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Report

Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030

November 2018

Prepared by:
Adam Cooper (IEI) and Kellen Schefter (EEI)

Executive Summary

The transition to electric vehicles (EVs) is well underway with more than 1 million EVs on U.S. roads as of October 2018. Automakers are responding to customer demand and are developing more EV models, including both plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs), that are increasingly cost-competitive with internal combustion engines. In addition, customers are purchasing EVs in record numbers, and electric companies are working with stakeholders to move the EV infrastructure market forward.

Electric transportation is a win-win. It meets customer needs, provides environmental benefits, and supports America's energy security.

The future of electric transportation is evolving rapidly. In response, the Edison Electric Institute (EEI) and the Institute for Electric Innovation (IEI) have developed this updated EV sales forecast through 2030 and have estimated the associated charging infrastructure needs.¹ The EEI/IEI forecast is a consensus forecast based on five independent forecasts.

The results show the following:

- The **stock of EVs** (i.e., the number of EVs on the road) is projected to reach **18.7 million in 2030**, up from slightly more than 1 million at the end of 2018 (see Figure 1). This is about 7 percent of the 259 million vehicles (cars and light trucks) expected to be on U.S. roads in 2030.
- It took 8 years to sell 1 million EVs. We project **the next 1 million EVs** will be on the road in less than 3 years—by early 2021.
- **Annual sales of EVs** will exceed 3.5 million vehicles in 2030, reaching more than 20 percent of annual vehicle sales in 2030 (see Figure 2). Compared to our 2017 forecast, EV sales are estimated to be 1.4 million in 2025 versus 1.2 million.²
- About **9.6 million charge ports will be required** to support 18.7 million EVs in 2030 (see Figure 3). This represents a significant investment in EV charging infrastructure.

1. The 2018 forecast is an update to: *Plug-in Electric Vehicles Sales Forecast Through 2025 and the Charging Infrastructure Required*. Edison Electric Institute and Institute for Electric Innovation. July 2017. [http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20PEV%20Sales%20and%20Infrastructure%20thru%202025_FINAL%20\(2\).pdf](http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20PEV%20Sales%20and%20Infrastructure%20thru%202025_FINAL%20(2).pdf)

