Technical Primer for Strategies and Techniques for Reducing the Installation and Operating Costs of Electric Vehicle Supply Equipment (EVSE)

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Technical Primer for Strategies and Techniques for Reducing the Installation and Operating Costs of Electric Vehicle Supply Equipment (EVSE)

Report Summary

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Notice

Abstract

The plug-in electric vehicle (EV) charging technologies and strategy options described in this report were developed to offer lower cost options for *long-dwell* or *long-duration* public/shared parking venues to decrease the cost barrier to market acceptance of EV charging infrastructure. Long-dwell parking is defined here as six or more hours per day per parking event. Long-dwell public/shared parking venues include (but are not limited to): long-term airport parking, multi-family dwellings (e.g., condominiums and apartments), park-and-ride commuter parking, transit (e.g., bus and train), workplaces, and hotels. (Shorter duration parking and higher rate charging are not included in this report.) EVs include both battery-electric vehicles (BEV), for example, Nissan Leaf and Chevrolet Bolt and plug-in hybrid electric vehicles (PHEV), for example, Toyota Prius Prime and Ford Fusion Energi. The lower cost and/or lower power charging technology and strategy options described in this report provide options for facility operators to install more cost-effective EV charging for their customers. The options are applicable for both new installed and upgraded and expanded EV charging installations. This technical primer summarizes a comprehensive companion report that is based on a project funded by the New York State Energy Research and Development Authority (NYSERDA).

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1 Introduction

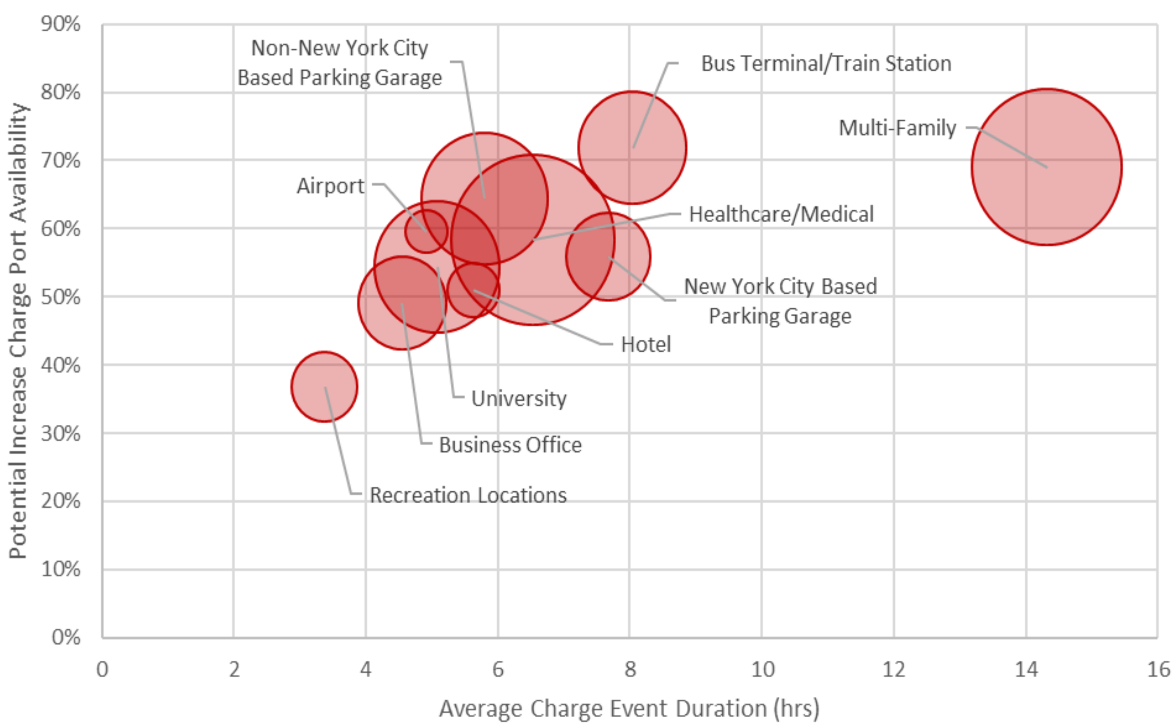
The plug-in electric vehicle (EV) charging technologies and strategy options described in this report were developed to offer lower cost options for *long-dwell* or *long-duration* public/shared parking venues to decrease the cost barrier to market acceptance of EV charging infrastructure. Long-dwell parking is defined here as six or more hours per day per parking event. Long-dwell public/shared parking venues include (but are not limited to): long-term airport parking, multi-family dwellings (e.g., condominiums and apartments), park-and-ride commuter parking, transit (e.g., bus and train), workplaces, and hotels. (Shorter duration parking and higher rate charging are not included in this report.) EVs include both battery-electric vehicles (BEV), for example, Nissan Leaf and Chevrolet Bolt and plug-in hybrid electric vehicles (PHEV), for example, Toyota Prius Prime and Ford Fusion Energi. The lower cost and/or lower power charging technology and strategy options described in this report provide options for facility operators to install more cost-effective EV charging for their customers. The options are applicable for both new installed and upgraded and expanded EV charging installations. This technical primer summarizes a comprehensive companion report that is based on a project funded by the New York State Energy Research and Development Authority (NYSERDA). For more in-depth discussion and details, visit nyserda.ny.gov/About/Publications/Research-and-Development-Technical-Reports/Transportation-Reports on NYSERDA's webpage and scroll down to 18-23 Strategies and Techniques for Reducing the Installation and Operating Costs of EVSE.

