

SITING AND DESIGN GUIDELINES FOR ELECTRIC VEHICLE SUPPLY EQUIPMENT



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TABLE OF CONTENTS

INTRODUCTION	
Overview	1
Charging Basics	2
Levels of Charge	3
SITE SELECTION AND DESIGN	
Site Selection	4
Site Design Elements	5
EVSE Interfaces	5
Network Interface	6
Urban Interface	8
Power Interface	9
Parking Interface	10
EVSE Interface	12
SIGNAGE AND WAYFINDING	
Regulatory	14
Wayfinding	15
INSTALLATION CONTEXTS	
Implementation Considerations	16
Commercial	18
Multi-Unit Residential	21
On-Street	23
Service Station	25
Fleet	27
RESOURCES	28



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NOTICE

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INTRODUCTION

Overview Charging Basics Levels of Charge

OVERVIEW

Charging stations are the point of connection to the electrical grid for electric vehicles (EVs), and the point of power for EV drivers. With the anticipated growth of EVs as a widespread transportation choice, the incorporation of electric vehicle supply equipment (EVSE) will become a critical element of city and town planning and designing from a master plan for site-specific installation.

EVSE is a new infrastructure typology. Unlike traditional fueling stations for gas engine vehicles, EVSE lets drivers charge up at home, at work and countless places in between. In fact, this is one of the central value propositions behind EVs—the ability to charge from the grid anytime, anywhere. Estimates suggest that approximately 80%–90% of charging occurs at home, and nearly all of those homes are of the single-family variety. These design guidelines focus on the other 10%–20% of charging—multi-unit dwellings; publicly-accessible locations such as downtown lots, on-street spaces, and highway stops; and private locations including offices and fleet depots—which are critical to establishing a full network of charging options. Expanding the infrastructure network will help make EVs a viable option for all drivers, even those without garages. The benefits come from extended infrastructure networks that are consistent, accessible and easy to use from place to place. EVSE deployment depends on cooperation, a process in which municipalities, the development community and the EV industry will all play leading roles.

The purpose of these design guidelines is to identify and diagram key siting and design issues that are relevant to local governments as well as developers, homeowners, businesses, utility providers and other organizations interested in best practices for EVSE implementation.

The guidelines are organized into two main sections.

ELEMENTS OF SITE DESIGN

Site-level planning creates the user and public interface for EV charging. Critical factors in early EVSE deployment include the following:

- Accessibility and ease of use
- Visibility
- Safety for installers, users and the public

The guidelines explore communication networks, connection to the grid and user interface, as well as considerations that range from the parking spot up to the urban scale. Every site is unique. These guidelines set out a framework for analyzing site conditions, typical issues and for locating additional resources.

INSTALLATION SCENARIOS

These guidelines present analysis and site design solutions that approach these considerations from the perspective of installation scenarios. Surface lots, on-street parking, parking decks or garages, in-transit and trucking applications comprise the primary installation scenarios that, collectively, cover a majority of potential EVSE applications.

Siting and installation of EVSE will depend on a number of considerations, including: proximity to power supply, parking space size and orientation, pedestrian traffic, lighting and visibility. Many of these considerations are not yet standardized in terms of functionality, and others fall outside the realm of the standards and codes system, such as aesthetics. Each EVSE installation will be different, so these guidelines take the important step of establishing baseline considerations that are predicated on a typology of sites.

CHARGING BASICS

EVSE COMPONENTS

EVSE delivers electrical energy from the power source to the EV, and ensures that an appropriate and safe flow of electricity is supplied to the vehicle. EVSE is the main interface between user, vehicle and utility.

BATTERIES

Most EVs use lithium-ion batteries for their relatively good power performance, energy storage density, rapid charge capability and long life span. The size and energy density of batteries will greatly impact the future of EV range, functionality and consumer cost. As storage capacity increases—and as battery size and weight decrease—charging times and driving distance will change according to new technology.

CHARGING STATION

There are currently three categories of charging stations, which correspond to the three levels of charge detailed in the diagram on the following page. The charging station acts as the point of transfer from grid to vehicle, and for level 2 and up contains network communications, utility communications and monitoring, payment interface and, oftentimes, user information opportunities, such as advertising screens.

The majority of the charging operation actually occurs inside the vehicle's on-board charger, where the conversion from alternating current (AC) to direct current (DC) takes place at charging levels 1 and 2, and the battery charge is regulated.

CONNECTORS AND CORD SETS

Most EVs and EVSE use the Society of Automotive Engineers (SAE) J1772 connector and receptacle that is standard for both level 1 and 2 charging equipment. Nearly all EVs come equipped with a portable level 1 cord that can plug into a typical wall outlet.

Standardization in this area is an ongoing issue for DC fast charging. Almost all current DC fast charge EVSE in the US use the CHAdeMO connector, developed in Japan and used by Japanese EVs like the Nissan LEAF and Mitsubishi iMiEV, allows vehicles to connect to DC fast chargers. In October 2012 the SAE finalized the standard for a "hybrid" connector, which allows all charging to occur through a single receptacle on the EV. American auto manufacturers are expected to begin installing in vehicles beginning in 2013.

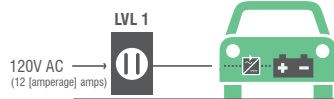
The National Electrical Code (NEC) requires that cords be no longer than 25 feet, unless the charging station is equipped with a retraction or other cord control device. However, experienced installers recommend site design that will require no more than 3-5 feet of cord distance from vehicle to charging station or outlet to minimize tripping hazards.



IMAGE 1. FROM LEFT TO RIGHT: J1772 CONNECTOR AND J1772 DC FAST CHARGER (DCFC) COMBO CONNECTOR

LEVELS OF CHARGE: DIAGRAMS AND ATTRIBUTES

LEVEL 1



ATTRIBUTES:

- A standard outlet can potentially fully recharge an EV battery in 8–12 hours, though larger batteries, such as on the Tesla Model S, would require between 1 and 2 days
- This level is often sufficient for overnight, home charging
- Standard outlets can also provide an option for “peace of mind” charging using onboard equipment on the go
- Uses standard J1772 coupler
- In-vehicle power conversion

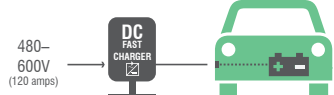
LEVEL 2



ATTRIBUTES:

- Free-standing or hanging charging station units mediate the connection between power outlets and vehicles
- Requires installation of charging equipment and often a dedicated 20–80 amp circuit, and may require utility upgrades
- Well-suited for inside and outside locations, where cars park for only several hours at a time, or when homeowners seek added flexibility of use and a faster recharge
- The public charging network will comprise primarily level 2 charging stations
- Public context requires additional design features, such as payment and provider network interfaces or reservation systems
- Uses standard J1772 coupler
- In-vehicle power conversion, charging speed limited by the onboard charger

DC FAST CHARGE



ATTRIBUTES

- Free-standing units, often higher profile
- Enable rapid charging of EV battery to 80% capacity in as little as 30 minutes
- Electrical conversion occurs in EVSE unit itself
- Relatively high cost compared to level 2 chargers, but new units on the market are more competitively priced
- Draws large amounts of electrical current, requires utility upgrades and dedicated circuits
- Beneficial in heavy-use transit corridors or public fueling stations
- Standard J1772 “combo” coupler approved in October 2012



SITE SELECTION AND DESIGN

Site Selection

Connection to Power Networks and Communications Existing Infrastructure EVSE Interfaces

Site Design Elements

Installation Access Operation

SITE SELECTION

Selecting a site for EVSE installation will likely require consideration of a combination of factors. While every site is unique and every EVSE host has priorities for installation, common physical elements characterize every EVSE site design.

CONNECTION TO POWER

When installing EVSE or EVSE-ready wiring, a dedicated circuit may be required or optimal. This can be added to an existing panel, or planned for in new construction. Dedicated circuits may require a new conduit, in addition to the conduit running from the panel to the EVSE's location. Costs rise as cable length increases due to the installation costs of construction and trenching. Experienced installers recommend not exceeding 25 feet of conduit from panel to EVSE site, but this will vary widely.

Most facilities have accessible 120V circuits sufficient to power level 1 EVSE. Level 2 charging requires 208-240 volts and at least 15-30 amps. Many jurisdictions require or recommend a dedicated branch circuit for level 2 charging. The existing electrical panel in most installations, especially older structures constructed prior to 1960, will not have the system capacity to handle large and continuous loads. While level 2 EVSE is similar to other household appliances like clothes dryers, the continuous nature of the load may be a burden on the system. Installation of dedicated branch circuits/new panels may reduce safety risk and assist with peak load management in scenarios with multiple charging vehicles.

NETWORKS AND COMMUNICATIONS

Most public EVSE will contain an advanced metering system and link to a network that tracks usage, bills customers and manages electrical loads. Some EVSE will connect to telecommunications networks using wi-fi, Ethernet or cellular connections. This type of communication is especially important for managing user messaging and other technology advances that regulate information about available charging stations and when

a driver's charge is complete. Complications for network connections arise in garages, where repeaters may need to be installed in order to guarantee network signals. Potential installation sites should be assessed for their network connection ability.

EXISTING INFRASTRUCTURE

Construction costs are the number one driver of added expense for EVSE, and the cost differential depends on the work required. Existing elements such as landscaping, walkways, curb cuts and other structural elements should be considered in an EVSE site plan. These elements add costs for removal or relocation, in addition to acting as barriers to accessible charging. Trenching, curb cuts and drilling through hardscaping or structural elements to add new conduits to connect EVSE to power sources can also be cost prohibitive. When possible, consider trenching through landscaping, although the EVSE should always be mounted on a concrete or other hard surface pad and protected from traffic.

EVSE INTERFACES

Each of the broad-based considerations discussed above impacts planning at multiple scales. Interfaces—points of interaction—set up actors, relationships and decision making, determining specifics of EVSE site design and implementation strategies. The following sections diagram site design components and relationships governing installation, use and maintenance from different points of reference, including:

- 1) Network Interface (page 6)
- 2) Urban Interface (page 8)
- 3) Power Interface (page 9)
- 4) Parking Interface (page 10)
- 5) EVSE Interface (page 12)

SITE DESIGN ELEMENTS

INSTALLATION

These site design elements are considerations for initial site planning and design. They contribute to costs and determine what type of EVSE to install.



CHARGE LEVEL



PROXIMITY TO POWER



MOUNTING APPROACH



NUMBER OF CORD SETS



PARKING SPACE DIMENSIONS



ENVIRONMENTAL CONDITIONS



TECHNOLOGY



HAZARDS

ACCESS

Accessibility has many aspects and includes wireless connections to communications networks, as well as access to buildings. These site design elements relate to the user experience.



NETWORK CONNECTION



ACCESSIBILITY



PROXIMITY TO TRAFFIC



PROXIMITY TO BUILDING ENTRANCE



PROXIMITY TO ELEVATOR



LIGHTING



SIGNAGE AND WAYFINDING



PEDESTRIAN TRAFFIC

OPERATION

These elements of site design relate to day-to-day use of the EVSE as well as long-term goals of hosts and operators.



HOST-OPERATOR AGREEMENTS



VISIBILITY



LOCATION IN LOT



METERING



LENGTH OF STAY



FUTURE-PROOFING

1) NETWORK INTERFACE

Many EVSE and EV manufacturers include on-board or on-unit technology enabling network communications and metering. Networks help maximize drivers' access to EVSE by providing a mechanism through which drivers can most efficiently locate and cycle through EVSE parking spaces.

Car to parking spot communication occurs through cellular network communication, alerting drivers to charging space locations in public areas through on-vehicle systems or smart phone apps. Developments on the horizon include built-in sensors that help determine if spaces are free.

