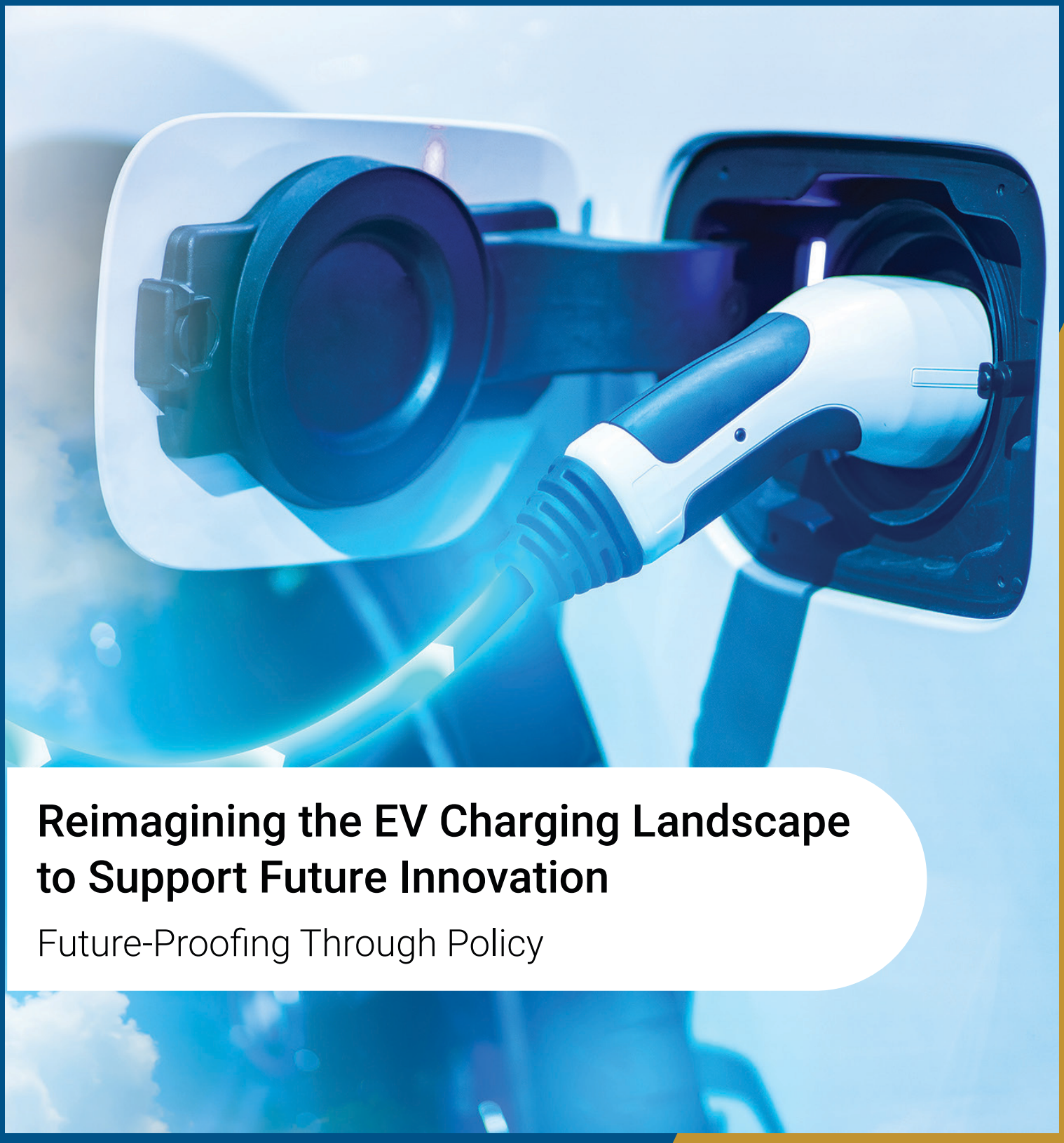
BLACK & VEATCH

RV INDUSTRY ASSOCIATION



Reimagining the EV Charging Landscape to Support Future Innovation

Future-Proofing Through Policy

Table of Contents

1.0 Executive Summary

As the United States (US) continues its transition to vehicle electrification, the federal government is investing $7.5 billion through Fiscal Year 2026 – $5 billion for DC fast charging – to deploy public electric vehicle (EV) charging infrastructure to drive adoption and alleviate the range anxiety that many consumers still feel. Unfortunately, nearly all publicly deployed charging infrastructure features traditional pull-in charging designs that presents challenges for a growing category of use cases – EVs towing recreational vehicles (RVs) or other recreational trailers, electric-assist RV trailers, electric motorized RVs (eRVs), as well as other electrified medium- and heavy-duty (M/HD) vehicles.

