Mobility consumer research from 2019, there are a few interesting shortcomings around the awareness and acuity of charging EVs.

The survey interviewed buyers of new vehicles in countries and regions all over the world on topics from connectivity and safety to electrification perspectives. Of the respondents who had not purchased a hybrid or EV, cost, lack of charging stations, time to charge, and range were the major pain points that kept customers in traditional internal combustion engine (ICE) vehicles (Figure 5). Lack of charging station availability came in as the second most important detractor at 54% of respondents, while time required for charging came as the third most important detractor at 41% of respondents.

Furthermore, among those who bought an EV, there are yet more concerning results. Looking at consumer perception on a global basis, 51% of respondents who bought an EV said they were not familiar with any public vehicle charging locations near where they live and work.[10] As mentioned before, any vehicle owner who does not see charging stations nearby will be less likely to believe they can maintain their current mobility needs with an EV.

Nationwide, 29% of U.S. EV owners who said they wouldn't buy another EV (15%) believed the public charging infrastructure in their locality was insufficient.[11] Regionally, the West Coast states of California, Oregon, and Washington currently make up 47.2% of the U.S. EV VIO. Respondents from this region felt strongly that their charging infrastructure was inadequate compared with other regions of the U.S. where EV uptake has not yet reached congested levels.

FIGURE 5: CONSUMER BARRIERS TO PURCHASING AN ELECTRIC VEHICLE



Source: S&P Global Mobility eMobility Consumer Survey, 2021

10 S&P Global Mobility, *Automotive E-Mobility Consumer Analysis* 2021.

11 S&P Global Mobility, *Automotive E-Mobility Consumer Analysis* 2021.

MARKET REPORT

U.S. Historical Electric Vehicle and Electric Vehicle Supply Equipment Market Report

To understand where the market will likely be in the coming years and what it will take to get there, it is important to first be familiar with current market conditions. The following section provides summaries of current EVSE, EV new vehicle registrations (NVR), and EV VIOs to give context to how the U.S. EV market has been developing, its total size, and the current service level.

PLUG-IN VEHICLES IN OPERATION

S&P Global Mobility VIO and NVR data sets provide the most complete and accurate picture of where vehicles are registered when they are first purchased and throughout their life cycle. In Figure 6, plug-in VIO has been isolated and compared against the total VIO population to determine the current adoption of EVs in the top 15 states and nationally. These data represent light consumer vehicle registrations only.

FIGURE 6: CURRENT U.S. PLUG-IN VEHICLES IN OPERATION, TOP 15 STATES (MOST REGISTERED EVS IN TOTAL)

STATE	PLUG-IN VEHICLES IN OPERATION			SHARE OF TOTAL VEHICLES IN OPERATION (percentage)		
	PLUG-IN XEV	BEV	PHEV	SHARE PLUG-IN XEV	% BEV	% PHEV
California	768,473	476,268	292,205	2.38%	1.48%	0.91%
Florida	102,290	74,698	27,592	0.57%	0.41%	0.15%
Texas	83,253	59,123	24,130	0.35%	0.25%	0.10%
New York	80,951	42,762	38,189	0.68%	0.36%	0.32%
Washington	78,097	56,262	21,835	1.11%	0.80%	0.31%
New Jersey	50,592	35,509	15,083	0.70%	0.49%	0.21%
Arizona	50,403	35,711	14,692	0.73%	0.52%	0.21%
Illinois	45,558	29,886	15,672	0.43%	0.29%	0.15%
Massachusetts	43,532	25,009	18,523	0.78%	0.45%	0.33%
Colorado	40,885	28,312	12,573	0.78%	0.54%	0.24%
Oregon	39,417	25,421	13,996	1.06%	0.68%	0.38%
Georgia	38,623	27,194	11,429	0.41%	0.29%	0.12%
Pennsylvania	38,211	22,144	16,067	0.33%	0.19%	0.14%
Maryland	36,729	22,106	14,623	0.73%	0.44%	0.29%
Virginia	36,131	22,765	13,366	0.48%	0.30%	0.18%
Top 15	**1,533,145**	**983,170**	**549,975**	**0.93%**	**0.59%**	**0.33%**
National	**1,876,293**	**1,188,318**	**687,975**	**0.66%**	**0.42%**	**0.24%**

FIGURE 7: MAP OF U.S. STATES, BY PLUG-IN VEHICLES IN OPERATION VOLUMES

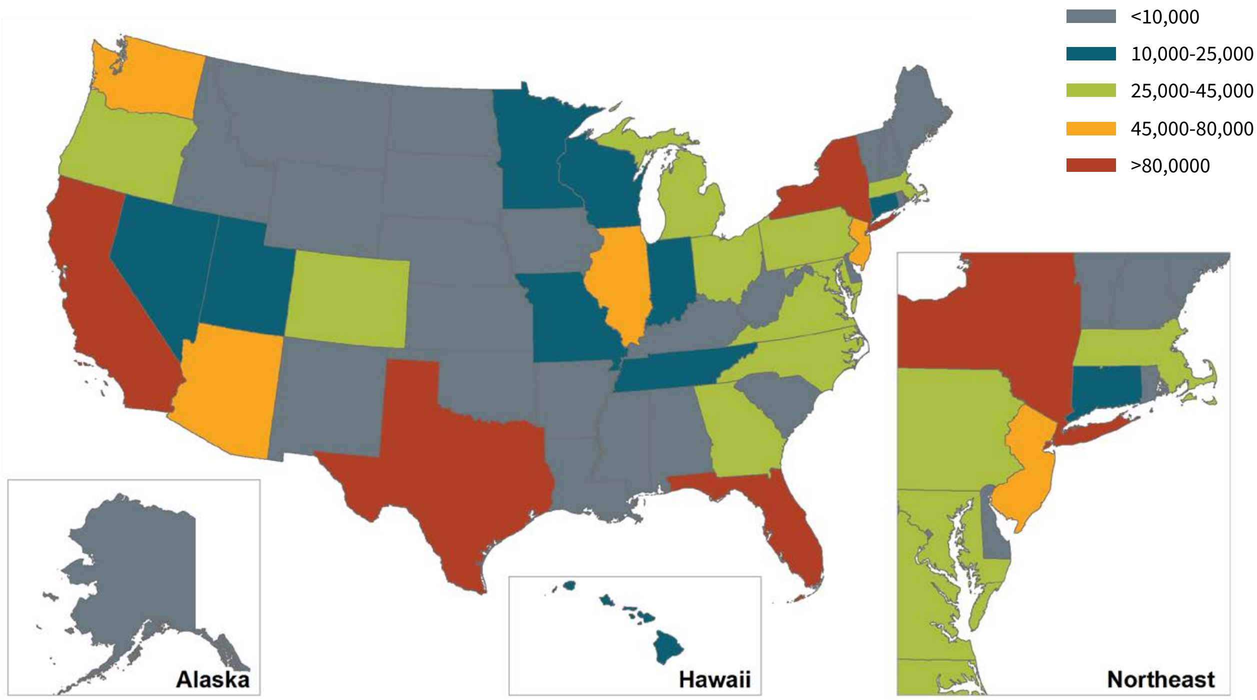


Figure 7 shows the U.S. mapped by plug-in EV VIO volume categories. Currently only a few states have an adoption of EVs higher than 1%, and even California has just 2.4% of vehicles registered as EVs. Outside of the top 15, Hawaii and Washington, D.C., come in at 1.3% and 1.5% adoption, respectively. California is home to 40.9% of all EVs and PHEVs in the U.S., and the top 15 states are home to 81.7% of EVs registered in the U.S. as of July 2021.

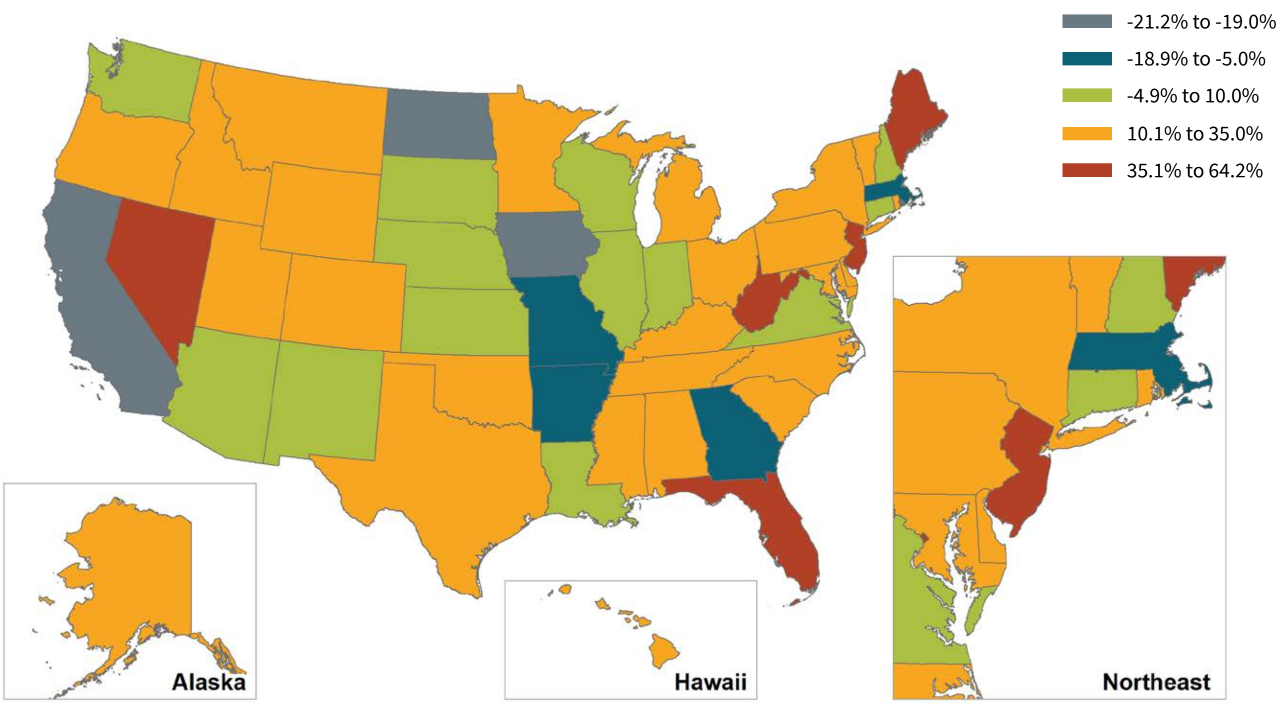
PLUG-IN NEW VEHICLE REGISTRATIONS

The EVSE requirement is primarily determined by the number of EVs in operation within a given market, but for additional context, Figure 8 details the new registration development seen over the past three years. The year 2020 was challenging for many industries, and the automotive sector was no exception. Despite the challenges, several states, including Florida, New Jersey, Pennsylvania, and Texas, showed substantial growth last year.

FIGURE 8: U.S. NEW VEHICLE REGISTRATIONS, PLUG-IN ELECTRIC VEHICLES, BY TOP 15 STATES

STATE	2018	2019	2020	JAN-JULY 2021	CHANGE 2018-2020
California	145,255	135,075	115,539	84,393	-20.5%
Florida	13,257	16,272	20,157	13,837	52.0%
New York	14,565	13,156	17,090	11,585	17.3%
Texas	11,173	14,438	13,643	11,705	22.1%
New Jersey	8,661	8,926	13,337	7,742	54.0%
Washington	12,140	11,560	11,755	7,616	-3.2%
Massachusetts	8,693	6,997	8,110	5,417	-6.7%
Colorado	6,747	7,578	7,718	5,039	14.4%
Illinois	6,949	6,375	7,398	5,027	6.5%
Pennsylvania	5,733	5,587	7,015	4,625	22.4%
Arizona	6,703	7,046	6,825	4,551	1.8%
Maryland	5,902	6,371	6,552	4,185	11.0%
Oregon	5,616	6,493	6,366	4,538	13.4%
Virginia	6,157	5,946	5,924	4,476	-3.8%
North Carolina	4,492	4,816	5,102	3,955	13.6%
Top 15	262,043	256,636	252,531	178,691	-3.6%
National	308,147	302,665	303,766	220,187	-1.4%

FIGURE 9: MAP OF U.S. BY NEW PLUG-IN ELECTRIC VEHICLE REGISTRATIONS GROWTH 2018-2020



As seen in Figure 9, according to S&P Global Mobility's new registration data, California new registrations have declined year-over-year from 2018 to 2020, but strong 2006–2021 numbers point to a reversal of that trend this year for the state as well as the entire nation. Since January 2018, California has been home to 64% of new EV registrations, however that share of the EV market has declined to 38%. This is a testimony to the increasing adoption of EVs across the country, not necessarily a decline in gross sales in California. Among these are Nevada, Florida, Maine, New Jersey, and West Virginia. While those are standout states, much of the U.S. in Figure 9 is colored yellow, indicating a 10.1% to 35% plug-in vehicle registration growth, demonstrating the trend is not isolated to a few states but to the nation as a whole.

California is home to 40.9% of all EVs and PHEVs in the U.S., and the top 15 states are home to 81.7% of EVs registered in the U.S. as of July 2021.

ELECTRIC VEHICLE CONSUMER PURCHASE TRENDS

Figure 10 is a summary of the top 22 BEV models (excludes PHEV) in the U.S. and indicates whether they were purchased as an additional vehicle for the household (garage) or to replace a retired or trade-in vehicle. It is clear that, compared to gas models, BEVs are typically purchased as additions to the garage. But in the first quarter of 2021, for the first time more than 25% of new BEVs where purchased as a replacement, according to S&P Global Mobility Retail Loyalty data. This trend may point to an increased williningness of consumers to rely on BEVs as their primary vehicle.

Building off Figure 10, Figure 11 looks at vehicle-buying households in the first six months of 2021 who either purchased a BEV or were an exisiting BEV owner who returned to market. Of the households who purchased an EV in the first half of 2021, 66.5% had most recently purchased a gas-powered vehicle. Of households who already owned an EV and returned to market in the first half of 2021, 53.4% chose to purchase another and 36.1% returned to gas.

These numbers tell a story that the majority of pure EV owners who return to market are happy enough with their EV to buy another. It also clairifies a commonly held notion that for many consumers a gas-powered vehicle is still most desirable, at least until the required infrastrucure and EV technology mature. Furthermore, Figure 12 shows a clear clustering of EV loyalty along the coastal regions. However, loyalty rates are growing in the lower Midwest and the South-Central U.S., with EV powertrain loyalty over 35%.