Consumer to charging network communication enables payment for publicly-accessible EVSE. Public EVSE will need to track usage and potentially bill consumers by charging network, typically connecting to back-office billing software. Such communications will involve an ongoing evolution of business models; currently, most networks require members to swipe an access card that links charging to an account. Not all networks are yet compatible across charging platforms, but innovation in the area of communications will ultimately improve overall efficiency and ease of use.

EVSE to utility communication can enable better service, even adapting the rate of flow of electrical current to the unit, such as at times when grid loads are high—and when rates peak.

In each of these communications areas, data collection will improve systems and let us learn more about EV charging demand.

PHYSICAL NETWORKS

EVSE is connected via physical road and highway networks, and electrified corridors extend the effective battery range of an EV.

ENFORCEMENT MECHANISMS

Networks can help mitigate emerging issues in the EV driver community. Systems like alerts and other communication-based approaches can help ensure more efficient access to and use of publicly-accessible EVSE charging spaces.

Network-based communication and community enforcement may help to avoid regulatory enforcement—a more costly approach for local jurisdictions responsible for ticketing and towing. As an alternative to enforcing parking ordinances, networks can disincentivize prolonged parking by charging for time in addition to electricity, where allowed.

NETWORKED COMMUNICATIONS

- 1) EV to parking space sensor
- 2) EV to EVSE
- 3) EVSE to grid
- 4) Consumer to payment network
- 5) Consumer to vehicle
- 6) EVSE to host/operator



FIGURE 1.
EXAMPLE CELLULAR APPLICATION INTERFACE



TECHNOLOGY

Charging networks are currently experimenting with options. It is widely agreed that a common platform for communication will be via smart phones, in addition to built-in vehicle technology.

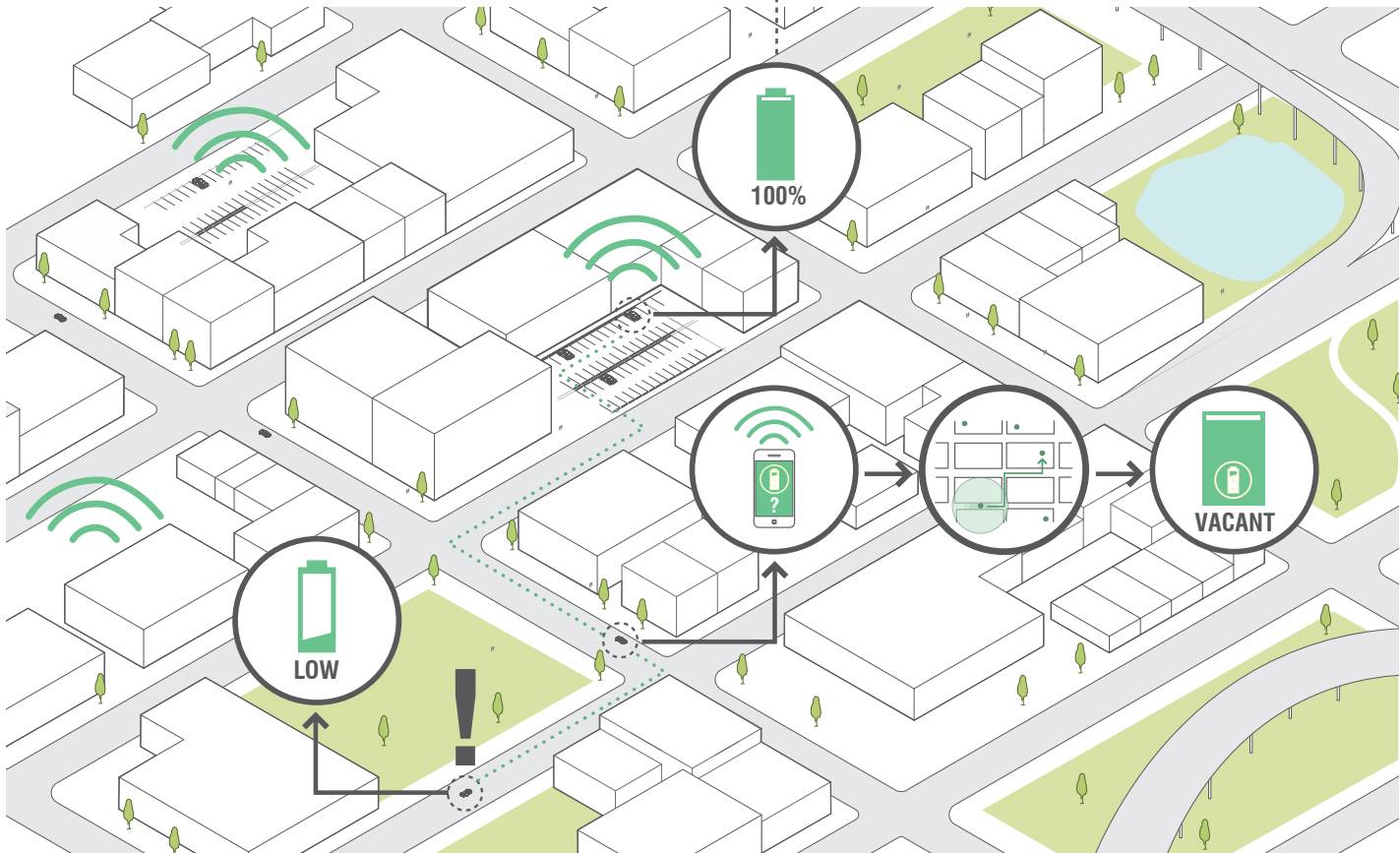
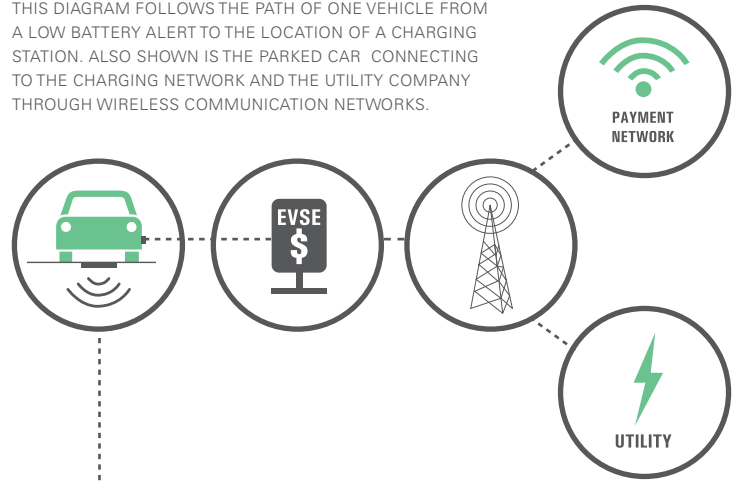
This type of technology depends on network access in all locations. Hardwiring and wireless network connections may require special equipment to bring these networks to remote or indoor scenarios.



METERING

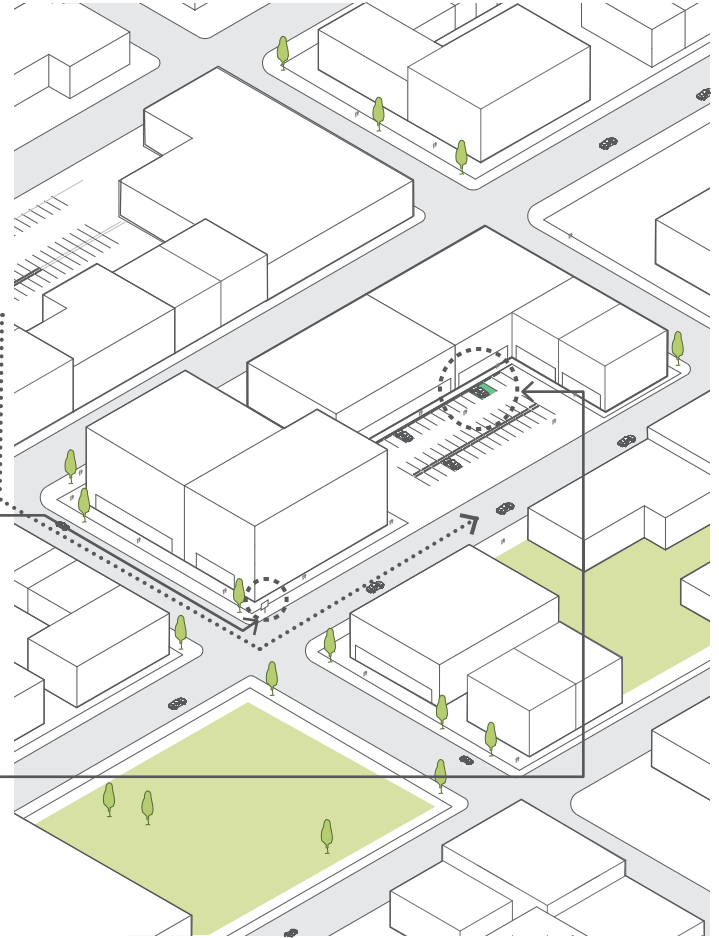
Most EVSE have integrated payment technologies. Whether in residential or public locations, EVSE will need to communicate with the utility grid in order to measure and meter electricity used.

FIGURE 2. NETWORKED PATHWAY TO A FULL CHARGE
THIS DIAGRAM FOLLOWS THE PATH OF ONE VEHICLE FROM A LOW BATTERY ALERT TO THE LOCATION OF A CHARGING STATION. ALSO SHOWN IS THE PARKED CAR CONNECTING TO THE CHARGING NETWORK AND THE UTILITY COMPANY THROUGH WIRELESS COMMUNICATION NETWORKS.



2) URBAN INTERFACE

The urban interface of the EVSE includes the larger-scale systems and patterns that relate to traffic, frequency of EVSE use and accessibility, as well as the fine-grained details of how the EVSE and EV driver interact with the streetscape. Placement of EVSE with respect to building frontage demonstrates host priorities. From an owner or host perspective, the urban scale includes location choice and the management of the EVSE and parking space. The urban interface considers functional and aesthetic aspects of site design.



PROXIMITY TO TRAFFIC

Physical proximity to heavy traffic use may be positive (high traffic volume) or negative (difficult to install on-street EVSE). Large-scale traffic patterns and counts determine viability of locations for most commercial operations, and such analytics may be used for EVSE location choice.



SIGNAGE AND WAYFINDING

User visibility begins with wayfinding systems that provide consistent and clear signage to direct EV drivers to parking spaces. Signage should have a hierarchy, helping to direct drivers and organize the EVSE infrastructure network at the urban scale. Consistency and visibility of signage throughout a city, state or region can help drivers locate EVSE regardless of network access.



PROXIMITY TO BUILDING ENTRANCE

Placement of the EVSE determines its visibility and accessibility, typically with respect to priority parking spaces—those that are located a short distance from building entrances. EVSE hosts that choose to highlight the EVSE through prominent placement may incur higher installation costs, due to increased distance from panels.



PEDESTRIAN TRAFFIC

High traffic areas offer visibility and challenges. EVSE and cord sets should not interfere with pedestrian routes; charging stations should not be placed in a location that would cause a cord to be a tripping hazard. Pedestrian paths relate to site planning and design of parking lots, garages and other places. EVSE site choices should consider building entry ways, pathways, street crossings and meeting points so as not to impede pedestrians.

