SANDAG

Regional EV Charger Management Strategy

Regional Public Charger Operations and Management Strategy

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1. Introduction and Purpose

The San Diego Association of Governments (SANDAG) and local partners were awarded a California Department of Transportation (Caltrans) Sustainable Communities Planning Grant to develop a regional strategy to assist public agencies with providing readily and consistently available public electric vehicle (EV) chargers. The *Regional EV Charger Management Strategy* focuses on developing a structure of steps and considerations for installing charging private passenger vehicles and publicly accessible parking areas, such as parking lots for public buildings, park & rides, transit stations, rest areas, parks, libraries, recreation centers, and other publicly owned lots. This document identifies a suite of options for agencies to manage these public assets throughout their life cycles:

- Planning
- Deployment
- Operations and maintenance
- Relocation, refurbishment, or decommissioning

Effective asset management allows agencies to equitably increase EV adoption, streamline processes, and reduce costs.

The authors of the present strategy document compiled key components from other reports prepared for this effort:

- *Peer Agency Research and Analysis Summary Report* (November 2021)
- *Regional and Local Charger Management Practices Summary Report* (December 2021)
- *Asset Management Considerations Summary Report* (March 2022)

2. Planning and Installation

Best-Practices and Common Themes

Table 1. Best-Practices and Common Themes

Best-Practices	• Determine both current and **future needs** to ensure longevity and usefulness. • Use equipment compliant with **Open Charge Point Protocol** (OCPP) (e.g., chargers whose IP addresses can be reset, allowing another network to take over service). • Design parking–charging layouts so that each charging port may reach at least two parking spaces, enhancing resilience and utilization for growing demand. • Collect and analyze **port-level charging data quarterly.** Compare energy costs to the best-case scenario and use the analyses to determine how to provide lower-cost energy.
Common Themes	• Impacts of **funding/financing apparatuses** on EV supply equipment (EVSE) options, including equipment type and location. • Increasing focus on **dual-use-charging locations** to maximize benefits and utilization. • Increasing focus on issues of **equity and access**, ensuring public charging is available to all drivers, including lower-income individuals and those in need of accessible parking options.

The *Peer Agency Research and Analysis Summary Report* indicates that there are numerous ways to implement and manage public access EVSE—no two agencies were exactly alike in their approach. In many instances, the funding apparatus and/or terms of the funding agreement dictate the management strategy. The funding particulars, in turn, are functions of the needs and trends at the time the EVSE projects were implemented. Therefore, management strategies should be developed with a holistic, forward-looking approach that address both current needs and, to the extent possible, future needs. Proactive planning will minimize re-work, including drilling and restoring concrete and asphalt.

Planning Sites for Deployment

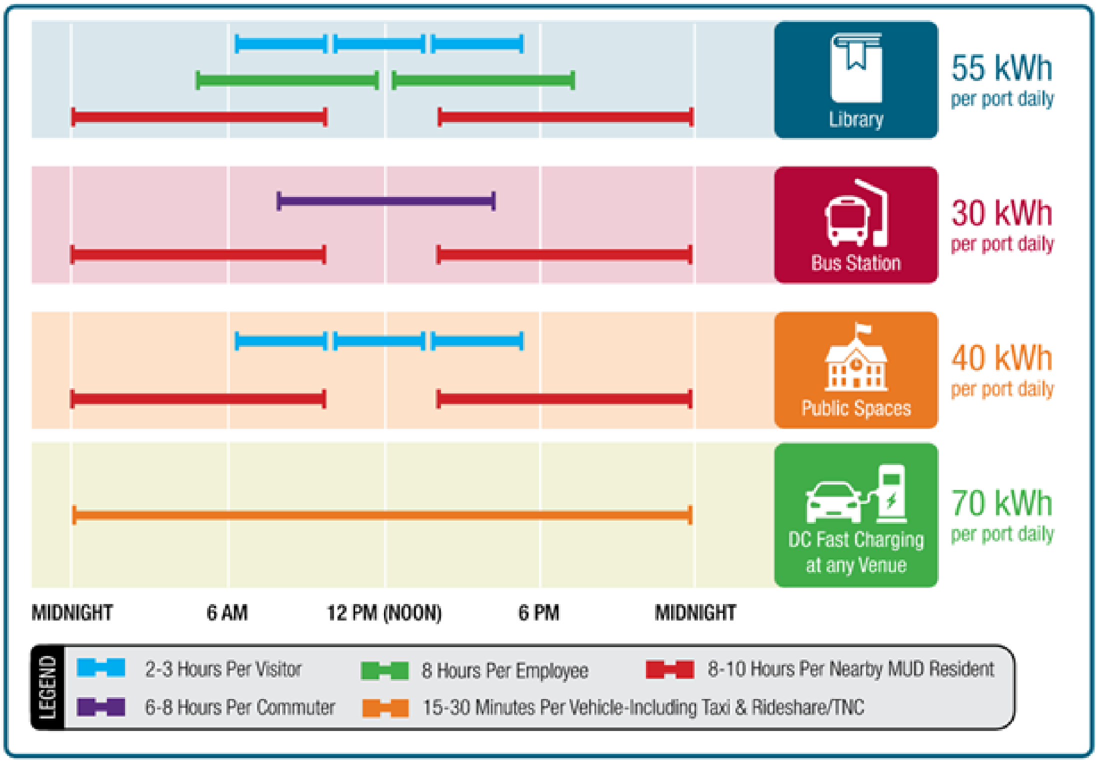
Agencies should be intentional in selecting locations for EV charging. Many public charging sites have been built based on the ease of construction, or the availability of funding to cover capital costs. As described later, agencies should consider filling gaps in the regional charging network, ensuring access in underserved communities, and sites with high anticipated usage when prioritizing sites for deployment of charging.

SDG&E will be a crucial partner early in the EVSE installation process, offering a realistic assessment of required site upgrades and the type and quantity of chargers that can be supported, both at the site level and on the regional electric grid.

To increase charging station utilization, stations should be sited where they will be accessible on a reliable basis and easily visible. This is frequently at stalls closest to a main entrance to the site's buildings, providing additional convenience to adopting EVs over ICE vehicles; however, these stalls may also be located elsewhere to keep infrastructure costs reasonable when electrical service is coming from a new utility connection instead of an existing building. Ideally, new sites will fill critical charging gaps rather than compete unnecessarily with private charging businesses. However, some degree of competition is healthy, as it promotes fair pricing and easy access. Appropriate policy and design allow for a broad user group.

Figure 1 notes how different user groups can overlap at a given venue to increase station use throughout the day, enhancing the business case for either for-profit or revenue-neutral operations. In other words, charging behaviors—such as the most popular times throughout the day for charging and the duration of those charging sessions—can inform agencies about the most productive, least-cost charging installation.

Figure 1. Charging Scenarios for Various Public Locations



Installing EV chargers is easiest and lowest cost when constructed concurrently with other site improvements. Planning for EV charging installation to take place alongside other upcoming projects can jumpstart benefits. Public agencies may consider implementing policies that call for review of upcoming construction projects to determine whether and how EV charging can be included, even if only to build parts of a full installation (e.g., trenching or electrical conduit stub outs).

Approaches for planning EV charging differ between sites that are undergoing new construction and sites that are simply being modified. Existing facilities will need to carefully assess how their EV charging installations will fit into their existing site usage. These assessments may include parking policy, ADA updates, and on-site facility manager feedback on station usage and difficulties. Potential hurdles include identifying whether to upgrade existing electrical systems to accommodate "traditional" (grid-tied) EV chargers, how to place charging stations to minimize conduit run and maximize charging access, how to mitigate EV chargers supplanting parking spots, and what type of EV charging systems will work best for current and future site use cases.