2 New York State Long-Dwell EVSE Utilization

Each EV charging venue type as well as each charging site has unique operating circumstances. New York State long-dwell parking charging station—or electric vehicle supply infrastructure (EVSE)—utilization data were analyzed by Idaho National Laboratory and Energetics to (1) determine the usage characteristics of each type and (2) identify technology and strategy options to reduce installation and operations costs for new installations—and for expanding and upgrading existing installations. Some long-dwell EV parking venues showed better potential for implementing hardware or management strategies. All options should be evaluated on a per-site basis to incorporate site-specific details.

Figure 1 shows EV charging characteristics for venue types based on the average event duration (total time connected to a charging station), the potential for shared station use (percentage of time an EV was connected to a charging station but not drawing power), and the average utilization. (Larger "bubbles" indicate longer average connection times).

Figure 1. Long-Dwell Station Usage Characterization



The analysis also developed the following for each long-dwell parking venue type:

- A plug-in event duration distribution (see Figure 2)
- A charging station use profile (see Figure 3)
- An alternative charging-power level analysis (see Figure 4

Figure 2. Multifamily Dwelling Plug-in Event Duration Distribution

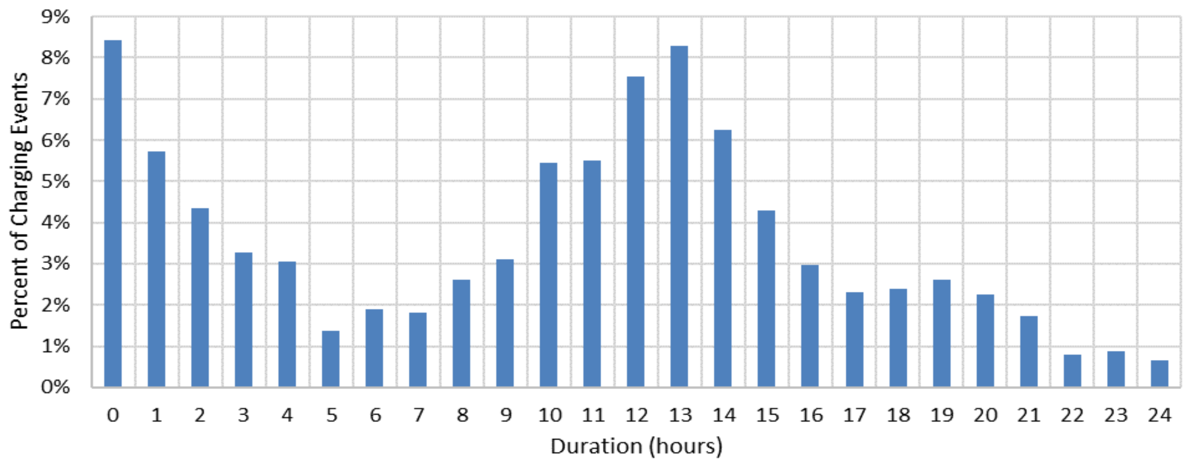


Figure 3. Multifamily Dwelling Charging Station Use Profiles

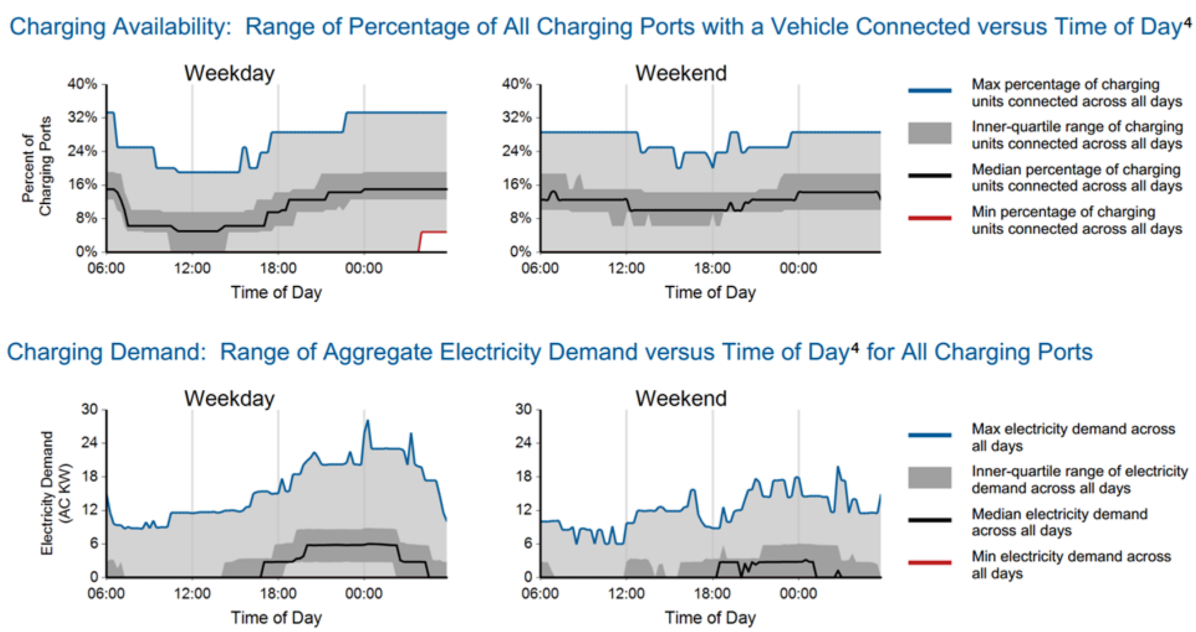
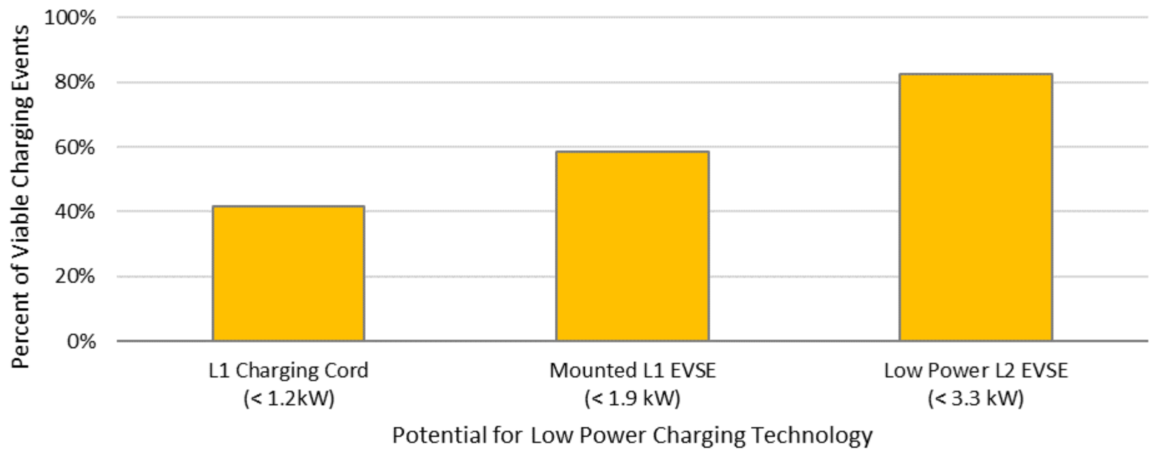