2. Ibid.

Figure 1. EEI/IEI Forecast of EV Stock in 2030

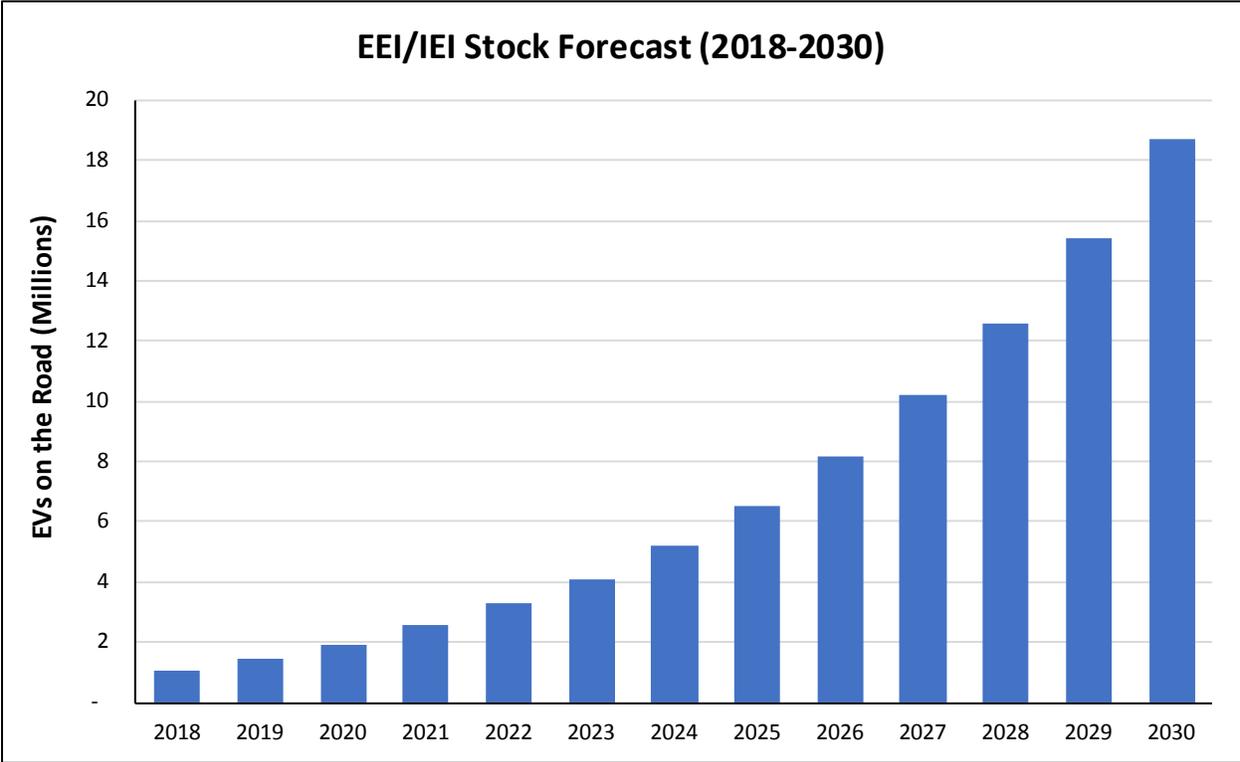


Figure 2. EEI/IEI Annual EV Sales Forecast as Percent of Total Vehicle Sales

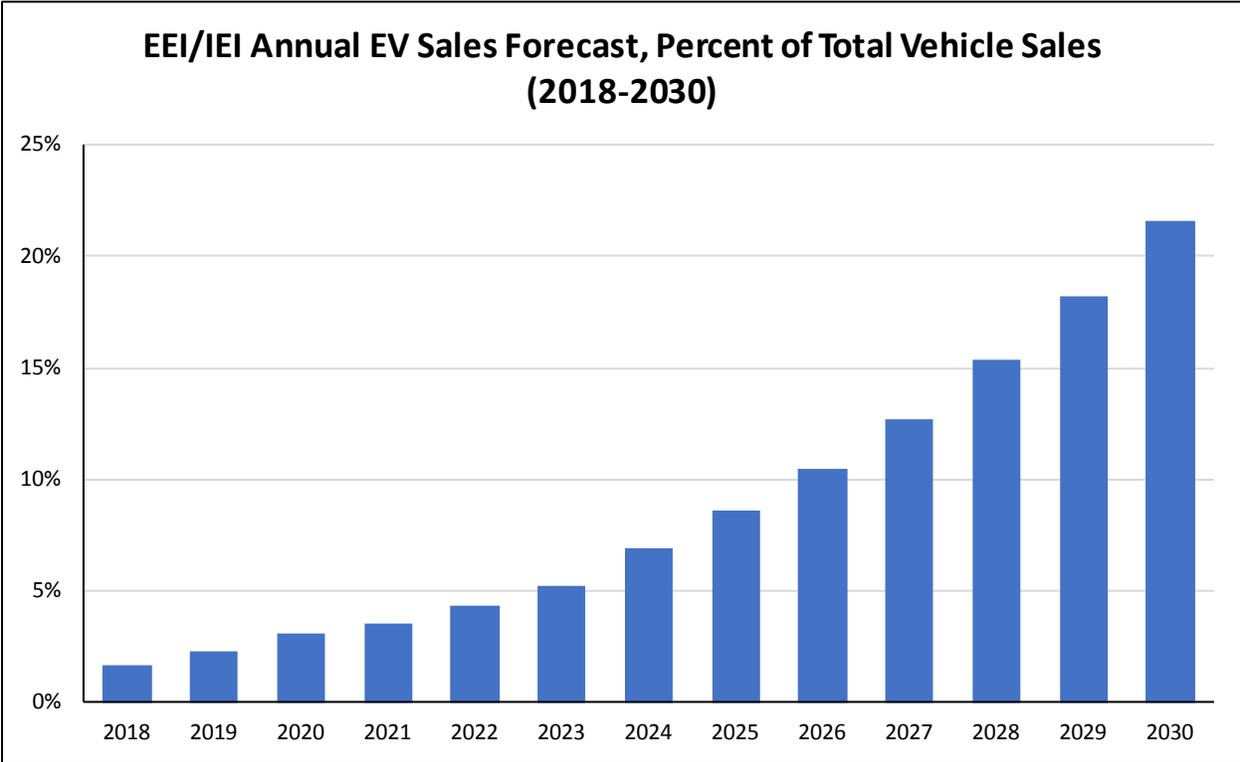
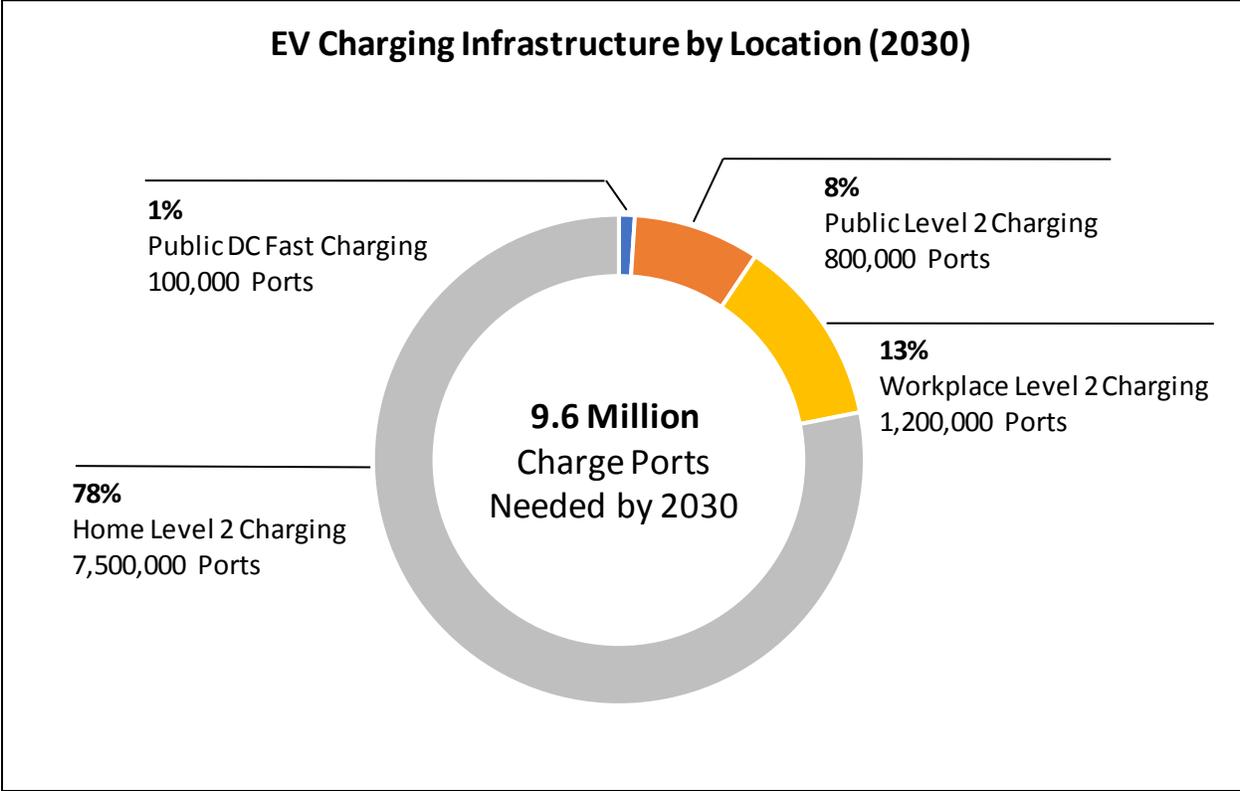