With new construction sites, EV charging design can be accounted for in the overall site plan from inception, allowing for a more seamless integration of charging spots with parking policy and ADA requirements. A blank-sheet approach allows the site host to approach charger installation much more easily, and with less cost. New charging installs should be deployed in a manner that will easily lend itself to future expansion. Depending on future charging expectations, the site may elect to install oversized transformers, run additional EV charging conduit "stub-outs," and/or preemptively oversize electrical panels to allow for the quick and inexpensive addition of new stations with less site disturbance.

Whether the site is a new construction build or capital improvement of existing facilities, if the facility is expected to undergo continued development, it may be important to consider what future use case(s) will be supported at the site. EV charging can be posed as a continuing and compelling use case to ensure that it remains available through any turnover/development.

Site Selection

Sites should be selected and prioritized based on a balance between the public good that the installation brings to the community and the installation's practicality and cost. Several factors may be assessed when quantifying the public good and economics associated with each candidate site:

- Number of DC and Level 2 charging ports close to the site
- Regional commuting patterns in and out of the site and its surroundings
- Number of EVs registered in the site's census tract and neighboring tracts
- Gaps in the existing charging network
- Location visibility and proximity to major corridors
- Existing site electrical infrastructure
- Variety of user types (e.g., public transport commuters who park at the bus station or residents of a multi-unit dwelling [MUD]) the site can support (see **Figure 1,** above)

In addition, community awareness of the local EV charging network must be built through intuitive signage, highly visible station design, and strategic siting to build utilization and a record of reliability.

Community equity must be pursued for charging installations planned, sponsored, or regulated by municipalities. Organic EVSE development in low-income and disadvantaged communities has lagged significantly behind development in wealthier areas. Deliberate consideration will be required to fill existing charging gaps to serve such communities, following the lead of the California Electric Vehicle Infrastructure Project (CALeVIP) and Power Your Drive, whose initial funding rounds allocated funding to disadvantaged communities. MUD residents and residents of these communities should have easy and convenient access to public sites. Drivers both within and external to these communities must have access to energy which is priced according to fair market rates, and which is relatively insulated from transient spikes. Given the impact of pricing on station utilization, particular consideration must be given to how to implement rate structures for stations within disadvantaged communities – determine whether rates will be dynamic based on user's registered ZIP code, low across all user groups due to the station's location within a DAC or based on another factor that dispenses fuel at an equitable and fair price. Note that per kWh pricing for chargers with variable charging rates is preferred, as costs and energy dispensed can vary widely when billed by time.

Under best-practices, an installation project lead should review the local permitting process during project planning to become familiar with the potential barriers and/or requirements specific to that municipality. Examples of potential obstacles include, but are not limited to:

- Aesthetic alterations (AB 1236(Chiu, 2015)/AB 970(McCarty, 2021) note that this is not a valid issue to block EV charging)
- Zoning conflicts (AB 1236/AB 970 note that this is not a valid issue to block EV charging)
- Inconsistency with accessibility requirements
- A lack of familiarity with the power requirements of EV charging and load management

Permitting is frequently an in-depth process requiring discussions, site visits, and modifications to ensure compliance with utility, municipal, and other legislative requirements. Given the effort involved at each level of permitting, it is strongly recommended that separate permitting processes be undertaken in parallel with each other, rather than waiting for each agency's permitting process to be completed before moving to the next process. In addition to reducing the overall time spent, parallel permitting efforts allow for better cross-stakeholder communication to determine the best path forward through frequently overlapping regulations. Representatives from all agencies should be prepared for increased interagency communication during initial project planning phases, as it will be critical to ensure that a project's design conforms to established standards.

Permitting

American Disabilities Act Compliance

As previously mentioned, the ADA requires public facilities, including EV charging to be accessible. California Building Code (CBC) Chapter 11B requires the first station installed (and potentially more) to be accessible. Additional accessible spots may be required based on the total number of chargers.

Table 2. Number and Types of Accessible Spaces, as Mandated by the CBC, below, references the CBC mandates for specific counts and types of accessible spaces, based on the total number of chargers installed at a site.

Table 2. Number and Types of Accessible Spaces, as Mandated by the CBC

Total Number of EVCS at a Facility	Minimum Number (by type of EVCS Required to Comply with Section 11B-812: Van Accessible)	Minimum Number (by type of EVCS Required to Comply with Section 11B-812: Standard Accessible)	Minimum Number (by type of EVCS Required to Comply with Section 11B-812: Ambulatory)
1 to 4	1	0	0
5 to 25	1	1	0
26 to 50	1	1	1
51 to 75	1	2	2
76 to 100	1	3	3
101 and over	1, plus 1 for each 200, or fraction thereof, over 100	3, plus 1 for each 60, or fraction thereof, over 100	3, plus 1 for each 50, or fraction thereof, over 100

The code does not require that accessible parking with EV charging be signed unless five or more EV chargers are provided; striping and identification of accessible spots vary based on tiers. For example, a small parking lot that has only installed 3 EVCS is only required to ensure that 1 charging spot is van-accessible, and has a wider-than-standard width. The space is not required to be striped or signed as handicap-accessible. However, a site with 20 spaces is required to provide both a van-accessible space and a standard-accessible space, the latter of which is required to conform to striping and signage requirements for accessible spaces.

Per California Assembly Bill 1100, local jurisdictions may count dedicated parking spaces for EV charger equipment or future EV charger installations as one space towards the minimum parking requirements. Additionally, AB 1100 allows local jurisdictions to count accessible parking spaces as two spaces towards minimum parking requirements[1].

Coastal Commission Process

Multiple entities may be responsible for determining whether an EV charging installation will require a Coastal Development Permit for proposed installation within San Diego's designated Coastal Zones. Jurisdictions with certified Local Coastal Program (LCP) zones can issue permits consistent with their

[1] https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=VEH&sectionNum=22511.1)

LCPs, although EV charging has not normally been included as planned uses in the LCP. The Coastal Commission should be engaged in cases where an EV installation is desired within the designated coastal zone. The Commission may have concerns with EV charging reducing parking available for general coastal access, though provisions in AB1100 count EV charging spaces as regular parking.

CALGreen Compliance

Per the latest 2019 California Green Building Standards (CALGreen), newly constructed publicly owned or commercial sites require a certain number of charging spaces based on the total number of parking spaces in the lot. The number required by CALGreen varies by tier in lots with fewer than 200 spaces; in lots with 201 or more spaces, the required number is a flat 6% of total spaces.

Table 3. Number of Nonresidential EV Charging Spaces, as Mandated by CALGreen (2019)

Total Number of Spaces	Number of Required EV Charging Spaces (2019)
0 – 9	0
10 – 25	1
26 – 50	2
51 – 75	4
76 – 100	5
101 – 150	7
151 – 200	10
201+	6% of total

Although these requirements do not apply to existing properties, they can serve as guidance when jurisdictions are planning other facility upgrades.

New CALGreen requirements will be implemented starting January 1, 2023. These changes are outlined as follows:

Table 4: 2023 CALGreen requirements for new construction at residential buildings

Site Type (New Construction)	2023 CALGreen Requirements
Hotels, Motels, MUDs (Under 20 units)	• 10% of parking spaces must be EV Capable. Panel and system must show ability to deliver a simultaneous minimum of 40A of current to all required EV spaces. • 25% of parking spaces require installed Level 2 receptables (240V/20A minimum)
Hotels, Motels, and MUDs (Over 20 units)	• 10% of parking spaces must be EV Capable. Panel and system must show ability to deliver a simultaneous minimum of 40A of current to all required EV spaces. • 25% of parking spaces require Level 2 receptables (240V/20A minimum) • 5% of parking spaces require full Level 2 EVSE
MUDs (Parking structure additions and alterations)	• 10% of total parking spaces must be EV Capable. Panel and system must show ability to deliver a simultaneous minimum of 40A of current to all required EV spaces.