Figure 4. Multifamily Dwelling Alternative Charging-Power Level Analysis Results



The data analysis results showed that all long-dwell parking venues can benefit from the evaluated approaches, some more than others.

Charging stations for *multifamily dwellings* (also referred to as multi-unit dwellings) have regularly occurring long-duration events, in which connected vehicles are charged much longer than necessary. The results showed that multifamily dwellings have high potential for implementing charging station management and/or hardware strategies to lower the installation and operations costs for new installations. The results also indicated that there are options to maximize existing infrastructure usage, to avoid or delay investment in additional stations.

Charging stations at *transit stations* also have regularly occurring long-duration events, in which connected vehicles are charged much longer than necessary. These two venues typically serve the same group of PEV drivers on a daily basis, with PEVs parking for a period of eight hours or more for an entire workday in transit stations and overnight in multifamily dwellings. Consistent and long-charge events were also typical at *workplace* charging stations (e.g., business offices, healthcare, and universities). Charging station use in *multi-use parking garages and lots* were analyzed in and around New York City. These locations have varied use including short- and long-dwell parking and charging event characteristics. The analysis showed potential for some of the low-cost charging technologies and approaches, but their use is location specific and will require additional data analysis to develop an appropriate solution. Other long-dwell PEV parking venues including *airports, hotels,* and *recreational locations* had very limited charging station usage data. The lack of data and the fact these stations experienced a wide range of charging event durations means that strong conclusions could not be made.

3 EV Charging Infrastructure Technology Options

EVSE Options

A range of EVSE technology options are available for long-dwell parking. All use the standard SAE J1772 vehicle charging connector. The lowest cost option is an *alternating current (AC) Level 1 outlet* that connects to a *AC Level 1 EVSE cordset,* which is attached to and comes with the vehicle. The recommended outlet is a high-quality National Electrical Manufacturers Association commercial grade—such as hospital grade—ground fault current interrupter (GFCI) that meets the National Electric Code requirements. The chargers are powered by 120 volts-alternating current (VAC) on a dedicated 15-amp (A) circuit and provide up to 1.4 kilowatts (kW) of power and approximately 5.0 miles of driving range per hour of charging (approximately 30 miles in a six-hour charge).

An *AC Level 1 EVSE* has more functionality and convenience for a somewhat higher cost. It is powered by 120VAC a 20 A circuit and provides up to 1.9 kW and approximately 7.0 miles of driving range per hour (approximately 42 miles in a six-hour charge).

Low power (3.3 kW) AC Level 2 EVSEs are standard AC Level 2 EVSEs that are powered by 240VAC on a 20 A circuit (lower than the maximum allowable), providing up to 3.3 kW and approximately 10–12 miles of driving range per hour (approximately 60–72 miles in a six-hour charge).

A typical *AC Level 2 EVSE* uses 240VAC or 208VAC input power on a 40 A circuit to provide up to 6.6 kW and delivers approximately 20–25 miles of range per hour of charging (approximately 120–150 miles in a six-hour charge).

EVSE costs vary based on the power level, features, and whether the stations are networked or managed. Charging infrastructure installation costs vary widely by location depending on the site configuration. Various factors influence installation costs (wire-run length, obstacles to routing wires, trenching length, pavement/concrete repair, etc.) as well as any needed utility infrastructure upgrades. Installation costs often exceed the charging station hardware costs. Because of these factors, the costs depicted are not definite costs, but rather a representative range of examples to guide the charging infrastructure design development. Table 1 summarizes the EVSE specifications, performance, and cost characteristics.