FIGURE 10: OVERALL U.S. ELECTRIC VEHICLE RETAIL PURCHASE TYPE (ADDITIONAL VS. REPLACEMENT) OF TOP U.S. BEV MODELS

Addition to garage (vs. replacement)

TIME PERIOD	TOP 22 BEV MODELS	COMPETING GAS MODELS
2020-Qtr1	78.1%	52.7%
2020-Qtr2	76.4%	46.6%
2020-Qtr3	75.4%	46.4%
2020-Qtr4	75.7%	47.9%
2021-Qtr1	74.7%	42.7%

Source: S&P Global Mobility Retail Loyalty

FIGURE 11: U.S. ELECTRIC VEHICLE RETAIL PURCHASE POWERTRAIN LOYALTY

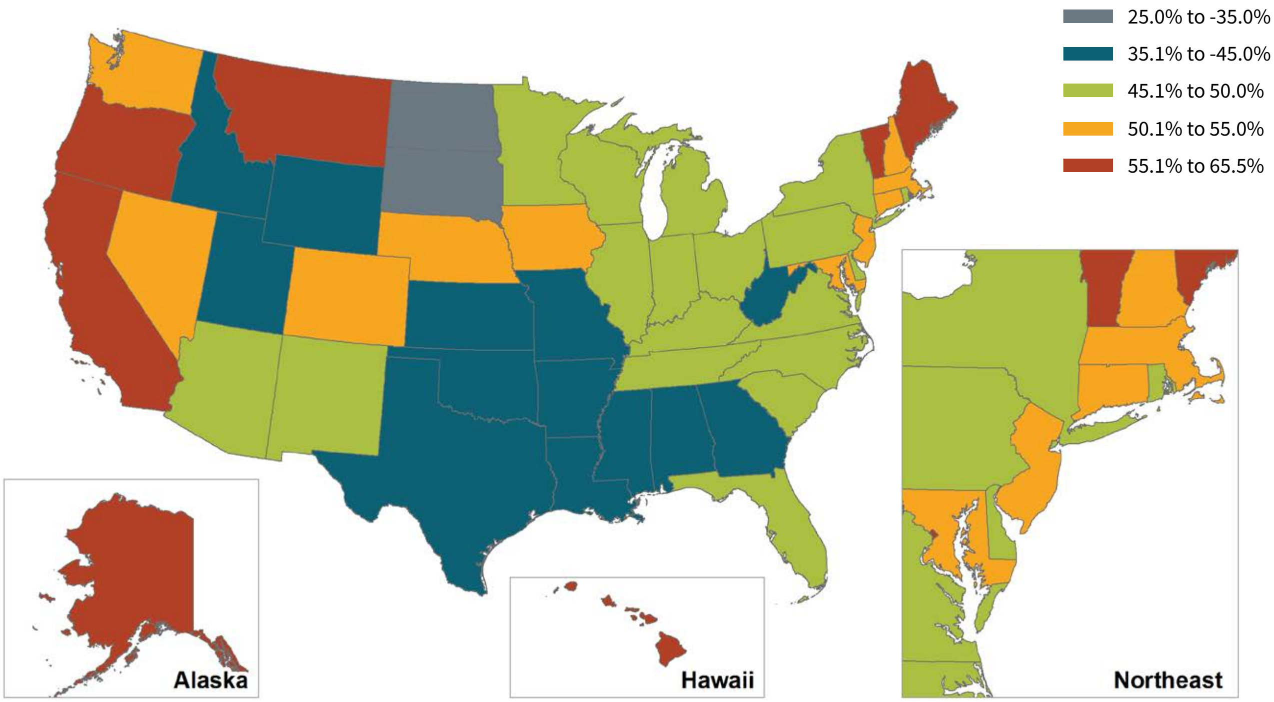
Previous vehicle and next purchase decisions 06-21 YTD

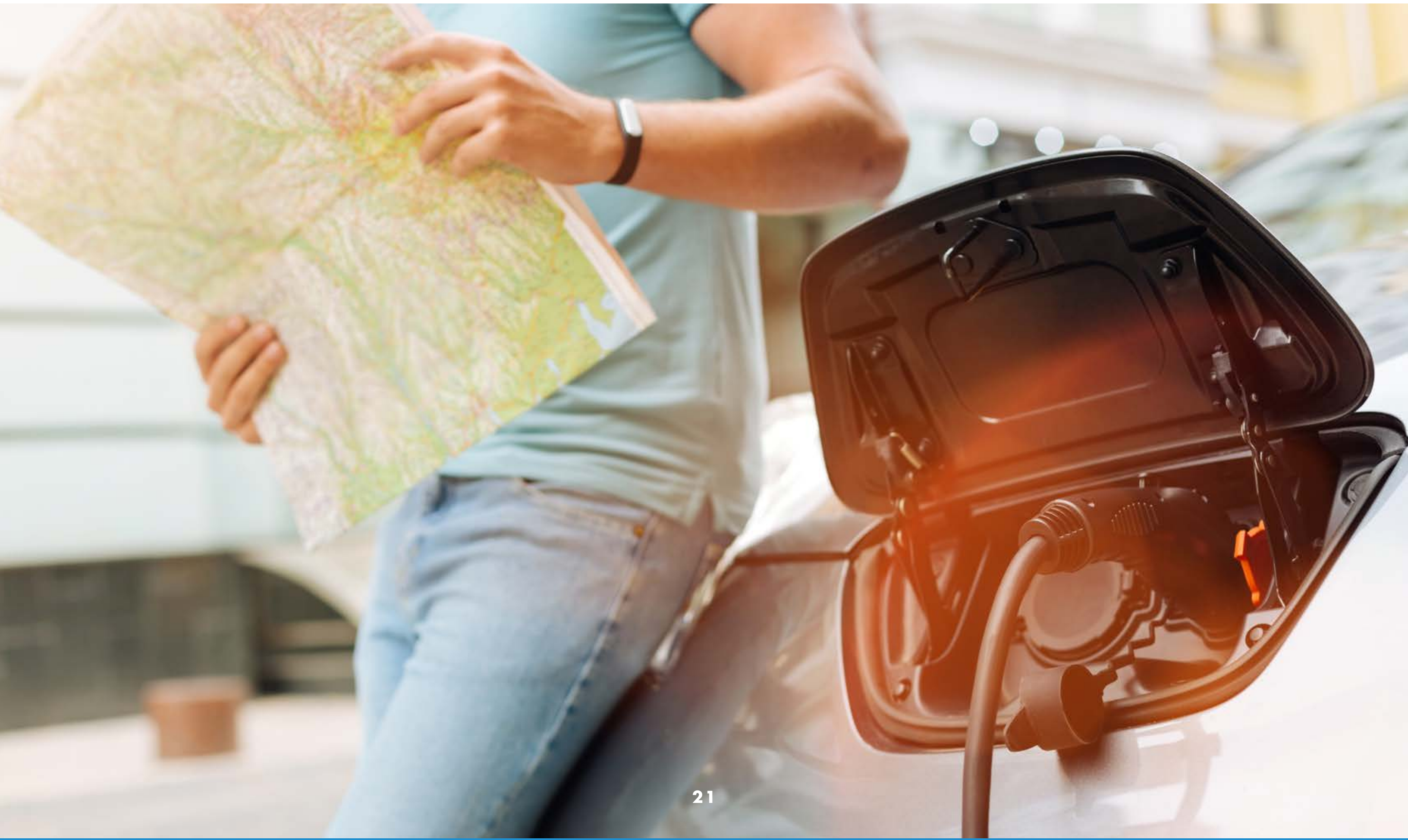
FUEL TYPE	BEV PURCHASERS' PREVIOUS PURCHASE	BEV OWNERS' NEXT PURCHASE
Diesel	1.9%	2.0%
Electric	18.6%	53.4%
flexible (gas/eth)	3.1%	0.8%
Gasoline	66.5%	36.1%
Hybrid	9.9%	7.8%

Source: S&P Global Mobility Retail Loyalty

This metric is mapped by state in Figure 13

FIGURE 12: MAP OF U.S. BY ELECTRIC VEHICLE OWNER POWERTRAIN LOYALTY





ESTABLISHED PUBLIC ELECTRIC VEHICLE SUPPLY EQUIPMENT

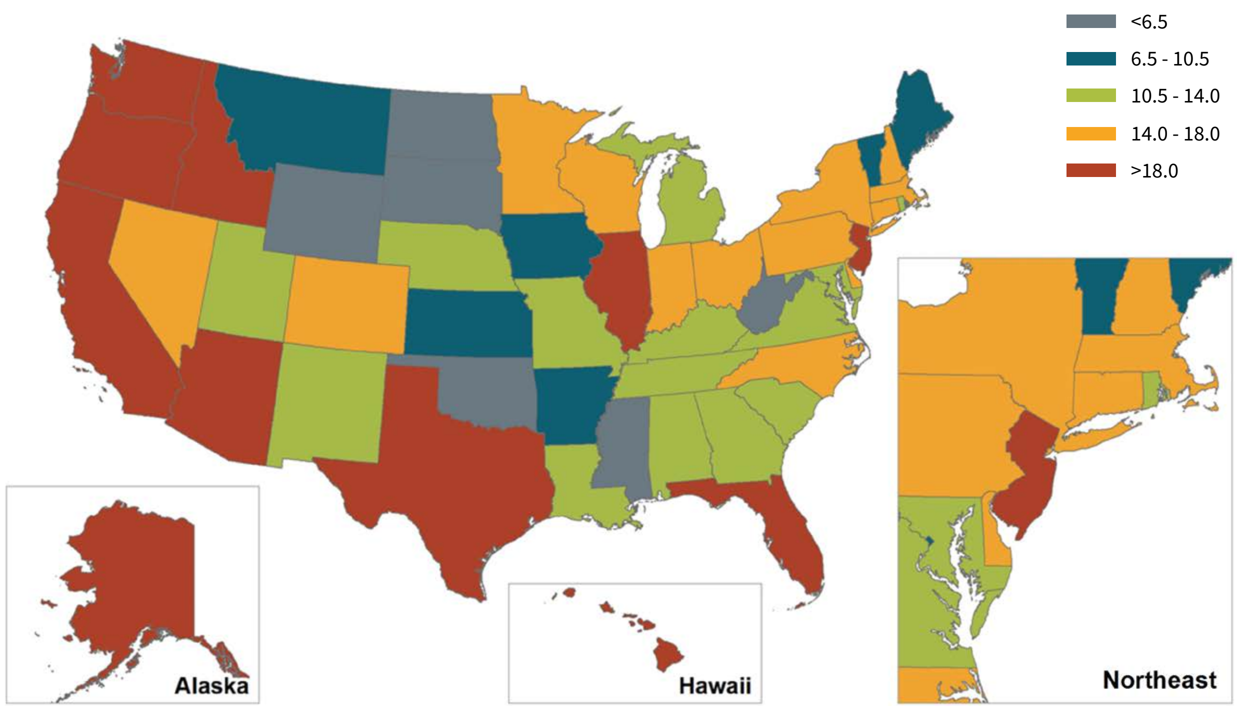
Figure 13 details the existing publicly available EVSE infrastructure in the top 15 states and nationally. Level 2 refers to AC charging and Level 3 refers to DCFC. According to PlugShare (Sept 2021), these top 15 states currently make up approximately 73% of all public EVSE nationally. CCalifornia is home to 28% of all charging locations and 30% of all charging stations in the U.S., although only 19% of Tesla-networked stations are found in California.

This stark difference in distribution between the Tesla network and the rest illustrates how Tesla's network is intended to support brand growth, compared to most charging networks, which seek to serve existing and forecasted demand.

FIGURE 13: U.S. PUBLIC ELECTRIC VEHICLE SUPPLY EQUIPMENT COUNTS, BY TYPE AND LEVEL

		CHARGING STATIONS					CHARGER OUTLETS			
STATE	CHARGING LOCATIONS	STATION COUNT	TESLA STATIONS	LEVEL 2	LEVEL 3	TOTAL OUTLET COUNT	LEVEL 2	LEVEL 3	TESLA DEST.	TESLA SUPER
California	7,790	26530	5,465	6,626	4,439	32603	22,002	5,136	1,927	3,538
New York	2,546	5457	1,628	3,321	508	6976	4,786	562	1,158	470
Florida	2,401	5312	1,492	3,134	686	6068	3,770	806	796	696
Texas	2,021	3869	1,240	2,202	427	4530	2,753	537	703	537
Washington	1,634	3700	565	2,599	536	4375	3,132	678	231	334
Massachusetts	1,254	2809	345	2,234	230	3984	3,366	273	105	240
Georgia	1,271	3040	708	1,878	454	3693	2,446	539	420	288
Colorado	1,261	2496	529	1,467	500	3205	2,072	604	288	241
Maryland	1,077	2728	351	1,822	555	3173	2,219	603	140	211
Virginia	1,072	2615	777	1,317	521	2889	1,491	621	395	382
Pennsylvania	1,247	2233	562	1,469	202	2748	1,925	261	256	306
North Carolina	1,157	2250	543	1,458	249	2669	1,829	297	279	264
Michigan	1,184	2318	366	1,607	345	2639	1,899	374	142	224
Illinois	1,163	2162	584	1,356	222	2569	1,680	305	278	306
Oregon	1,009	2140	383	1,401	356	2432	1,612	437	216	167
Top 15	**28,087**	**69659**	**15,538**	**43,891**	**10,230**	**84553**	**56,982**	**2,033**	**7,334**	**8,204**
National	**42,402**	**95290**	**22,213**	**59,013**	**4,064**	**115197**	**6,452**	**6,532**	**10,753**	**11,460**

FIGURE 14-A: MAP OF U.S. BY RATIO OF PLUG-IN ELECTRIC VEHICLES TO PUBLIC CHARGING STATIONS



Source: PlugShare, September 2021; S&P Global Mobility Vehicles in Operation, July 2021

High EV-to-EVSE ratios are visible along the West Coast and in Arizona, Florida, Illinois, New Jersey, and Texas (Figure 14). According to many internationally recognized sources, a ratio of greater than 15 EVs to 1 EVSE station represents a congested infrastructure. According to S&P Global Mobility custom analysis, nationally there are 19.7 EVs for every one charging stations, and looking at this state by state provides a stark picture of where the need is highest today. However, the states to focus on will change slightly in the future.

ELECTRIC VEHICLE RANGE VS. CHARGING TIME TRENDS

S&P Global Mobility forecasts look deep into the technical elements and components of all vehicles, including EVs. Just as ICE vehicles have long competed on certain technical efficiency ratings, EVs also differ in myriad ways. For example, while many EVs might

FIGURE 14-B: PLUG-IN ELECTRIC VEHICLES TO PUBLIC CHARGING STATIONS

STATE	TOTAL RATIO	LEVEL 2	LEVEL 3
California	29.0	41.4	96.3
Florida	19.3	26.0	74.0
Texas	21.5	28.7	86.4
New York	14.8	18.1	82.8
Washington	21.1	27.6	89.8
New Jersey	30.2	47.8	81.6
Arizona	31.1	42.4	116.1
Illinois	21.1	27.9	86.3
Massachusetts	15.5	18.6	92.6
Colorado	16.4	23.3	55.2
Oregon	18.4	24.4	75.4
Georgia	12.7	16.8	52.1
Pennsylvania	17.1	22.2	75.2
Maryland	13.5	18.7	47.9
Virginia	13.8	21.1	40.0
Top 15	**22.4**	**30.7**	**83.3**
National	**19.7**	**26.9**	**73.5**

have a similar-sized battery—often between 40 and 80 kilowatt-hour (kWh) in capacity—charging those batteries can vary based on on-board charging equipment, software, and even the chemistry of the battery cells. Other aspects like energy efficiency (miles per kWh) and driving range are often direct comparables.

According to S&P Global Mobility, looking across all EVs produced in North America in 2021, the weighted average driving range today is 317 miles on a full charge. This number is forecasted to drop down to 270 miles in 2025 as more lower-cost, lower-spec EVs begin outnumbering the higher-end, longer-range EVs that have made up a bulk of the current volume.

However, as these vehicles range from 270 to 315 miles or more, charging times will be a critical component to the end user's perception of convenience and user experience. Using the same weighted averaging, in 2021 the average EV produced in North America will take approximately 1.5 hours to charge to 80% on a 50 kW DCFC. Due to the model mix, charger technologies, and software, this number is expected to increase to approximately two hours by 2025. Interestingly, the rated charge times increase here due to a significant increase in battery capacity among the high-end, premium EVs, which skew the weighted average toward longer recharge rates. Another factor to consider for consumers is the state-of-charge (SoC) when they begin their session. SoCs will directly impact how fast or slow a charge session is completed.