Table 5: Number of Nonresidential EV Charging Spaces, as Mandated by CALGreen (2022)

Total Number of Nonresidential Spaces	Number of Required EV Charging Spaces (2022)	Number of EV Charging Stations* to be Provided
0 – 9	0 (+0 from 2019)	0
10 – 25	4 (+3)	0
26 – 50	8 (+6)	2
51 – 75	13 (+9)	3
76 – 100	17 (+12)	4
101 – 150	25 (+18)	6
151 – 200	35 (+25)	9
201+	20% of total (+14%)	25% of EV capable spaces

* A "charging station" entails at least one Level 2 port, but additional Level 2 or DC Fast charge ports may be supplied. If stations are managed by an automatic load management system (ALMS), a single vehicle must charge at no less than 30A; EVSE must deliver no less than 3.3 kW with multiple EVs charging simultaneously.

Easement Considerations

Leveraging a utility program or using public funding can come with stipulations. Easements may be placed to ensure that the electric utility is able to access and maintain the utility-owned electrical infrastructure supporting a funded charging installation. New and existing easements and how they interact with site operations should be considered.

Ideally, utility-owned equipment should be located at the edge of an installation site closest to where the chargers will be located. This will minimize both the area required for a utility easement and the length of trenching and conduit run needed to supply power to the chargers.

A primary consideration of this is transformer and/or switchgear placement. A utility has the ability to access and control the portion of land surrounding the assets they control—meaning that if a transformer and switchgear are placed in the center of a site's parking lot, there may be significant impacts to the site's daily operations if issues arise with either component. More importantly, an agency may be prohibited from changing the surrounding area's uses for the term of the easement, usually 10 years or more. The presence of a utility easement could inhibit facility renovation or replacing a parking area with new development.

Easements also present a potential delay in the permitting process; depending on utility policy and process complexity, securing easements may take a significant amount of time. Best practice dictates that this be discussed and finalized during the initial planning stages of installation with San Diego Gas and Electric (SDG&E).

Ownership Structure

One of the most important aspects of implementing and maintaining an EV charging installation is determining which ownership structure to pursue. There are a wide range of operational and ownership models, from full ownership by the site host (typically the owner of the site – but whoever is responsible for the continued operation and management of the site) to ownership and operation by an external EV service provider, or EVSP. Each ownership structure has its own characteristics, including differing approaches to upfront cost share and operational cost recovery, site leasing structures, and reporting requirements. **Table 6**, below, illustrates the spectrum of ownership models and provides brief snapshots of the typical characteristics associated with each model.

Table 6. Various EV Charging Site Owner–Operator Relationships

Operational Model	Capital Costs	Network Costs	Payment Processing	Benefits	Challenges	Appropriate Conditions
Agency owner / operator	Part of host capital improvement programs	Paid by the host	Network takes a small percentage	Host has full control over pricing	Higher costs to the host unless external funds are secured	High site host involvement, capital available for improvements and infrastructure upgrades
Agency owner / EVSP operator with revenue share	Shared based on terms of initial agreement	Lower cost to site host	Network takes a higher overall percentage of revenue	Partnership encourages high utilization designs, regular reporting, marketing	Record-keeping transparency, higher electricity cost to end-user	Moderate site host involvement, capital available for improvements and infrastructure upgrades
Agency make-ready / turn-key operator	Make-ready built by site host (can be grant- or utility-funded); equipment provided by EVSP	Limited cost to host	May be negotiable	Host may be able to influence retail prices to encourage EV adoption	Coordination of construction from potentially two entities (to-the-meter / from-the-meter); less interest from vendor if unable to see hardware charge for network fees	Host willing to provide a site and parking spaces, hands-off site host, No capital beyond make-ready
Utility make-ready / agency operator	Limited to purchase and installation of hardware	Negotiable by host	Negotiable by host	Host has more control	Utility easements and influence over location, minimum ports required	Moderate site host involvement requires a utility make-ready program
Utility owner / operator	Utility / ratepayers	Paid by utility	No influence	Host has limited responsibility (cost, etc.) or influence	5- to 10-year easements, potentially uncompetitive electric pricing compared to gasoline	Charging installed under utility incentive program
EVSP owner / operator with a public site lease	None to site host	None to site host	None to site host expected	Host has limited responsibility, with low or no cost to site host	5- to 10-year lease with renewal options, Issues with public contracting rules (need to go to RFP, private activity on public property), potentially uncompetitive electric pricing compared to gasoline	Receptive local agencies/municipality, hands-off site host and longer planning timelines

Regardless of ownership structure, a key component of seamless EV charging is ensuring that the chargers are available, operational, and accessible. Much more is involved than simply ensuring that stations are physically present. To build an effective charging network, EV chargers must be sufficiently reliable that drivers are confident they can receive a charge whenever required. If chargers are installed under an "own and operate" structure in which the site has full control over its infrastructure, the site will be responsible for ensuring that chargers are kept up to date with industry standard technologies and maintained in good operating condition. In alternative ownership structures, agreement language with vendors, suppliers, and the site should be standardized to ensure ideal operating conditions are maintained for the long term. Upkeep would involve upgrading stations, ensuring warranties are in place with each generation of charger, and conducting ongoing proactive maintenance.

Electrical and Usage Characteristics

Chargers come in a wide variety of power levels that require differing investments of infrastructure preparation, as shown in **Figure 2**.

Figure 2. Capital Considerations of Charging Equipment Speed

$ Least Costly ← → $$$ More Costly

Infrastructure Capital Cost Considerations

OVERALL CAPITAL COSTS	LEVEL 1	LEVEL 2	LEVEL 2+	LEVEL 3 (DCFC)
EQUIPMENT COST PER PORT	$10-25	$200-$600	$1,000-$4,000	$10,000-$50,000
INSTALLATION COST PER PORT	$0-$1,000 per connector	$3,000-$6,500 per connector	$5,000-$7,500 per connector	$70,000-$90,000 per connector (typically 2 ports)
CHARGE RANGE	1.2kW: ~40 miles during workday/overnight	3-7kW: 10-25 miles each hour	7-19kW: >25 miles each hour	50kW: ~150 miles each hour
WARRANTY & REPLACEMENT COSTS	Lower warranty & replacement costs	Low-cost replacement instead of warranty	Higher warranty & replacement costs	Highest warranty & replacement costs
PARKING TURNOVER	Minimal to none	Medium need for parking	Higher need for parking turnover	Must have hourly parking turnover
SUPPORTING HARDWARE INSTALLATION	Most likely to use existing hardware	Likely to need installation	More likely to need installation	Most likely to need installation
CARS PER DAY	1-3 cars	3-10 cars	5-20 cars	30 cars

Variables affecting cost decisions range from the per-port capital cost associated with each type of charging, to the expected charge rates, to the vehicle turnover rates that each charging type is best suited to support.

The maximum power and number of chargers that can be installed will be limited by the site's electrical capacity and associated characteristics. Of particular concern are the following components:

- **Electrical panel:** Each charging port will often require a dedicated circuit. While a 40-amp circuit is often used for a single 7.2 kW Level 2 charging port, 40 amps is often oversized. As a result, vehicles charge quickly and then remain connected but not charging. For sites with limited available electrical capacity, an EVSE project manager may be able to increase the number of chargers that can be installed by procuring lower-power chargers or chargers with power outputs that can be moderated or managed. In addition, limitations on electrical capacity may be mitigated by setting up the site such that more than two parking spaces can access each port. On the other hand, a direct current (DC) fast charger may require its own dedicated electrical circuit capable of supporting 100 amps or more.
- **Transformer:** The project manager should assess whether the site has enough space on its existing transformer to allow for number of EV chargers planned for installation. Once the existing capacity for charging hardware and quantity of ports is determined, the project manager can work with the utility company to assess the additional load that will be placed on the transformer. If upgrades are required, the utility company will be able to help install and implement the new equipment.
- **Electrical rate:** The site's utility bill will indicate which rate applies to existing accounts, helping to estimate ongoing electrical costs. The agency may benefit by switching to a better electrical rate in general or by installing a dedicated billing meter to monitor electricity dispensed by the chargers. Higher-power EV stations will incur much higher costs under an electrical rate with demand charges; setting up a fair fee structure for public charging can help maintain a healthy balance between revenue and usage.
- **Physical space:** The site's physical layout may limit the number of charging station installations, which is particularly important when considering upgrades to an existing site. Under the American Disabilities Act (ADA), the first station installed (and potentially more, depending on the number of chargers installed) must be ADA van accessible, which may affect the striping for other spaces. Additionally, charger siting may be limited to within a short distance of a new service drop (if required), and electrical infrastructure (e.g., transformers, standalone switchgear) will need adequate installation space.