MANAGEMENT OF SPACE

At the urban scale, EVSE hosts or owners (e.g., garage managers, retail chain stores, transportation authorities) are responsible for managing the use and maintenance of the EVSE and parking space. On-site relationships are very important to user experience (accessibility or charge network access, for example). EVSE locations and amenities depend on the motivation of EVSE hosts. Green branding or points for the U.S. Green Building Council's LEED certification, providing customer amenities, and a company's sustainability mission are all examples of factors that determine whether a parking operator chooses to host EVSE and where within the lot these are located.

3) POWER INTERFACE

The ability to connect to a power source is the top priority for EVSE site design—without power, there is no charge. The EVSE’s connection to both vehicle and power source occurs across boundaries of ownership and management and includes both the public and private sectors. There is a potentially complex set of relationships and costs, with different aspects of the power connection occurring in one or both of two areas: the public realm, including the public right-of-way, and the private space. These relationships have physical and business implications.

ELECTRICAL CAPACITY

Connecting EVSE to a power source will require evaluation of existing electrical capacity. This has two parts: the electrical system at the location of the EVSE installation, and the capacity of neighborhood systems to support many EVs charging at once. Electrical cabinets, panels and circuitry will need to accommodate the anticipated additional load. Some municipalities, such as Vancouver, Canada, have used their building codes to require that new construction allow sufficient space within electrical rooms for panels and other equipment required to increase capacity in the future.

Utilities will be at the center of discussions of capacity. In addition to ensuring safety where EVSE is installed, utilities are concerned with overloading local transformers. Jurisdictions such as Maryland have passed legislation that allows for the disclosure of EV owner data to utilities, enabling them to plan for neighborhood power needs.

CONSTRUCTION COST

The cost differential for EVSE installation is represented by the power interface. Considering a site’s power sources and capacity will help plan for lower-cost installations that require less physical construction.



PROXIMITY TO POWER SOURCE

Installing the EVSE close to the required power source reduces the need for cutting, trenching and drilling to add new conduits to reach the EVSE. Additionally, the cost of installation can be reduced if the existing conduit has adequate capacity for EVSE.



METERING

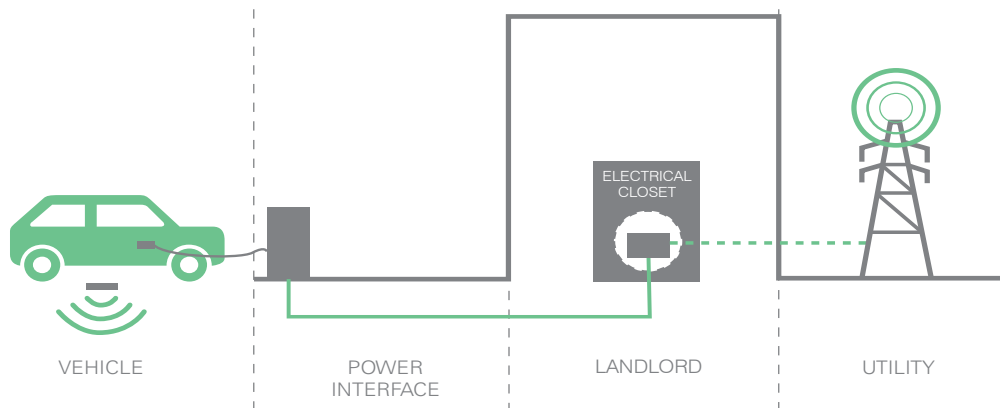
Separate or sub-metering allows electricity used by EVSE to be isolated from the rest of a building’ or structure’s energy usage, though distinguishing usage between multiple cords of an EVSE can only be accomplished by the EVSE itself. For locations with multiple EVSE, it is best practice to separately meter each. Smart meters, through a network connection to the utility, help users and utilities to balance electrical use across peak energy times.



HOST-OPERATOR AGREEMENTS

Different ownership and management structures will determine the degree of difficulty associated with accessing power supply, running conduit and maintaining EVSE. The relationship of owners and operators is critical, as different business models will place different requirements on navigating these relationships. The utility will work with the host or operator to bring the power connection to the site.

FIGURE 3.
ZONES OF OWNERSHIP AND MANAGEMENT IN THE EVSE INFRASTRUCTURE DOMAIN
THE EVSE INFRASTRUCTURE DOMAIN INCLUDES ALL CHARGING-RELATED EQUIPMENT FROM THE COUPLER THAT CONNECTS THE CHARGER TO THE VEHICLE TO THE ELECTRICAL PANEL AND CONDUIT THAT CONNECTS THE CHARGING STATION TO THE UTILITY GRID. THE OWNERSHIP AND MANAGEMENT OF EACH AREA THAT THE EVSE CONNECTS TO WILL REQUIRE CONSULTATION AND POSSIBLE PARTNERSHIP TO INSTALL CHARGING EQUIPMENT.



4) PARKING INTERFACE

With regard to parking spaces, EVs will require certain considerations above and beyond typical design approaches to parking lots and garages. At this scale, the physical requirements take precedence but the user experience must be considered. Cost-adding concerns are largely addressed in the previous section; however, design choices such as canopies, alternative power sources and other extras will add expense. Adding EVSE into the typically tight mix of parking lot and garage planning may cost planners and developers some valuable floor area; EVSE installation and access can require several extra square feet of space.

For safety, extra care in general should be given to placement of electrical equipment in areas that will experience extreme weather or pooling of water.



SIGNAGE AND WAYFINDING

Guiding a car to the space is one function of signage, but the parking interface requires clear markings that designate the space for EVSE charging only. Markings appearing on the ground similar to striped spaces (reserved for handicapped parking) as well as on vertical surfaces should be used.



PARKING SPACE SIZE

In addition to standard parking space considerations, when siting EVSE, the charging equipment must not interfere with passenger loading and unloading nor impact adjacent traffic.



MOUNTING APPROACH

Site design will specify a mounting approach. Choice of EVSE unit design will allow site planners to save space by choosing a configuration that maximizes square footage: wall- or ceiling-mounted products will be appropriate where floor area is at a premium, while charging stations with multiple cord sets will enable one unit to serve multiple spaces.



LIGHTING

Visibility is critical for EV driver safety and helps to deter vandalism of the equipment. Most parking facilities are designed with lighting that is suitable for EVSE installations. Dim lights or cables can create tripping hazards. Lighting upgrades (such as to more sustainable fluorescent lamps) may also present an opportunity to extend wiring for EVSE installation.

WAYS TO AVOID
TRIPPING
HAZARDS

- CAR STOPPER

- BOLLARD

- ELEVATED
CONNECTOR
MOUNTING

FIGURE 4.

EVSE PROTECTION

WHEEL STOPS AND BOLLARDS OFFER PROTECTION OF THE EVSE FROM TRAFFIC INCIDENT, AND CAN ALSO SERVE TO BLOCK PEDESTRIAN ACCESS FROM TRIPPING HAZARDS. COST AND SPACE WILL DETERMINE WHAT TYPE, IF ANY EVSE PROTECTION IS SUITABLE. WALL-MOUNTED BARRIERS AND SETBACKS ARE OTHER PROTECTION OPTIONS.



ACCESSIBILITY

It is necessary to create spaces and routes that are safe and accessible to drivers of all physical abilities. In general, EV drivers spend more time than usual maneuvering around a parking space in order to connect and disconnect from the EVSE. Accessibility strategies should seek to limit tripping hazards and minimize liability concerns. Accessibility is also about Americans With Disabilities Act (ADA)-compatible designs and space designation. Wheelchair accessible EV charging needs a free path from the space to the building entrance. Standards are being considered to determine how many, if any, EVSE spaces in a lot should be ADA-accessible.

FIGURE 5.
STANDARD PARKING SPACE CONSIDERATIONS
MORE THAN TYPICAL SPACE IS REQUIRED IN ORDER
TO ENSURE SAFE AND EASY MOVEMENT AROUND THE
CHARGING STATION.

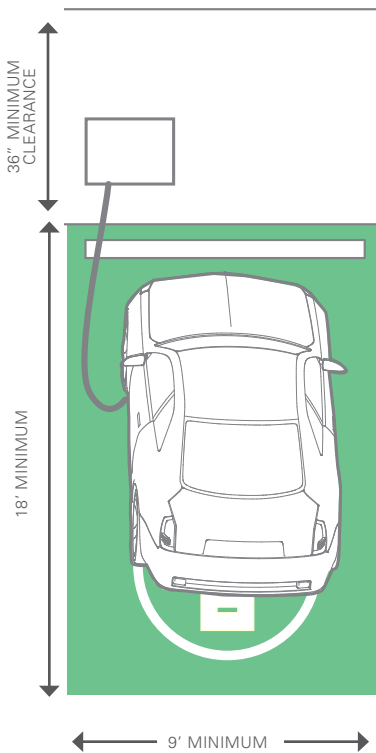


FIGURE 6.
PARKING SPACE CONSIDERATIONS FOR
WHEELCHAIR ACCESSIBILITY
THE GROUND SURFACE SHOULD BE FIRM, LEVEL, AND
HAVE A SLOPE NO MORE THAN 2% IN ANY DIRECTION

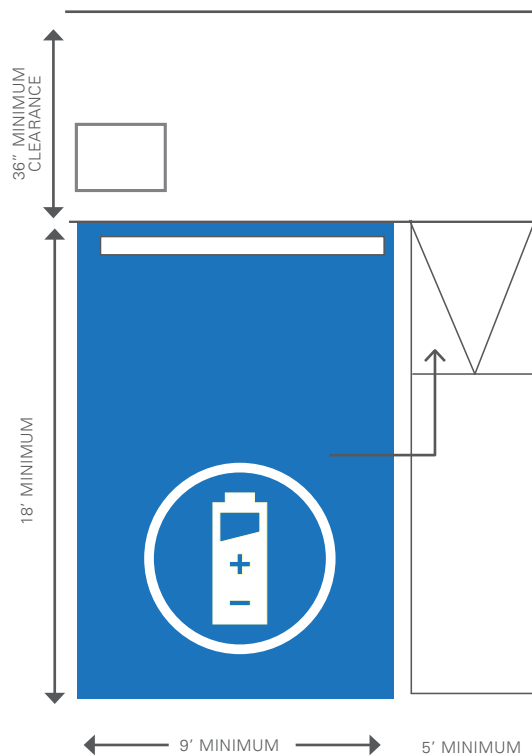


FIGURE 7.
POSSIBLE VARIATIONS FOR
WHEELCHAIR ACCESSIBLE EVSE
CHARGING SPACES

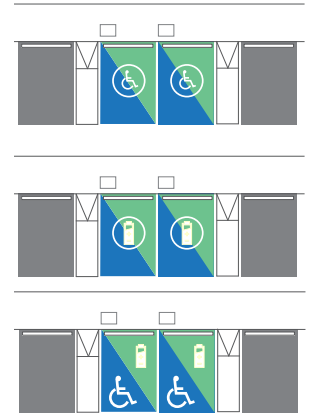
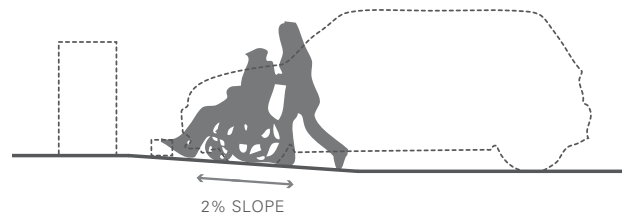


FIGURE 8.
MULTI-DIMENSIONS OF ACCESSIBILITY
VERTICAL SIGNAGE (SEE SECTION ON SIGNAGE AND WAYFINDING FOR
MORE DETAIL) SHOULD DESIGNATE WHETHER EVSE IS WHEELCHAIR-
ACCESSIBLE. THE GROUND SURFACE SHOULD BE FIRM, LEVEL, AND HAVE A
SLOPE NO MORE THAN 2% IN ANY DIRECTION



5) EVSE INTERFACE

THE CHARGING EXPERIENCE

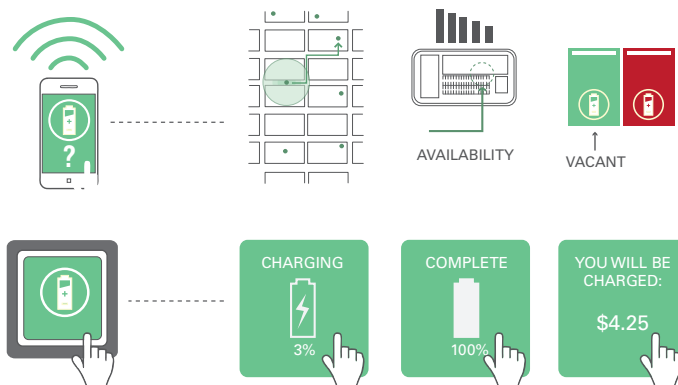
Most EVSE is equipped with touch screens and video capability, providing a forum for user information, ranging from communicating EV driver account details to local news content. Branding also plays a role in bringing information to drivers. The user experience at the EVSE site presents branding opportunities for the EVSE host's, installer's, or partners' purposes.