The natural conclusion here is that the evolution of the public charging network must strive for higher power kW ratings on average, especially among Level 3 charging stations. However, a debate is currently underway on the viability of Level 2 AC charging versus high-powered Level 3 charging options. Many industry officals believe the effectiveness of an average Level 2 charging station with 7.2 kW of power on a full-size truck with a 150 kWh battery is pretty low, when it could very well take more than 20 hours to reach 80% charged. Meanwhile, if plugged into a high-powered 350 kW DCFC, the same truck might reach replace with 80% state of charge in three hours, with the first 10 minutes providing upward of 100 miles of range, before tapering off to lower power rates.

In reality, neither are a perfect solution. Low-power AC charging provides a lower cost to install, operate, and charge, which will attract economically oriented developers, whereas higher powered DCFC stations are not only much more expensive to install and operate but also drive higher costs to end users to overcome demand charges (which assess fees based on a customer's peak electricity usage) or result in higher margins to operators. Yet, despite the user-experience advantage, costs and physical installation constraints of high-powered DCFCs may prove to be too challenging to overcome for many developers.

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Herein lies a potential for a "Goldilocks solution." The 25 to 50 kW DCFCs have a smaller footprint than those 150 and 350 kW chargers, and while they require power transformers, they are still much less expensive to install and operate in the long run. Furthermore, they provide a decent charge time to both mainstream and high-end EVs without costing the end user as much in charge session fees. Obviously, all of these considerations will be measured when developers are choosing which power rating and technologies to install, but only the future will determine if these mid-range DCFCs prove most valuable in a majority of scenarios.

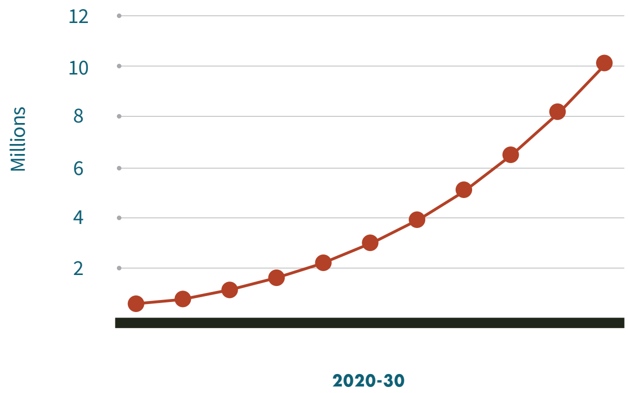
U.S. NATIONAL ELECTRIC VEHICLE SUPPLY EQUIPMENT FORECASTING

Among the major countries in the Americas, most of the charging station deployments are expected to be in the U.S., followed by Canada and Mexico. According to the S&P Global Mobility EV charging infrastructure forecast, in 2020, the U.S. accounted for about 90% of the charging stations deployed across North and South America; Canada accounted for 8%.

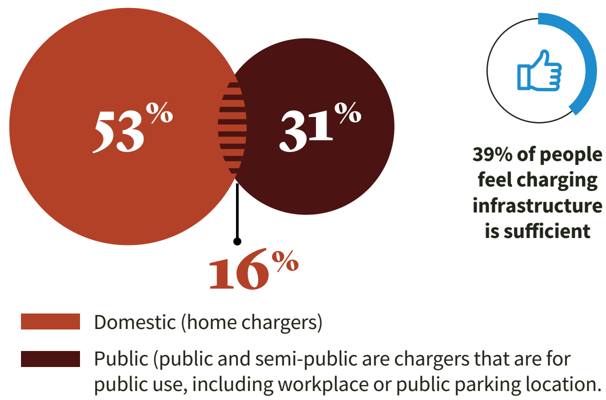
FIGURE 15: U.S. ELECTRIC VEHICLE SUPPLY EQUIPMENT INSTALLATION GROWTH

United States: Cumulative growth in domestic and public EV charging stations

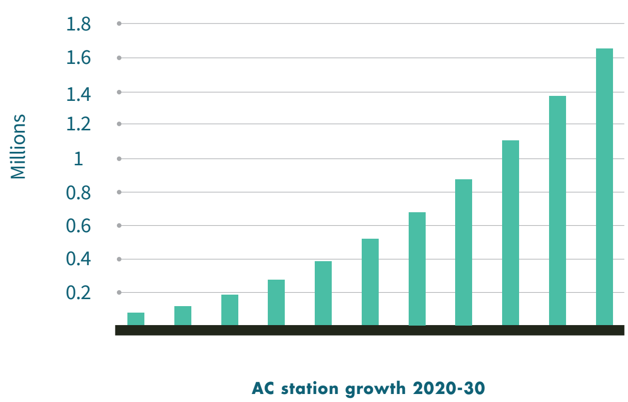
DOMESTIC CHARGING STATION GROWTH (2020-30)

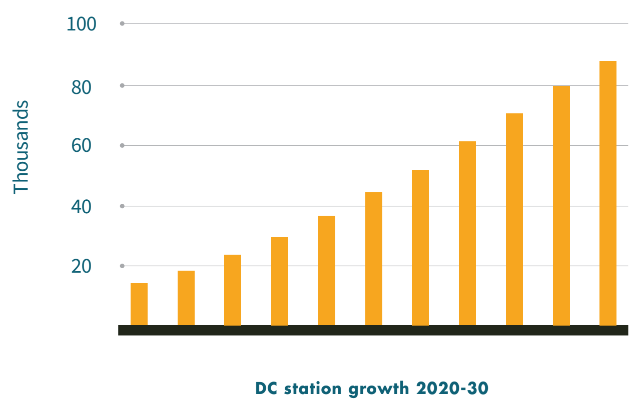


PREFERRED PLACE AND ADEQUACY OF CHARGING INFRASTRUCTURE



AC VS DC PUBLIC AND SEMI-PUBLIC CHARGING STATION GROWTH (2020-30)





Note: The E-Mobility consumer survey 2021 is a separate offering of S&P Global Mobility and is neither related to nor has any influence on the EV charging infrastructure forecast. The sufficiency of the charging infrastructure survey is not limited to the EV owners.

Source: S&P Global Mobility 2021

Domestic charging is still expected to be a preferred source of charging among U.S. EV owners and as such will grow to over 10 million charging stations in homes across the U.S. by 2030 (Figure 15). Furthermore, public charging stations will grow in commensurate volumes with AC charging reaching more than 1.7 million units by 2030 and DC charging reaching nearly 90,000 at the same time.

S&P Global Mobility expects that the on-road EVs in the U.S. will increase from 1.4 million in 2020 to about 18.1 million units in 2030, a massive 29% compound annual growth rate, and by that time will represent about 5.9% of the vehicle parc. Such rapid increase in EV penetration in the U.S. market, coupled with the favorable regulatory policy developed by the government, is driving the rapid deployment of both public and domestic charging stations in the U.S.

In November 2021, President Joe Biden signed into law a $1.2 trillion infrastructure bill.[12] The bill is expected to support the automotive industry in many ways, including improved road conditions, cleaner commercial vehicles, EV battery factories, battery recycling, and lithium mining and refining. However, one of the largest EV appropriations will be toward vehicle charging. Some $7.5 billion has been allocated to alternative fueling stations, primarily for EV chargers and supporting infrastructure across the country. S&P Global Mobility expects this funding will support the installation of approximately 400,000 new charging stations over the next five years through 2026. This is in comparison to the promise of 500,000 U.S. public charging stations that Biden promised voters by 2030.

S&P Global Mobility expects that the addition of 400,000 new public charging stations via Biden administration funding will not be enough to support the massive influx of EVs in the region by 2030. There will be a gap to fill.

According to PlugShare (Sept. 2021) in 2021, there were about 95,000 public charging stations in the U.S., of which approximately 22,000 were Tesla-specific charging stations, leaving only 73,000 for owners of other brands' EVs. S&P Global Mobility forecasts that by 2030, the cumulative deployment of public charging stations will increase to approximately 1.8 million units. At this level, the approximate EV-to-EVSE ratio nationwide would be 10.4, providing a nearly optimal ratio. As estimated, if we assume the infrastructure bill will provide 400,000 new stations, in addition to the 73,000 existing public stations, the U.S. will have a sizable gap of more than 1.3 million stations needed to keep the EV-to-EVSE ratio within a sustainable level.

We can presume that future federal funding may occur, but fortunately, the development of charging infrastructure in the U.S. is not limited to EVSE companies, original equipment manufacturers (OEMs), or the federal government; it is also driven by individual states, utilities, and corporate institutions that are actively partnering with technology suppliers to deploy an increasing number of charging stations.

S&P Global Mobility expects that the addition of 400,000 new public charging stations via Biden administration funding will not be enough to support the massive influx of EVs in the region by 2030. There will be a gap to fill.

The recent Southern California Edison plan to spend $436 million, together with New York utilities' plan to spend $701 million, will support the development of nearly 100,000 EV charging stations. (Walton, 2020) (Balaraman, 2020) Investments like these in multiple states should provide a substantial support against the federal funding to get the U.S. infrastructure to a sustainable density at 1.8 million stations by 2030. Because so much of the momentum will be carried by state- and utility-level investments, it is critical to investigate the state-level EV VIO trends to ensure infrastructure development is deployed where it will be in demand.

12 Infrastructure Investment and Jobs Act, H.R.3684, 117th Congress, introduced June 4, 2021, signed November 15, 2021, available at https://www.congress.gov/bill/117th-congress/house-bill/3684/text.

U.S. STATE-LEVEL ELECTRIC VEHICLE FORECASTING

PLUG-IN NEW VEHICLE SALES FORECAST

The EVSE forecasting in this report leverages S&P Global Mobility's unrivaled competency in light-vehicle sales forecasts for predicting the market demand. This forecast (Figure 16)represents new vehicle sales, different from vehicles in operation, and considers many factors and draws upon expertise from across S&P Global Mobility, incorporating model policy, economic indicators, production capacity, and more. This forecast is regionalized using a robust methodology combining factors of historical vehicle registrations, demographic and socioeconomic data, and housing development information to arrive at a granular forecast for use in planning EVSE requirements at a micro-geography level.

Shown in Figure 16, in 2030, California is expected to contribute 17.4% of new plug-in EV registrations (at roughly 484,000), and the top 15 states will contribute a combined 73.4% (versus 38% and 81% in 2006–2021, respectively). The growth in EVs is expected to expand in the coming years as traditional OEMs ramp up model rollouts and emerging start-ups work to establish their place in the market.

FIGURE 16: U.S. STATE-LEVEL PLUG-IN ELECTRIC VEHICLE SALES FORECAST THROUGH 2030, TOP 15 STATES

STATE	MODEL YEAR 2023	MODEL YEAR 2025	MODEL YEAR 2028	MODEL YEAR 2030
California	286,903	345,964	462,204	483,859
Texas	92,239	146,210	212,157	240,297
Florida	95,387	145,935	212,493	236,646
New York	74,661	99,022	129,026	154,760
Michigan	48,022	79,523	118,677	135,103
Illinois	48,867	67,185	87,384	102,730
New Jersey	46,528	62,212	81,945	99,202
Pennsylvania	40,211	55,818	75,989	91,512
Oklahoma	34,004	53,274	74,122	86,106
Ohio	33,858	50,565	70,337	84,952
Georgia	31,384	46,233	67,476	74,831
North Carolina	24,744	38,044	53,410	63,423
Virginia	25,598	35,249	51,305	62,172
Arizona	26,827	38,599	55,409	61,614
Massachusetts	30,434	36,895	49,386	58,891
Top 15	939,667	1,300,728	1,801,320	2,036,098
National	1,189,311	1,756,572	2,429,161	2,775,727

FORECAST OF ELECTRIC VEHICLES IN OPERATION

The new vehicle sales forecast in Figure 16 was subsequently converted to a VIO forecast through a methodology, which combines the historical VIO with forecasted sales, applies yearly scrappage, and models change-of-ownership as older-model EVs shift to different markets over time (Figure 17).

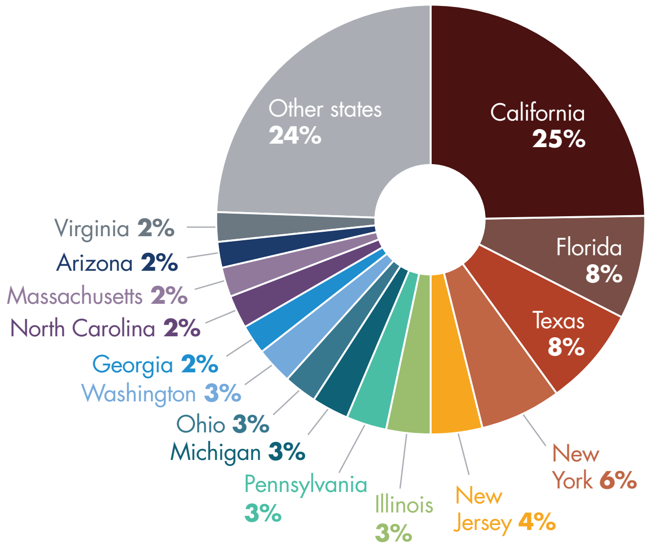
Figure 17 shows that, by 2030, California is expected to hold 24.9% of plug-in VIO with the top 15 states having a combined 75.7% (versus 41% and 81.7% in 2006–2021, respectively). The percentage growth from 2025 to 2030 is expected to vary widely by state as emerging markets pick up speed and states home to early adopters build on their existing base. To achieve this growth to 2025, 2030, and beyond, a significant investment in infrastructure is required to support mass-market adoption of EVs.

It is important to contrast the significant growth rates in EV VIO with the forecasted EV VIO market share, when combined with ICE and hybrid vehicles. To this end, nationally, the U.S. vehicle parc is forecasted to be approximately 307 million vehicles in 2030 among all cars, light trucks, and SUVs. Even as sales and cumulative VIO of EVs expand, the market is only expected to have about 5.9% be plug-in EVs by then.

FIGURE 17: U.S. STATE-LEVEL PLUG-IN ELECTRIC VEHICLES IN OPERATION FORECAST THROUGH 2030, TOP 15 STATES

STATE	VIO 2025	VIO 2030	GROWTH 2025-30
California	2,943,532	4,518,839	53.5%
Texas	373,007	1,413,638	279.0%
Florida	353,572	1,367,370	286.7%
New York	384,381	1,118,911	191.1%
Michigan	219,987	690,699	214.0%
Illinois	186,769	585,425	213.4%
New Jersey	169,174	577,492	241.4%
Pennsylvania	121,643	490,824	303.5%
Oklahoma	123,873	474,604	283.1%
Ohio	268,907	465,586	73.1%
Georgia	141,039	439,410	211.6%
North Carolina	128,006	411,960	221.8%
Virginia	191,189	408,620	113.7%
Arizona	159,463	393,973	147.1%
Massachusetts	149,554	378,517	153.1%
Top 15	5,914,098	13,735,870	132.3%
National	7,457,557	18,149,360	143.4%

2030 PLUG-IN VIO FORECAST BY STATE



U.S. STATE-LEVEL ELECTRIC VEHICLE SUPPLY EQUIPMENT FORECASTING

The forecasting of EVSE is a data driven process, taking into consideration the expected future plug-in electric vehicles in operation along with factors which influence out-of-home charging requirements including housing mix, miles traveled, and parking habits. The S&P Global Mobility methodology combines these inputs and was used to forecast EVSE requirements at a CT level. This highly granular forecast was then aggregated for the purpose of this report. A state-level prioritization has been created from the resulting aggregation to help guide industry stakeholders in the coming years.