SDG&E must be consulted early on in a site's EV charging planning to assess the level of power that the transformer and panel can support, as well as the additional capacity that the site's regional utility grid can support. If additional power or capacity is desired, the ideal setup should be discussed with a utility representative to determine a) whether the project is feasible, and b) the specific upgrades that should be enacted.

Growth and Expansion

Scalability is a key component of a successful regional charger management strategy. Currently, agencies generally install only the charging infrastructure for which there is a demonstrated need in the here-and-now. However, designing for future expansion, such as overbuilding or capping off trenches with handholes and pull-boxes—will pay dividends. Thinking ahead during the design phase can limit recurring costs from:

- Mobilizing construction crews
- Trenching, then back-filling, pavement
- Upgrading electrical infrastructure (transformers, conduit, electrical panels)
- Designing and permitting

While a thorough assessment of currently expected charging behavior and needs at the site is crucial in establishing the scale of a baseline charging installation, it is also important to determine how the site's needs are likely to evolve over the course of the next five to ten years with rising EV adoption rates. Determining whether the site will be able to continue meeting local demand may reduce costs in the long run.

Regardless of the desired time horizon, the installation should be sized based on realistic usage and available budget. Factors such as vehicle dwell time and parking turnover are central to matching charging hardware power and type to installation locations, and in determining what types of management policy to adopt.

One example of matching site characteristics to charger management can be seen when balancing charging speed with expected demand. If charging demand is expected to grow relatively slowly, load management may ensure that charger usage does not strain the site's electrical infrastructure, even if more ports are added to meet increased demand. However, guaranteeing a rate of charge to additional ports (as in situations in which a bank of chargers is being expanded for more capacity or upgraded to a faster speed) will require significantly more effort after initial installation.

Technology, Equipment, and Data

The technical equipment should follow Open Charge Point Protocol (OCPP), which ensures hardware IP addresses can be changed. This protocol allows flexibility so that station hosts are not indefinitely committed to individual network providers, which in turn enables adaptation to current market trends (in terms of best-cost EVSE and EVSP, for example) while leaving space for future changes to the network vendor. When selecting a vendor, one requirement should be the ability to aggregate data across stations to inform decision-making.

Additional Energy Systems and Solutions

EV charging is increasingly being considered for integration with other systems, such as battery storage or local generation, often using software that can actively monitor and manage vehicle charging rates based on factors such as other on-site demands and utility signals.

Load Management

Load management functionality, frequently offered in chargers installed with wireless capability and software, can provide substantial benefits if the site has restrictions associated with power demand or electrical capacity.

In its simplest forms, load management can cap either net system demand or certain vehicles to a maximum power level. For example, a transit center with fast chargers could automatically limit light-duty vehicles to charge at only 6 kW of power, while allowing transit buses to receive 100 kW of power. Alternatively, the center could simply limit the overall system maximum to 200 kW of power at any given time.

More advanced forms of load management may use time of day, vehicle state of charge, or driver input to determine how to distribute charge to vehicles that are plugged into a system. For example, if a load-managed system operating on a circuit that supports 100 kW of power has 10 cars are plugged in, that system might simply split the charge 10 ways and give each vehicle 10 kW of power; however, an advanced load management system could prioritize faster charging to vehicles with more immediate power needs, while throttling the charge rate to vehicles with enough flexibility to be completely charged later.

In either form, load management generally allows for the installation of more chargers than the infrastructure could support at full capacity. Load management therefore allows for improved charger availability and reduces the odds that a driver will be stranded by non-operational stations.

Onsite Distributed Energy Resources (DERs)

In some cases, EVSE projects may incorporate battery storage and/or solar or wind power generation to bolster onsite energy resilience and reduce the amount of energy used from the grid. These projects frequently have additional questions that should be considered and answered for each site – some of the most important are outlined below.

- What impacts will load spikes and demand changes have on utility bills? Is it necessary to mitigate these impacts? Examine how chargers are being used, paying close attention to when maximum usage occurs and the amount of demand that chargers incur. Sizing an onsite energy resource to buffer against sharp increases in charging demand can reduce utility demand charges, but may not be economically optimal given the high upfront cost of energy installations.
- Does the site need backup power to address, for example, the risk of Public Safety Power Shutoffs? Consider the number and frequency of PSPS events that have affected the site and the number of drivers that may require reliable power from the site. If there are other charging sites or residences nearby that have battery storage, a new site may not require as much backup capacity since demand will be distributed amongst other stations.
- Is there an emissions credit plan, such as through the Low Carbon Fuel Standard (LCFS), that would benefit from capturing renewable energy to use later? If onsite generation and battery storage are both deemed to be attractive to the site host, it may make sense to oversize generation and battery capacity to generate LCFS credits, which can then be sold as a source of additional revenue generation. Agencies should discuss this proposal with SDG&E if it is of interest.
- Will the site have load when solar or wind is producing? Depending on the specific characteristics of the expected usage, this may provide a rationale to slightly oversize onsite generation to ensure that power is always flowing to all devices connected to that generation (e.g., battery storage, all chargers, any building integration).
- Will including DERs provide public funding or tax benefit opportunities? Reviewing funding opportunities offered by state governments and local utilities may provide additional economic rationale for supplementing sites with onsite generation.

Minimal-Infrastructure Solutions

Some sites do not support permanent EV charging installations, such as when site usage changes are expected, electrical infrastructure upgrades are planned, or there is no utility support for EV charging. In such cases, modular or infrastructure-light systems may be an option for temporary deployments that can still provide full-service charging.

Self-contained, make-ready systems are available from several manufacturers. A system typically consists of a transformer, switchgear, and stub-outs built into a mobile container unit. The system requires a power feed from the utility, and EV charging hardware must be supplied, but the permanent make-ready work is significantly reduced.

Other options for infrastructure-light solutions include:

- Battery-supported charging
  - Battery-supported or battery-buffer chargers typically act as capacitors – devices able to take power from the grid at low demand, and discharge power at higher levels or with additional functionality. For example, the FreeWire Boost DC Fast charger uses battery storage to take energy from the grid using Level 2 infrastructure (~7.2kW), but is able to dispense energy to vehicles at full DC Fast charge rates – over 10x that. The battery significantly reduces the cost of demand charges incurred by high-powered chargers. Mobile chargers have also been developed; batteries are slow-charged from the grid outside of business hours and moved to vehicles to dispense charging at Level 2 rates.
- Generation-integrated power supplies
  - Charging solutions may integrate onsite generation into their charger offerings. Larger, more powerful chargers are typically permanent installations; smaller chargers offer additional portability but typically compromise by lowering charging powers. For example, the BEAM EV-Arc is a fully modular solution that can be deployed quickly and impermanently, relying only on an integrated solar panel and batteries to supply power to an EV charger. However, the total daily charging capacity of these systems is limited by the onboard batteries. Conversely, Paired Power ties solar canopies to Level 2 charging, but requires additional permitting and hard-wired equipment.

As part of SDG&E's Rule 45, the utility will be responsible for funding utility-side upgrades for EV charging. The funding covers planning, designing, and engineering; purchasing and installing meters and transformers; installing conduits and service up to the meters; installing service drops; and trenching and excavating to the meters.