Table 1. EV Charging Infrastructure Specifications, Performance, and Cost Characteristics

Type	Charging Infrastructure Cost	Installation Cost	Input Power	Maximum Output Power (kW)	Driving Miles per Hour Charge	Driving Miles per Six Hour Charge
AC Level 1 Outlet	$100	$100-$1,000	120VAC, 15-20 A	1.4	5	30
AC Level 1 EVSE	$300-$1,500	$300-$5,000	120VAC, 20 A	1.9	7	42
AC Level 2 EVSE (low power)	$300-$1,500	$500-$8,000	240VAC, 20 A	3.3	10-12	60-72
AC Level 2 EVSE	$400-$6,500	$1,000-$10,000	240VAC or 208VAC, 40 A	6.6	20-25	120-150

EVSE Power Management Options

AC Level 2 plug sharing can be accomplished by configuring EV parking spots to enable a single charging station to serve multiple vehicles throughout the day. The charging station must be installed so that the charging cord is accessible to multiple parking spaces, allowing the cord to be transported from one EV to another during the day without moving vehicles. Users must return to the vehicles during the day for this strategy to work, which may not be feasible in every parking application. Alternatively, the driver could move the EV to another parking spot to allow another EV driver to use the station. Charging station use policy solutions (e.g., for workplaces or multifamily dwellings) such as (1) limiting charging times, (2) reserving nearby EV charging staging spaces to move vehicles to/from, and (3) developing communications strategies (e.g., calendar applications and social media pages) have been proven to be effective. The largest potential savings from using this approach that maximizes the EVSE utility is from avoiding additional equipment and electrical service capacity upgrade costs.

Simple *power sharing dual-port AC Level 2 charging stations* are powered by the same input power as a standard single charger. These charging stations share the power between the two connected vehicles based on need. When one vehicle is connected, the charging station functions as a standard charging station. When two vehicles are connected, internal hardware shares the available power between the two vehicles based on need. The hardware costs can be somewhat (~25–30%) higher than two stand-alone EVSEs, but the electrical infrastructure costs and system demand charges will be lower. The largest potential savings from using this approach is from reducing demand charges and electrical service upgrade costs.

Automated power management systems actively control/manage the power among multiple charging stations at a facility to minimize the system-level electrical demand and cost impacts by optimizing charging times and rates. Some systems communicate with the grid and incorporate pricing signals in the management algorithms. System costs (initial and monthly) can be high but can be a cost-effective solution for long-dwell parking situations, where the AC Level 2 charging is needed, but there is limited available electrical service capacity or minimizing demand charges is critical. The largest potential savings from using this approach is from reducing demand charges and avoiding electrical service upgrade costs.

4 Technologies and Strategies for Installing New Long-Dwell EV Charging Stations

The evaluated technologies and installation strategies for new long-dwell charging station installations are summarized in the following passages. The equipment required and how each option could be implemented are described.

AC Level 1 Outlets and EVSE Cordsets are an option but cannot meet all EVs' charging needs. This option, however, can be a good initial step for parking facilities interested in low cost charging but are uncertain about making a larger investment, or are uncertain about the EV parking customer's charging needs. Outlet durability and concerns regarding vandalism, theft, and wear and tear of a customer's personal EVSE cordset may limit the use of this option, requiring further evaluation before selection. AC Level 1 charging stations use the same electrical wiring infrastructure, so the charging infrastructure could be upgraded in the future if needed, once EV charging demand increases and the system's costs are quantified for the parking facility operator. The largest potential savings of this approach are from low hardware costs, low installation costs, lower electrical service cost, and minimizing demand charges.

AC Level 1 Charging Stations provide sufficient energy to EVs for many long-dwell charging events. Two AC Level 1 EVSE can be installed in place of a standard AC Level 2 EVSE to provide double the number of charging ports and still serve the customers' charging needs. This approach limits the total installation peak power and maximum sustained power draw to reduce electrical infrastructure requirements. AC Level 1 EVSE hardware and installation costs are only slightly lower than for AC Level 2 EVSE. The largest potential savings from using this approach is from lower electrical service cost and minimizing demand charges.

Low Power (3.3 kW) AC Level 2 Charging Stations provide sufficient energy to EVs for most long-dwell charging events. The peak power and maximum sustained power draw are lower compared to typical 6.6 kW AC Level 2 EVSE. This can be an option to increase the number of available charging ports, compared to AC Level 2 EVSE, while providing higher charging power than AC Level 1 infrastructure and limiting the required electrical service capacity. The higher power compared to AC Level 1 will satisfy parking customers that park for somewhat shorter durations and/or require more charge. Because standard AC Level 2 hardware is used, if needed at a later time the full power capability (e.g., 6.6 kW) can be achieved with an electrical service capacity upgrade. The largest potential savings from using this approach is from lower electrical service costs and reducing demand charges.