The RV industry is making significant investments in both eRVs and electric-assist travel trailers and expects to bring these products to market in the near future. Two eRV prototypes have already debuted: THOR Industries' Thor Vision Vehicle and Winnebago's eRV2. Airstream's eStream is an electric-assist travel trailer prototype.

To better prepare for the future, some of this once-in-a-generation federal funding should be invested in deploying pull-through charging sites that can service these use cases. A failure to act proactively will slow the electrification of commercial vehicles and hinder the growth of new products, including eRVs. Furthermore, acting now to incorporate pull-through charging will prevent the need for more costly retrofitting of existing EV charging stations in the not-so-distant future.

The Federal Highway Administration (FHWA) guidance on the use of the $5 billion in National Electric Vehicle Infrastructure (NEVI) funds indicated that states should consider "future-proofing" for growing demand and higher charger power levels by acknowledging the growing electrification of larger, M/HD commercial vehicles and vehicles pulling trailers, all of which require pull-through stations:

> "However, States are encouraged to consider large vehicles, including medium- and heavy-duty vehicles (such as electric school buses and delivery vehicles) and vehicles with attached trailers. Pull-through charging stations may provide better access for vehicles pulling a trailer; pull-through charging stations provide ample room to move around a vehicle that may take longer to charge, because they allow vehicles to exit the station without backing up and preclude the need to decouple the trailer to fit within the parking area adjacent to the charger."

2.0 The Current EV Charging Landscape

Electrification in the US is seeing large investments to meet the ambitious federal targets announced in 2021, including the target to have 50 percent of all new vehicles sold in 2030 be zero emission vehicles. Thanks to the federal subsidies to purchase EVs and increasing customer interest in the ever-widening selection of passenger and pickup truck EVs, it is estimated 35 million EVs will be on the road in 2030. The US anticipates 500,000 public charging stations, including 50,000 direct current fast chargers (DCFCs), would be required to support that level of adoption.

Nearly all public infrastructure deployed today is pull-in designed, presenting serious challenges for the growing category of use cases laid out above. The only option for larger motorized eRV classes and M/HD EVs is to pull in and occupy multiple stalls, which reduces the availability of chargers for other EV drivers at a site. This option for larger EVs assumes that there are no overhead obstacles (i.e., canopy) preventing the vehicle from pulling into a stall. EVs with towable RVs or other trailers have a second option: to decouple by parking, un-hitching, pulling in to charge, and then re-hitching. Enough space would be required to maneuver and decouple. Both options generate congestion and safety concerns that would affect all consumers on the site.

As of May 2023, public pull-through charging facilities are currently scarce, as shown by this list of known deployments and plans for public pull-through stations in the US:

- TeraWatt Infrastructure is developing the first pull-though network along Interstate 10, from California to Texas, targeting M/HD trucks (long haul/trucking operations) and set to be commissioned this year.
    - This network will likely consist entirely of pull-through

charging stations as such a design is necessary to accommodate larger vehicles. It is unclear whether this network will be strictly for commercial vehicle use or available for other EV consumers.

- Electrify America currently has only one site with pull-through charging stations, which is in Baker, California.
  - In its next deployment phase, Electrify America plans to deploy a standard of six stalls per location with two stalls planned to be pull-through.
- The first Rivian Adventure Network charging site opened June 2022 in Salida, Colorado, with four DCFCs, one of which is pull-through.
  - Rivian will be expanding its network with the inclusion of pull-through stations. However, these stations are currently only available to Rivian customers.

The dearth of pull-through charging sites means pull-through consumers – RVers with towable trailers, eRVs, and other M/HD vehicles – will ultimately hinder the availability, utilization, and associated revenue of pull-in stations because these oversized vehicles will block multiple charging stalls or roil the station's traffic pattern by requiring EVs to unhitch and park the towable somewhere else.