At the scale of the vehicle, the interface connecting the EV and the EV driver to the charging station highlights the final group of site design considerations.

The EVSE interface presents design challenges for several key exchanges:

- 1) Physical interface of the technical components
- 2) Human and technology interface

FIGURE 9.
EXAMPLES OF USER INTERFACE



MOUNTING APPROACH

Site design will specify a mounting approach, which will affect users' interaction with the EVSE. EVSE models should be chosen to allow users easy access to the electric cord and EVSE interface.



NUMBER OF CONNECTORS

The method of coupling the EV to the charger impacts placement at the site and ease-of-use for EV drivers.



ACCESSIBILITY

At the EVSE scale, accessibility refers to the ability of the EV driver to comfortably and safely plug in and access any on-screen or other controls on the EVSE unit. The location of the on-vehicle inlet to connect to the EVSE coupler presents an accessibility issue for EV drivers at this scale. As a rule of thumb, EVSE should be located in the first 1/3 of a parking space, preferably directly ahead, to allow drivers to plug in with minimal draping of the cord.



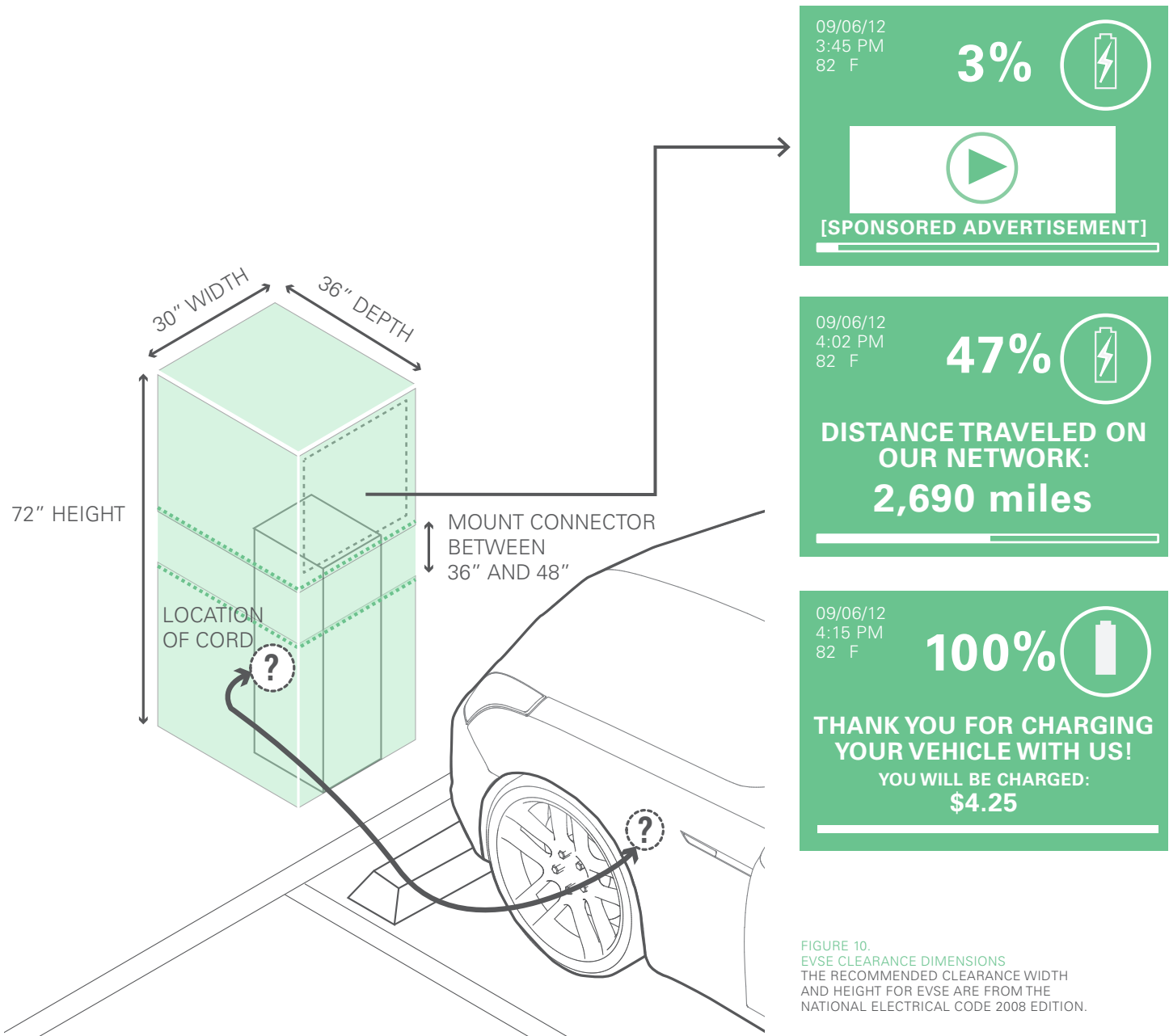
TECHNOLOGY

Communications systems linking the EV to the EVSE via sensors (such as those that detect the presence of the vehicle and can indicate that the space is occupied).



SIGNAGE AND WAYFINDING

Signage indicating parking information and directions on how to operate the EVSE completes the signage hierarchy.





SIGNAGE AND WAYFINDING

Regulatory Wayfinding

Signage designates EV parking spaces and helps EV drivers locate charging stations. Regulatory signage designates a space and restrictions regarding its use, while wayfinding signage directs drivers to charging stations; both should be provided in a consistent and accessible style.

The United States Department of Transportation Federal Highway Administration publishes a guide, *Manual of Uniform Traffic Control Devices* (MUTCD) that sets signage standards used by road managers nationwide on all public and private roads. Local regulations also come into play. Local jurisdictions, property owners and parking managers will have preferences for look and function of signs. For EVSE, the goal should be clarity and consistency, particularly in the early stages of the sector's development. A common visual identity will reduce confusion and increase public awareness of EVSE.

It is important for local jurisdictions and designers to note that any deviance from MUTCD regulations requires approval under the "experimentations" waiver. Overall regulations applicable to EV charging designation signage include color and placement hierarchy. The examples of signage offered in these guidelines are intended to be illustrative. Jurisdictions and designers will need to ensure their signs and systems comply with any applicable regulations.

REGULATORY

Regulatory signs indicate who may park in a designated location. Common examples of regulatory include handicapped parking designations, curb striping, no parking or permit-only signs. Regulations can be communicated through wording or design, such as through the color. A report on EVSE signage written by ECOTality for the EV Project recommends a combination of visual and written cues. These would include both an EV symbol and regulatory instructions. A symbol and wording, such as "Electric Vehicle Charging Only," can be used in combination.

Vertical or pole-mounted signage is the most standard (please reference the following page for examples). Pavement markings, similar to those used at handicapped-accessible parking spots, can also be used for clear designation of EV parking spaces. For handicapped-accessible EV parking spots, additional pavement markings can indicate ADA routes that must be kept clear. See page 11 for several possibilities for designating handicapped-accessible EV charging spaces.

Other regulations, such as the length of parking if the electricity is provided with the cost of parking, can be indicated. Signs associated with DC fast chargers should indicate a time limit of up to one hour, for example. This is one example of how signage

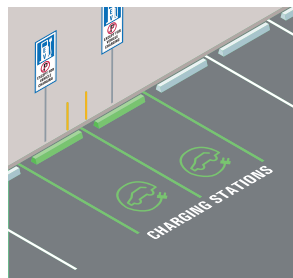


FIGURE 11.
PAVEMENT MARKINGS
EFFECTIVE WAYS OF CLEARLY DESIGNATING SPACES FOR ELECTRIC VEHICLE CHARGING.

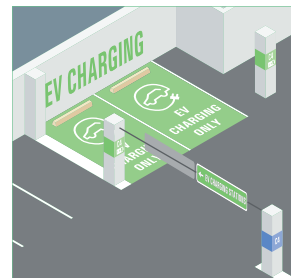


FIGURE 12.
WALL MARKINGS
PARKING GARAGES OFFER MANY SURFACES FOR SIGNAGE TO BE ATTACHED OR PAINTED.

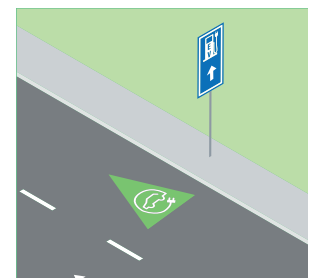


FIGURE 13.
WAYFINDING SIGNAGE
DIRECTS DRIVERS TO EV CHARGING STATIONS AND CAN INDICATE WHAT TYPE OF EVSE IS AVAILABLE.

can work with local parking management strategies to establish clear expectations for EV and non-EV drivers. Time limits will also include the participation of local authorities or parking managers to enforce the regulations established on the sign.

Information on the charging station should also indicate voltage and amp levels and any fees or safety information. Electrical codes will ask hosts to indicate the date of installation, equipment type and model and owner contact information on the EVSE.

WAYFINDING

Wayfinding describes a system of signs that do just that—help people find their way. In the case of EVSE, wayfinding systems will direct drivers to EVSE locations. These signs can be located on adjacent streets, access points to parking areas and highways. Pavement markings can also offer additional guidance and point drivers to the exact spaces. It may also be beneficial to drivers if signs indicate the level of charging available.

The MUTCD provides guidelines for developing wayfinding signage systems. Community wayfinding signs have a lower placement priority than other guide signs. MUTCD also suggests that color coding can be an effective way to differentiate between different types of destinations.

Where wayfinding signs can be installed will be an area of potential contention for EVSE. At present, community wayfinding signs cannot be installed on freeway or expressway main lines or ramps. Nor can they be used to designate primary destinations. Recognizing the need to connect a decentralized infrastructure system, moving forward, it will be necessary for communities and for the Federal Highway Administration to consider what type of destination an EV charging station is, and whether EV charging station locations can be indicated to drivers en route along major highways.

COLOR AND SYMBOLS

Currently, a variety of symbols, colors and wording are used for EVSE and the associated regulations. As such, signs can be extremely confusing and may result in non-EV drivers unintentionally using these spaces. Color choice also poses a communication problem. Blue is often mistaken for accessibility, green is mistaken for short term parking and red is associated with prohibited action.

