# PROJECTIONS, CHALLENGES, AND OPPORTUNITIES IN THE U.S. EV CHARGING NETWORK PART 1

A lot has been written about EVs, and, of interest to electric utilities, the nation's EV charging network, which seems to be having trouble keeping pace with the increased number of EVs on the road. What is the latest?

In the first part of this two-part white paper, we will look at what the U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) anticipates in the next few years related to the EV charging infrastructure. In the second part, we will look at the current status of the EV charging network nationwide, as well as the implications (both challenges and benefits) for electric utilities.

According to a report published by the U.S. Department of Energy in 2023, U.S. climate goals for economy-wide net-zero greenhouse gas emissions by 2050 will require rapid decarbonization of the light-duty vehicle fleet, and plug-in electric vehicles (PEVs) are poised to become the preferred technology for achieving this end.

And, according to a 2023 Argonne National Laboratory report, the speed of this intended transition to PEVs is evident in actions taken by government and private industry, both in the United States and globally. New PEV sales reached seven to ten percent of the U.S. light-duty market.

Globally, according to “The 2030 National Charging Network: Estimating U.S. Light-Duty Demand for Electric Vehicle Charging Infrastructure,” a report published by the National Renewable Energy Laboratory (NREL), PEV sales accounted for 14 percent of the light-duty market in 2022, with China and Europe at 29 percent and 21 percent, respectively.

A 2021 executive order from the White House targets 50 percent of U.S. passenger car and light truck sales as zero-emission vehicles (ZEVs) by 2030, and California has established requirements for 100 percent light-duty ZEV sales by 2035, with many states adopting or considering similar regulations.

These goals were set prior to passage of the landmark U.S. Bipartisan Infrastructure Law and Inflation Reduction Act, which provide substantial policy support through tax credits and investment grants. Companies in the automotive industry have committed to this transition, with most companies rapidly expanding offerings and many pledging to become ZEV-only manufacturers. Many auto manufacturers are targeting ZEV-only sales within the next one to two decades.

The combination of policy action and industry goal-setting has led analysts to project that, by 2030, PEVs could account for between 48 percent and 61 percent of the U.S. light-duty market.

This transition is unprecedented in the history of the automotive industry and will require support across multiple domains, including adequate supply chains, favorable public policy, broad consumer education, proactive grid integration, and, of course, a national charging network.

As established by the Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law, the Joint Office of Energy and Transportation is setting a vision for a national charging network that is convenient, affordable, reliable, and equitable to enable a future where everyone can ride and drive electric.

The NREL's "2030" report supports the vision of the Joint Office by presenting a quantitative needs assessment for a national charging network capable of supporting 30 million to 42 million PEVs on the road by 2030.

Estimating infrastructure needs at the national level is a challenging analytic problem that requires quantifying the needs of future PEV drivers in various use cases, under region-specific environmental conditions, and with consideration for the built environment. The modeling approach used by the NREL is used to draw the following conclusions:

**1 -** Convenient and affordable charging at/near home is core to the ecosystem, but must be complemented by reliable public fast charging. Industry focus groups with prospective PEV buyers consistently reveal that consumers want charging that is as fast as possible. However, consumer preferences tend to shift after a PEV purchase is made and lived experience with charging is accumulated. Home charging has been shown to be the preference of many PEV owners due to its cost and convenience. This dichotomy suggests that reliable public fast charging is key to consumer confidence, but also that a successful charging ecosystem will provide the right balance of fast charging and convenient destination charging in the appropriate locations. Using sophisticated planning tools, this analysis finds that a national network in 2030 could be composed of 26 million to35 million ports to support 30 million to 42 million PEVs.

For a mid-adoption scenario of 33 million PEVs, a national network of 28 million ports could consist of:
- 26.8 million privately accessible Level 1 and Level 2 charging ports located at single-family homes, multifamily properties, and workplaces;
- 182,000 publicly-accessible fast charging ports along highway corridors and in local communities; and
- one million publicly accessible Level 2 charging ports primarily located near homes and workplaces (including in high-density neighborhoods, at office buildings, and at retail outlets).

In contrast to gas stations, which typically require dedicated stops to public locations, the PEV charging network has the potential to provide charging in locations that do not require an additional trip or stop.

Charging at locations with long dwell times (at/near home, work, or other destinations) has the potential to provide drivers with a more convenient experience. This network must include reliable fast charging solutions to support PEV use cases not easily enabled by destination charging, including long-distance travel and ride-hailing, and to make electric vehicle ownership attainable for those without reliable access to charging while at home or at work.

**2 -** Fast charging serves multiple use cases, and technology is evolving rapidly. The majority of the 182,000 fast charging ports (65 percent) simulated in the mid-adoption scenario meet the needs of those without access to reliable overnight residential charging (estimated as three million vehicles by 2030 in the mid-adoption scenario). Support for ride-hailing drivers and travelers making long-distance trips accounts for the remainder of simulated fast charging demand (21 percent and 14 percent, respectively). While most near-term fast charging demand is simulated as being met by 150-kW DC chargers, advances in battery technology are expected to stimulate demand for higher-power charging. The NREL “2030” report estimates that, by 2030, DC chargers rated for at least 350 kW will be the most prevalent technology across the national fast charging network.