Funding Sources

Costs associated with EV charging installations can be divided into two main categories: capital costs and ongoing costs. Capital costs (also known as upfront costs or make-ready costs) represent the one-time costs of installing EV chargers – for example, purchasing equipment, digging trenches and installing conduit, and upgrading a site's electrical infrastructure all fall under capital costs. Ongoing costs are the recurring fees associated with operating the EV chargers: this may include electricity, any networking fees, and/or any fees paid to turnkey companies that own and operate the chargers. Separate funding sources are available for capital costs and ongoing costs, which are outlined below.

Capital Funding

Power Your Drive 2.0

SDG&E is beginning its Power Your Drive 2.0 program (PYD2.0) to provide workplace and MUD charging. The utility covers construction costs up to, and in some cases including, the Level 2 charging station, as well as station design and operation. PYD2.0 participating hosts must open a new dedicated utility account, which will require a station to be metered independently from the rest of its host site. This may require additional electrical infrastructure and result in the chargers being placed on a separate electrical rate. However, the PYD program may offer simplified solutions for billing usage to drivers. Billing options can be discussed with an SDG&E representative and be taken into account in the planning process.

Municipal Capital Projects

Upcoming capital projects by local municipalities are opportunities to install EV charging more cost-effectively; as noted above, incorporating charging into an existing construction project is less expensive than stand-alone work. Careful advance planning can avoid doing work twice, such as excavating and back-filling paved areas, and can help prepare for future increases in EV demand through make-ready preparation.

Volkswagen Environmental Mitigation Trust Funding

Funding for medium-duty, heavy-duty, and off-road vehicles and infrastructure is available through the Volkswagen Environmental Mitigation Trust, with additional funding installments scheduled for disbursement in 2022–2023.

Discretionary Grant Program for Charging and Fueling Infrastructure

Established as part of the Bipartisan Infrastructure Law, this program allows for communities and organizations to submit proposals to deploy publicly accessible EV chargers along highway routes designated as EV charging corridors. Specific implementation rules are still pending, but at least half of the funding in California must be used to establish community grants for projects within rural, low- and moderate-income neighborhoods, and communities with low ratios of private parking spaces (such as multi-unit dwellings with street parking).

National Electric Vehicle Infrastructure Program

The National Electric Vehicle Infrastructure (NEVI) program will allocate California approximately $384 million in funds over 5 years to build out charging stations along highway corridors, primarily for the purpose of filling gaps in light-duty fast charging infrastructure along designated EV charging corridors. Stations may also be designed to meet community needs adjacent to highway corridors. Higher powered DCFC (150KW+) and ISO 15118 standards are expected to be key to the NEVI buildout. Additional programs supporting community charging may be launched in the future. Current program guidance can be found at driveelectric.gov.

Alternative Fuel Vehicle Refueling Property Tax Credit

The federal Alternative Fuel Vehicle Refueling Property Tax Credit, though lapsed at time of this writing, has been renewed several times and has applied retroactively each time. The credit covers 30% of the total cost of purchase and installation, to a maximum of $30,000.

Operational Funding

Low Carbon Fuel Standard Credits

The Low Carbon Fuel Standard (LCFS) is a California regulation to lower the carbon content of all transportation fuels sold in California. LCFS offers an opportunity for entities putting electricity into vehicles to monetize the carbon reduction resulting from dispensing this lower-carbon fuel. Entities can opt into the program and generate LCFS credits for many vehicle classes, including off-road equipment. Credits can be sold on the open market and help influence a given installation's positive business case.

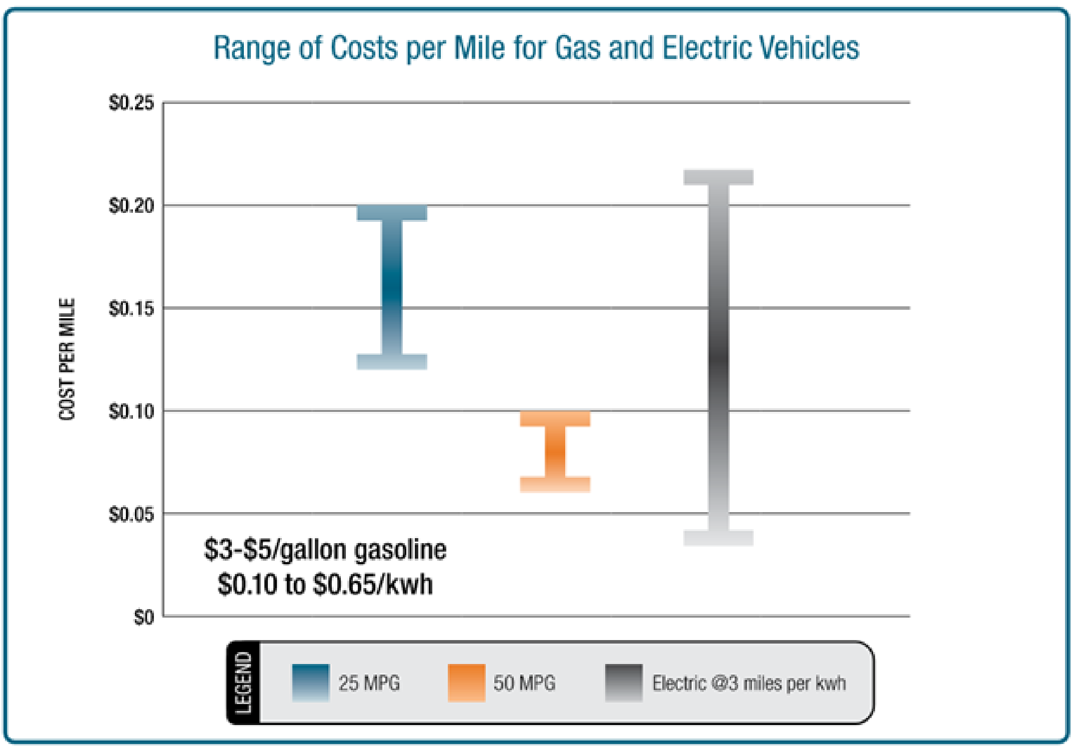
SDG&E Emergency Load Reduction Program

SDG&E recently has begun their Emergency Load Reduction Program (ELRP), which covers EVs. Incentives are paid out for energy avoided (using "normal" as the baseline) on high-load days. Some EV service providers operate similar programs that reward drivers for allowing flexibly controlled charging accounting for renewable energy, which also plays into LCFS.

Cost Recovery from User Fees

Levying fees on drivers can help to mitigate operational costs resulting from electricity delivery and network fees; however, those seeking to host EV charging should consider the attractiveness of the retail costs facing drivers. **Figure 3**Figure 3 shows that under the best circumstances, electricity can be very low-cost compared to gasoline. On the other hand, high-retail electricity costs are possible and may discourage EV drivers from using the site, revert to gasoline-powered vehicles, or never transition to electric in the first place.

Figure 3. Range of Costs per Mile for Gas and EVs



Assessing how chargers are levying fees on a site's users is important. Balancing revenue with usage may be highly dependent on the site's ownership structure. On a per-kilowatt-hour (kWh) basis, sites with low usage may not be able to recoup fees in a way that can cover the initial costs of installation; higher-use sites should be priced by assessing utility pricing on electricity and reviewing local pricing at other charging stations. Time-based pricing is effective and fair only for chargers with a guaranteed power output, as energy dispensed by stations with features such as dynamic power-sharing may vary widely and unpredictably based on site utilization, and can very easily result in expensive per-kWh rates or long residence times if charging rates are slower than expected.

Higher-priced stations may need to present additional functionality to maintain usage levels or risk losing customers, such as faster charging rates or avoiding the need to move vehicles after charging is complete (ideally by providing more charging plugs than demand would typically require).

Most agencies prioritize providing a reliable service over making a profit. Some agencies are interested in possible future revenue generation, but in general, agencies lean toward setting charging fees that, at a minimum, offset the cost of electricity—and possibly other operational costs, including data management, station connection to networking services, and maintenance.