LANGUAGE

There is a need for clear language on all regulatory and wayfinding signs. “No Parking Except for Electric Vehicle Charging” has been recommended to be used on regulatory signs. Signs should use

the term “charging” to eliminate confusion for drivers of hybrid electric vehicles, or EVs that do not need to charge. This language also encourages drivers to move their EV once charging is complete. It is important to indicate the active use of the charging station for EVSE designated parking stalls.

INFORMATION AND ADVERTISING

The many surfaces of the EVSE can be used to display information, such as how to use the machine or level of power. Display screens also may provide status information for the user and other communications, including advertising and branding for the EVSE host or partners.

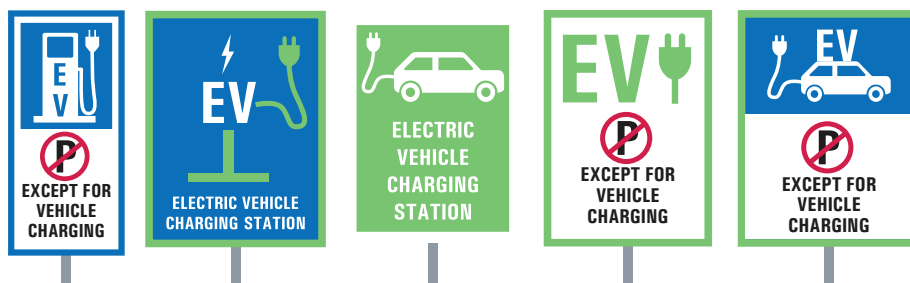


FIGURE 14.
EV-ONLY SIGNAGE EXAMPLES

A COMBINATION OF SYMBOL AND TEXT IS RECOMMENDED. THE TERM “CHARGING” SHOULD BE USED TO ENSURE HYBRID VEHICLES DO NOT USE THE SPACES FOR PARKING. THE SELECTED ELECTRIC VEHICLE SYMBOL SHOULD BE LARGER AND MORE PRONOUNCED THAN THE NO-PARKING SYMBOL TO AVOID CONFUSING MESSAGES.



INSTALLATION CONTEXTS

Implementation Considerations

Factors Affecting EVSE Installation

This section is intended to illustrate basic site design concerns and wider implementation considerations, such as the motivations of the EVSE installer, costs and operational issues that are relevant to shaping EVSE deployment on a site-by-site basis. The installation contexts described in the following pages of this guide will place design issues in perspective. It is acknowledged that each context shown here would include a wide degree of site-specific variation.

IMPLEMENTATION CONSIDERATIONS

MARKETS AND MOTIVATION

Placement of the EVSE will depend on host motivation. For example, green branding opportunities require prominent placement while the provision of EV charging for employees might mean settling for more economically efficient locations. The host's understanding of the EVSE users at their site and the benefits that the EVSE will provide them with will inform decisions about their site locations and expenditures.

INFRASTRUCTURE COSTS

The capital outlay associated with EVSE includes the purchase of the unit and the construction costs associated with trenching,

structural, utility or electrical work. Soft costs are incurred through the permitting, maintenance and network servicing of EVSE.

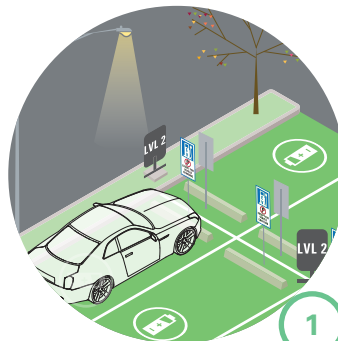
In some cases, EVSE manufacturers and service providers will supply the EVSE unit for free if they are in position to collect data or fees associated with the EVSE usage. As a result, the business models of the EVSE manufacturing groups may have an influence on emerging EV locations based on their ability to collect fees in certain kinds of locations.

REGULATIONS

Ordinances serve planning and permitting purposes at the city-wide scale and are another layer of agreement for developers and EVSE hosts. Liability issues associated with hazards and accessibility are another regulatory concern.

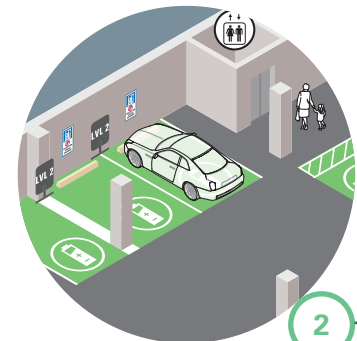
HOST AGREEMENTS

Tenants, such as retail operators, contract with landowners; both of these parties may assume responsibility for EVSE-related costs, but landlords will likely assume liability for the EVSE. Owners, tenants, developers, parking lot operators and EVSE networks may be operators of the EVSE.



1

COMMERCIAL LOT

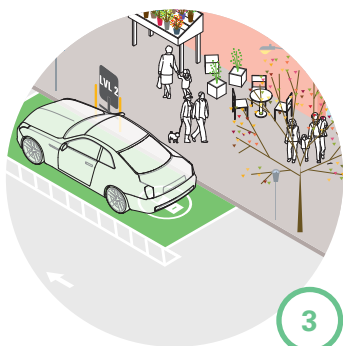


2

MULTI-UNIT RESIDENTIAL

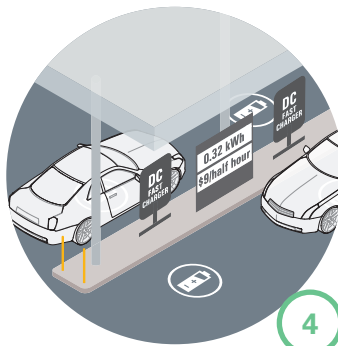
FACTORS AFFECTING EVSE INSTALLATION

MARKET ANALYSIS	TARGET MARKETS	What are the host's motivations and goals for EVSE installation?
	DEMAND	How does anticipated use determine the scope of work for charging stations and EVSE-ready sites?
	HOST LOCATION	Does the retail, commercial or residential location affect the rate of use?
ECONOMIC FEASIBILITY	EVSE COST	Will grant or program funding be available? What is the marginal cost of additional EVSE?
	CONSTRUCTION	Is trenching or other heavy work required?
	SERVICE UPGRADE	What is the cost of a service upgrade? How does this impact location?
	MAINTENANCE	What will annual upkeep cost?
	REVENUE	What business model is most appropriate for recuperating the host's or network's capital outlay?
	FISCAL IMPACTS	What costs and benefits are associated with public or government-installed EVSE?
LEGAL	REGULATIONS	What codes and ordinances apply to the site, construction and electrical installation?
	LAND USE	Are there any local barriers to where EVSE can be installed?
	LIABILITY	What entity takes responsibility for any necessary insurance or other liability measures?
	TERMS	What agreements and contracts are necessary or advisable to install and operate EVSE?
OPERATIONS	MANAGEMENT	What entity (host/site owner/network/municipality) will operate and maintain the EVSE?
	UTILITY	What upgrades to service, conduit installation, and metering are needed?
	EQUIPMENT	Will installation require equipment or technology upgrades beyond the charging station itself?
	SCENARIOS	What alternative installation scenarios could reduce costs or increase revenue?



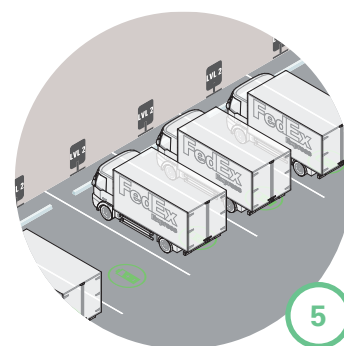
3

ON-STREET
PARKING



4

SERVICE
STATION



5

FLEET

1) COMMERCIAL

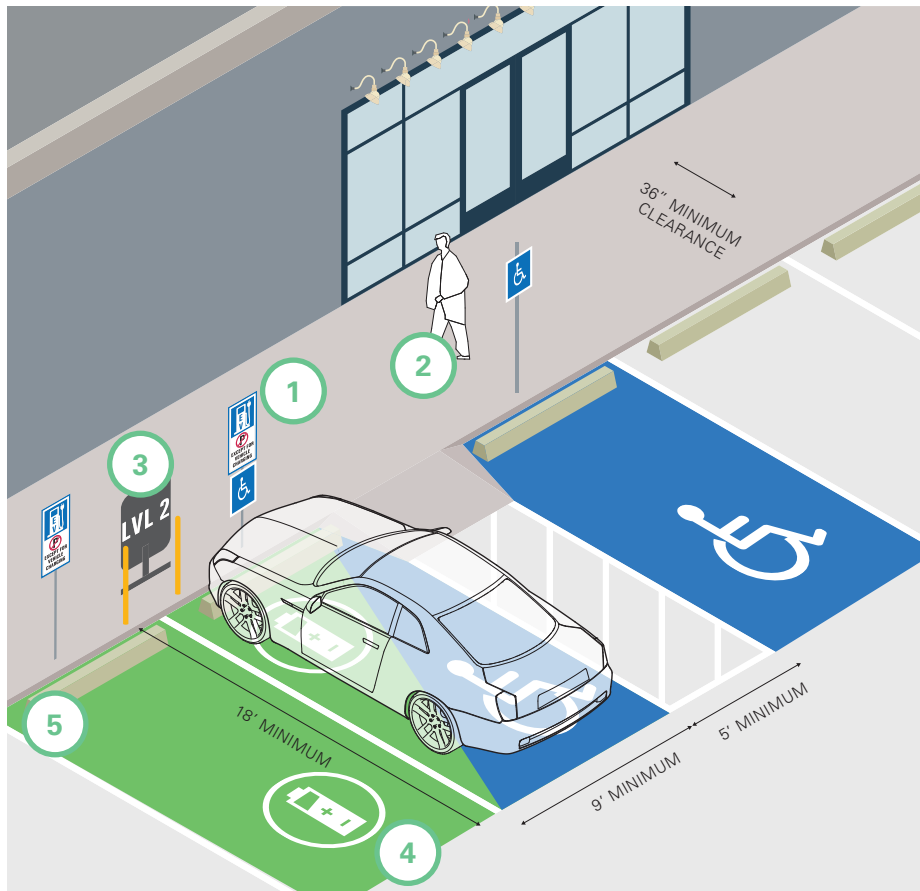


FIGURE 15. SITING AND DESIGN GUIDELINES FOR A COMMERCIAL LOT

Retailers and other commercial operators will be among the early adopters of EVSE. For retail and commercial parking, priority considerations may include satisfying customers, branding the retail outlet or serving employees. The outcomes for the decisions about site location and design will vary depending on the key host motivations. The chart on page 19 associates the EVSE decision-making process for commercial parking lots with iconography describing the relevant site design elements.

1) Signage is critical for finding designated spaces within a busy lot. For large and heavily trafficked lots, vertical signage indicating EVSE charging is key. This type of signage should not be used for commercial purposes, such as branding.

2) Pedestrian safety in commercial areas is critical. ADA requires a minimum of 36" clearance between building wall and street furniture or signage, so care should be taken not to obstruct pathways for safety and egress.

3) Commercial operators seeking to highlight "green" branding will choose to install EVSE in prime parking spaces. Priority locations communicate to customers the value that the EVSE host places on sustainable business, while incentivizing EV drivers to patronize their store. In some locations, however, such as hospitality businesses with long or overnight stays or those with valet parking, it may be more advantageous to position EVSE further out in the lot, leaving prime spaces free for all customers.

4) Installing EVSE in prime parking spaces will likely add additional expenses, as these spaces are often far from the electrical panel, which are commonly located at the back of a building. Trenching, running additional conduit and replacing paving are the types of construction activities that account for the primary expenditures associated with EVSE.

5) Placing EVSE close to the door is an incentive and an out-front location may act as an additional deterrent to vandalism or other damage. Care should be taken to allow sufficient room for user access, including curb cuts, as well as methods to prevent tripping over cords.