**3 -** The size and composition of the 2030 national public charging network will ultimately depend on evolving consumer behavior and will vary by community. While growth in all types of charging is necessary, the eventual size and composition of the national public charging network will ultimately depend on the national rate of PEV adoption, PEV preferences across urban, suburban, and rural locations, access to residential/overnight charging, and individual charging preferences.

Sensitivity analysis suggests that the size (as measured by number of ports) of the 2030 national public charging network could vary by up to 50 percent (excluding privately accessible infrastructure) by varying the share of plug-in hybrids, driver charging etiquette, and access to private workplace charging. Additionally, the national network is expected to vary dramatically by community. For example, densely-populated areas will require significant investments to support those without residential access and ride-hailing electrification, while more rural areas are expected to require fast charging along highways to support long-distance travel for those passing through.

**4 -** Continued investments in U.S. charging infrastructure are necessary. A cumulative national capital investment of $53 billion to $127 billion in charging infrastructure is needed by 2030 (including private residential charging) to support 33 million PEVs. The large range of potential capital costs found in this study is a result of variable and evolving equipment and installation costs observed within the industry across charging networks, locations, and site designs. The estimated cumulative capital investment includes:
- $22–$72 billion for privately accessible Level 1 and Level 2 charging ports;
- $27–$44 billion for publicly accessible fast charging ports; and
- $5–$11 billion for publicly accessible Level 2 charging ports.

The cost of grid upgrades and distributed energy resources have been excluded from these estimates. While these excluded costs can be significant in many cases and will ultimately be critical in building out the national charging network, they tend to be site-specific and have been deemed out of scope for this analysis.

**5 -** Existing announcements put the United States on a path to meet 2030 investment needs. This report estimates that a $31-billion to $55-billion cumulative capital investment in publicly accessible charging infrastructure is necessary to support a mid-adoption scenario of 33 million PEVs on the road by 2030.

As of early 2023, the NREL “2030” report estimated that $23.7 billion of capital had been announced for publicly accessible light-duty PEV charging infrastructure through the end of the decade, including from private firms, the public sector (including federal, state, and local governments), and electric utilities.

Public and private investments in publicly accessible charging infrastructure have accelerated in recent years. If sustained with long-term market certainty grounded in accelerating consumer demand, these public and private investments will put the United States on a path to meeting the infrastructure needs simulated in this report. Existing and future announcements may be able to leverage direct and indirect incentives to deploy charging infrastructure through a variety of programs, including from the Inflation Reduction Act and the Low Carbon Fuel Standard, ultimately extending the reach of announced investments.

While this analysis presents a needs-based assessment where charging infrastructure is brought online simultaneous to growth in the vehicle fleet, actual charging infrastructure will likely be necessary before demand for charging materializes. The position that infrastructure investment should "lead" vehicle deployment is based on the understanding that many drivers will need to see charging available at the locations they frequent and along the highways they travel before becoming confident in the purchase of an electric vehicle.

On the other hand, infrastructure investment should be careful not to lead vehicle deployment to the point of creating prolonged periods of poor utilization, thereby jeopardizing the financial viability of infrastructure operators. These considerations suggest that the balance of supply and demand for charging should be closely monitored at the local level, and that steps should be taken to enable the efficient deployment of charging (defined as minimizing soft costs), including streamlined permitting and utility service connection processes. While not the case today, an environment where infrastructure can be deployed efficiently enables the industry to responsively balance the supply of infrastructure subject to forecasts for unprecedented increases in demand.

NREL's "2030" study reflected on how charging infrastructure planning has often been analogized to a pyramid, with charging at home as the foundation, public fast charging as the smallest part of the network at the tip of the pyramid, and destination charging away from home occupying the middle of the pyramid.

While this concept has served a useful purpose over the years, NREL recommends a new conceptual model. The balance of public versus private charging and fast charging versus destination charging suggests a planning philosophy akin to a tree.

As with a tree, there are parts of the national charging network that are visible and those that are hidden. Public charging is the visible part of the network that can be seen along highways, at popular destinations, and through data accessible online. Private charging is the hidden part of the network tucked away in personal garages, at apartment complexes, and at certain types of workplaces. This private network is akin to the roots of a tree, as it is foundational to the rest of the system and an enabler for growth in more visible locations.


If access to private charging are the roots of the system, a reliable public fast charging network is the trunk, as it benefits from access to charging at home and other private locations (a key selling point of PEVs) and ultimately helps grow the system by making PEV ownership more convenient (enabling road trips and supporting those without residential access). While fast charging is estimated to be a relatively small part of the national network in terms of number of total ports, it requires significant investment and is vital to enabling future growth by assuring drivers they will be able to charge quickly whenever they need or want.

The last part of the system is a broad set of publicly accessible destination charging locations in dense neighborhoods, office buildings, and retail outlets where the speed of charging can be designed to match typical parking times (“right-speeding”). This network is similar to the branches of a tree in that its existence is contingent on a broad private network and a reliable fast charging network. As with the branches of a tree, the public destination charging network is ill-equipped to grow without the support of charging elsewhere.

In the second part of this white paper, we will look at the current status of the EV charging network nationwide, as well as implications (both challenges and benefits) for electric utilities.