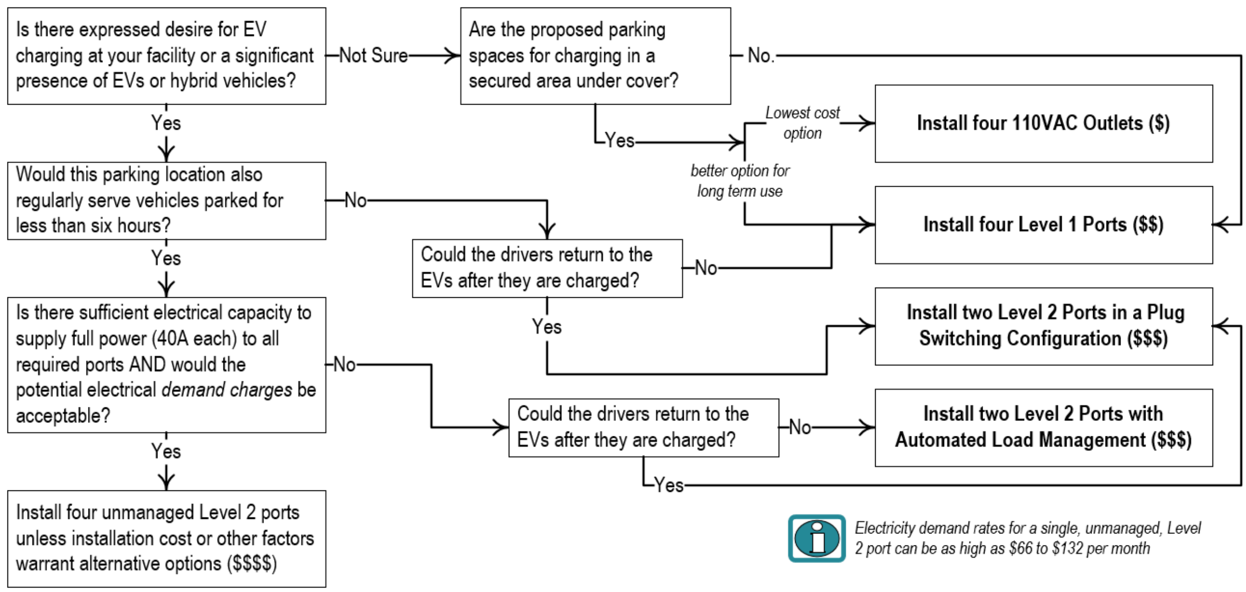
AC Level 2 Plug Sharing, either by vehicle owners or by a valet service, can be implemented by properly locating the EVSE and nearby parking spots to allow for plug sharing. Charging station use policy solutions (e.g., limited charging times, reserved nearby EV charging staging spaces to move vehicles to/from, and communications strategies) must be developed and implemented. As a convenience, additional designated EV parking (without a charging station) spaces could be designated near the charging stations to provide drivers with a convenient nearby spot to move their vehicle once charged. This approach that maximizes the EVSE utility but requires action by the EV drivers or valet service which is not feasible in every setting. The largest potential savings from using this approach that maximizes the EVSE utility is from avoiding additional equipment, avoided/delayed electrical service capacity upgrade costs, and managing demand charges.

AC Level 2 Power Management: Installing either *power sharing dual-port AC Level 2 charging stations* or an *automated power management system* can be a cost-effective strategy for long-dwell parking situations where the AC Level 2 charging is needed, but there is limited available electrical service capacity or minimizing demand charges is critical. The largest potential savings from using this approach is from reducing demand charges and electrical service costs.

Low-Cost EV Charging Infrastructure Tool for New Installations

The simple long-dwell parking decision flowchart tool for EV infrastructure developed for host sites with no existing EVSE infrastructure provides help in identifying the appropriate installation strategy and is shown in Figure 5. The decision tool assumes that the majority of EVs will be plugged in for six hours or more, four vehicles will be charged in the same period, and the comparison baseline is 6.6 kW AC Level 2 charging stations. The baseline system would use two dual-port EVSE to charge four EVs in the same period.

Figure 5. Decision Tool Strategies and Techniques for Reducing the Installation and Operating Costs of EVSE for New Installations



4.1 Strategies to Expand Existing Charging Station Installations

Many locations with EV charging infrastructure have a dual-port AC Level 2 EV charging station(s). As EV adoption increases and there is more demand for charging stations, these site owners will need to explore options for adding charging stations, or to optimize the use of the existing charging stations. Installing additional AC Level 2 charging stations can be costly, particularly if upgraded electrical equipment and service is needed to provide sufficient power. The evaluated technologies and installation strategies for upgrading and expanding existing charging station installations are summarized in the following passages. Some options are the same as, or similar to, new installations. The equipment required and how each option could be implemented are also described.

Replace AC Level 2 Charging Station with Multiple AC Level 1 Charging: Two AC Level 1 charging ports can typically be powered using the same conduit and circuit as one existing 6.6 kW AC Level 2 EVSE with only minor changes. Removing one existing AC Level 2 station and replacing it with two AC Level 1 stations doubles the number of EVs that could charge at one time. The “lost” AC Level 2 charging station cost for the removed unit will be made up for by lower demand charges and servicing twice the number of EVs. The peak and average charging power will be lower than the baseline AC Level 2 station but will still be sufficient for many long-dwell parking locations. The largest potential savings from using this approach is from avoiding/delaying electrical service upgrades and reducing demand charges.