Figure 3. EV Charging Infrastructure in 2030 Based on EEI/IEI Forecast



Electric Vehicle Forecast

Approach

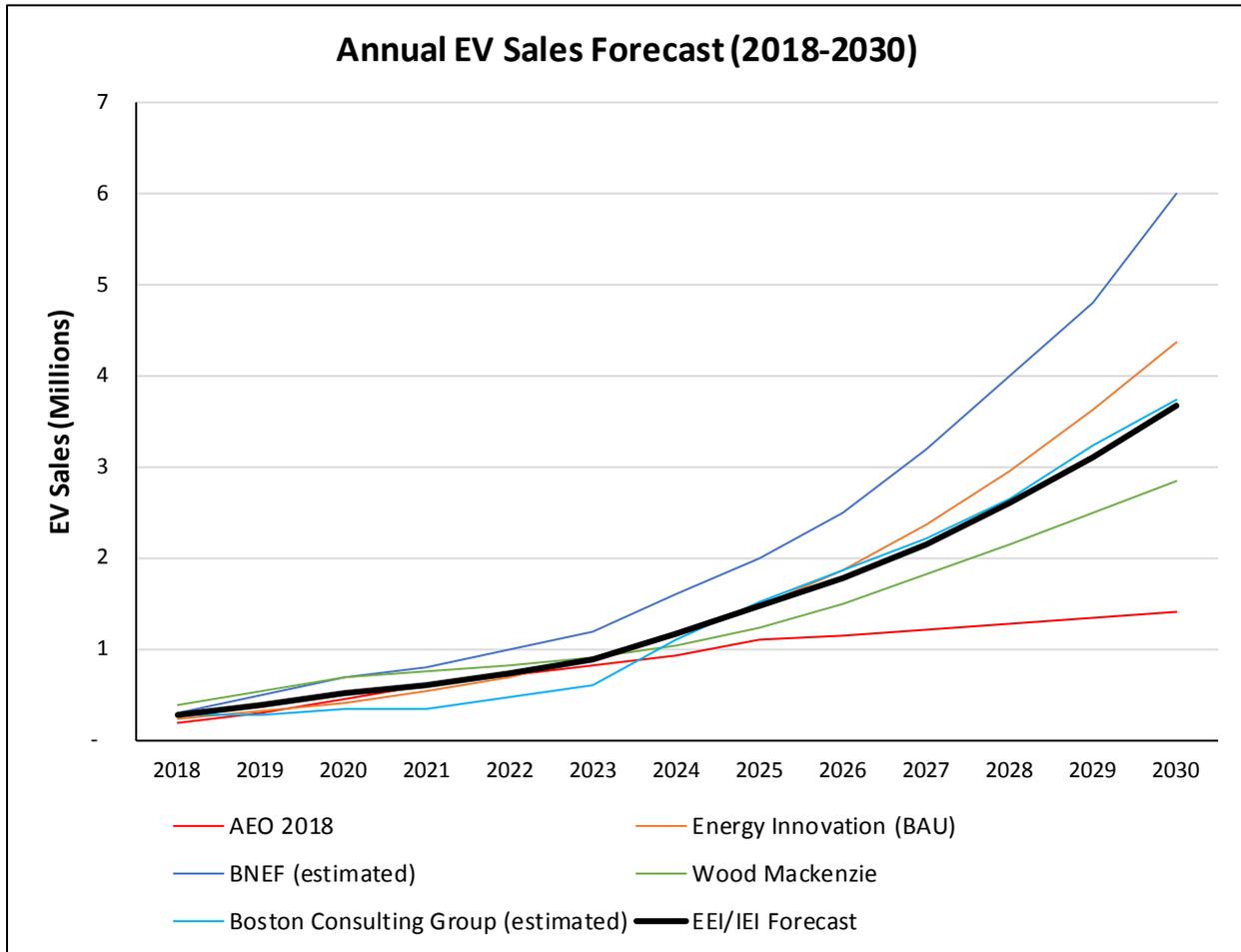
EEI and IEI developed a consensus forecast of EV sales projections from 2018 to 2030 based on five independent forecasts:

- Bloomberg New Energy Finance (BNEF) – Electric Vehicle Outlook 2018 (May 2018).³
- Boston Consulting Group (BCG) – The Electric Car Tipping Point (November 2017).⁴
- Energy Innovation – Energy Policy Simulator 1.4.1 (accessed July 2018).⁵
- U.S. Energy Information Administration (EIA) – Annual Energy Outlook 2018 Reference Case (February 2018).⁶
- Wood Mackenzie – The Electric Vehicle Outlook Data (August 2018).⁷

These forecasts were selected because they include three key factors: customer preference models that determine interest in EVs; declining battery costs that influence EV cost competitiveness with internal combustion engine (ICE) vehicles and manufacturer profitability; and fuel efficiency standards and environmental regulations.

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3. Electric Vehicle Outlook 2018. Bloomberg New Energy Finance. May 2018. <https://www.bloomberg.com/news/articles/2018-05-22/bp-invests-in-tech-to-charge-cars-as-quickly-as-filling-gas-tank> and <https://about.bnef.com/electric-vehicle-outlook/#toc-download>
 4. The Electric Car Tipping Point. Boston Consulting Group. November 2017. <https://www.slideshare.net/TheBostonConsultingGroup/the-electric-car-tipping-point-81666290> and <https://www.bcg.com/en-us/publications/2018/electric-car-tipping-point.aspx>
 5. Energy Policy Simulator. Energy Innovation. July 2018. <https://us.energypolicy.solutions/scenarios/home>
 6. Annual Energy Outlook 2018. U.S. Energy Information Administration. February 2018. <https://www.eia.gov/outlooks/aeo/>
 7. Electric Vehicle Outlook Data. Wood Mackenzie. August 2018.