PRIORITIZATION OF ELECTRIC VEHICLE SUPPLY EQUIPMENT EXPANSION BY STATE

The state prioritization can help planners and investors understand the level of EVSE development that is required to support the growth and adoption of plug-in EVs in each state. As shown in Figure 2 in the executive summary of this report, California stands alone as the top priority simply due to the huge volume expectations for this state, which has already gone far and above the rest of the country in terms of adoption, but as is seen in subsequent exhibits there are vastly differing levels of investment required for sub-areas of the state.

The next priority level is dominated by the high-population states of Florida, New Jersey, New York, and Texas. This group will require massive investment in EVSE to support the large volume of EVs expected to be registered by 2030 if even a relatively modest percentage of drivers adopt these vehicles.

Priority 3 states are those with minimal EV adoption today but stand to see the largest percentage growth rates. The total volume in these states will still be light in comparison to much of the country, but reasonable adoption is foreseeable if they have the infrastructure in place to lead growth.

Finally, Priority 4 states are those where expected volume is low to moderate but the growth rate is not astronomically higher than the national average. Some of these states already have relatively strong adoption of EVs and in general are expected to be good destinations for willing investors to expand EVSE networks and support growth over the coming years.

FIGURE 2: U.S. STATE-LEVEL ELECTRIC VEHICLE SUPPLY EQUIPMENT GROWTH PRIORITIZATION

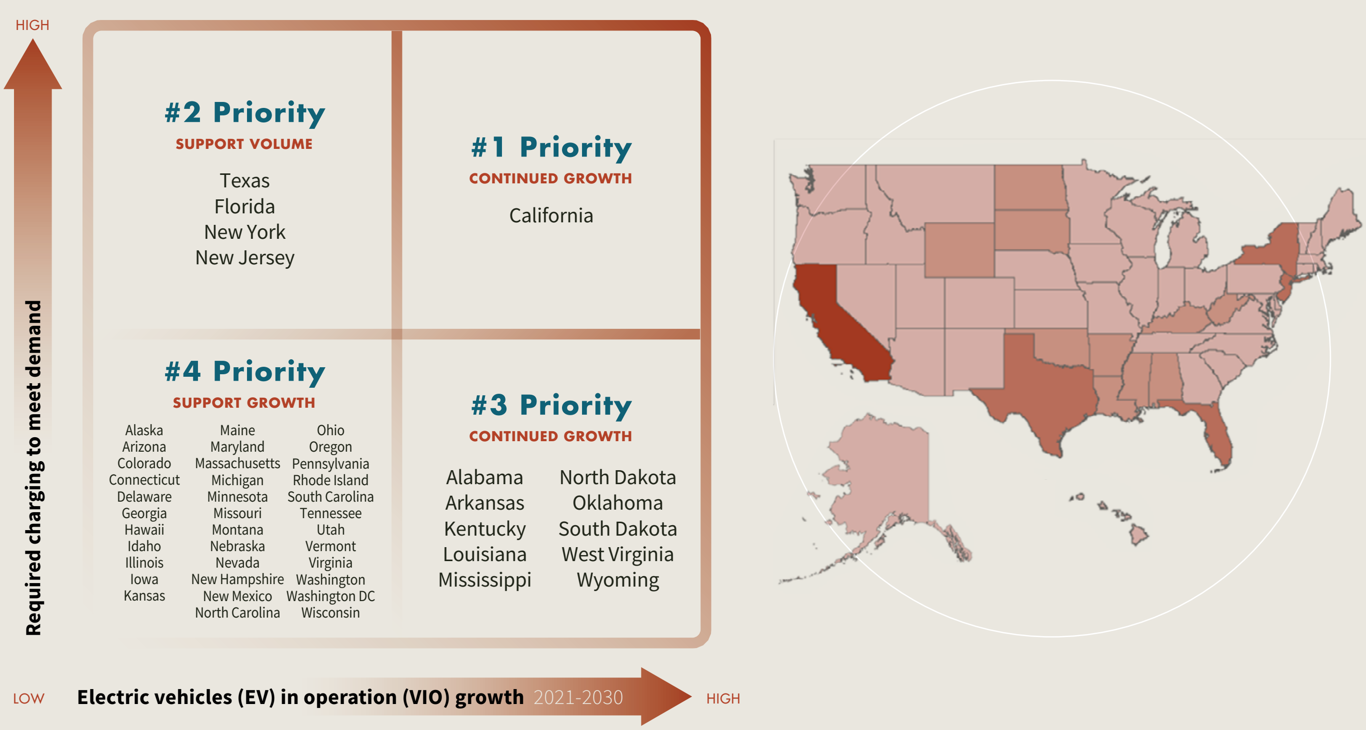


Figure 18 shows a matrix visualized in more quantifiable terms, with California excluded to help with chart scaling. In the upper left, the high-volume states of Florida, New Jersey, New York, and Texas have public AC EVSE (Level 2) requirements of 75,000 stations, up to nearly 130,000 for Texas. Of note, New Jersey and Texas have a lower volume of EVs in operation than Florida and New York, respectively, but are expected to require more EVSE due to the factors driving high rates of out-of-home charging.

Figure 19 is an expanded view of the lower left quadrant of Figure 18 to show how each of the Priority 4 states are plotted. This shows states like Illinois, Massachusetts, and Michigan will all need more than 45,000 AC charging stations installed and operational by 2030. This still pales in comparison to California or Texas, but it separates the Priority 4 states into yet another priorty split. Due to many factors, several states will need fewer than 10,000 AC charging stations by 2030 to sustain their forecasted EV VIO.

Additionally, Figure 20 tells a similar story for DCFC requirements, albeit with a lower overall volume. Florida, New Jersey, New York, and Texas all still place well into the Priority 2 zone, requiring between 3,200 and just under 6,000 DCFCs in place by 2030 to support the growth in the region. Notably, there are 15 states shown that will require 1,000 DCFCs in place (or more) by 2030 for a sustainable infrastructure.

FIGURE 18: 2030 REQUIRED AC CHARGING STATIONS, BY STATE AND PRIORITY LEVEL

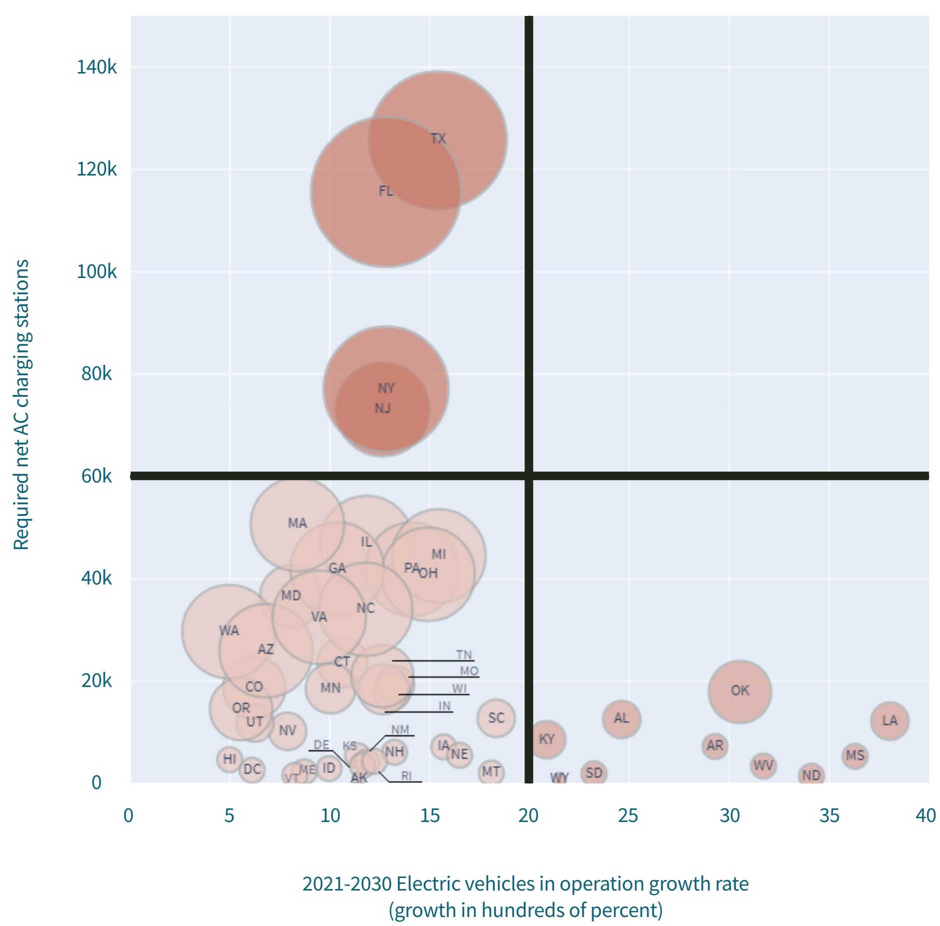


FIGURE 19: 2030 REQUIRED AC CHARGING STATIONS, PRIORITY 4 LEVEL STATES ONLY

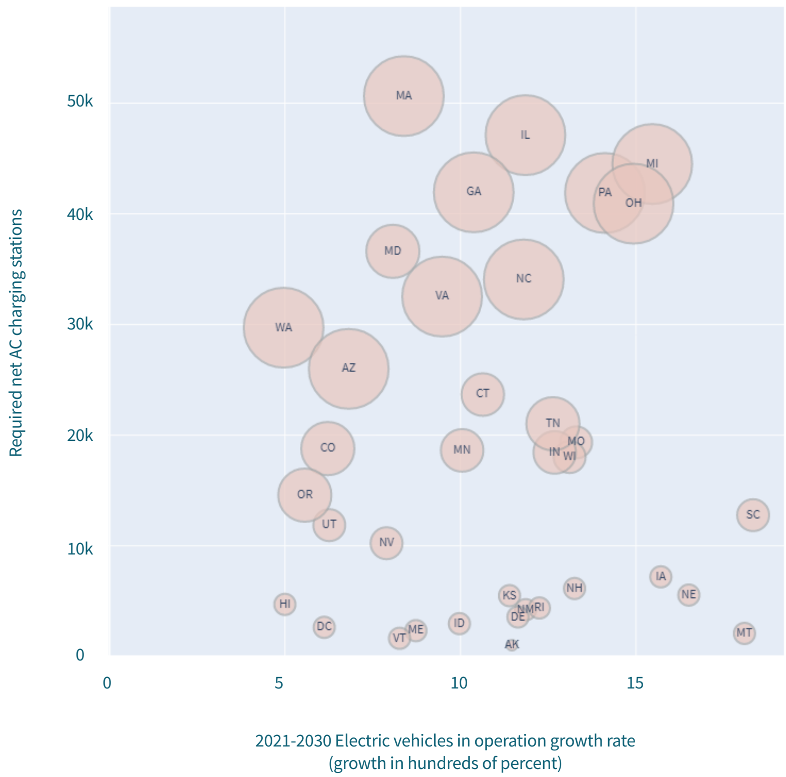


FIGURE 20: 2030 REQUIRED DC FAST CHARGING STATIONS, BY STATE AND PRIORITY LEVEL

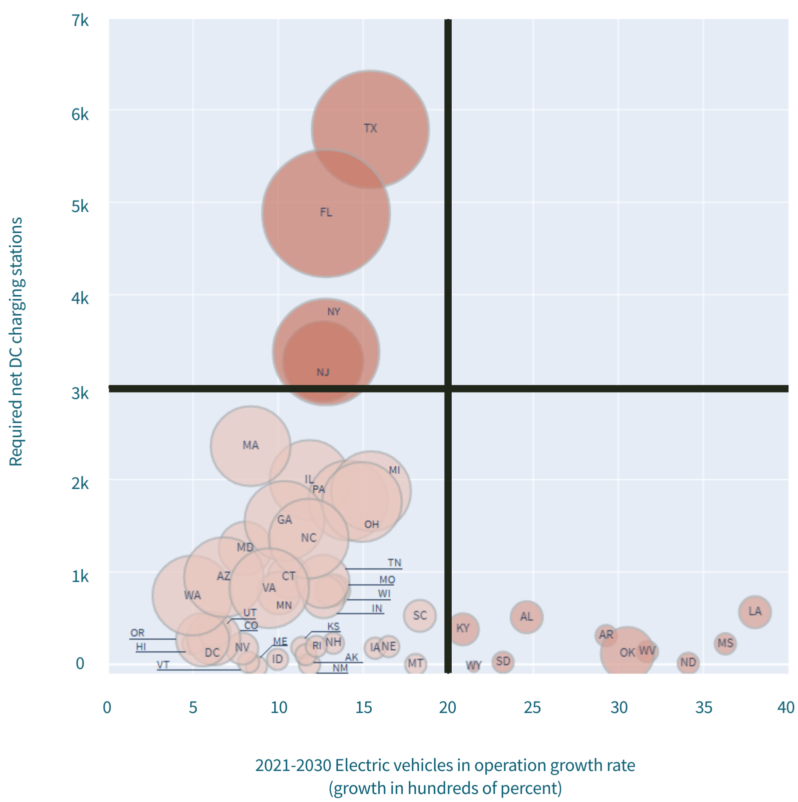


FIGURE 21: 2030 REQUIRED DC FAST CHARGING STATIONS, PRIORITY 4 LEVEL STATES ONLY

Likewise, Figure 21 is an expanded view of the lower left quadrant of Figure 20 to show Priority 4 states in greater detail. Interestingly, due to higher corridor traffic and population levels, the DCFC station requirements in Pennsylvania and Ohio will be much closer to Michigan and Illinois, which had a larger relative gap among AC charging needs. Nevertheless, most of these Priority 4 states will need more than 500 DCFC stations to sustain the EV VIO in 2030, separating them from lower-focus states in the Priority 4 range.

The primary factor influencing these results is per capita vehicle miles traveled. U.S. Department of Transportation data from July 2021 was used in conjunction with S&P Global Mobility VIO to index where travelers are taking longer trips. Drivers on urban New Jersey roads were shown to travel 26% farther than the regional average. Conversely, New York drivers tend to stay closer to home, traveling 19% less distance per capita.

Another critical factor that influences where charging infrastructure will be required on a micro-geography level is housing mix. Areas with a higher occurrence of multi-family dwellings will require more charging close to home given that, in general, home-charging infrastructure will be a greater challenge for these dwelling types. Considering that, nationally, approximately 74% of housing is single family with off-street parking or a garage, the housing mix is less of an influence when looking at a state-level view. But in local markets, understanding where multi-family dwellings are and where the EV owners in these dwellings park when they aren't at home will be critical in the development of convenient and sufficient EVSE infrastructure for those who cannot charge at home as readily.

A simple way to understand the required investment in EVSE through 2030 is to compare the required infrastructure to the volume of EVs in operation (Figure 22). Keeping in mind the expected national average of 11 EVs per Level 2 AC charger in 2030, with local adjustments based on per capita miles traveled and housing mix, the huge requirements of Priority 1 and 2 states compared to that of Priority 3 and 4 are clearly visualized. Amazingly, Figure 22 shows regions of California, like the Bay Area and Southern California, have the same (or greater) EVSE growth requirements as entire states, like Texas or Florida (see the next section for more information on how California is subdivided).