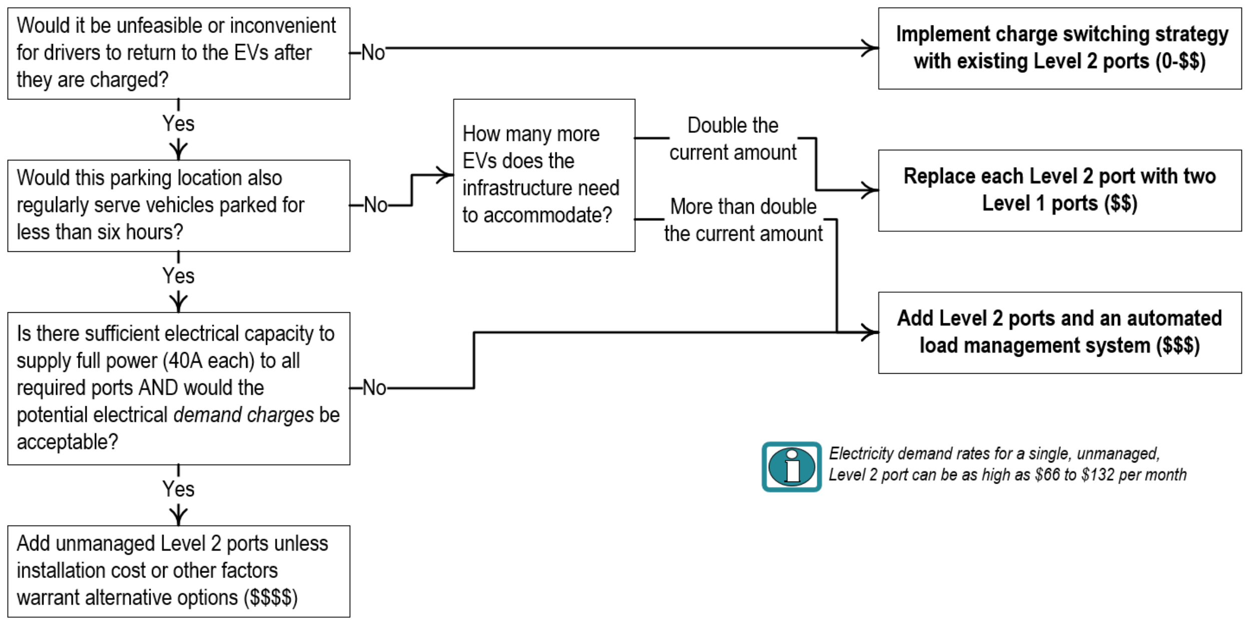
Implement AC Level 2 Charging Station Plug Sharing: If the existing station's charging cords can reach an additional adjacent parking space(s), the EVSE's use can be shared among multiple vehicles without any charging equipment investment or EV drivers moving vehicles. Charging station use policy solutions (e.g., limiting charging times, reserving nearby EV charging staging spaces to move vehicles to/from, and communications strategies) must be developed and implemented. The largest potential savings from using this approach that maximizes the EVSE utility is from avoiding additional equipment, avoided/delayed electrical service capacity upgrades, and managing demand charges.

Add AC Level 2 Charging Station Power Management: As with new installations, installing either power sharing dual-port AC Level 2 charging stations or an automated power management system can be a cost-effective strategy for long-dwell parking situations where the AC Level 2 charging is needed, but there is limited available electrical service capacity or minimizing demand charges is critical. The largest potential savings from using this approach is from reducing demand charges and electrical service upgrade costs.

Low-Cost EV Charging Infrastructure Tool for Expanding Existing Installations

A simple long-dwell parking decision flowchart tool for EV infrastructure was developed for host sites with existing EVSE infrastructure to provide help in identifying the best strategy to expand the number of charging ports (Figure 6). The decision tool assumes that the majority of EVs will be plugged in for six hours or more, four vehicles will be charged in the same period, and the comparison baseline is 6.6 kW AC Level 2 charging stations. The baseline system would use two dual-port EVSE to charge four EVs in the same period.

Figure 6. Decision Tool Strategies and Techniques for Reducing the Installation and Operating Costs of EVSE for Expanding Existing Installations



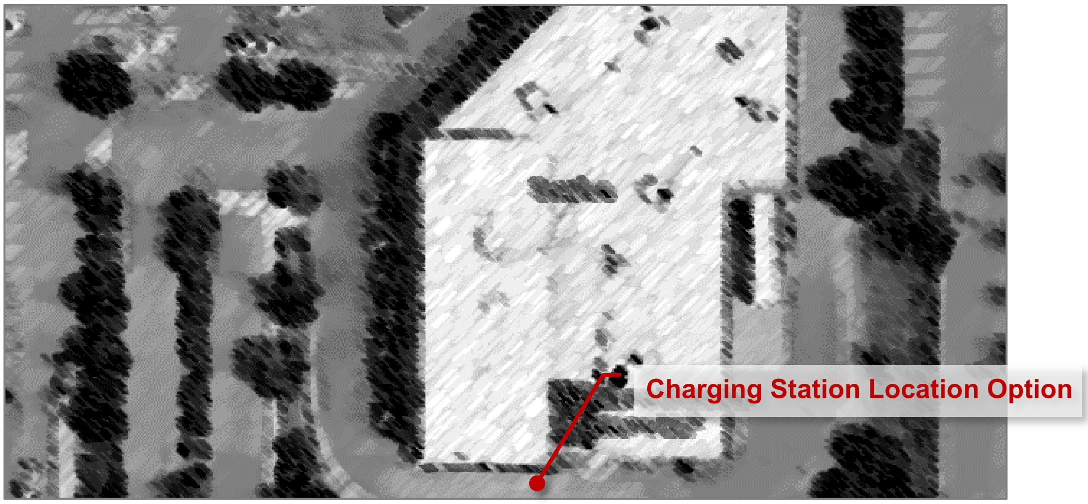
4.2 Estimated Costs and Savings of Strategies and Techniques for Reducing the Installation and Operating Costs of EVSE

There are a large number of potential options for each long-dwell parking venue based on the site-specific conditions. Because of this, it was not practical to attempt to describe every possible permutation and decision path through the flowchart. Instead, three test cases were developed for both the installation of new charging infrastructure and for expanding and upgrading existing charging infrastructure situations to serve as a guide/example for end users' utilization. An example of the process and results for each new installation and an expanded and upgraded installation are depicted in the following passages.

New Installations—Workplace Test Case

A small workplace location—a 30-employee lawyer's office (see Figure 7)—wants to install an EV charging station to provide employees with an option to plug-in while at work and to bolster the company's green image. No one currently drives an EV, but at least one employee may purchase one soon. The charging station will be primarily for employee use. The office is in a building with a larger retail store, so if the lawyer's office and building owner agree to share the station usage, there may be some occasional use by the retail store's customers.