Figure 4. EEI/IEI Annual EV Sales Forecast Compared to Selected Forecasts



Comparison to Automaker Announcements

Figure 4 shows that EEI/IEI forecasts 3.5 million EV sales in 2030. Comparing the forecasted EV sales to automaker announcements is a useful reality check. Some automakers publicly have announced EV sales targets and plans for future EV models. Based on these announcements, estimates from EV analysts, and our own assumptions, the minimum number of EV sales is around 2.5 million in 2030.⁸

Table 1 shows the actual percent of EV sales in 2017, the percent expected in 2030, and the likely number of EV sales in 2030 projected by manufacturer. Given that many of the manufacturers’ announcements are for 2020 or 2025 and that EV sales likely will continue to increase until 2030, we believe the projected forecast for 3.5 million EV sales is reasonable.

8. Individual automaker data was gathered from automaker websites, trade press articles, and public announcements.

Table 1. EV Sales in 2030 Projected by Vehicle Manufacturer

Manufacturer	% EV sales in 2017 (actual)	All vehicle sales expected in U.S. in 2030	% EV sales expected by given year	Estimated EV sales in 2030
BMW	6.0%	360,000	20% (2025)	72,000
General Motors	1.5%	3,000,000	5% (2030)	150,000
Honda	0.1%	1,650,000	15% (2030)	247,500
Mercedes	0.9%	380,000	25% (2025)	95,000
Nissan	0.7%	1,600,000	20% (2020)	320,000
Tesla	100.0%	850,000	100%	850,000
Toyota	0.9%	2,450,000	9% (2030)	220,500
Volkswagen	1.3%	630,000	25% (2025)	157,500
Volvo	3.5%	80,000	50% (2025)	40,000
Subtotal (Automaker Announcements)		11,000,000		2,152,500
Fiat Chrysler	0.5%	2,100,000	5% (2030)	105,000
Ford	0.8%	2,600,000	5% (2030)	130,000
Hyundai-Kia	0.5%	1,300,000	5% (2030)	65,000
Subtotal (Estimated)		6,000,000		300,000
Total		17,000,000	14%	2,452,500

Charging Infrastructure Needed to Support EV Market

The availability of EV charging infrastructure is fundamental to the growth of EVs. Unlike conventional vehicles, which typically refuel only at gasoline 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. This charging equipment, which often is referred to as a charging station or a charge port, comes in a variety of types and configurations, but is generally categorized by power level:

- **Level 1:** 120-volt, alternating current (AC) power. Level 1 charging refers to charging stations and conventional electric outlets that a driver may plug into via a charging cord set that typically is included with an EV. Level 1 charging adds about 4 miles of electric range per hour of charging.

For this analysis, we assume that half of all EVs with access to home charging will use Level 1 charging, while the other half will use Level 2. Level 1 charging also may be available at workplaces and public locations, but that is not considered in this analysis.

- **Level 2:** 240-volt, AC power. Level 2 charging stations typically are mounted on a wall or on a pedestal. Level 2 charging at home typically requires the installation of a 240-volt circuit. Level 2 charging adds about 10 to 20 miles of electric range per hour of charging.

For this analysis, we assume that all workplace and public locations use Level 2 charging.

- **DC Fast Charging (DCFC):** Converts AC electricity to direct current (DC) and delivers charge to the vehicle at high power, typically 50 kilowatts (kW) or greater. DCFC is intended to add a substantial charge to an EV in a short amount of time (e.g., more than 80 miles of range in about 30 minutes of charging, depending on battery size and power level).

For this analysis, we assume DCFC is used only at public DCFC locations at power levels of 50 to 150 kW and is only available for use by BEVs.

Table 2 summarizes the EV charging infrastructure locations, charging equipment type, and available charging time considered in this analysis. This analysis limits consideration to these major categories for simplicity.

Table 2. EV Charging Equipment by Location

Location	Charging Type Considered	Charge Time
Home (single family homes and multi-family dwellings)	Level 1, Level 2	Overnight (approx. 12 hours)
Workplaces	Level 2	Work day (approx. 8 hours)
Public Level 2	Level 2	Approx. 2+ hours
Public DC Fast Charging	DCFC	Approx. 30 minutes