FIGURE 22: 2030 REQUIRED AC CHARGING STATIONS AND PROJECTED ELECTRIC VEHICLES IN OPERATION BY STATE (CALIFORNIA BREAKOUTS)

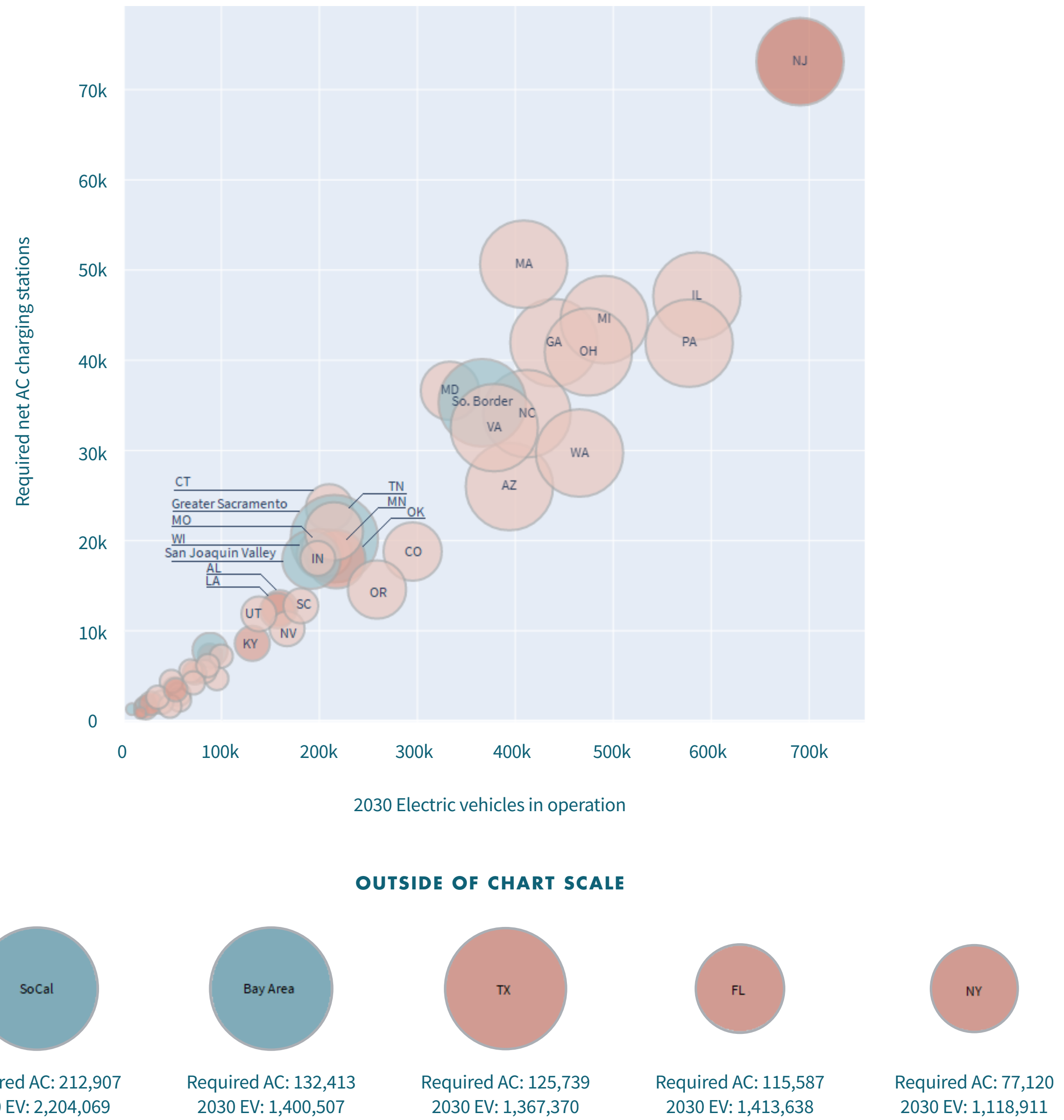


FIGURE 23: 2030 REQUIRED AC CHARGING STATIONS AND PROJECTED ELECTRIC VEHICLES IN OPERATION BY LOWER PRIORITY STATES COMPARED WITH SPECIFIC CALIFORNIA REGIONS

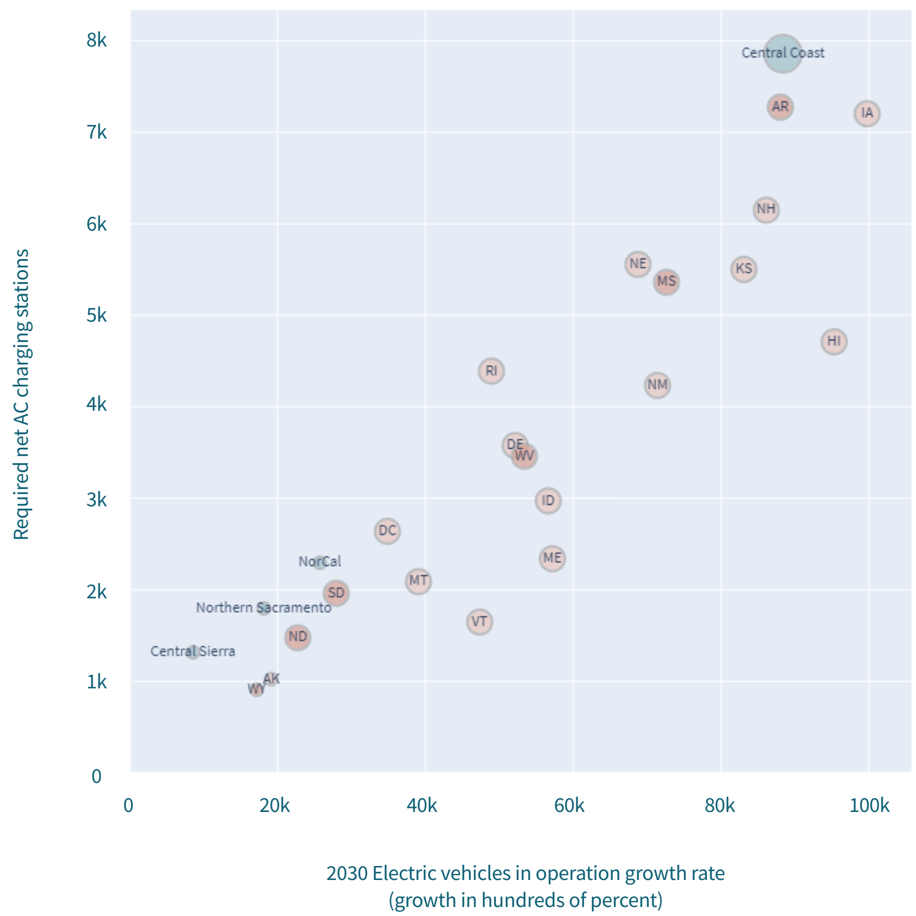


Figure 23 expands the lower left quadrant of Figure 22 to illustrate where some of the smaller regions of California by EV volume sit relative to the smaller states in the nation. The discrepancy throughout California is quite pronounced, with Southern California far and above even the largest of the Priority 2 states, while Greater Sacramento slots in among medium-volume Priority 3 and 4 states such as Tennessee or Connecticut. Northern California on the other hand falls among the lowest volume states (but nonetheless, this unpopulated area still matches the volume of several states in 2030).

PRIORITIZATION OF ELECTRIC VEHICLE SUPPLY EQUIPMENT EXPANSION WITHIN CALIFORNIA

Figure 24 illustrates the map of California broken out into nine economic regions, which brings the state's constituent parts in line with state-level numbers.

As seen in Figure 24, Southern California and the Bay Area (highlighted in dark blue in Figure 24) are still as large as Texas and Florida in terms of projected 2030 EV volume and EVSE needs, requiring roughly 210,000 and 140,000 AC chargers respectively by 2030. (Figure 25)

FIGURE 24: CALIFORNIA'S NINE MAJOR ECONOMIC REGIONS

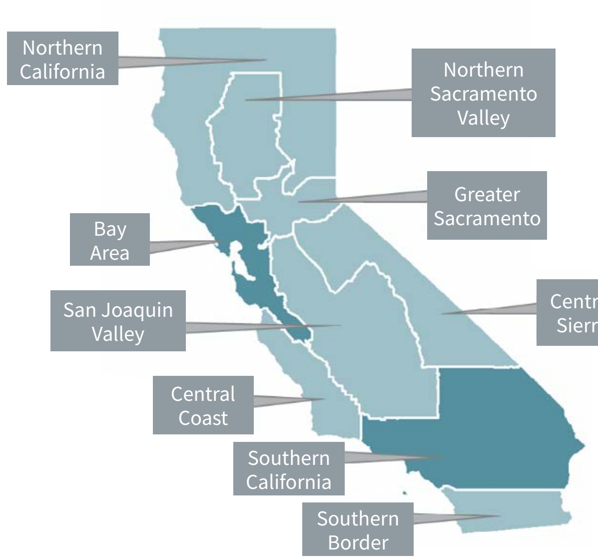
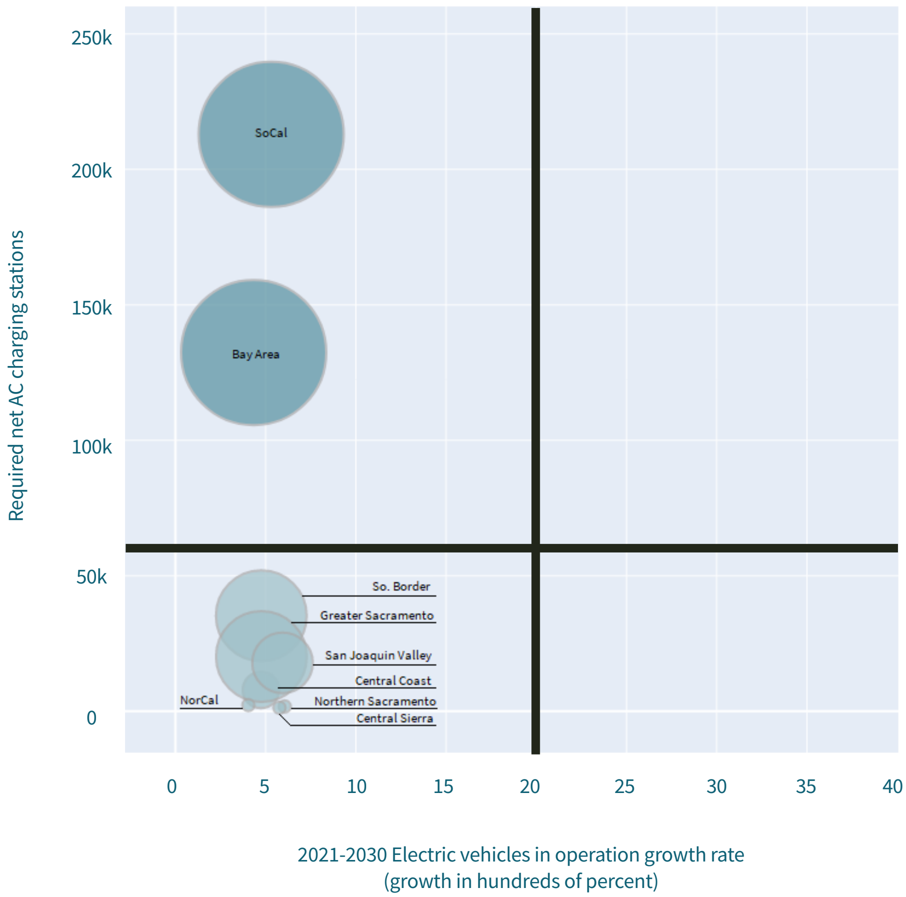


FIGURE 25: 2030 REQUIRED AC CHARGING STATIONS AND PROJECTED ELECTRIC VEHICLES IN OPERATION, CALIFORNIA BREAKOUTS ONLY



IDEAL FORECAST ELECTRIC VEHICLE TO ELECTRIC VEHICLE SUPPLY EQUIPMENT RATIOS IN 2030

The recommended EV-to-EVSE ratio in 2030 varies widely by state and compared to what we see today. California should have a much lower ratio to support true mainstream adoption of EVs and the ultimate push toward a pure electric future. Given that the large majority of EVs currently purchased are additions to the garage and that the EV market primarily sits in a premium segment, the need for out-of-home charging is likely far less for the average consumer today than it will be in the future. When the day comes that the typical EV consumer is a mass-market car buyer with no ICE vehicle in the garage for longer journeys or lives in an apartment complex with no dedicated at-home EVSE, the need for charging throughout the day publicly and semi-publicly will become of more paramount importance.

Figure 26 details how the forecast should evolve in each of the top 15 states and nationally. Overall, the 2030 ideal number of EVs to EVSE nationally is about 10.4 to 1 public/semi-public EVSE. This ideal figure would ensure that all markets across the whole of the U.S. do not experience infrastructure congestion and that EVSE is available to consumers across the common-place use of their vehicle.

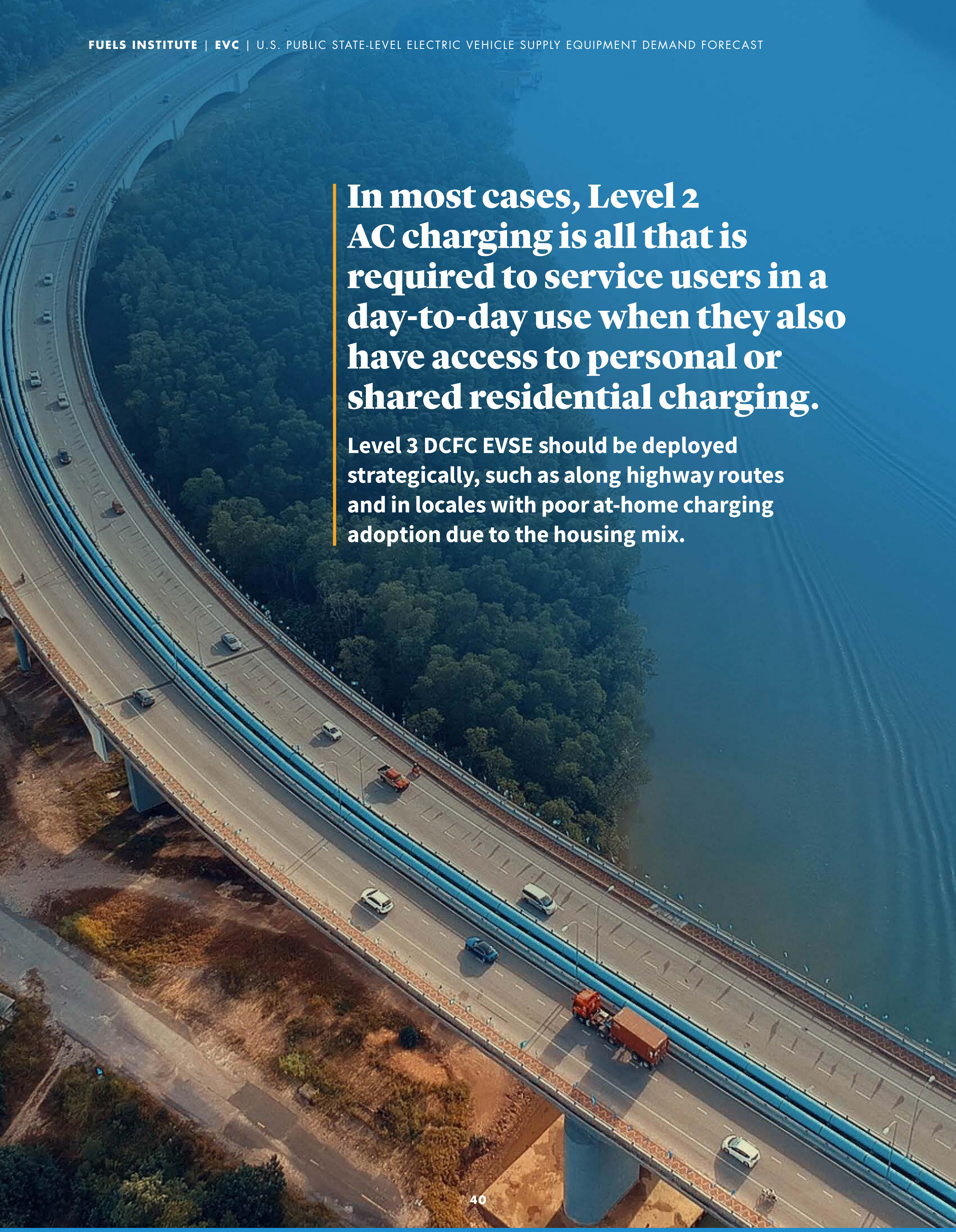
FIGURE 26: 2030 U.S. ELECTRIC VEHICLES IN OPERATION AND ELECTRIC VEHICLE SUPPLY EQUIPMENT RATIO FORECAST, TOP 15 STATES