Stations under legacy or early-generation agreements are priced higher than the current market rate - around $0.49/kWh - which is more expensive than gasoline on a cost-equivalent basis. The price on these stations covers the average electricity cost, but the fee collection is governed by a complicated revenue share agreement that has made agency revenue tracking and cost-benefit analysis difficult. These challenges highlight the importance of including language in the agreement to require revenue tracking to help agencies make future decisions based on data.

For agency-owned units, the agencies have full control over pricing, which they have generally set in the $0.30–$0.35/kWh range. The charging provider has a base monthly networking fee, and a small percentage for payment processing and often profit sharing. An agency with a large number of charging stations, or one that is in the process of contract renewal, is in a position to negotiate with vendors for lower fees.

Procurement and Installation

Procurement and Contracting

Once an agency has considered its charging goals, it will need to procure equipment or a vendor that can meet those needs. Procurements can be considered for multiple operational situations, including a procurement for a turnkey operator and another that covers equipment software and maintenance needs for which the agency has responsibility. A list of typical technical specifications and contracting terms can aid public bench solicitations.

Sourcewell and the California Department of General Services have public contracts for EV charging that serve as good sources for potential procurement lists. Sourcewell is a Minnesota government agency serving public agencies nationwide. It holds hundreds of cooperative contracts in a wide range of sectors from administrative services to fleets. The organization conducts competitive solicitations and then allows members to purchase from these contracts through local dealers. The California Department of General Services acts as the business manager for the state. Their leveraged procurement agreements (LPAs) allow state agencies, counties, cities, education departments, and other government entities to purchase directly from suppliers using existing contracts and agreements.

Table 7 Table 7**,** below, provides common specifications that could be included in a procurement for EV charging equipment or services. The list is based on a review of 18 contracts, 14 of which are current, with expiration dates between July 2022 and July 2025, and 4 of which expired in 2017 or 2018. There is a potential to consider procurements for multiple operational situations, including one for a turnkey operator and another that covers equipment software and maintenance needs where a site host has responsibility.

Regardless of the specific details of the charging equipment procurement, it will be crucial to understand the intended terms of the contract. At the highest level, roles and responsibilities should be clearly established as to whether the site host or the third-party operator:

- Ultimately owns the chargers
- Performs routine maintenance and upkeep of the chargers
- Repairs charging stations during and after the warranty period
- Responds to drivers' direct requests for assistance or troubleshooting
- Reports metrics out to stakeholders

Many vendors supply a software dashboard that can monitor and control charging assets. Agencies consider system offerings for ease of use to enable regular tracking of utilization growth rates during early years.

Table 7. Common Specifications for EV Charging

	Description	Considerations
Equipment Type	Plug type and physical hardware requirements	• J1772 is standard for Level 2 • CCS is the most widely accepted DC standard; however, due to the many legacy vehicles on the road, best-practice dictates that sites should include at least one CHAdeMO port • Tesla Superchargers are compatible only with Tesla vehicles • Power level should be considered
Billing Standards	Payment methods and collection process	• The station should meet California's open access standards and accept multiple forms of payment • EVSE standards set by the California Air Resources Board must be met • The processing fees (e.g., whether to have a standalone fee or bundle with other network fees) must be determined
Hardware / Software Certifications	Industry certifications	• Nationally Recognized Testing Laboratory (NRTL) certification must be obtained • Open automated demand response (Open ADR) facilitates participation in utility demand response programs
True Open Software Standards	Hardware that allows replacement IP addresses	• Open standards such as OCPP work only if hardware manufacturers allow for resetting IP addresses, such that any network can be hired to run the installation • OCPP-compliant hardware and software give more flexibility to change vendors in the future • OCPP 2+ incorporates ISO15118. This enables vehicle-to-charger communication for payment and energy management
Maintenance and Service Requirements	Warranty length and services Uptime requirements	• Ensure a clear understanding of maintenance and labor terms • Decide on an ownership structure: is an external entity responsible for ensuring chargers meet defined performance specifications, as in a turnkey contract? Or will maintenance and service be contracted separately?
Lifespan of Infrastructure / Replacement or Renewals	Expected operating life of equipment Regular schedule for replacement	• Underlying electric infrastructure can last decades, but the lifespan of public charging equipment is generally in 5 to 10 years • A turnkey contract can specify that equipment be replaced at the time of contract renewal or removed at cost to the provider
Communications Requirements	Methods of connectivity for billing, usage data, and diagnostics	• A reliable communications connection is needed • Cellular, Wi-Fi, and ethernet are options • Cellular modems do add to ongoing costs
Reporting Requirements	Data that network or station operators must make available	• In both ownership and third-party scenarios, networks should provide access to charging data to support management and reporting • Reporting may be necessary for compliance with any grant program terms
Parking / Charging Layout	Number and layout of spaces being made available for charging	• Specific spaces or the general area available for charging must be identified • Charger placement that allows the cord to reach multiple parking spaces increases station utilization cost-effectively • Site design must account for accessibility requirements • Site design must take lightning and safety considerations

3. Operations and Maintenance

Performance Requirements

Once the chargers have been successfully installed and commissioned (connected to the grid and any backend networks and deemed operational), the site becomes part of a charging network that will help the local community reduce air pollution and enjoy the benefits of electric transportation. However, there are some ongoing considerations and requirements that should be followed to ensure that the site remains reliable and accessible.

Performance and Reliability Monitoring

Once the chargers have been installed and operational for two weeks to a month, there should be a review of charger performance. Examining whether chargers are performing normally and meeting utilization expectations can reveal any early issues with installations and allow for the adjustment of fees and power levels to better balance revenue and usage.

Data Reporting and Sharing

Site hosts should require access to vendor dashboards that can monitor and report out on performance metrics, including energy dispensed, uptime, fault codes, and average power. This is important for benchmarking and learning for the next EV charging projects. While most of these sample metrics may be easily be quantified, "uptime" here may be defined as each charger's ability to serve a vehicle with charge. This involves ensuring that:

- Chargers are connected to their "backend" software networks
- All points of physical user interaction (screen, locks, vehicle connectors) are functional and working as intended
- Charger connections and disconnections can be completed without errors

These database files should be routinely downloaded and saved to secure local storage. Data-gathering and -sharing are vital to future planning and future-proofing. Having full access to port-level charging data allows the managing entity (municipal, county, transit authority, etc.) to develop a strategy that considers current use and identifies and addresses gaps.

Metrics that are frequently useful in gauging a charging station's effectiveness include:

- Charging session initiation and end times
- Total energy dispensed (kilowatt-hours, kWh)
- Maximum, average, or 15-minute session powers (kilowatts, kW)
- Fault codes triggered per session
- Number of daily sessions

Ideally, charging station data can be combined with driver survey results and public comments to assess community needs and opportunities for system improvements, in part through comparison with other charging stations in the vicinity[2]. Analyzing station data also provides

Parking Turnover and Management

Parking management may be an issue, especially where lots are used primarily by commuters parking for longer than it requires to charge their vehicles. Site planners may need to control space turnover to limit charging duration or to limit how long vehicles can utilize the space without actively charging, while

[2] https://berkeleyca.gov/your-government/our-work/adopted-plans/berkeley-electric-mobility-roadmap

considering the venue purpose. For example, commuter lots may allow 8 hours of parking, whereas overnight residential spaces may allow 6 – 10 hours, and shopping and recreation facilities could limit parking to 0.5 – 2 hours.

The simplest way to provide reliable access to charging ports is to design the space (including long enough cord sets) such that multiple parking spaces may be served by each EV charging station. Some sites are especially well suited for this solution – installations with shopping-center style parking lots ("head-to-head" spaces on either side of a central aisle) may provide the ability for any of four adjoining spaces to be served by a single EV charging plug. However, not all spaces are conducive to ample access and may provide less benefits for the investment – the linear nature of curbside charging, for example, may inherently limit charging to only one or two spaces.