3.0 Consumer Need for Pull-Through Charging

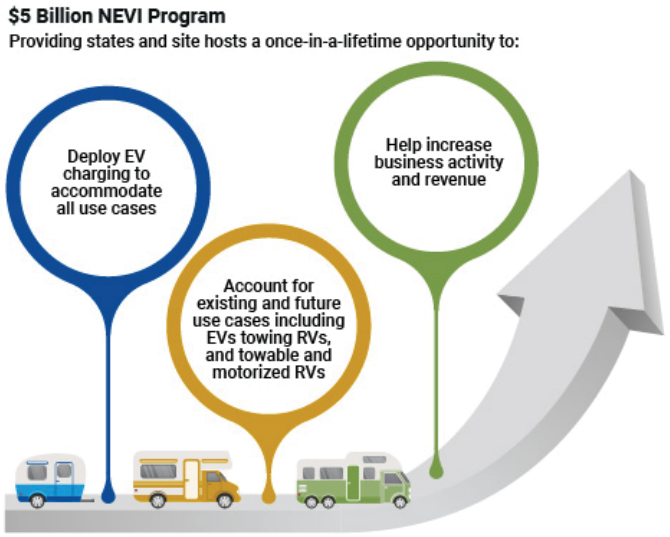
The types of EV consumers that will rely on a nationwide public network of pull-through DCFC stations include RVs (towable and motorized), vehicles towing recreational (e.g., boats, ATVs) or commercial (e.g., agriculture, landscaping) trailers, moving trucks (e.g., U-Haul), and other M/HD commercial vehicles. Key characteristics of consumers that will utilize pull-through sites include, but are not limited to, the following:

- Travel long distances.
- Tow trailers.
- Lower kilowatt-hour per mile (kWh/mile) efficiencies.
- Larger than standard vehicle lengths (with or without trailer).

These characteristics generate a need for fast charging infrastructure that can accommodate larger vehicle space requirements while preserving charger accessibility for other EV drivers and the safety of all users.

The American-made RV industry is a $140 billion industry that supports 680,000 American jobs and pays more than $48 billion in wages and $13.6 billion in federal, state, and local taxes. Roughly 85 percent of the RV market is towables. The entire outdoor recreation industry – much of which involves towing (RVs, boats, motorcycles, dirt-bikes, ATVs, snowmobiles, etc.) – has an economic impact of $862 billion, or 2 percent of the entire US economy.

The number of vehicles traveling for recreation is expected to continue to grow at a significant annual rate, and RV ownership is trending younger and more diverse. As recreational trailer and motorized RV owners and buyers transition to EV tow vehicles and/or eRVs, these consumers will accelerate market demand for pull-through charging stations. Deploying a national network of public pull-through infrastructure will positively impact EV adoption with these consumers because they will feel confident in their ability to take a more sustainable approach to recreational travel that is as feasible, safe, and accessible as using internal combustion engine vehicles.



Additionally, electrified RV trailers are coming on the market. These trailers will allow EV tow vehicles to travel with reduced range degradation, but they will also require pull-through sites to charge the electrified trailer.

Drivers requiring pull-through sites will increasingly expect the same services, accessibility, and simplicity for their EVs as they currently experience at gas stations, including the fastest "fill up" possible. States and businesses that invest in public pull-through charging networks will be rewarded with revenue and loyalty from leisure road-trippers towing RVs, M/HD vehicles, and more. However, if future public DCFC deployments do not consider the space requirements for pull-through consumers, the infrastructure would likely be insufficient to serve the expected dramatic growth in EV demand. Acting now to incorporate a mix to include pull-through DCFCs at public charging sites will be most cost effective, increase accessibility for all types of EV

drivers, and support the long-term success of America's electrification transition.

Although there is not an industry-adopted perspective on how payload affects range, in one case study, a Rivian R1T pickup pulling a 6,500 pound trailer experienced a 50 percent reduction in range. The average range of EV pickups and SUVs in the US is 268 miles. Recreational travel averages 5,000 miles annually, with each trip being approximately 250 miles; therefore, if an EV is towing and realizing a 50 percent reduction in range, the EV would require two or three charging stops during an average trip.

If recreational EV drivers are required to maneuver in tight spaces and decouple or if they do not have access to DCFCs, a poor customer experience is likely, which could delay adoption of EVs and push drivers to sites that have pull-through facilities. In conclusion, recreational consumers will see a decrease in value in transitioning to EVs if they cannot tow trailers to their destinations with a similar convenience as they can with traditional fuel vehicles. Investment in public pull-through fast charging networks that connect major corridors to major recreational destinations and points of interest is critical to the future of America's EV transition.