STATE	ELECTRIC VEHICLES IN OPERATION	AC REQUIRED	DC REQUIRED	AC RATIO	DC RATIO	OVERALL RATIO
California	4,518,839	455,915	24,216	9.9	186.6	9.4
Florida	1,413,638	120,153	6,382	11.8	221.5	11.2
Texas	1,367,370	129,196	6,862	10.6	199.3	10.0
New York	1,118,911	83,065	4,412	13.5	253.6	12.8
New Jersey	690,699	74,426	3,953	9.3	174.7	8.8
Illinois	585,425	49,072	2,606	11.9	224.6	11.3
Pennsylvania	577,492	44,072	2,341	13.1	246.7	12.4
Michigan	490,824	46,548	2,472	10.5	198.5	10.0
Ohio	474,604	42,619	2,264	11.1	209.7	10.6
Washington	465,586	33,079	1,757	14.1	265.0	13.4
Georgia	439,410	44,814	2,380	9.8	184.6	9.3
North Carolina	411,960	36,184	1,922	11.4	214.4	10.8
Massachusetts	408,620	54,115	2,874	7.6	142.2	7.2
Arizona	393,973	27,380	1,454	14.4	270.9	13.7
Virginia	378,517	34,414	1,828	11.0	207.1	10.4
Top 15	**13,735,870**	**1,275,050**	**67,724**	**10.77**	**202.8**	**10.2**
National	**18,149,360**	**1,649,942**	**87,636**	**11.00**	**207.1**	**10.4**

Given that the large majority of EVs currently purchased are additions to the garage and that the EV market primarily sits in a premium segment, the need for out-of-home charging is likely far less for the average consumer today than it will be in the future.

Our approach to forecasting the mix of Level 2 and Level 3 does not necessarily reflect how the market will ultimately play out but is intended to predict what is required if EVSE is deployed optimally based on EV vehicles in operation volumes regionally. In most cases, Level 2 AC charging is all that is required to service users in a day-to-day use when they also have access to personal or shared residential charging. Level 3 DCFC EVSE should be deployed strategically, such as along highway routes and in locales with poor at-home charging adoption due to the housing mix. It is important to note that S&P Global Mobility's assumptions for DCFC volumes were modeled prior to the release of the NEVI (National Electric Vehicle Infrastructure) Program Formula in February 2022.

Level 3 EVSE, of course, provides faster charging throughput, but this is not always of tangible benefit. According to the S&P Global Mobility mobility trace data, cars parked at shopping malls and other POIs have a higher likelihood of a 1-4 hour dwell time, where having more Level 2 EVSE is generally better than having only a few Level 3 EVSE. Cars often remain parked in charging spots for longer than needed in these environments, so why bother deploying an EVSE geared to high vehicle turnover when the investment can be better spent on being able to serve a higher concurrent volume of vehicles.



In most cases, Level 2 AC charging is all that is required to service users in a day-to-day use when they also have access to personal or shared residential charging.

Level 3 DCFC EVSE should be deployed strategically, such as along highway routes and in locales with poor at-home charging adoption due to the housing mix.

SELECT METRO-LEVEL ELECTRIC VEHICLE SUPPLY EQUIPMENT FORECASTING

It is important to view the EVSE forecasts on a micro-level of geography, because EVSE deployment is going to physically occur in the locales and municipalities where people live and work – and not on a federal or even state level.

To this point, this section provides a few samples for how EVSE forecasting will vary in different cities and core-based statistical areas (CBSAs) in the U.S. This section will look deeper at Detroit, Michigan, Dallas–Fort Worth, Texas, and Portland, Oregon, comparing how infrastructure looks today and how these cities should be addressing future charging demand and equity.

CASE STUDY

A Charging Desert in Detroit, Michigan

The EV landscape in 2021 reveals the segregation of EV buyers and inadequate infrastructure for vast parts of the population, particularly in low-income areas (visualized in blue in Figure 27). The area surrounding the downtown of Detroit is a particularly pronounced example, but situations like this exist throughout the U.S., even in California where EV adoption is most advanced.

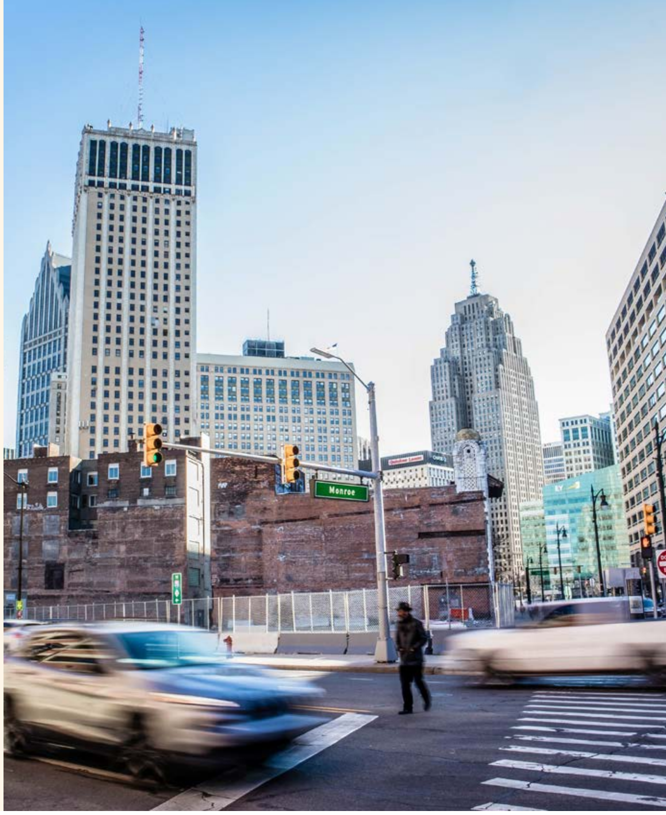


FIGURE 27: DETROIT, MICHIGAN: CHARGING DESERT IN THE CITY

15,350
EVs in operation

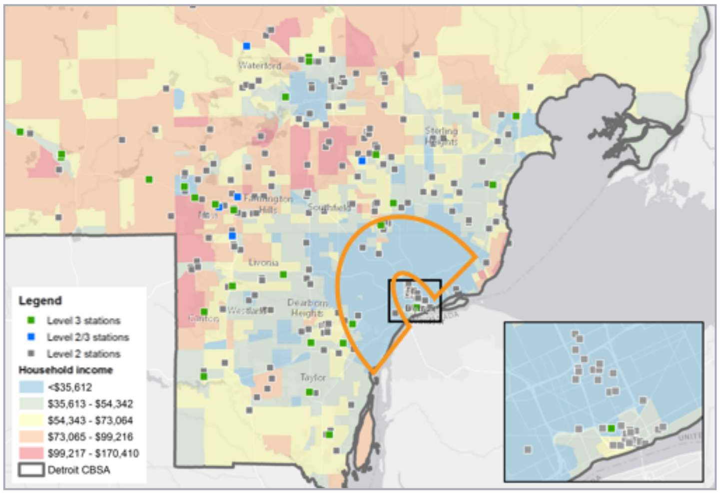
LEVEL 2 | LEVEL 3
861 | 119
Public EVSE

16.0
RATIO
Aligned to national average

15% of EV buyers are African American and Hispanic vs 25% total industry

74% of EV buyers are part of wealthy lifestage groups vs 40% for total industry

OVERLAY OF INCOME AND CHARGING POINTS

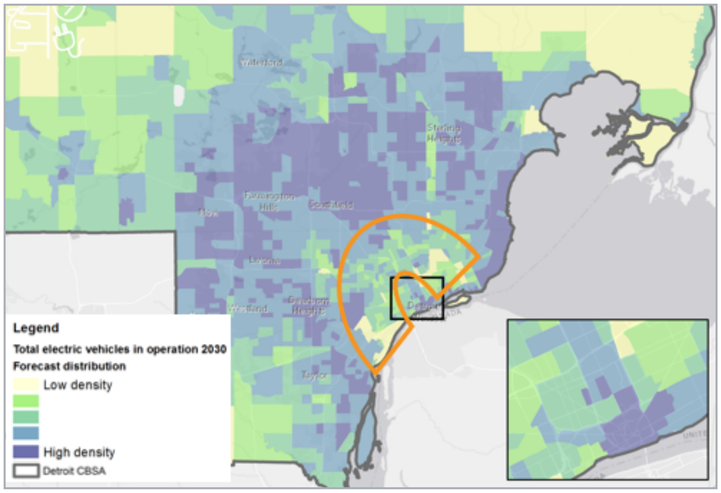


According to S&P Global Mobility custom analysis, 74% of EV buyers are apart of households that make more than $100,000 a year, compared to 44% for the overall automotive industry, which is of course a result of the luxury-leaning EV model lineup today. Furthermore, only 15% of today's EV buyers are African American or Hispanic, whereas those groups make up one-quarter of the whole U.S. automotive ownership. All of these factors have ramifications for where accessible, affordable charging stations are installed.

To ensure the success of mass-market EVs across the U.S.—which will require adoption from lower-income and more diverse buyers—the gaps in network coverage, which exist today, must be identified and filled in the coming years.

FIGURE 28: DETROIT, MICHIGAN: 2030 ELECTRIC VEHICLES IN OPERATION DISTRIBUTION BY CENSUS TRACT

ELECTRIC VEHICLES IN OPERATION
2030 forecast and distribution at census tract



MILES TRAVELLED INDEX

113%
vs North-Central average for urban roads

HOUSING MIX INDEX

72.3%
vs national average

PUBLIC/SEMI-PUBLIC EVSE DEMAND FORCAST 2030

EVSE LEVEL 2
28,125
AC charging

EVSE LEVEL 3
1,420
Fast charging

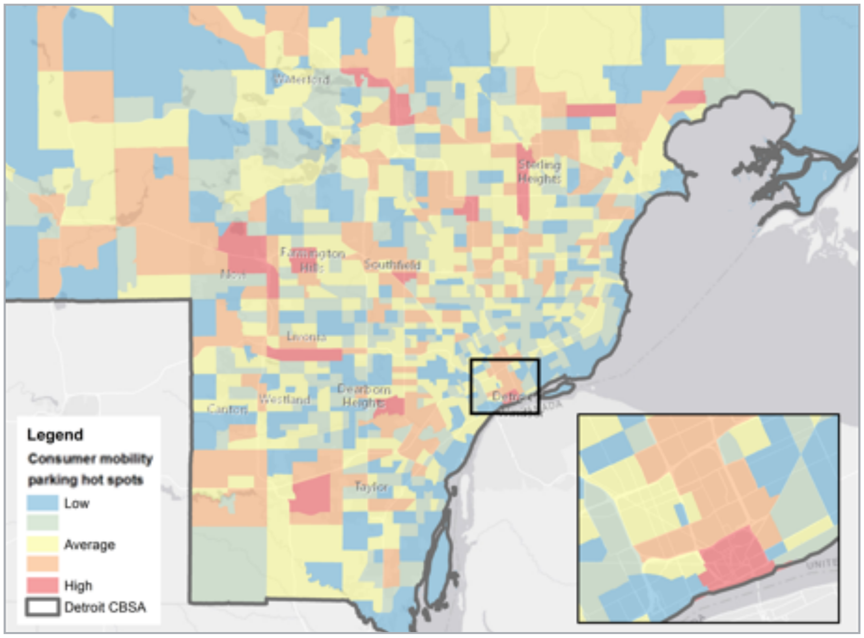
Figure 28 illustrates that, by 2030, EV VIO will reach a moderate density within the areas of Detroit with households whose self-reported income were in the lowest income bracket (avg. household income of $49K<), as mass-market OEMs roll out economy-class options and older-model EVs contribute to used car supply. The suburban areas of the CBSA will also expand in volume over this period, and to support this growth, the Detroit CBSA is expected to need 28,125 Level 2 AC chargers and 1,420 Level 3 DCFCs by 2030 to support that future EV charging demand.

Our housing mix index looks at the ratio of multi-family homes to single-family homes, and while the national average is approximately 74%, the Detroit CBSA indexes below that average of multi-family housing at around 72.3% of the index average. This means it has a higher percentage of single-family homes than the national average.

Furthermore, the vehicle miles traveled (VMT) index for the Detroit CBSA is also higher than other cities in the North Central U.S. region (U.S. Bureau of Transportation Statistics (BTS), 2021)at 113% of the index average. Both the lower percentage of multi-family homes and the statistically longer drive times contribute to a respectively low requirement of Level 2 AC charging—a technology that meets the needs of more buyers with long commutes and no garage at home for charging.