In a local example of parking management, the University of California, San Diego (UCSD) uses a system that notifies a driver when someone else is waiting for their charging spot and will ticket drivers who overstay. However, due to the high demand for parking on campus, many drivers will risk being ticketed rather than search for another parking spot. In some locations, UCSD is using PowerFlex for adjustable load management. This solution has allowed UCSD to replace a single Level 2 charger with three units on the original circuit, while splitting or otherwise sharing the available electric capacity. With these chargers, each driver provides an estimated time of departure and the estimated number of miles needed (e.g., the distance that will be traveled before the next charge). The network then optimizes power delivery to serve users but does not exceed the circuit limit. Importantly, with more charging stations and the ability to shift power between stations, vehicles no longer need to be moved in the middle of the day.

In another local scenario, San Diego Metropolitan Transit System (MTS) is aiming for two- to four-hour charging maximums, but typical commuters are parked for eight to 10 hours at MTS park & ride lots. MTS would like to prioritize EV charging for transit riders and has considered tying the charging fee to whether the driver switches modes at the station; however, this would require additional infrastructure, such as gates and connections to the fare system. Similarly, airport customers often charge their vehicles for four hours but remain parked for multiple days. In both scenarios, least-cost, slow and simple charging can be used.

As a general practice, charging fee structures that ramp up past a certain charge or plug-in time are appropriate and effective in places with short dwell times, where parking is typically not at a premium and drivers have easy access to their cars, such as a library parking lot, a parking structure for a retail store, or a large public parking lot near a city park. In such areas, supplying additional chargers would incur unnecessary costs from hardware, construction, and ongoing operational network fees.

Many network software systems allow parking fees that can be billed concurrent with or after charging. This system encourages users to move their cars when charging is complete. The parking fees can also be an additional source of revenue. However, these systems are not practical in locations where people do not return for many hours, such as park & rides and medical centers. Most turnkey providers typically use a per-kilowatt-hour and parking fee model at stations they own and operate. UCSD prices its charging on the lower end to offer a reasonable price alternative to home charging and to encourage mid-day charging on the university's lower-carbon microgrid. For sites with long-dwell-time charging, innovative automated load management systems offer a way both to shift charging to lower-carbon times and to reduce the need for drivers to move their cars midday.

Many agencies seek to set a user fee set only to recover costs. Caltrans has a specific policy to not make a profit and is seeking federal guidance on restrictions around charging revenues along interstate highways. For SDG&E's Power Your Drive (PYD[3]) program, the utility owned and operated the program-sponsored stations. Stations set up through the Electrify Local Highways[4] program use time-of-use charging that charges higher fees at times the grid is strained. PYD and the program customers have demonstrated the flexibility to charge during low-cost and often low-emissions periods and to limit charging during grid-constrained periods.

Fee structures set up to encourage movement after a certain number of hours may be beneficial in short-dwell situations with plentiful parking. However, in areas with significant (>2-hour) dwell times and difficult parking, it may make more sense to increase the number of available stations and parking spaces with charger access, and to implement a load-management system to avoid issues with site electrical capacity. Scenarios with even longer dwell times (>5 hour) and high usage may be best suited for Level 1 charging, which will significantly decrease installation and demand costs. Situations that would suit load-managed moderate-power charging include street parking near a popular shopping mall, student parking lots within college campuses, or a public beachside parking lot; load-managed low-power charging would be appropriate for commuter lots, campus residence halls, or shared-use parking lots near multifamily dwellings.

Additionally, active parking management may prove beneficial to stations that have limited or waived fees, or stations that are frequently blocked by internal combustion vehicles or EVs that are not charging. Parking enforcement staff are crucial to providing reliable charger availability by enforcing EV-only parking and parking duration. Enforcement often starts with courtesy notifications but can move to parking tickets or towing. Clear communication of parking policy is essential and can be accomplished through clear signage or by requiring drivers to review and accept the policy prior to charging.

Energy Management

On some of its rates, SDG&E bills a charge based on the maximum average power demand (in kilowatts [kW]) observed over a 15-minute interval. For an independently-metered charging installation, this can be found by examining the "demand charge" section on the meter's SDG&E bill. Due to their high-power draw, DC Fast Charger installations with multiple chargers are particularly susceptible to extremely high demand charges. If the demand charge is too high, it can make it impossible for a charging site to cover its costs. Strategies exist for reducing the maximum power of the system – potential avenues include using the software integrated into the chargers or installing an active load management system (as discussed earlier).

Behavioral Adjustments and User Training

Common behaviors seen with EV charging stations are blocked chargers (both by EVs and by internal combustion vehicles), damaged equipment, and poorly maintained equipment. Workplace sites can benefit from simple education on charging etiquette to ensure vehicles adhere to a fair charging schedule such as limiting charging time, promptly unplugging and moving vehicles after charge sessions end, and taking care not to inadvertently damage equipment. Public chargers may benefit from clear signage noting that spaces are for EV charging only. More advanced steps include maintaining access control oversight by the site host and through the charging network to ensure customers agree to policy and accept any additional fees that result from policy violations.

[3] The final report on SDG&E Power Your Drive is publicly available and may be a useful resource when considering charging at workplace or MUD sites.

[4] This public charging project was reported on for the Priority Review Projects final report.

EV Data Communication and Security: Best-Practices

WiFi-connected EV chargers are internet-of-things (IoT) devices and have been the targets of a rising number of cyberattacks against public infrastructure. Some EV chargers use relatively simplistic internal computers to enable their connectivity functions. These can be accessed by opening the charger's case and directly connecting to exposed ports. Ensure that tamper-detection sensors and/or alarms are installed on EVSE enclosures. Ideally, WiFi-connected chargers will be connected to their own secure wireless subnetwork featuring WiFi Protected Access (WPA2) passkeys to control access. Cellular networks and/or gated internet connections are additional options to isolate EVSE network traffic to a subnetwork. Network traffic should be encrypted with FIPS-compliant cryptographic hardware to limit external interception and access. Discuss plans for cybersecurity and compliance with data security standards with your EVSE vendor to ensure that they are adhering to accepted best practices for IoT cybersecurity.

Driver Communications

A crucial part of the user experience is the ease and predictability of charging. Some chargers are equipped with backend networks that allow drivers to see, in real time, the number, type, and location of plugs that are available. These chargers may additionally allow for communication with popular charger-listing apps and sites, or allow for chargers to be reserved, thereby guaranteeing access to charging. The convenience of knowing what to expect at a given site could increase its attractiveness (and, therefore, its usage). A site planner can consult with the EV network provider to determine whether this functionality is available.

Maintenance Requirements

Ongoing operations and maintenance have been challenging, especially as many of the charging stations that were originally installed with grants in 2011–2015 are reaching the ends of their useful lives. The EVSP market is growing very rapidly, and agencies have felt the effects of the associated market volatility. Company mergers, bankruptcies, and acquisitions can result in service disruptions and charger reliability issues, weakening customer confidence in public charging. For example, one local municipality had challenges with a vendor that became unresponsive and was no longer adhering to the contractual agreement for station operations and maintenance, and only saw improvement when staff began exploring a switch to a different provider. Agencies should be aware that these issues may arise and take measures to reduce the effects on their charging services.

Some vendors offer comprehensive service packages, although these can be cost-prohibitive. To balance the cost of these service packages, one approach is to keep a service agreement in place for stations with highest utilization, and repair stations with lower utilization through a separate on-call maintenance contract. Another approach could be to replace broken stations entirely instead of paying for the ongoing maintenance package through the vendor, although this strategy is cost-effective only when procuring lower-cost charging stations.