Figure 7. Example: Small Workplace Interested in Charging Stations



Using the strategies for a new station flow chart to determine an effective strategy for increasing charging capacity at this site could result in the following:

Is there expressed desire for EV charging at your facility or a significant presence of EVs or hybrid vehicles?
YES. At least one employee is likely to purchase an EV soon, and the demographics of employees at this lawyer's office align with likely EV owners.

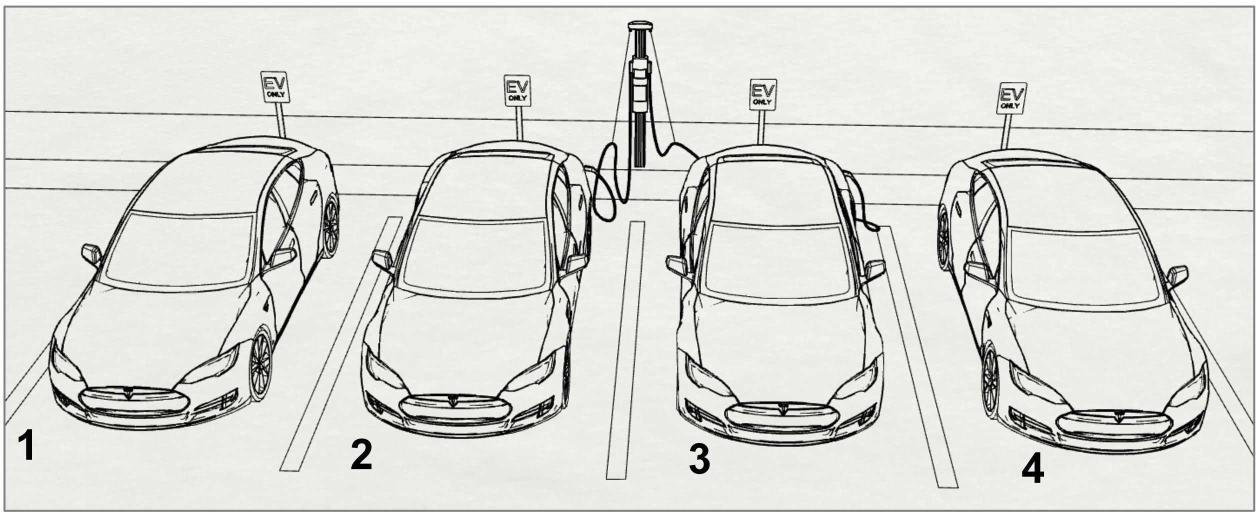
Would this parking location also regularly serve vehicles parked for less than six hours?
NO. This installation is for employees who regularly park for the entire 8-hour workday. If an employee is meeting a client, the employee could be parked for a shorter time, or customers of the retail store could potentially use the parking spaces during non-working hours but neither situation is critical for planning the charging stations.

Could the drivers return to the EVs after they are charged?
YES. The parking is right outside the office.

Recommendation
One dual-port AC Level 2 charging station can serve more than two EVs by implementing a policy to share charging and incorporating additional dedicated EV parking spaces to facilitate plug switching.

With a new installation, the dual-port AC Level 2 station could be installed so the charging cords could reach up to four vehicles without moving the vehicles. Charging stations can be optioned with longer cords, which facilitates this strategy. More EVs could be charged if they were moved once charged. As shown in Figure 8, Vehicles 1 and 2 could share a charging cord from a properly located charging station and Vehicles 3 and 4 could use the other cord. The outer vehicles may need to be oriented to ensure that the cordset on the EV can reach the outlet on the charging port. The office should set up an interoffice calendar or communication chain for EV drivers to coordinate charging times.

Figure 8. Proposed EV Charging Layout for Workplace to Facilitate Plug Sharing



Installing one dual-port AC Level 2 charging station with longer cords could save $3,200 in hardware costs plus an additional $3,000 in installation costs compared to the baseline approach of two dual-port AC Level 2 stations to charge four vehicles (Figure 8). For this situation, most EVs will likely be fully charged after four hours, plug sharing could enable serving four vehicles with half the number of installed ports. Potential annual demand charges are based on $10 per kW with maximum charging station power draw aligning with the facility's peak demand. By having EVs share charging cords, only a maximum of two EVs would simultaneously draw power instead of four EVs if four EVSE were installed. The resulting decreased annual demand charges could be as high as roughly $1,500. The five-year savings from this approach could be a significant $14,120. The savings could be used to fund expanding the infrastructure to satisfy increased demand.

Table 2. Estimated Charging System Costs for Workplace Example

Hardware	Hardware Costs	Installation	Total Installed Cost	Maximum Annual Demand Charges	5-Year Costs
Install Four AC Level 2 EVSE Charging Ports (baseline)	$6,400	$8,000	$14,400	$3,168	$30,240
Install Two AC Level 2 Charging Ports in a Plug Switching Configuration (proposed)	$3,200	$5,000	$8,200	$1,584	$16,120
Potential Savings	$3,200	$3,000	$6,200	$1,584	$14,120

5 Expanding Existing Installation—Multifamily Dwelling Test Case

A common parking area for a shared-use facility, such as a clubhouse, currently has one dual-port AC Level 2 charging station. Charging is provided for free to residents. As more tenants drive EVs, additional charging capacity will be needed because residents do not have a dedicated parking spot to install their own charging stations. Residents with nearby units can conveniently park and charge at this location overnight. Other tenants may prefer to charge their vehicles while using the clubhouse facility for a few hours in the evening or morning. These tenants will require the higher rate AC Level 2 EVSE. Power routing for the original station required boring under the pavement—a costly undertaking. The same process would be required to add another AC Level 2 station. Using the flow chart for strategies applied to existing stations would have the following results:

Would it be unfeasible or inconvenient for drivers to return to the EVs after they are charged?
YES. EV are commonly parked to charge overnight. Residents are not willing to get up at night to move their vehicle.