FIGURE 29: DETROIT, MICHIGAN: CURRENT PARKING HEAT MAP PATTERNS

PARKING HEAT MAP BASED ON CONSUMER MOBILITY PATTERN

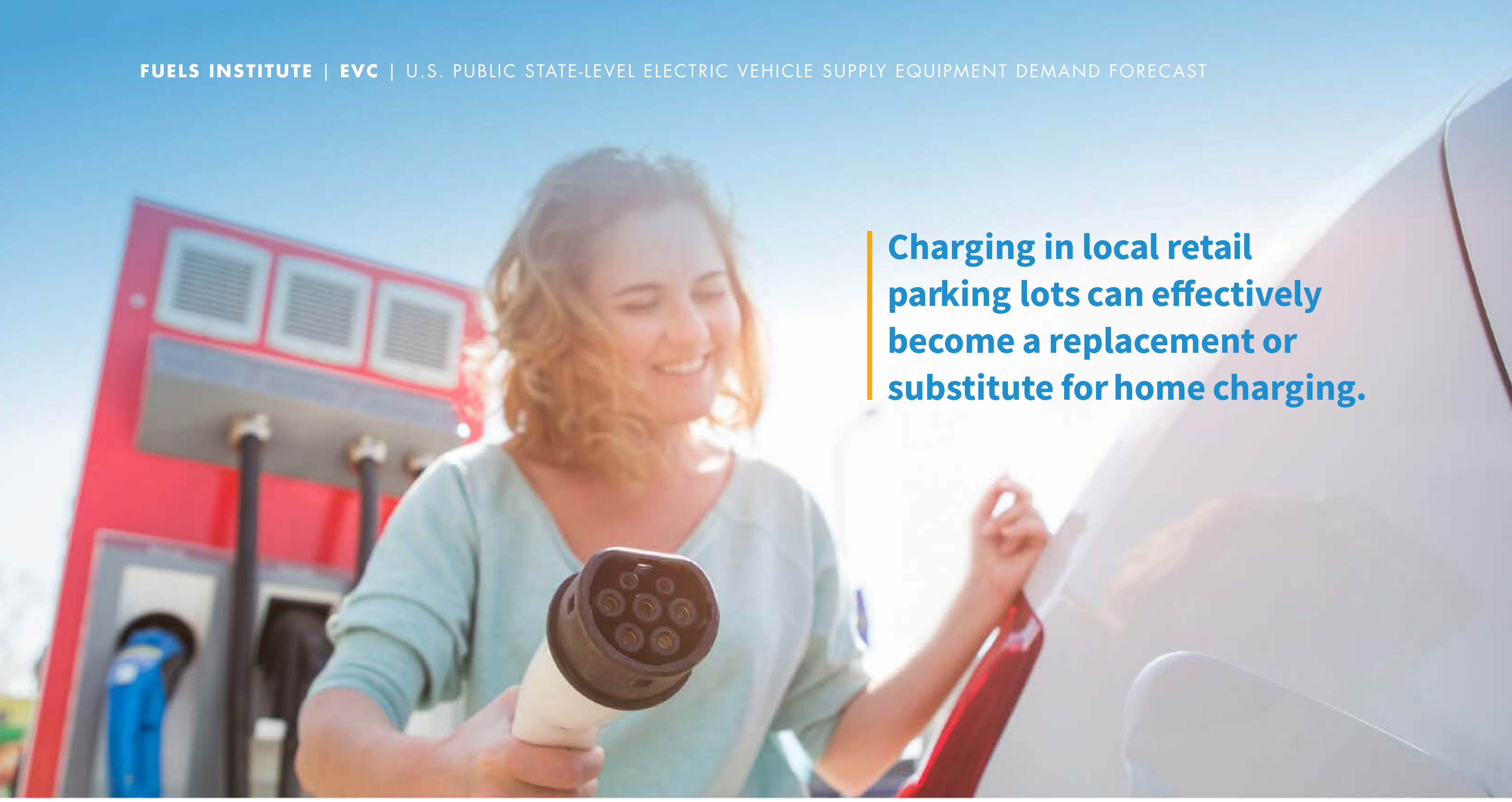


BIG DATA ANALYTICS TO IDENTIFY

- **Consumer traffic**
- **Parking hot spots**
- **Catchment areas**
- **Frequency and intervals**
- **Predicted high load times**

S&P Global Mobility used consumer mobility data to identify where a population is moving throughout the day, to better inform where people park and, subsequently, where they will want public charging. To prevent (or eliminate) EV charging deserts, government and industry will have to install charging stations where they are not prevalent today, to encourage EV sales growth. EV registration distribution is not the most relevant factor; understanding consumer mobility pattern is key. Figure 29 shows the parking hot spots in the Detroit CBSA, based on these patterns.

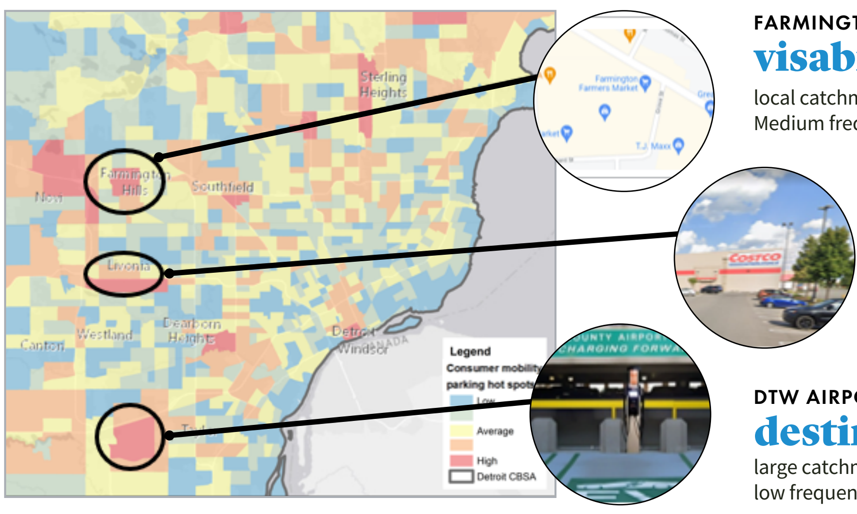
Thus, we have a classic “chicken and egg” problem—consumer mobility and behavior drive local infrastructure deployment, yet without the EVs on the road, infrastructure build-out seems illogical. However, as mentioned earlier, the consumer perception of accessible charging is a common reason against the adoption of EVs. In today’s market, general consensus says if you build infrastructure where consumers can find it (i.e., where they are parking) then EV adoption will succeed.



Charging in local retail parking lots can effectively become a replacement or substitute for home charging.

FIGURE 30: DETROIT, MICHIGAN: CURRENT PARKING HEAT MAP PATTERNS, OVERLAID WITH POINT OF INTEREST DATA

PARKING HEAT MAP BASED ON CONSUMER MOBILITY PATTERN



FARMINGTON RETAIL CENTER

visability + convenience

local catchment area
Medium frequency | Ø 1,884 vehicles/day

LIVONIA BIG BOX RETAIL

convenience charging

medium catchment area
high frequency | Ø 3,610 vehicles/day

DTW AIRPORT

destination charging

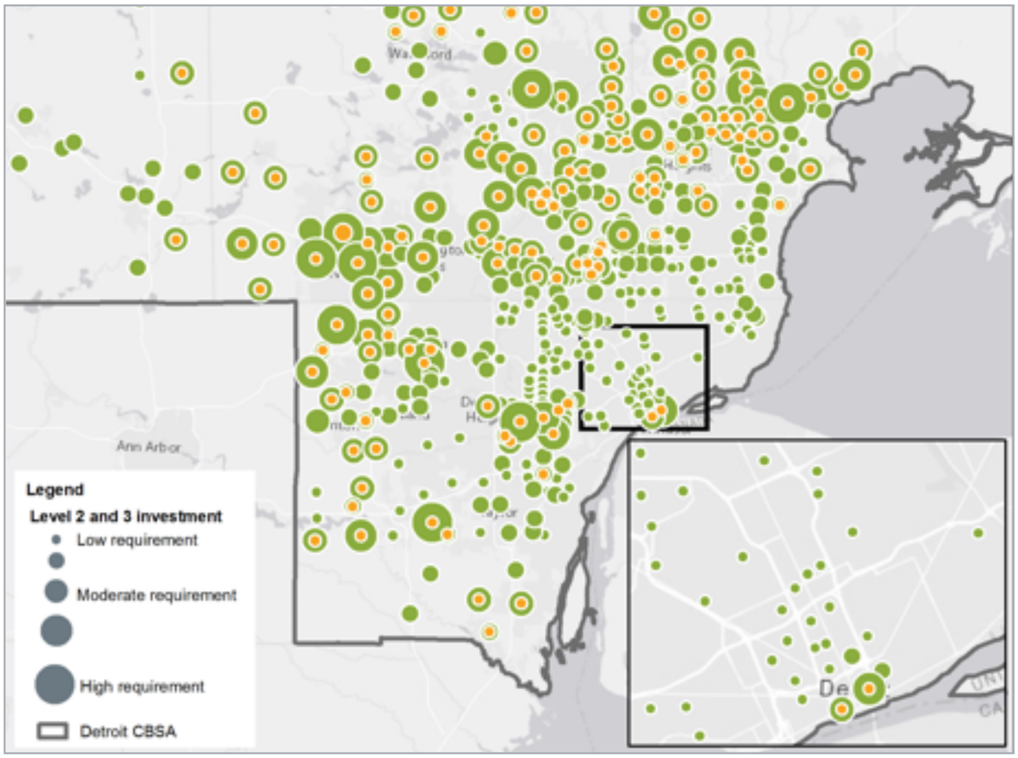
large catchment area (extending beyond Detroit CBSA)
low frequency

Looking deeper in the data, it is important to consider actual implementation strategy, as this may vary based on the POI around any particular parking hotspot. As shown in Figure 30, destination charging (such as airports) has a larger catchment area and less frequency of use by individuals. On the other hand, charging in local retail parking lots has a smaller catchment area but higher frequency and can effectively become a replacement or substitute for home charging for individuals with home-charging constraints.

FIGURE 31: DETROIT, MICHIGAN: MAP OF ELECTRIC VEHICLE SUPPLY EQUIPMENT INSTALLATION REQUIREMENTS BY 2030

Level 2 EVSE   Level 3 EVSE

LEVEL 2 AND 3 INVESTMENTS UNTIL 2030 BY MICRO LOCATION



The implementation of EVSE infrastructure will inevitably follow demand but must also encourage EV adoption. The level of investment required in the current charging desert, in the Detroit CBSA, is small relative to the overall market but must not be overlooked. As shown in Figure 31, Level 2 EVSE must grow dramatically, represented by the larger green bubbles throughout the near suburbs to Detroit. Furthermore, Level 3 DCFCs should be distributed widely among the northern suburbs and along the major corridors, such as the highways to Ann Arbor, Michigan.

To promote EV ownership across all groups, equitable and convenient charger access for all is critical, with the number and types of chargers scaled appropriately to potential demand.

CASE STUDY

Supporting Growth in Dallas, Texas

Highly populous metros in states with fast-growing EV volumes are struggling to maintain a stable ratio of vehicles to chargers. Dallas–Fort Worth, Texas, has this problem. Figure 32 shows the CBSA's current ratio of 23.6 EVs per charger, which is well above the national average of 19.7.

FIGURE 32: DALLAS, TEXAS: SUPPORTING ELECTRIC VEHICLES IN OPERATION AND ELECTRIC VEHICLE SUPPLY EQUIPMENT GROWTH

29,848
EVs in operation

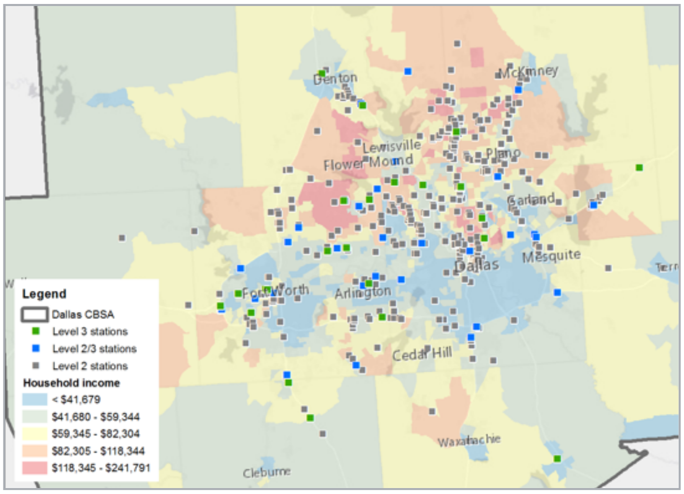
LEVEL 2 **1,049** | LEVEL 3 **214**
Public EVSE

23.6
RATIO
Above national average

+22.1%
EV new registrations are growing fast in Texas, +22.1 2018-20 vs -1.7% nationally

<900
Over 900 Level 2/3 plugs have been added since January 2019 in Dallas of the 1,273 present today.

OVERLAY OF INCOME AND CHARGING POINTS

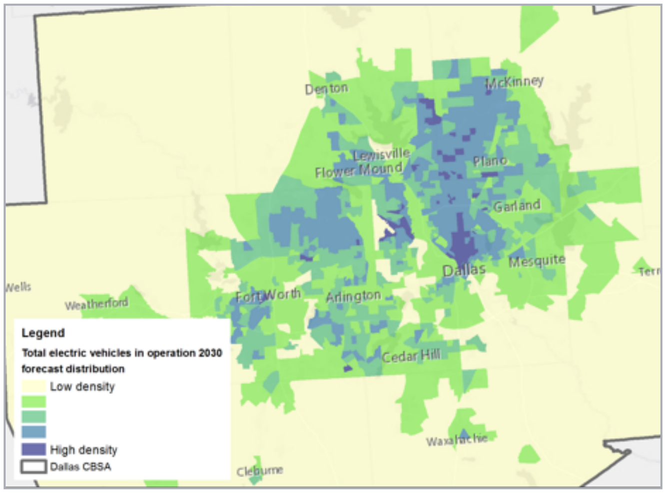


Growth is already taking off in Texas, with 22.1% more EVs registered in the state during 2020 than 2018. Dallas has been home to a sizable portion of this growth and reached a total of 29,848 EVs in operation as of July 2021.

More than 900 Level 2 and 3 stations have been added in the Dallas CBSA over the last two years in response to this growth, but relative to the national average ratio of EVs to EVSE, the infrastructure is already falling behind growth in EV VIO. This is exactly why S&P Global Mobility categorizes Texas as a Priority 2 state.

FIGURE 33: DALLAS, TEXAS: 2030 ELECTRIC VEHICLE IN OPERATION DISTRIBUTION BY CENSUS TRACT

ELECTRIC VEHICLES IN OPERATION
2030 forecast and distribution at census tract



MILES TRAVELLED INDEX

110%
vs South Gulf average for urban roads

HOUSING MIX INDEX

118%
vs national average

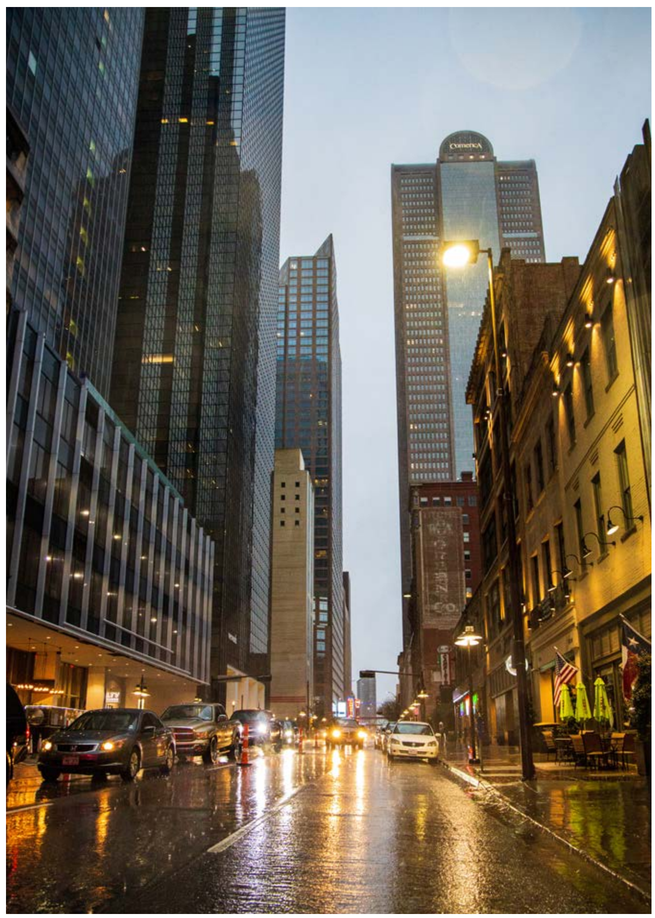
PUBLIC/SEMI-PUBLIC EVSE DEMAND FORCAST 2030

EVSE LEVEL 2
40,696
AC charging

EVSE LEVEL 3
2,161
Fast charging

As with the analysis in Detroit, it is important to look at the housing mix and the VMT index to determine how the EV VIO growth in this market will impact public charging demand. Figure 33 shows that while VMT figures are similar to Detroit, the multi-family housing mix in the Dallas–Fort Worth CBSA at 118% of the index average is much higher than the national average. About 30% of households are multi-family in the Dallas–Fort Worth CBSA, compared to roughly 25% nationally and in the state of Texas.

Despite this, Dallas is expected to see high growth in EV registrations over the coming years and will require significant investment in charging infrastructure to support this volume. S&P Global Mobility estimates 40,696 Level 2 AC chargers and 2,161 Level 3 DCFCs will be required in Dallas–Fort Worth by 2030 to keep up with public charging demand. This equates to a more than thirty-fold increase in publicly available EVSE by 2030 to support this highly populated metropolitan area.