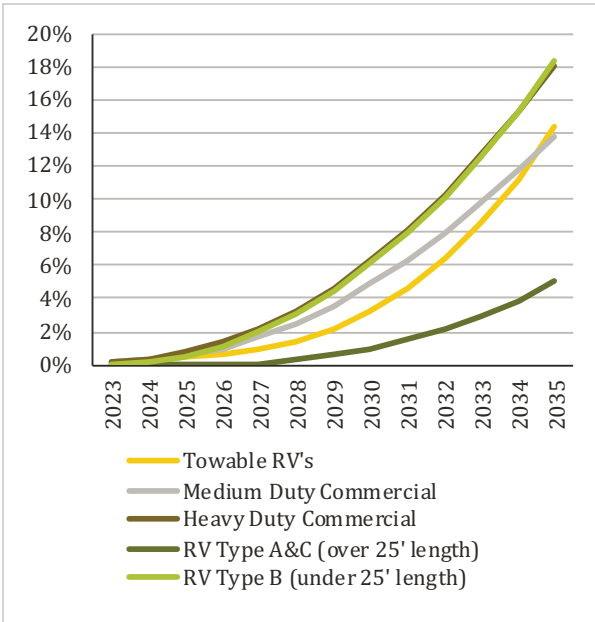


Figure 3-1 EV Adoption Forecast by Vehicle Type

Black & Veatch has developed a forecast to highlight the anticipated EV adoption of RV-related pull-through consumers. This model is based on 20 years of RV industry sales and life-cycle data, proprietary information, and advanced data modeling. Figure 3-1 displays the percentage of vehicles on the road each year that will be electric and will best be served by public pull-through charging stations. Towable RVs were created as a subset of passenger vehicles; therefore, this forecast does not anticipate electric trailer adoption, but rather, the adoption of passenger EVs that pull towable RVs. However, electrified trailers will be on the roads in coming years and will require pull-through sites no matter whether the tow vehicle is electrified or not.

By 2035 it is estimated that 14 percent of towable RV owners will drive EVs (745,551 units). For motorized RVs, Type Bs will likely begin transitioning to EVs in 2024, with up to 18 percent electric Type Bs (38,702 units) on the road by 2035; Type A and Type C adoption is anticipated to begin later in 2026 and reach 5 percent EV adoption (59,142 units) by 2035. M/HD vehicles were included as a strong ancillary consumer for pull-through charging; large commercial vehicles that travel long distances and/or do not have a "home base" (such as independent owner-operators) will rely on public charging stations that accommodate their space requirements.

4.0 Designing for Pull-Through Charging

The future of electrification merits a firm investment in DCFC pull-through charging. Black & Veatch recommends that 50 percent of all chargers at a given EV charging facility be designed to accommodate pull-through charging. This availability would accommodate both those vehicles that require the space and standard vehicles that are looking for a quick charge and return to the road. Given the minimum of four chargers required under the NEVI program, it would also ensure that both an EV tow vehicle and an electrified towable would be able to simultaneously charge.

Several planning and equipment considerations can be evaluated early in the site design process to maximize the economic returns for a facility. It may be economically beneficial to install an energy management system (EMS) to mitigate potential utility fees such as site upgrade costs and demand charges. The use of a battery energy storage system (BESS) could also provide economic benefits by incorporating on-site solar generation and demand reduction and by shifting energy use to more favorable time of use periods. It is advisable to use charging equipment with multiple ports (dual or quad); all the designs being proposed include dual ports on all charging units to allow for load sharing and

additional revenue generating opportunities for the EV charging equipment. Chargers with multiple ports also ensure the fastest path to the greatest number of charging ports.

A cord length as long as possible is recommended to accommodate charged vehicles and towables where the charging port is in a nonstandard location, with a minimum length of 16 feet. However, cable lengths of 20 to 26 feet are available in the market.

The front-to-back spacing between aligned chargers in an aisle should be large enough to allow for trailers and other towed vehicles without blocking chargers and to allow a tow vehicle and electrified trailer to charge at the same time. A front-to-back spacing of roughly 30 feet is recommended. Bollards, shrubbery, and signage should be kept at a safe distance from the charging equipment. Several NEVI-funded sites have been observed where the charging configuration could easily accommodate a passenger EV towing a trailer with the simple removal of EV charging parking signage separating two pull-in parking stations.

In addition to cord lengths, several other design and equipment specifications must be considered. Table 4-1 outlines several design items and suggested specifications for design, equipment, and layout.