IMAGE 2. MILILANI, HI THE EVSE IS MOUNTED ON AN EXISTING POST AS TO NOT SHORTEN THE PARKING SPACE OR INTERFERE WITH PEDESTRIAN ROUTES.



IMAGE 3. BURBANK, CA THE EVSE IS PLACED ON A CONCRETE PAD IN EXISTING LANDSCAPING, TAKING ADVANTAGE OF EXISTING OPEN SPACE IN FRONT OF THE PARKING SPOT WITHOUT REDUCING SIZE.

1A) MID-LOT

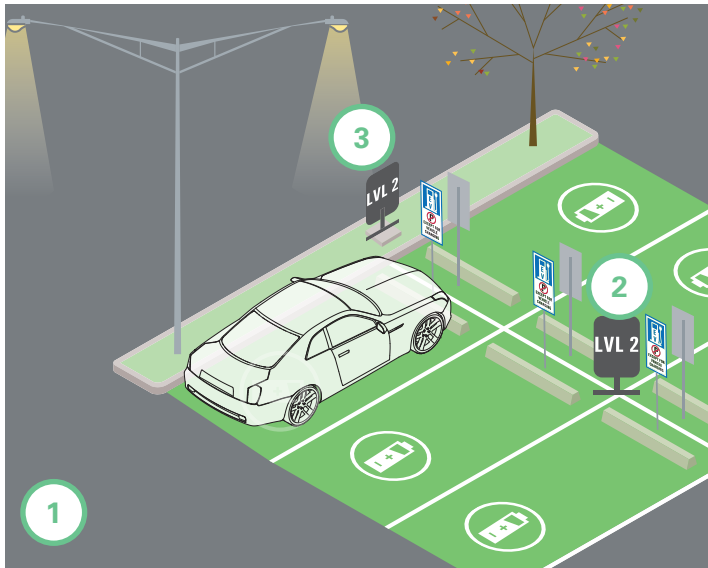


FIGURE 16. SITING AND DESIGN GUIDELINES FOR A MID-LOT

1B) CARPORTS

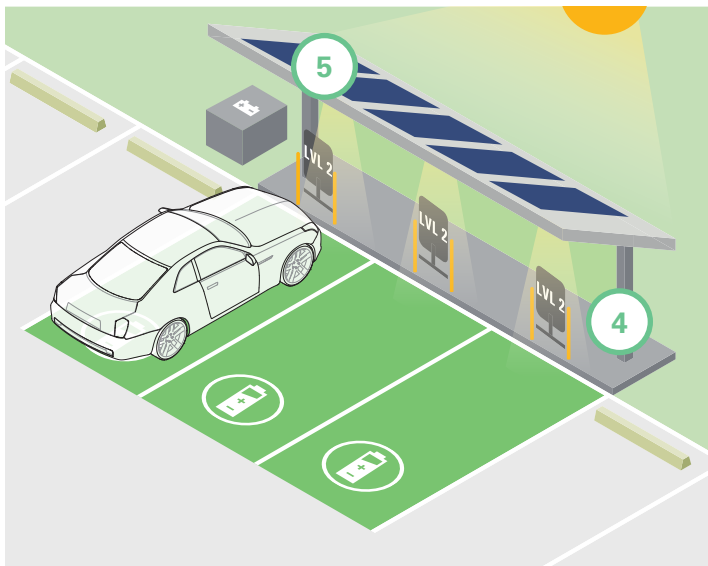
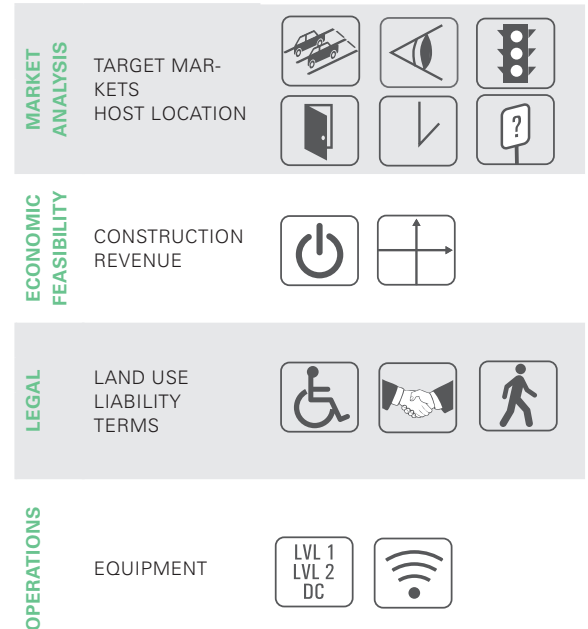


FIGURE 17. SITING AND DESIGN GUIDELINES FOR CARPORTS

PRIORITIES FOR RETAIL AND COMMERCIAL PARKING



1) Mid-lot parking represents a range of opportunities. In some cases, such as big-box stores or most shopping center locations with no building-adjacent parking, mid-lot spaces will be prime locations for EVSE. The same installation can take place further from the building entrance as well.

2) EVSE can maximize small spaces by being installed in locations accessible to multiple parked vehicles. Wheel stops protect the EVSE but may present a tripping hazard.

3) Landscaped areas can accommodate EVSE as well, but concrete pads are necessary to anchor the device.

4) Canopies and carports add visibility, shelter and opportunities for signage. Price Chopper supermarkets, for example, are installing canopies to designate EVSE parking spaces, which will feature a sustainability branding campaign.

5) Photovoltaics are a natural fit for canopy designs. Solar-assisted EVSE enhance green marketing, and in instances where connections to the grid are impracticable, there is potential for a closed-loop setup containing substantial battery storage.

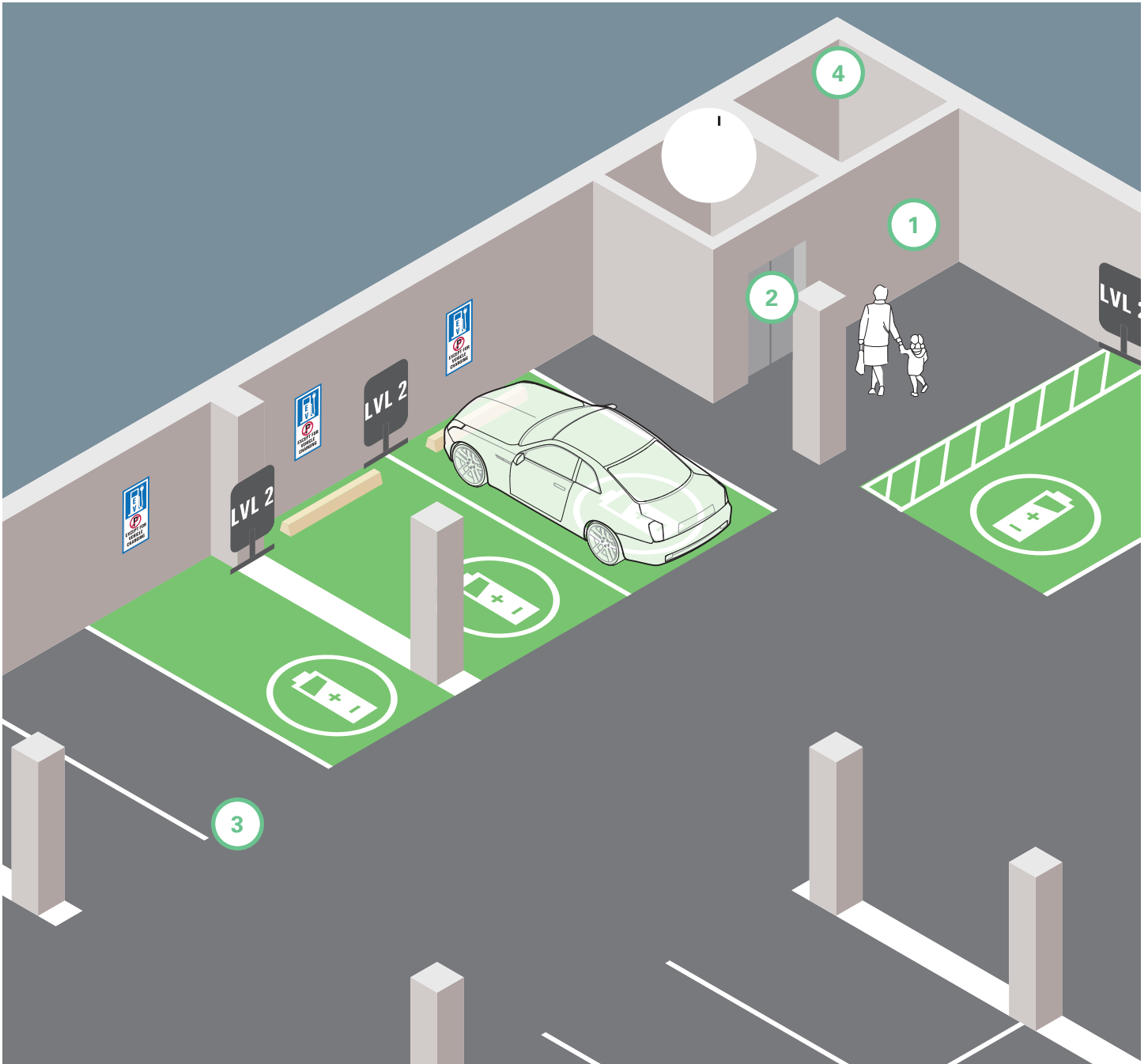
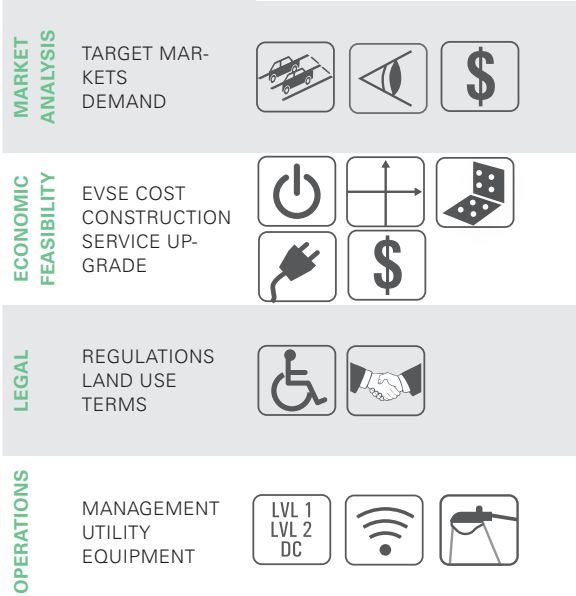


FIGURE 18. SITING AND DESIGN GUIDELINES FOR MULTI-USE RESIDENTIAL PARKING

2) MULTI-UNIT RESIDENTIAL

PRIORITIES FOR MULTI-UNIT RESIDENTIAL



Multi-unit residential applications are among the most complex. While estimates presume that up to 90% of EV charging will occur at home, issues arise for drivers without private, off-street parking. While residential parking arrangements range widely and include both surface and structured garage parking, the scenario presented here looks at an indoor garage. Management considerations include differences in owner vs. renter-occupied buildings and designation of parking spaces. Developers of new construction housing with parking garages should consider the opportunity to add EVSE-ready wiring at construction, which is much less costly than retrofitting in the future when demand arises. In general, the decision to include EVSE in a residential application will hinge on a developer/owner's choice to provide EVSE as an amenity to residents.