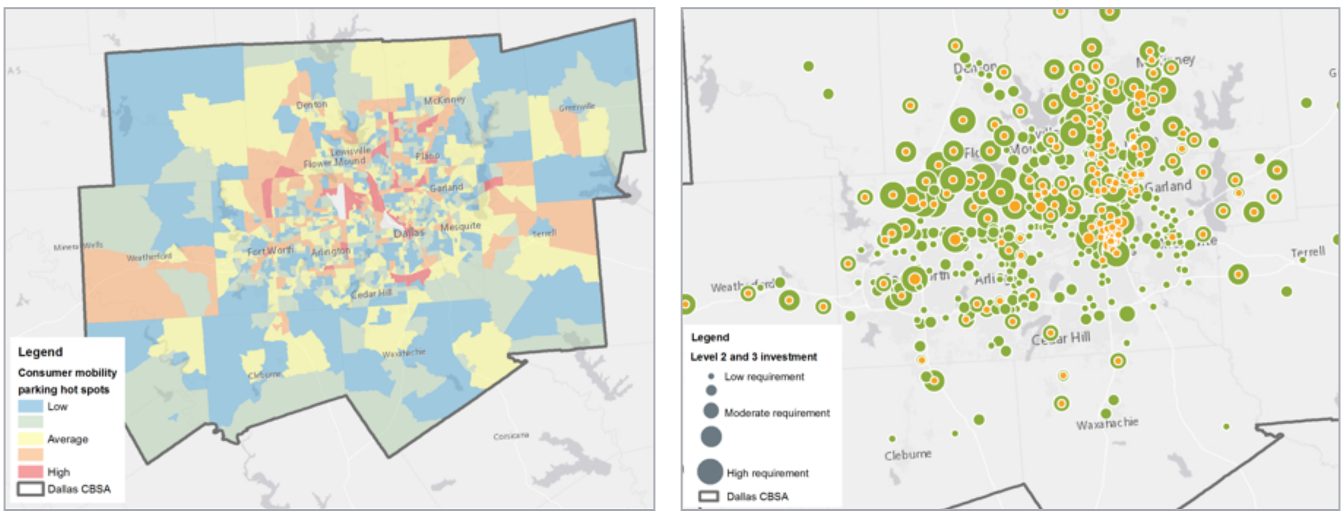
As is the case nationwide, the infrastructure mix should be largely weighted to Level 2 AC chargers, with Level 3 DCFCs seeing around an eight-fold increase over today. Yet downtown Dallas and the supporting suburbs to the north and west will require the most charging station growth in the CBSA, as seen in Figure 34. Fort Worth, however, and the surrounding areas to the south and east of Dallas will require dramatically less EVSE infrastructure. Should population and consumer mobility trends begin to change in the Dallas–Fort Worth CBSA, the current forecast might mislead developers.

FIGURE 34: DALLAS, TEXAS: CURRENT PARKING HEAT MAP AND FORECASTED ELECTRIC VEHICLE SUPPLY EQUIPMENT REQUIREMENTS IN 2030

Level 2 EVSE   Level 3 EVSE

PARKING HEAT MAP BASED ON CONSUMER MOBILITY PATTERN

LEVEL 2 AND 3 INVESTMENTS UNTIL 2030 BY MICRO LOCATION



CASE STUDY

Equitable Growth in Portland, Oregon

In Oregon, the Portland CBSA is home to over 75% of EVs in the state, and while EVSE infrastructure is struggling to keep pace, the implementation is well distributed thus far (Figure 35).

FIGURE 35: PORTLAND, OREGON: EQUITABLE GROWTH IN ELECTRIC VEHICLES IN OPERATION AND ELECTRIC VEHICLE SUPPLY EQUIPMENT

30,749
EVs in operation

LEVEL 2	LEVEL 3
1,155	**286**

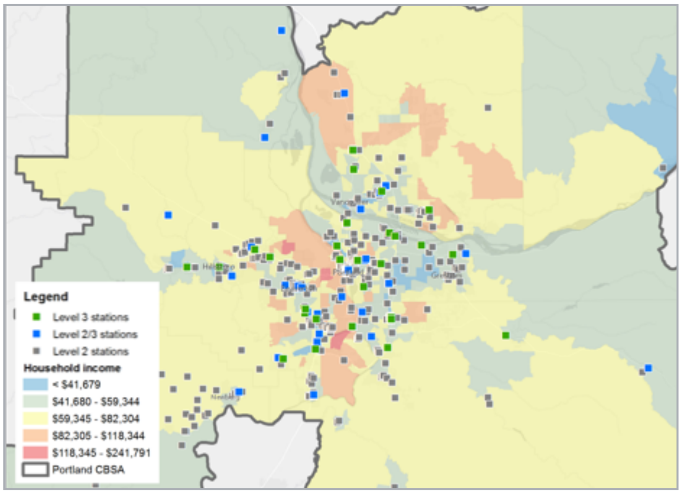
Public EVSE

21.3
RATIO
Above national average

top 15
Oregon is among the top 15 EV states today and top 20 in 2023

Portland displays an equitable implementation of EVSE to income

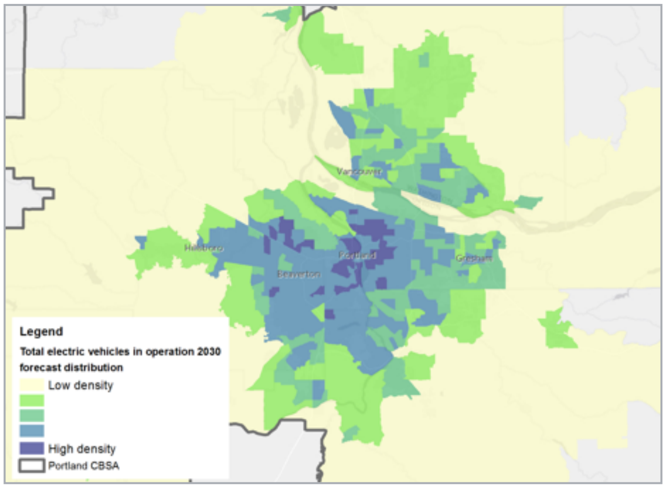
OVERLAY OF INCOME AND CHARGING POINTS



Portland displays an equitable implementation of EVSE among both wealthy (average income of $100K>) and low-income neighborhoods (avg. $49K<). Likewise, the CBSA's forecasted EV VIO is well distributed with only a few pockets of high density in downtown Portland (Figure 36).

FIGURE 36: PORTLAND, OREGON: 2030 ELECTRIC VEHICLE IN OPERATION DISTRIBUTION BY CENSUS TRACT

ELECTRIC VEHICLES IN OPERATION
2030 forecast and distribution at census tract



MILES TRAVELLED INDEX

86%
vs West region average for urban roads

HOUSING MIX INDEX

115%
vs national average

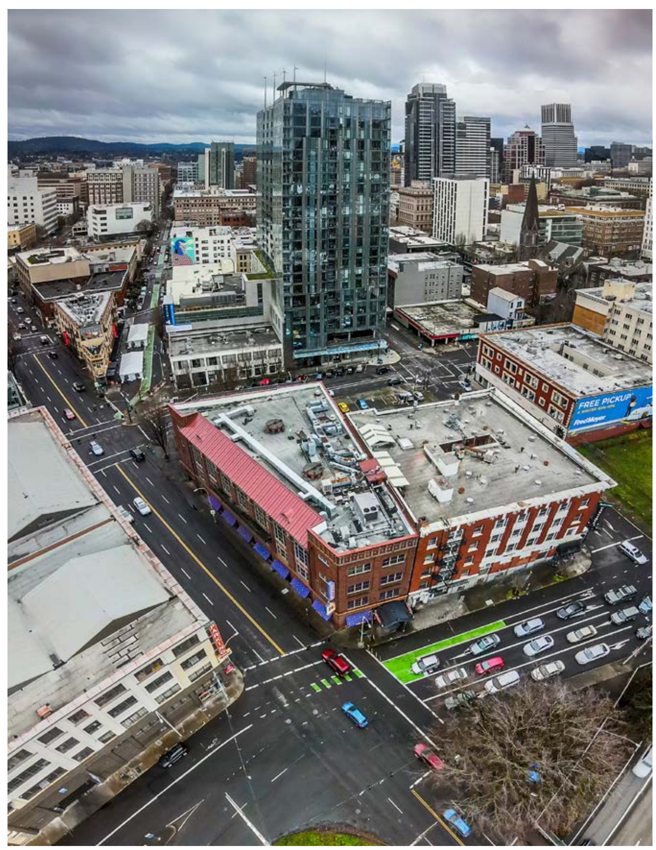
PUBLIC/SEMI-PUBLIC EVSE DEMAND FORCAST 2030

EVSE LEVEL 2
11,970
AC charging

EVSE LEVEL 3
635
Fast charging

Portland residents also travel fewer miles per capita than the West region, but, as in Dallas, Portland has a higher share of multi-family housing versus national (Figure 36). The Portland CBSA indexes above at 115% of the index average. As such, 11,970 public/semi-public Level 2 EVSE and 635 Level 3 EVSE will be required to support the Portland CBSA under this 2030 forecast of EV VIO.

As Portland's EV base grows in the coming years, the area will be required to build EVSE to support the non-garaged households that cannot install private charging infrastructure. Thirty percent of households in Portland are part of multi-family buildings, compared to approximately 24% for the state of Oregon and 25% nationally. The CT level parking hot spots in Figure 37 show high propensity in Portland, Beaverton, and in census tracts along the river, as well as many yellow and orange average to high-parking areas that will need to support public demand.

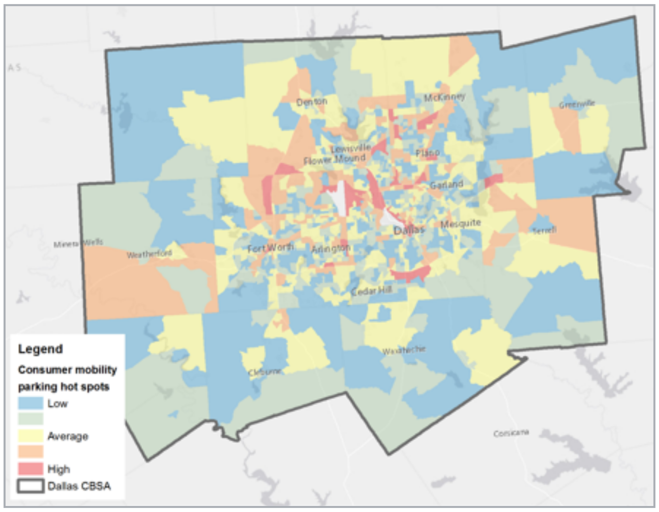


Notably, to provide corridor support along the U.S. I-5 interstate highway, DCFC will be required to be oriented both north and south of downtown Portland and along U.S. Highway 26, which runs out to the coastal cities.

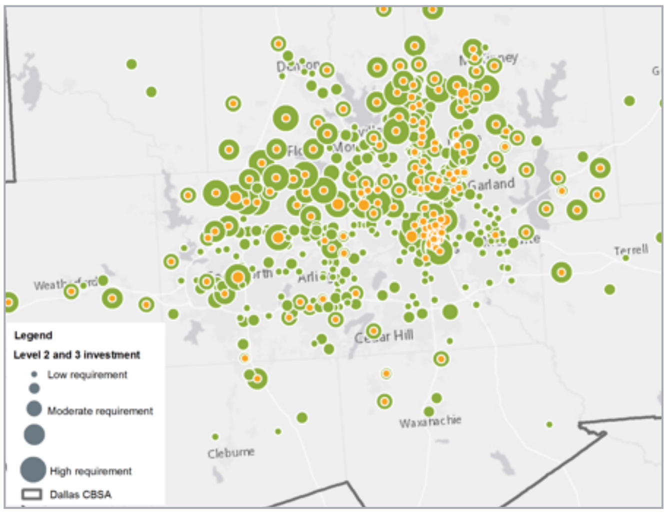
FIGURE 37: PORTLAND, OREGON: CURRENT PARKING HEAT MAP AND FORECASTED ELECTRIC VEHICLE SUPPLY EQUIPMENT REQUIREMENTS IN 2030

Level 2 EVSE   Level 3 EVSE

PARKING HEAT MAP BASED ON CONSUMER MOBILITY PATTERN



LEVEL 2 AND 3 INVESTMENTS UNTIL 2030 BY MICRO LOCATION



SUMMARY AND STUDY

The infrastructure development prioritization within this report is intended to provide a clear and digestible picture of what will be required for light consumer EV markets over the coming years on a U.S. sub-national level to stakeholders across the industry. While there is a definite focus on the highest-volume markets, it is just as important to prioritize build-out in medium- and small-volume states where the growth needs to be supported and even encouraged.

S&P Global Mobility forecasts more than 18.1 million EVs to be on the road in 2030, and as of today, everyone from OEMs to governmental bodies are investing a great deal of personnel and capital in making this notion a reality. To support this volume of vehicles, around 1.8 million chargers will be required by that same 2030 milestone. Of this, as much as 95% could be Level 2, built with the intent of servicing many vehicles concurrently. The remaining Level 3 EVSE should then be deployed strategically to support instances where fast charging and high throughput is required and worth the additional cost and load on the electrical grid. This is based on the technology that can be predicted today, and the mix of Level 2 and Level 3 EVSE that the research suggests will make the greatest impact toward providing the right balance of convenience (both in terms of charge speed and widespread availability), feasibility, and cost to implement and maintain.

This report has shown there is no one-size-fits-all method of supporting EV adoption and EVSE infrastructure build-out. The local and regional advantages and disadvantages for EVs in certain markets mean that there must be a tailored approach to ensure each market is served according to its individual characteristics. This means each market should consider the right mix of convenience and visibility within populous areas, coverage of interstate corridors, and balancing equitable implementation with profitable investment.

Involvement also must come from a variety of stakeholders, whether it is a charging network operator looking to build an expansive and profitable network, a utility company ensuring the underlying grid is in place, a POI like a mall or theater looking to add value for its patrons, or a local government ensuring all its citizens have access to charging while contributing to society and the economy.

In summary, the trajectory of EV adoption and the installation of the supporting EVSE infrastructure is on a good trajectory in many parts of the U.S. The early development thus far has begun to prove that EVs are a viable alternative for an ICE vehicle.

The local and regional advantages and disadvantages for EVs in certain markets mean that there must be a tailored approach to ensure each market is served according to its individual characteristics.

Although the model and customer experience of how we power and fuel these vehicles is markedly different from the traditional intermittent trips to the gas station, the mix of charging and battery technologies can provide a good EV user experience and will only improve with time.

The next critical step is to rapidly scale up the development of infrastructure as EVs begin to move from a niche, premium product to a widespread and ubiquitous form of transportation. If OEM and government electrification plans are to come to fruition in a way that provides a high-quality experience, where users stay loyal to EVs, the EVSE infrastructure build-out must not follow adoption; it must take place in lockstep and at times even lead it.

APPENDIX, GLOSSARY, AND BIBLIOGRAPHY

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Electric Vehicle Council
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The Electric Vehicle Council is a non-advocacy organization whose mission is to coordinate the efforts of organizations actively engaged in supporting the deployment of EV charging infrastructure. The EV Council works to distribute existing research and education materials to amplify and enhance its value to the market, as well as conducts original research to fill gaps in knowledge and further educate interested stakeholders concerning the opportunities, challenges, and successful strategies associated with the installation and operation of EV charging stations.

For more information on the Electric Vehicle Council and a current list of members, please visit: fuelsinstitute.org/Councils/Electric-Vehicle-Council

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