Item	Specifications	Considerations
Distance Between Charging Aisles	Single Lane – HDV 14’ minimum aisle width	Provides enough space for M/HD and Type A RVs to maneuver in and out
	Single Lane – MDV and towables 13’-6” minimum aisle width	Provides enough space for medium-duty and EVs with towables to maneuver in and out
	Multi Direction 28’ minimum double aisle width	Provides enough space for medium-duty and EVs with towables to maneuver in and out
	ADA Accessible 16’ minimum aisle width	Allows for a vehicle 5’ from charger to access charger
Distance Between Chargers on an Aisle	30’-40' between front and rear charger	Permits charging of a tow and towed vehicle simultaneously
Cable Length and Management	16’ minimum cable length	Improves accessibility and allows reach for ports at front and back of vehicle
	20’ and over cable length preferred	Allows access to charge ports on far side of vehicle
Charging Cable Management	Cable retraction and management system	Prevents damage to cables and improves ease of use and accessibility
Charger Power and Ports	Minimum dedicated 150 kW per port	Meets NEVI funding minimum throughput requirements
	Dual port dispensers	Improves utilization of pull-through layouts

Table 4-1 Design and Equipment Considerations for Pull-Through Charging

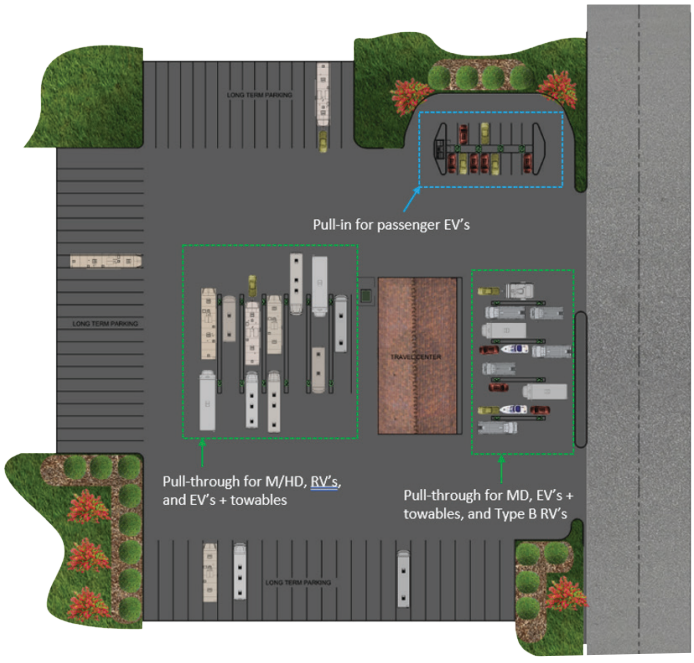


Figure 4-1 Illustration of Charging Hub with Pull-Through Chargers

Figure 4-1 shows a conceptual rendering of a pull-through charging hub. The look and feel would be like traditional gas stations and travel hubs. Multi-direction lanes would allow for medium-duty vehicles and vehicles pulling towables (RVs, recreational, and commercial trailers) to utilize the bank of chargers to the right of the travel center. In addition, the site would have single vehicle (one direction) lanes for the larger M/HD vehicles and Types A and C RVs to provide access to the bank of chargers to the left of the Travel Center shown in the figure. This arrangement would allow flexibility for the site to accommodate all types of consumers and maximize utilization.

The option of including one or two chargers should be considered when banks of chargers for the larger vehicle use cases are designed. Figure 4-1 shows the option of each pull-through lane with two chargers at the front and back. This placement would increase flexibility for

because two larger vehicles could be served at once; the front vehicle could pull up far enough to accommodate another vehicle at the back or allow a vehicle to charge while also charging its towable.

Figure 4-2 shows a rendering of a common four-port NEVI site (right bank of chargers within a parking island) and what it might look like to retrofit the site to include another bank of dual-port chargers with multi-directional pull-through lanes to accommodate larger vehicle use cases. This design also includes the flexibility to charge two vehicles at the same time or a vehicle and a towable if the total trailer and vehicle length is under approximately 40 feet.