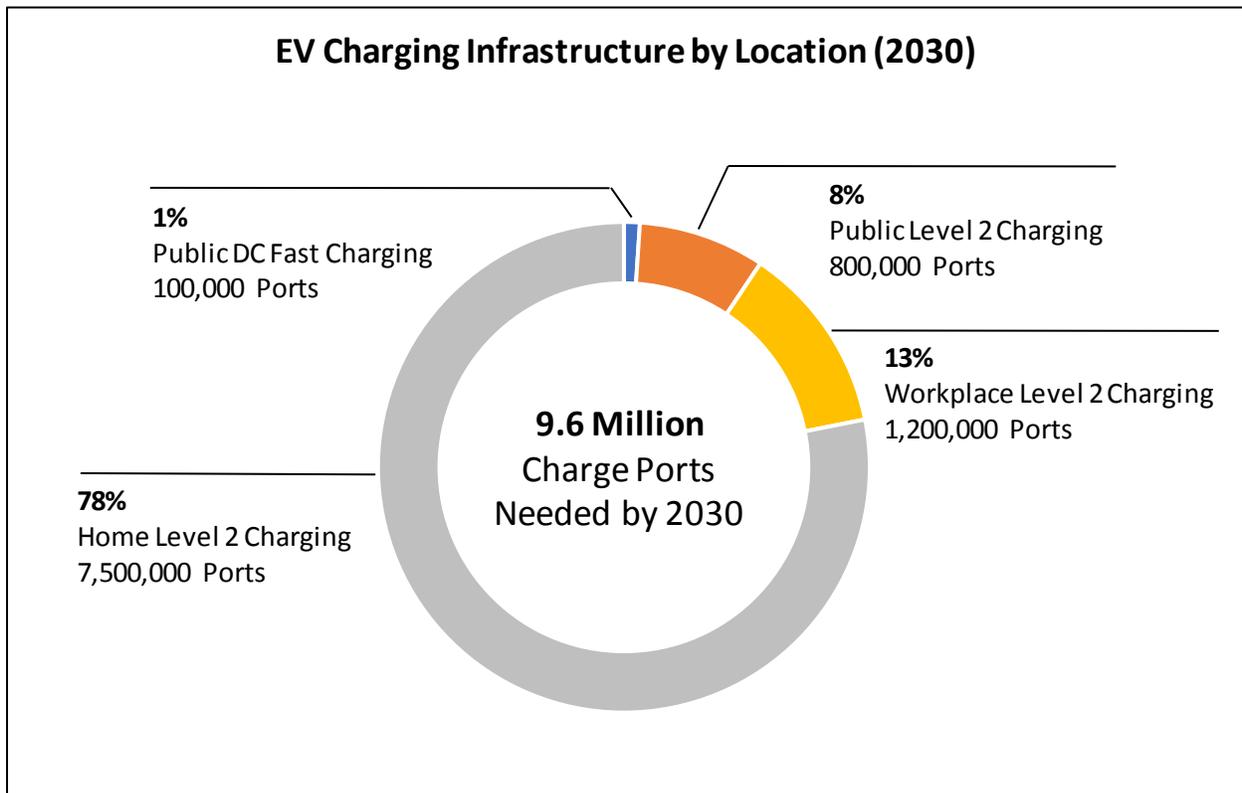
To date, the majority of EV charging occurs at home. However, having charging infrastructure at workplaces or in public settings allows EV owners to drive more miles on electric, enables longer trips, and reduces range anxiety. In addition, public charging infrastructure is important for EV owners who do not have dedicated home charging, such as in multi-family dwellings (e.g., apartment buildings) or those with street parking.

Modeling the Charging Infrastructure Needed to Support EV Growth

EEI and IEI estimated the EV charging infrastructure needed to support the more than 18 million EVs projected to be on the road in 2030 using the Department of Energy’s Electric Vehicle Infrastructure Projection (EVI-Pro) Lite tool.⁹ The EVI-Pro Lite tool is a simplified, publicly accessible version of a model developed by the National Renewable Energy Lab (NREL) to estimate the demand for EV charging infrastructure. The tool estimates the number of charging ports needed within a city or state to support a given EV population, based on vehicle travel patterns as well as EV and charging station characteristics. The tool allows users to adjust key assumptions, such as the mix of BEVs versus PHEVs and the amount of charging done at home.

Based on the EEI/IEI forecast, we estimate that about 9.6 million charge ports will be needed to support the 18.7 million EVs projected to be on the road in 2030.¹⁰ The mix of charge ports by location is shown in Figure 5.

Figure 5. EV Charging Infrastructure in 2030 Based on EEI/IEI Forecast



9. See <https://www.afdc.energy.gov/evi-pro-lite> (accessed October 2018).

10. This analysis considers only incremental charging ports needed. The home Level 2 charging plugs are incremental because they are assumed to require new charging equipment and installation in a home. An equal amount of Level 1 charging is assumed to be available at home locations (e.g., via conventional outlets) and, therefore, is non-incremental.

Our assumptions include:

- **EV Population:** The EVI-Pro Lite tool does not provide a national calculation option, so the results shown are the sum of the outputs for individual analyses of all 50 states and the District of Columbia. The 18.7 million EVs were allocated by applying a uniform sales growth rate to each state. Since the tool limits the EV population to no more than 10 percent of all registered vehicles, states that exceeded this market share were capped at 10 percent and the excess vehicles were allocated to the remaining states based on their EV market share. This effectively shifts the EV distribution among the states closer to that of the conventional vehicle population, which is reasonable as EVs become more mainstream.
- **Vehicle Mix:** The EVI-Pro Lite tool simplifies EV models to four types – PHEVs with electric ranges of 20 and 50 miles and BEVs with electric ranges of 100 and 250 miles. This analysis assumed a split of: 15 percent 20-mile PHEVs; 25 percent 50-mile PHEVs; 15 percent 100-mile BEVs; and 45 percent 250-mile BEVs. While the current EV population is roughly 50-50 split between PHEVs and BEVs, this projected split reflects a 60-40 bias toward BEVs that is estimated based on automaker product announcements. This effectively increases the number of DCFC ports needed, while reducing the number of Level 2 ports.
- **Support for PHEVs:** The EVI-Pro Lite tool allows users to select “partial” or “full” support for PHEV drivers. The full support option adds Level 2 chargers at workplaces and public locations, such that most PHEV trips can be completed on the electric range only, while the partial support option assumes more PHEV trips will be completed using the gasoline range once the electric range is depleted. This analysis chose the full support option, with the assumption that PHEV drivers will seek to maximize their electric miles and minimize their gasoline miles and that providing the necessary charging infrastructure to do so will be needed to drive adoption to the forecasted level. This assumption effectively increases the number of Level 2 ports.
- **Home Charging:** The EVI-Pro Lite tool default assumption is that all EV drivers have access to overnight charging at home and begin each day with a full charge. While this assumption may closely approximate the EV population today, this analysis assumes that the forecasted EV buyers will resemble conventional vehicle households more closely. Studies suggest only about 80 percent of households have access to off-street parking, and even fewer have access to a *dedicated* off-street parking space.¹¹ This analysis assumed 80 percent of the forecasted EV population would have access to home charging, which effectively increases the charging ports needed in other locations. Additionally, this analysis assigned a home Level 2 charging station to half of these EVs with home charging (40 percent of the forecasted EV population), with the assumption that Level 1 charging at home will be available and sufficient for the remaining EVs.