IMAGE 4. PARAMUS, NJ BY MOUNTING THE EVSE ON AN EXISTING POST BETWEEN SPACES, PARKING SPACE SIZES ARE MAINTAINED AND WHEEL STOPS OR BOLLARDS DO NOT NEED TO BE INSTALLED

- 1) How EVSE electricity consumption is metered and billed is a central multi-unit residential question. Typically, tenants or owners will be billed for the electricity used in their unit; installing split metering for parking lot electricity use and assigning usage to the unit is a challenge.
- 2) The location of EVSE within a residential garage will involve costs associated with extending conduits from the available panel or electrical room, which will be the primary consideration. However, buildings that provide EVSE space in only the most accessible locations may feel push back from residents who are not EV drivers, particularly in the early stages of EV adoption.
- 3) Garages have limited available space, and are constructed in modules, meaning that adding one or two additional spaces for EVSE to a plan may not be possible. Finding space within an existing layout that is suitable for EVSE involves some creativity. Smaller spaces like Image 4 can often accommodate charging with the right mounting approach. Underutilized space near ramps or entrances can also often accommodate temporary EV charging.
- 4) EVSE-ready installations should ensure sufficient space in the electrical room or closet for the future inclusion of capacity, panels and, potentially, charging equipment.

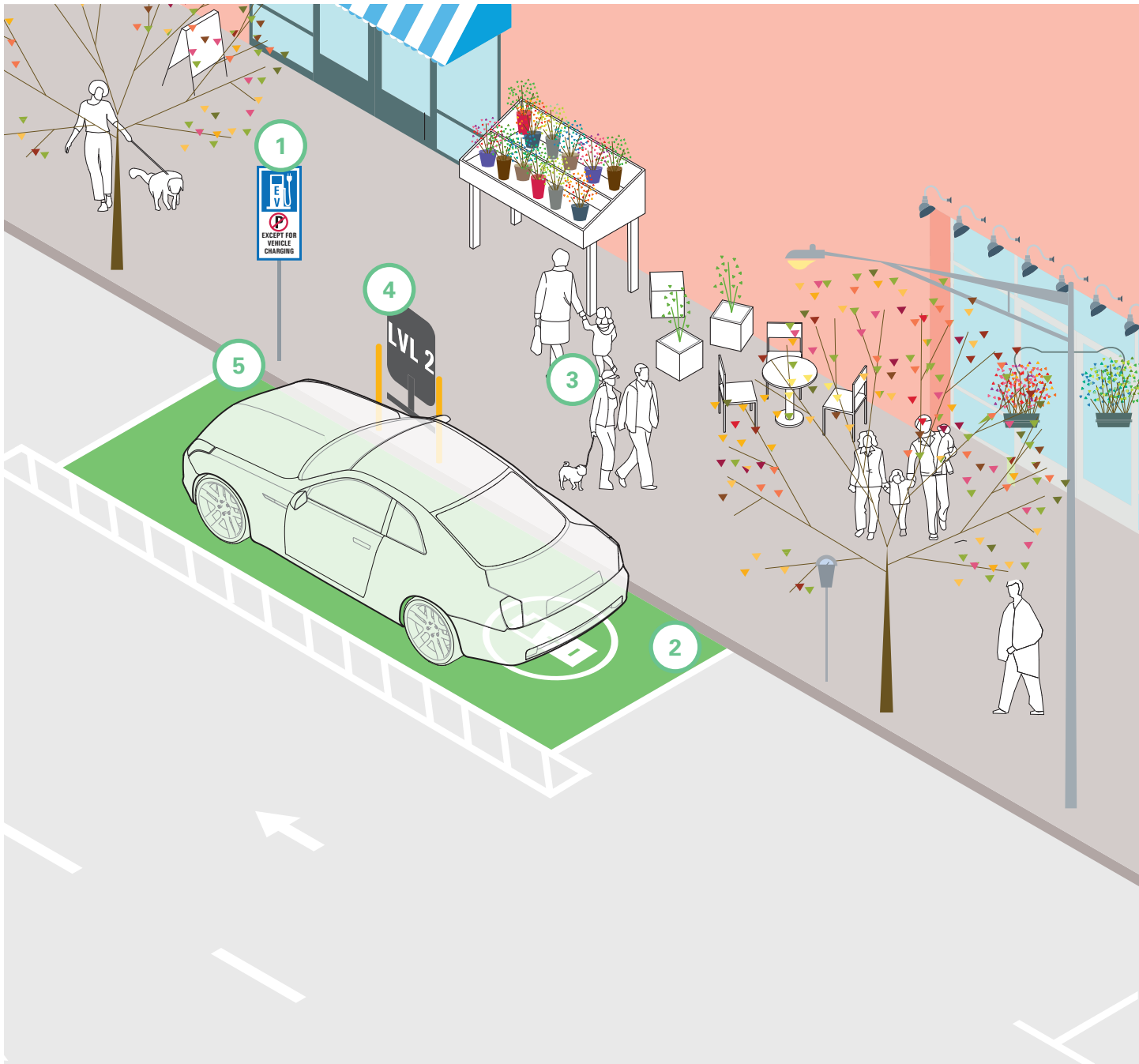


FIGURE 19. SITING AND DESIGN GUIDELINES FOR ON-STREET PARKING

3) ON-STREET

PRIORITIES FOR ON-STREET PARKING

MARKET ANALYSIS	DEMAND				LVL 1 LVL 2 DC
	HOST LOCATION				
ECONOMIC FEASIBILITY	EVSE COST				
	CONSTRUCTION SERVICE UPGRADE MAINTENANCE FISCAL IMPACTS	LVL 1 LVL 2 DC			
LEGAL	REGULATIONS				
	LIABILITY				
OPERATIONS	MANAGEMENT UTILITY EQUIPMENT SCENARIOS	LVL 1 LVL 2 DC			

For urban centers and main streets, on-street parking is one of the primary types of parking available. Providing EVSE in parallel or angled parking spaces in these highly trafficked areas is tricky but not impossible: London, UK has recently installed hundreds of on-street EVSE, and Portland, OR has created “Electric Avenue,” an on-street demonstration project. Central issues and priorities outlined here point to challenges and opportunities for this context. For example, municipalities or businesses looking to install on-street EVSE will weigh costs associated with accessibility and liability with the opportunity to provide widely-accessible EVSE in the public realm. Many municipalities have yet to consider zoning and other design issues for on-street parking. This can be another hurdle for developers, and points to the need for municipalities to address on-street parking locations.

1. Signage and wayfinding is crucial for locating and designating EVSE charging spaces in the public realm. Municipalities or districts seeking a green identity may choose to locate EVSE spaces in prominent locations, and incorporate identity campaigns into accompanying signage. Signage should also designate limits of use. Enforcement should be provided by traffic police who issue tickets for metered parking, and penalties should be enforced in order to maximize use of the EVSE.

2. Street markings can further identify spaces, but striping or painting should be distinct from no parking or bike lane designation.



IMAGE 5. LONDON, UK CORD MANAGEMENT TECHNOLOGY AND EVSE PLACEMENT IS ESPECIALLY IMPORTANT FOR ON-STREET PARKING SO AS TO NOT CREATE TRIPPING HAZARDS. EVSE SHOULD NOT BE PLACED IN A LOCATION THAT WOULD CROSS SIDEWALKS OR PEDESTRIAN PATHS. RETRACTION DEVICES OR A PLACE TO HANG PERMANENT CORDS AND CONNECTORS SUFFICIENTLY ABOVE THE GROUND SHOULD BE PRESENT ON ALL EVSE.

3. Placement of EVSE in the public right-of-way is a challenge. Charging stations with simple and streamlined designs are desirable, as the EVSE will be a part of an existing streetscape that may already contain numerous obstacles, such as planters, benches, bike racks, signage, vending and merchant furniture or displays.

4. On-street EVSE may be provided in partnership with owners of nearby businesses or buildings, from which power may be drawn. Alternately, electricity may come from existing on-street sources, including city-owned lines, telecommunications companies through phone booths and private sources connecting to street lighting, among others. Ownership of the conduit will determine metering and billing responsibility and options.

5. Access for all drivers will include allowing sufficient space to maneuver to the front and side of the EV in order to attach the coupler to the vehicle. Drivers may be required to enter oncoming traffic in order to reach the EV's port. EVSE placement will also help accessibility; because of the location of EVSE inlets on most EVs is the front grill or over a front wheel, EVSE should be installed at the front third of a parallel space. For angled front-in parking, EVSE can occupy the triangular left over space at the front.

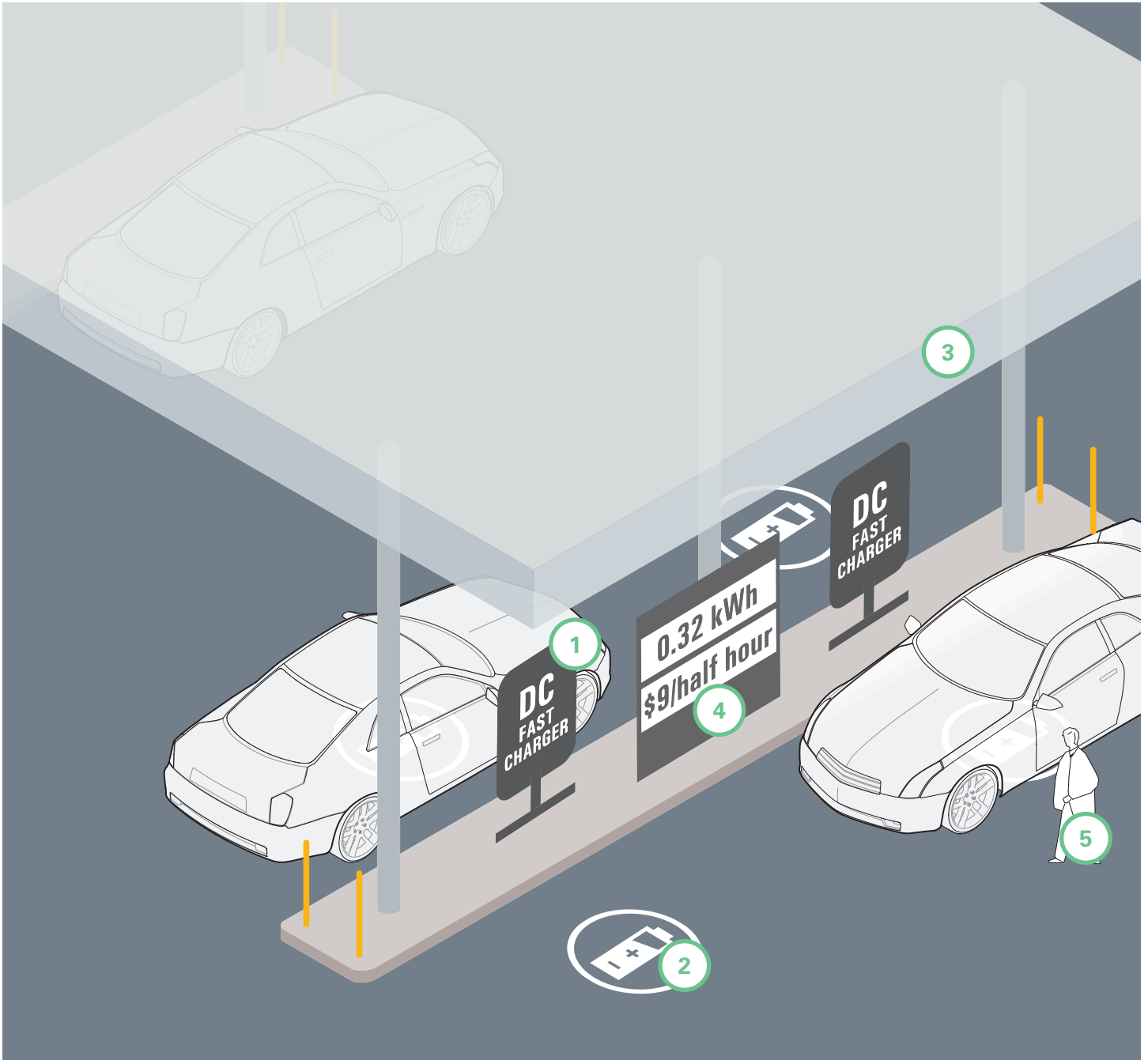
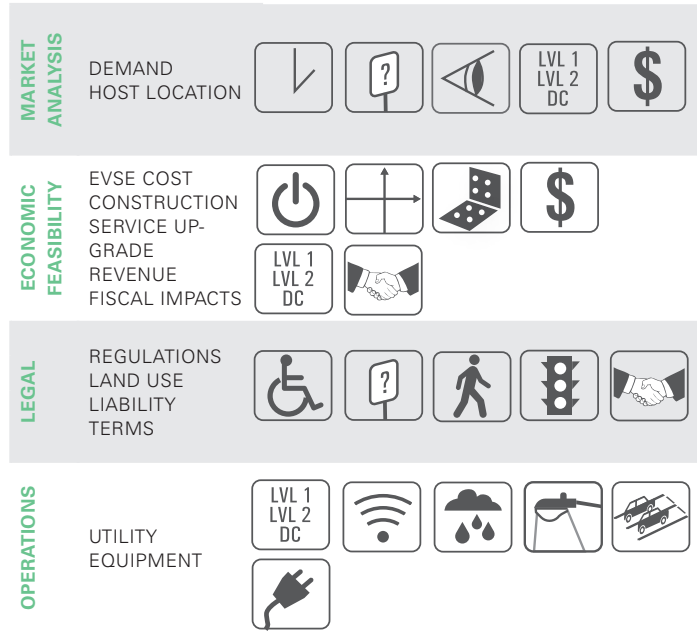