Pull-through charging infrastructure improves accessibility for drivers and vehicles that are not well-served by existing pull-in charging infrastructure. Pull-in chargers are often installed on top of or behind curbs, which limits access to those in wheelchairs. EV charging stations are typically unattended and, therefore, accessibility should be considered carefully in the site design. Effort should be made to accommodate drivers with limited hand dexterity, amputations, or other disabilities. Sufficient space should be provided in aisles to allow users requiring mobility devices easy access and operability of the chargers. Section 508 of the Rehabilitation Act, Americans with Disabilities Act (ADA) regulations, and International Building Codes should be referenced to confirm that minimum access requirements are met.

5.0 Conclusion

The momentum in EV sales and adoption across the US can be sustained only if the entire EV consumer population has access to convenient and safe charging infrastructure along interstates, highway corridors, and near popular destinations. EV towing applications continue to grow, and electric-assist trailers and eRVs will soon enter the market. As adoption grows, these consumers will present an increasing need for public DCFC pull-through charging stations. Other EV consumers, including M/HD commercial vehicles, will continue to reach higher adoption rates and exponentially benefit from access to public DCFC pull-through stations.

Figure 4-2 Illustration of Retrofitting an Existing EV Charging Site

The $5 billion NEVI program is once-in-a-generation opportunity. It is critically important to invest today to deploy EV charging infrastructure designed to accommodate all EV use cases, including RVs – towable and motorized. It is substantially more expensive to retrofit EV charging sites to adapt for these growing EV consumer bases.

States that use NEVI funds for public pull-through charging networks will see several returns, including the following:

- Increased business activity and revenue from EV-owning leisure road-trippers towing trailers or driving eRVs.
- More efficient use of pull-in charging infrastructure, which need not accommodate larger EVs and EV-towed trailers.
- A faster transition of commercial fleets to EVs.
- More rapid progress toward climate goals because of fleet electrification.

Acting now to incorporate a mix of pull-through DCFCs at public charging sites is cost effective, improves accessibility for all types of EV drivers, and supports the long-term success of America's electrification transition.

Financial Analysis Report

As we examine pull-through vs. pull-in charging sites, there are several economic considerations that must be accounted for when determining the overall economic viability of a pull-through site. The two site design options can be compared based on the incremental differences of capital required to purchase and build the site while also examining the potential incremental revenue that can be achieved from a pull-through site.

The first capital consideration when comparing these two options for a charging site lies in the space requirements between a pull-in and pull-through site. The availability to support larger vehicles more seamlessly at a pull-through charging site results in the need for more land because of spaced out chargers and additional space to pull out of the stalls. The overall additional size for a site is dependent on how many charging stalls are within the site. For example, when comparing sites with 4 and 16 stalls, the additional footprint required for a pull-through site when compared to the pull-in footprint is 25% and 55% respectively.

With additional space and distance between chargers, the total make ready costs at each site will also be increased at a pull-through site. Pull-through sites consist of larger hardscaped square footage, more trenching work, and increased amount of cabling/conduit required to support the chargers. In comparison of total make ready costs between the two site options, a greenfield or new construction location was used to assume the maximum price differential. The analysis showed that a pull-through site would require roughly a 10-20% increase in overall make ready costs.

To offset the larger capital investment required for a pull-through site, there are many potential revenue advantages to a pull-through site that can help provide a positive payback. The combination of pull-through sites being less common than pull-in sites and the additional capital required should allow pull-through sites to realize a premium on their $/kWh charging services profitability (cost charged to customer to cover fees, energy costs, maintenance, etc.). A pull-through site's additional space allows for larger and higher-class vehicles to be able to utilize the site for vehicle charging which results in more kWh on average being delivered to the vehicle during a charging session. The design of the pull-through site also allows vehicles to que which can increase the efficiency and utilization of the site while vehicles cannot do the same at pull-in sites. At these pull-through sites, there is also an opportunity for ancillary services to be provided while the vehicles are charging in the form of convenience stores and other amenities. Convenience stores on average have a 5% profit margin with an average transaction per patron being $11.41 in 2021[1]. With eRV's being more likely to use a pull-through charging site, more families and overall patrons would be expected to visit the site which would result in additional ancillary revenue at pull through sites.

Considering variable capital and payback considerations on an incremental basis shows an approximate 3-4 years to payback the incremental capital costs required for the pull-through sites in comparison to pull-in sites with a 10-15% average increase in utilization. This increase in utilization would also result in approximately $100k - $350K in additional cash flow from profits on a 10-year NPV basis at a standard NEVI site. There are also non-revenue benefits for a pull-through charging site such as increased safety and accessibility with larger/spaced out charging stalls.

[1] Convenience Store News: June 2022, CSNews.com