11. Traut, Elizabeth, et al., U.S. Residential Charging Potential for Electric Vehicles, Carnegie Mellon University. <https://www.cmu.edu/me/ddl/publications/2013-TRD-Traut-et-al-Residential-EV-Charging.pdf> .

Approaches to Deploying EV Charging Infrastructure

The EV market is driven by a myriad of dynamics, including customer awareness and acceptance, the types of EVs available and their affordability, and the availability of charging infrastructure. It is well established that the lack of EV charging infrastructure is a primary barrier to EV adoption.¹² The analysis using the EVI-Pro Lite tool in this report estimates the charging infrastructure needed to support a certain level of EVs. In this section, we discuss approaches for deploying EV charging infrastructure.

Today, approximately 45,000 public Level 2 charging ports and 9,000 DCFC ports are available, including those dedicated to Tesla vehicles.¹³ The precise number of workplace Level 2 charging stations is unknown. Based on the EVI-Pro Lite tool results, as shown in Figure 5, more than 2 million charge ports in workplaces and public locations will be needed by 2030. The significant difference between the current availability of charging infrastructure and the expected charging infrastructure needed suggests a growing “infrastructure gap” that must be addressed.

One of the impediments to widespread charging infrastructure availability is the cost. The costs associated with EV charging infrastructure include the equipment itself, ongoing operation and maintenance costs, and the installation costs needed to get power to the charging station site. These costs can vary widely, from a few hundred dollars to install a Level 2 charger at home to tens of thousands of dollars to install a DCFC.¹⁴ Much of the EV charging infrastructure to date has been paid for by the customer or entity that hosts the charging equipment (the “site host”), whether that is a homeowner, a commercial property owner, or a public entity.

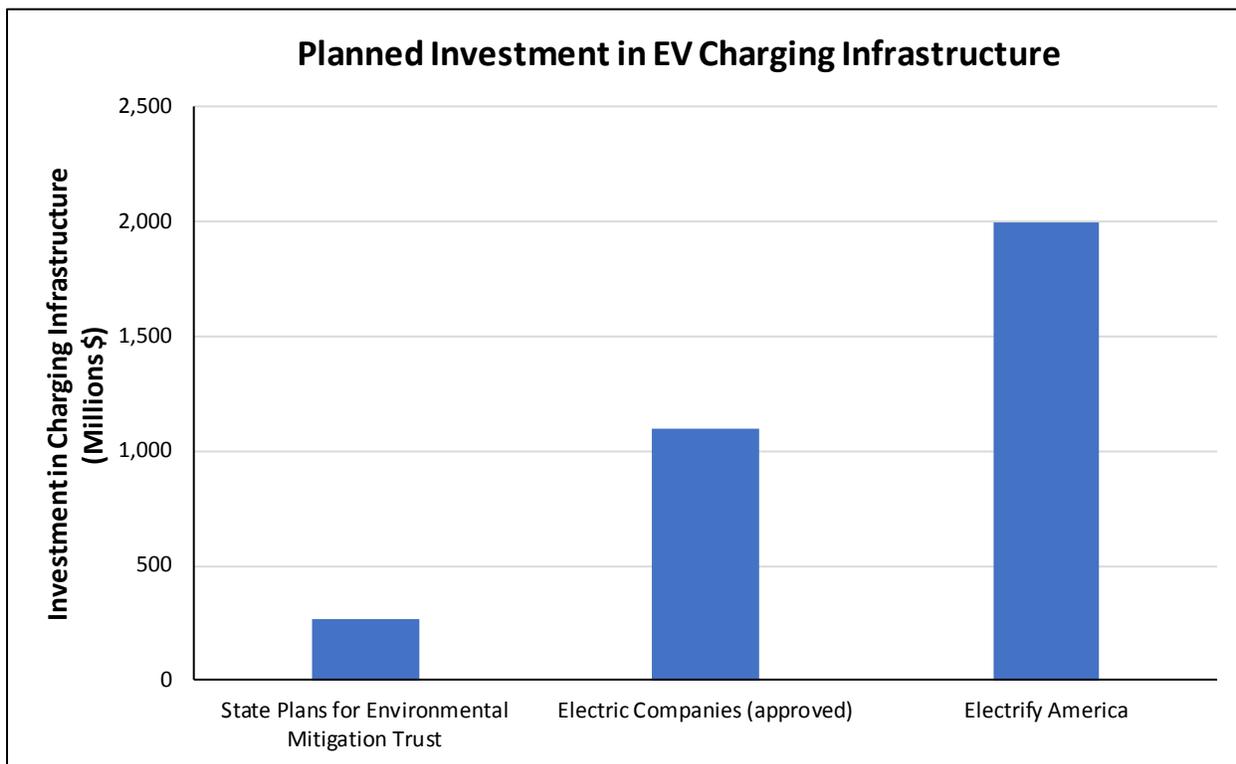
12. NREL, *Consumer Convenience and the Availability of Retail Stations as a Market Barrier for Alternative Fuel Vehicles*, <https://www.afdc.energy.gov/uploads/publication/56898.pdf>

13. U.S. Department of Energy, Alternative Fuels Data Center. http://www.afdc.energy.gov/fuels/stations_counts.html (Accessed November 2018)

14. U.S. Department of Energy, *Costs Associated With Non-Residential Electric Vehicle Supply Equipment*, https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf

The EV charging marketplace is evolving, and different approaches to providing the charging infrastructure for the EV market are being deployed. Some of the entities that are investing in charging infrastructure are below and are summarized in Figure 6.