FIGURE 20. SITING AND DESIGN GUIDELINES FOR SERVICE STATION PARKING

4) SERVICE STATION

PRIORITIES FOR SERVICE STATION CHARGING



Service station charging will most closely approximate the experience of gasoline fill stations, and will likely be accommodated at existing service station locations. This type of charging will prioritize speed and convenience, allowing drivers to pull in off the road and top off a battery in order to continue for longer distances. Service station operators may have to contend with negative customer perception about the proximity of electricity and gasoline, but in fact, this scenario does not present any clear additional user hazard.



IMAGE 6. BEAVERTON, OR THE EVSE IS INTEGRATED INTO EXISTING INFRASTRUCTURE. IT IS LOCATED BETWEEN OTHER GAS PUMPS AS TO NOT BLOCK TRAFFIC SINCE THE CHARGING VEHICLE MAY BE PARKED FOR UP TO HALF AN HOUR.

- 1) The type of EVSE most appropriate will likely be DC fast charging. Allowing customers to quickly charge up while in transit is the most important aspect of this context.
- 2) Clear markings for EVSE charging is essential in order to avoid customer confusion, as many DC fast EVSE models resemble standard gasoline pumps. Location on the service station site must not interfere with vehicles accessing the gasoline pumps.
- 3) Protecting DC fast chargers from the elements at outdoor locations is both a customer amenity and desirable safety precaution for electrical devices.
- 4) Service stations will need to partner with EVSE networks or establish their own appropriate charge-for-charge model.
- 5) Customer amenities are crucial, as drivers will need a safe place to wait for up to a half hour while their vehicle charges. Rest stops already have these options, but standard service stations may need to consider a covered seating area or expanding the convenience retail model to include a café.

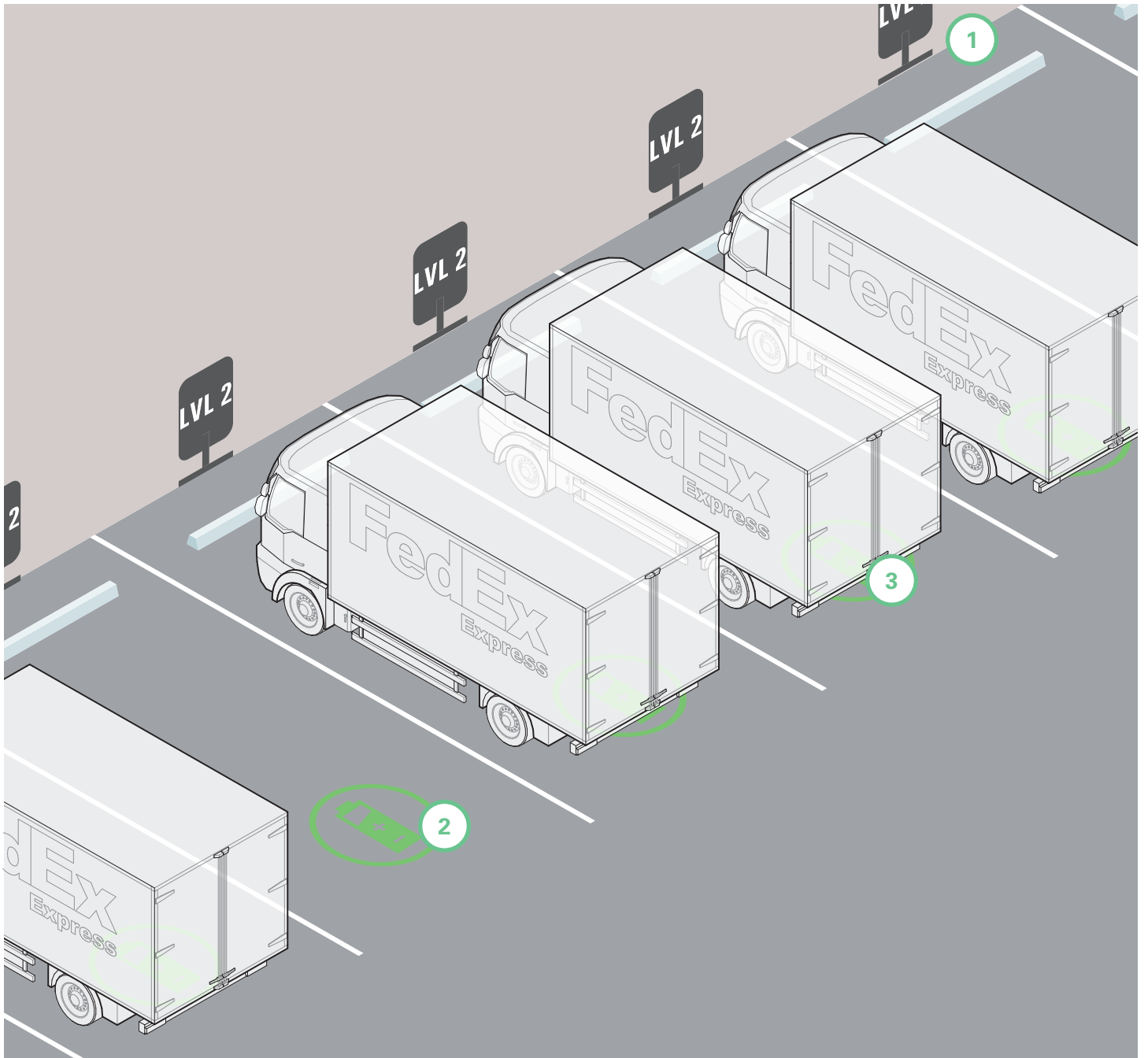
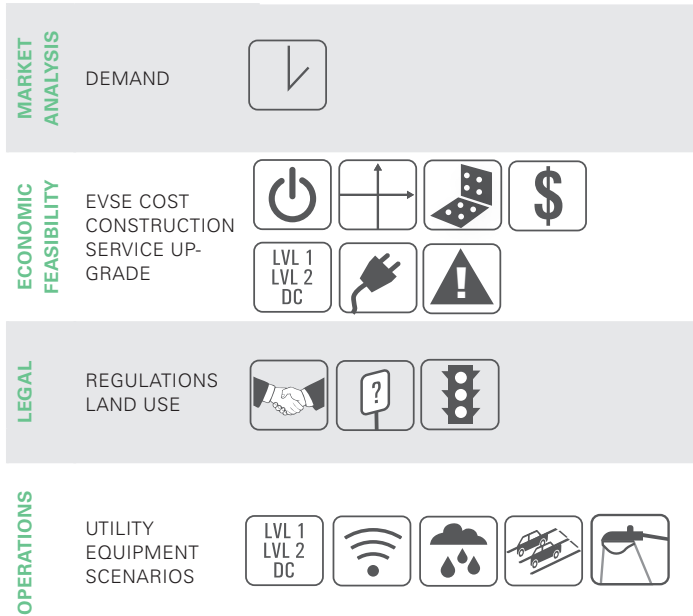


FIGURE 21. SITING AND DESIGN GUIDELINES FOR COMMERCIAL FLEET PARKING

5) FLEET

PRIORITIES FOR COMMERCIAL FLEET CHARGING



Commercial trucking represents a growth area for EV use. Benefits associated with reduced air pollution will make EV fleets an important option for inner city freight hubs. Several large corporations, such as FedEx, Frito Lay and Duane Reade have begun to incorporate EVs into their commercial fleets. Green loading zones will be located at delivery locations and will designate areas near loading docks, or on the street adjacent to building freight entrances, and eliminate the environmental hazards associated with idling diesel engines. However, fleet use is not limited to delivery vehicles. University or medical campuses, governments and car share companies are all incorporating EVs. All fleet vehicles will need a place to charge overnight at their home parking location.



IMAGE 7. FRITO LAY COMMERCIALLY AVAILABLE TRUCKS SUCH AS SMITH ELECTRIC'S NEWTON, PICTURED ABOVE, USE THE STANDARD J1772 CONNECTOR, BUT MANY FLEETS USE PROPRIETARY ADAPTERS.

- 1) Proximity to building entrances is a different consideration for fleet vehicles. For green loading zones, accessibility to freight entrances and elevators is the primary consideration. For other fleet charging, operators may desire a location further from building entrances so as not to impede delivery traffic or other industrial operations.
- 2) Length of stay for fleet vehicles will help site planners to determine the appropriate level of charge. For green loading zones with a fast turnaround, DC fast charging may become the norm, although level 2 will be more cost effective and standard for the immediate future.
- 3) Overnight charging is necessary but may place a burden on the existing systems. Most industrial locations will already have access to heavy power in the buildings, but bringing power to the charging location will add to installation costs and the addition of numerous large EV batteries to the circuit will dramatically increase the system's load. Local electrical service transmission capacity is a central concern, and site designers will work with the local utility to ensure that any necessary upgrades are made.



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- Image 2. Ozawa, Ryan. *Electric Vehicle Parking*. Available from: Flickr. JPG Digital Image, <http://www.flickr.com/photos/hawaii/6879222319/> (accessed August 11, 2012).
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- Image 6. Tenney, Sam. *A new Chevron station at the corner of Allen and Murray boulevards in Beaverton features an eco-roof, a geothermal system, a solar array, and an electric-vehicle charging station*. Available from: Daily Journal of Commerce Oregon. JPG Digital Image, <http://djcoregon.com/news/2011/10/04/beaverton-gas-station-goes-green-with-help-from-eugene-company/> (accessed August 12, 2012).
- Image 7. *Frito-Lay Smith EV*. Available from: Fleets and Fuels (Business Intelligence For Clear Transportation Professionals). JPG Digital Image, <http://www.fleetsandfuels.com/fuels/cng/2012/05/100-more-smith-evs-for-frito-lay/> (accessed August 16, 2012).