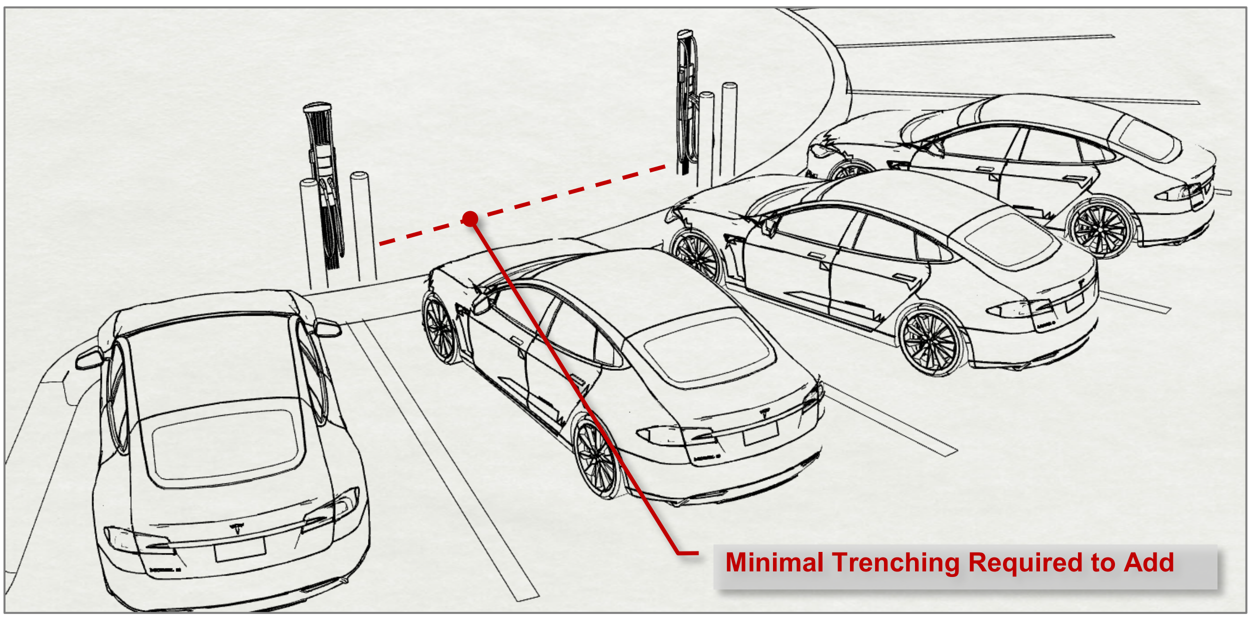
Would this parking location also regularly serve vehicles parked for less than six hours?
YES. Some residents, particularly those that have a unit farther from this location, may require and prefer to charge during a shorter period of time while they are using the facilities. AC Level 2 charging is needed to meet their requirements. .

Is there sufficient electrical service capacity to supply full power (40A each) to all required ports AND are the potential electrical demand charges acceptable?
NO. The source of power is on the other side of the parking lot, so it would be costly to bring another circuit to this location. The clubhouse is also close to maxing out the present electrical service. To continue to offer charging for free, the property manager must minimize the ongoing costs which is not possible with additional electrical demand costs.

Recommendation
Installing one additional dual-port AC Level 2 EVSE would allow four EVs to connect and provide higher power levels for shorter-term charging. Integrating a power charge management solution with the stations could leverage the present electrical power run to the existing station to reduce installation costs and maintain current (or lower) peak electrical demand.

Adding one dual-port AC Level 2 station would only require new trenching between the stations (through soft soil), as shown in Figure 9, and not need a new power run across the parking lot. The automated management system would share the existing power among all four charging ports but allow charging at the full 6.6 kW capability of the AC Level 2 stations when only one EV is plugged into each charging station. When a third or fourth EV is plugged in, the automated power management system can be configured to either divide power equally between all the vehicles or wait until after the first vehicles are fully-charged before charging the others. The system will determine the most efficient approach.

Figure 9. Proposed Strategy for the Multifamily Dwelling Location to Expand the Existing Charging Infrastructure



Estimated costs for installing and operating one additional dual-port AC Level 2 charging station with an automated power management system (using the existing electrical circuit) compared to the baseline case of adding one dual-port AC Level 2 charging station on a new circuit are shown in Table 2. The initial total installed cost savings are low ($500) due to the automated power management system's upfront costs. However, future stations added at this location will use the automated power management system and the existing power supply, so the incremental cost will be significantly less. The automated power management system will maximize annual savings by minimizing demand charges ($10 per kW used in these calculations with maximum demand from the charging stations aligning with the facility's peak demand). The resulting decreased annual demand charges could be as high as roughly $1,650. The five-year savings from this approach could be a significant $8,840. The savings could be used to fund expanding the infrastructure to satisfy increased demand.

Table 3. Estimated Charging System Costs for Multifamily Dwelling: Parking Location Example

Hardware	Hardware Costs	Installation	Automated Power Management System	Total Installed Cost	Maximum Annual Demand Charges	5-Year Costs
Add one dual-port AC Level 2 EVSE Ports (baseline)	$3,200	$10,000	$0	$13,200	$3,168	$29,040
Add one dual-port AC Level 2 ports and an automated power load management system (proposed)	$3,200	$1,500	$8,000	$12,700	$1,500	$20,200
Potential Savings	**$0**	**$8,500**	**-$8,000**	**$500**	**$1,668**	**$8,840**

* Includes service fees for automated power management system

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