Figure 6. Planned Investment in EV Charging Infrastructure



- **State governments:** Twenty-four states have some type of incentive (e.g., grant or tax credit) to support the deployment of EV charging stations. The Environmental Mitigation Trust, established in October 2017 under the Volkswagen diesel emissions settlement, will provide states and Indian tribes with \$2.925 billion to mitigate emissions of nitrogen oxides (NOx). States may use up to 15 percent of their funds to deploy EV charging infrastructure. So far, 41 states have allocated at least some of their funds to EV charging infrastructure, representing more than \$265 million in potential investment.¹⁵
- **Automakers:** Tesla has built a “Supercharger” network of about 5,000 DCFC ports at 560 locations in the U.S. dedicated to its vehicles.¹⁶ Other automakers including BMW, General Motors, Nissan, and Volkswagen also have invested in public charging stations in targeted locations, with partners such as ChargePoint and EVgo managing the

15. Atlas EV Hub, <https://www.atlasevhub.com/materials/vw-environmental-mitigation-fund-tracking/state-tracking-dashboard/>

16. U.S. Department of Energy Alternative Fuels Data Center, <http://www.AFDC.energy.gov>

stations.¹⁷ Electrify America, a subsidiary of Volkswagen established as part of the diesel emissions settlement, is required to spend \$2 billion over 10 years (2017-2027) to deploy charging infrastructure and related activities to support the EV market.¹⁸

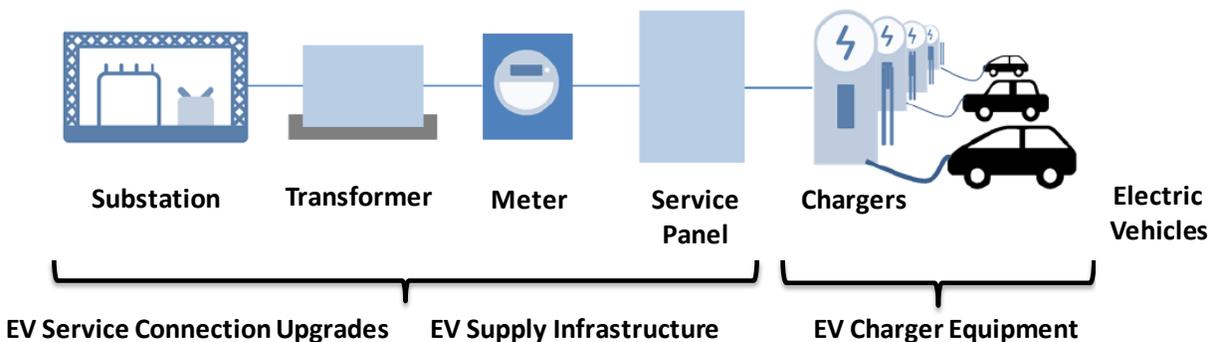
- Electric companies: Electric companies across the country increasingly are gaining state regulatory approval to invest in electric transportation. These investments are primarily in EV charging infrastructure deployment, but also may include charging infrastructure for other applications (such as medium- and heavy-duty trucks and buses), as well as other market support activities such as customer education and outreach. As of September 2018, approved investments totaled more than \$1.1 billion.

Electric Company Role

Electric companies are well-positioned to deploy EV charging infrastructure. Electric company investment in charging infrastructure may take many different forms, including:

- Developing “make-ready” infrastructure, which includes service connection upgrades and new supply infrastructure to bring power to the charging equipment (see Figure 7); the site host is responsible for procuring the charging equipment.
- Installing and owning all infrastructure up to, and including, the charging equipment itself; either the electric company, the site host, or a third-party may operate and maintain charging equipment.
- Offering incentives, typically in the form of rebates, to defray some or all of the cost of the charging equipment and/or the installation costs.

Figure 7. Illustration of EV Charging Infrastructure



17. See <http://www.autonews.com/article/20180723/MOBILITY/180729957/ev-charging-network-us>.

18. See <https://www.electrifyamerica.com/our-plan>

In addition, electric company investments can support the smart integration of EV charging load into the distribution grid in different ways, including:

- Offering electric rates that encourage EV charging at specific times of the day (e.g., at off-peak times).
- Requiring charging equipment associated with these programs to be ready for managed charging, such as being capable of receiving demand response signals.
- Helping to educate EV drivers and site hosts to choose the appropriate rates and connect them with charging equipment providers.

Policy and Technology Factors to Consider

Federal Policy Issues

Policy developments at the federal level that could impact the U.S. EV market within the timeframe of this forecast include:

- **Vehicle fuel efficiency and GHG standards:** In August 2018, the U.S. Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) proposed modifications to tailpipe greenhouse gas (GHG) emissions and Corporate Average Fuel Economy (CAFE) standards for light-duty vehicles.¹⁹ The agencies propose to freeze standards for model years 2021-2026 at model year 2020 levels, rather than increasing standards through 2025. The EPA/NHTSA proposal would eliminate California's waiver under the Clean Air Act, including the Zero Emission Vehicle (ZEV) program that requires an increasing number of ZEV sales—primarily EVs—through 2025.
- **Qualified Plug-In Electric Drive Motor Vehicle Credit (IRC 30D):** Reduces the purchase price of EVs. The credit is structured to phase out for an individual automaker when it sells 200,000 qualifying vehicles. Tesla has exceeded the cap, and General Motors is close behind.

The outcome of the EPA and NHTSA proposal is not determined as of this writing. The EEI/IEI forecast is not driven exclusively by these policies. The other market conditions that are driving EV sales to overperform regulation likely still will be present even if these policies are weakened, but directionally these would have a negative impact on the EV market.

19. See <https://www.epa.gov/newsreleases/us-epa-and-dot-propose-fuel-economy-standards-my-2021-2026-vehicles>

Battery Costs Trending Down

Declining battery costs and growing customer demand for EVs act as an accelerant to EV sales. Cost reductions in battery packs enable longer-range EVs, increase cost-competitiveness with ICE vehicles, and result in automobile manufacturers producing a wider variety of EVs across more vehicle segments to better meet customer demand.

- Between 2010 and 2017, battery pack costs [\$ per kilowatt-hour (kWh)] declined by about 20 percent per year. Bloomberg New Energy Finance estimated battery pack costs in 2017 at \$209 per kWh.²⁰
- Boston Consulting Group projects that battery pack costs at \$100 per kWh will create price parity with ICE vehicles between 2025 and 2030, constituting a 50-percent cost reduction for battery packs from 2017 realized prices.²¹

Effect of Shared-Use Mobility on EV Infrastructure

Along with electrification, the movement toward shared-use mobility is one of the major transformations occurring in the transportation sector. Shared-use vehicles, such as in ride-hailing platforms like Uber and Lyft and carsharing services like Zipcar, Maven, and Car2Go, generally have higher utilization than private-use passenger cars. Expanded adoption of shared-use vehicles likely will have significant impacts on EV charging infrastructure needs, which are not captured by the EV forecast and by the estimated infrastructure needs presented in this paper.

To consider the effects of shared-use mobility, EEI and IEI used an eMobility Infrastructure Model developed by Siemens.²² This tool was developed to help cities quantify the projected charging infrastructure needed for private EVs, fleets of shared EVs, and electric buses. EEI and IEI adjusted the tool's inputs to approximate the U.S. vehicle population, then compared a baseline scenario where private-use vehicles continue to dominate the market to a scenario where 20 percent of passenger miles are completed with shared-use fleet vehicles.

Major takeaways from this exercise are:

- Highly utilized shared-use fleet vehicles deliver more passenger miles per vehicle than private-use vehicles. The adoption of shared-use fleet vehicles means fewer vehicles overall are needed to deliver the same total passenger miles.

20. See <https://about.bnef.com/blog/tumbling-costs-wind-solar-batteries-squeezing-fossil-fuels/>

21. See <https://www.bcg.com/en-us/publications/2018/electric-car-tipping-point.aspx>

22. Thayne, Julia; Leah Lazer, Dr. Noorie Rajvanshi, and Sarah Barnes. 2018. Shared eMobility Infrastructure Model v.1.1. Siemens Urban Development.

- Assuming EVs are adopted at the same rate by private drivers and shared-use fleets, reducing the total vehicles on the road also reduces the number of EVs on the road—leading to a lower number of EV charging stations overall.
- While the need for charging stations decreases, the mix of charging station locations and types changes. Shared-use EVs perform more daily driving than private-use EVs and, thus, require proportionally more “opportunity” (i.e., public) charging stations. Additionally, more “depot” charging stations for shared-use fleet EVs will be needed, such as in shared-use parking garages or dedicated charging hubs.

More research is needed to quantify the impacts of shared-use mobility on the need for charging infrastructure, particularly as the various services (rental cars, ride-hailing, carsharing, etc.) evolve over time. Nevertheless, charging infrastructure providers should consider how to accommodate increases in shared mobility.

Conclusion²³

With more than 18 million EVs anticipated to be on the road in the United States by 2030 and with every EV owner expecting to be able to charge his or her car at home, on the street, at the office, at shopping locations, or along major highways, targeted deployment of charging infrastructure and coordinated collaboration among all stakeholders are required. Electric company participation in the development of EV charging infrastructure supports state-level clean energy and transportation goals, expands customer choice, and helps to scale and ensure the availability of needed EV charging infrastructure to support the growing number of EVs on U.S. roads.

23. EEI and IEI would like to thank and recognize Research Assistants Tisura Gamage and Joel Jaeger who collected data and contributed to the EV sales forecast and charging infrastructure analysis; Eric Wood with NREL for advice on using the EVI-Pro Lite tool; and, Dr. Noorie Rajvanshi and Julia Thayne with Siemens for use of the Shared eMobility Infrastructure Model.

About the Institute for Electric Innovation

The Institute for Electric Innovation focuses on advancing the adoption and application of new technologies that will strengthen and transform the energy grid. IEI's members are the investor-owned electric companies that represent about 70 percent of the U.S. electric power industry. The membership is committed to an affordable, reliable, secure, and clean energy future.

IEI promotes the sharing of information, ideas, and experiences among regulators, policy makers, technology companies, thought leaders, and the electric power industry. IEI also identifies policies that support the business case for the adoption of cost-effective technologies.

IEI is governed by a Management Committee of electric industry Chief Executive Officers. In addition, IEI has a Strategy Committee made up of senior electric industry executives and a select group of technology companies on its Technology Partner Roundtable.



Institute for Electric Innovation

701 Pennsylvania Avenue N.W.
Washington, D.C. 20004-2696
www.edisonfoundation.net

About the Edison Electric Institute

The Edison Electric Institute (EEI) is the association that represents all U.S. investor-owned electric companies. Our members provide electricity for about 220 million Americans, and operate in all 50 states and the District of Columbia. As a whole, the electric power industry supports more than 7 million jobs in communities across the United States. In addition to our U.S. members, EEI has more than 65 international electric companies with operations in more than 90 countries, as International Members, and hundreds of industry suppliers and related organizations as Associate Members.



Edison Electric Institute

701 Pennsylvania Avenue NW
Washington, D.C. 20004-2696
202.508.5000 | www.eei.org