Agencies may also arrange follow-up contracts with a cost-effective repair service that can group together multiple repairs in a single service call, a strategy that works best if the agency has a high volume of chargers to maintain. It may be helpful to seek out installation technicians that have passed an EVSE-specific training program, such as the Electric Vehicle Infrastructure Training Program (EVITP). Maintenance technicians, meanwhile, require less formal training: a familiarity with the diversity of options in EV network software and a continuous commitment to refreshing and updating their knowledge of charging technology may suffice. Some EVSE manufacturers offer trainings for service technicians

There are several options for implementing maintenance standards on a widespread basis within the county. SANDAG could consider a similar regional maintenance procurement model to provide interested agencies an affordable maintenance option, or as a back-up option to bridge service disruptions caused by EVSP market volatility. Maintenance service agreements may be required on an individual site basis as a stipulation for receiving funding, ensuring that all stations have a contractually established maintenance schedule. Development of standardized contract terms that specify performance metrics on reliability and maintenance requirements may also help agencies achieve more consistent performance results from vendors.

4. Life Cycle Considerations

Asset Useful Life

When developing a procurement contract, agencies should consider the entire life cycle of the EV charging infrastructure and assets. Several factors influence the duration of an asset's useful life, such as:

- the ability to keep the hardware in good working condition;
- warranty and maintenance contract duration;
- evolving needs for charging speed;
- the need for additional functionality;
- tax credit limitations;
- regulatory requirements; and
- evolving site usage

From a hardware standpoint, EV chargers are relatively long-lasting equipment. Generally, the life expectancy of an EV charger that is kept in good working condition is around 10 years. Keeping a station in good working condition involves keeping any cords from lying on the ground where they may be subject to crush damage, periodically checking to ensure that station hardware is not corroded from exposure to coastal environments or otherwise degraded by environmental wear, and monitoring station fault codes and repairing equipment in the event of component failure. Pest control may also be necessary, as the shelter and warmth provided by the charging hardware components may attract rodents and insects, which can prove detrimental to operation if pests interfere with the cables and airflow required to cool charging equipment.

The asset's useful life may additionally be dependent on the duration of the service warranty. Agencies should consider how they would prefer to maintain the equipment after the initial service warranty ends. Options include keeping the chargers operational and extending the service agreement, keeping the stations operational and handling repairs through a separate maintenance contract, decommissioning the chargers and preparing them for another vendor, or removing them entirely.

Over the past decade (approximately 2010–2022), EV charging stations have evolved rapidly alongside vehicle technologies, expanding from primarily Level 1 and Level 2 charging to encompass stations capable of delivering upwards of 150 kW of power to a vehicle—roughly 10 times faster than the fastest Level 2 charger. This rapid evolution in speed, however, matters mostly to sites with short dwell times that cater to urgent needs for range replenishment (e.g., highway rest stops or gas stations). For stations located away from major highways in more community-central locations, power levels can remain lower; around 50 kW should be enough to serve dwell times as short as 30 minutes. Longer dwell times can correspond with a decline in power dispensed to keep costs lower.

Another consideration is the additional functionality offered by new versions of charging hardware. These functionalities may include management features like load management, charge optimization, and access control; convenience features, such as the "Plug and Charge" aspect of ISO 15118; and the ability to feed power from a vehicle to a local facility grid (vehicle–grid integration, or VGI). These features can typically be obtained and implemented at a higher upfront cost at the outset of charging station installation, avoiding the need for short-term upgrades.

Asset useful life may also be defined by tax credit depreciation. Chargers that were installed using LCFS credits may become less economically viable after the credits have depreciated. Similarly, regulations may apply, requiring that the equipment must provide at least a certain duration of functional life to satisfy grant conditions.

Site developers are encouraged to carefully consider the features they may need over the next 10 years of station operation, accounting for any current or future site characteristics (on-site generation, VGI, battery storage). When charger technologies are closely compatible with site usage and needs, EV chargers are more likely to remain relevant and well-utilized.

Contract Development, Transition, and Renewal

Agencies should prepare for contract expiration well in advance, beginning at the time of contract drafting.

An important consideration at the time of contract drafting is to decide whether the provider should leave the hardware in place at the end of the contract, remove it, prepare the site for another vendor, or leave the transition option open for decision at the end of the contract. Clear roles and responsibilities should be established for asset ownership, maintenance, meter fees, performance data collection and analysis. It may be advisable to form an internal committee in advance of the transition to make these decisions.

For any installation involving feeding power back to a grid (as with vehicle-to-grid technology) SDG&E should be consulted to ensure that site equipment is able to support vehicle power transfer.

As a matter of best-practice, and in the interest of ensuring that charger hardware remains relevant for as long as possible, all charging hardware should support Version 1.6 or higher of the OCPP, a communication standard that separates the hardware and software of the charger, allowing a site host to transition between network providers as necessary.[5] Note that not all networks and chargers support OCPP v1.6. Providers will have specific information on charger-network compatibility. Staff may seek multiple quotes from service providers and leave time to perform an open procurement, as necessary.

At the conclusion of the contract, agencies should assess site performance and revisit if they would like to continue service, expand, or decommission the site. In the past, some agencies have experienced challenges with charging equipment becoming defunct due to the expiration of an agreement with the service provider, or due to the service provider's failure to perform the terms of the maintenance contract.

[5] Per https://afdc.energy.gov/fuels/electricity_infrastructure_development.html; "Cost Considerations – Networking."

Agencies should assess the contract structure and determine if they would prefer to extend, renew, modify the contract terms, or select a new provider.

Staff should also verify if the current contract includes removal of old equipment as necessary, and determine whether to include those terms in an updated contract. The contract renewal process is an ideal time to look back at total utilization and revenues. High utilization may indicate a need for expanded charging infrastructure. Total revenues and the percentage going to networking or services fees should be reviewed with an eye towards improving the financial picture in renewed contracts. Finally, the renewal process should consider whether new technologies should be integrated into new contracts.

Future Functionality Assessment

As discussed earlier in this document, building out electrical capacity and considering how a site's usage may change over time will be important in determining how the technology aspects of a charging installation will continue to evolve. The electrical and communications infrastructure that provide power to the chargers have a lifespan of 20–30 years, if not longer. Many early-adopter sites are on their third generation of chargers, while the underlying infrastructure supplying power to the chargers has often remained unchanged.

Regarding charging hardware and "add on" technologies, there are several prongs that can be pursued for eventual addition to a charging station installation:

- Demand mitigation: These technologies, including automated load management, local generation, and local storage, aim to reduce the amount of power that the charging system requires from the grid at any given time.
- Vehicle-to-everything (V2X): These technologies, including VGI and vehicle-to-grid (V2G), rely on controlling the power flowing to and from the vehicle. In V1G (unidirectional power flow), control relies on the automated throttling of charging based on utility grid signals; in V2G (bidirectional power flow), control involves site demand mitigation using the vehicles' batteries as a source of energy.
- Local generation or storage: In certain scenarios, local generation and storage may make EV installations feasible at sites that are experiencing difficulty with electrical permitting, that are facing expensive infrastructure upgrades, or that encounter grid power limitations. These technologies will also improve site resilience, as they can function independently off the electrical grid, and can offer EV charging even in the event of power outages.

Each subcategory of technology is reviewed briefly below in **Table 8.**

Table 8. Breakdown of Near-Market and Market-Ready Technologies

Technology Name	Technology Function	Best Suited For...	Technology Drawbacks
Automated Load Management (ALM)	Reduces demand charges and maximizes ability of infrastructure to serve vehicles	Sites that require more chargers than their electrical infrastructure (can support on a traditional basis)	• More expensive, or transfers LCFS earnings • Slower charging
Vehicle–Grid Response (V1G)	Provides an additional revenue stream from managed charging that responds to grid conditions	Sites with long charge and dwell times	• Slower charging • More expensive hardware

Vehicle-to-Grid (V2G)	Uses the vehicle's battery as an ancillary power source to offset the site's existing load.	Sites with high amounts of battery storage (many small vehicles or a few large vehicles) and long periods of reliable downtime, with significant existing loads.	• More expensive hardware • Specialized equipment required
Local Generation	Uses local power generation to reduce EV load, and improves resilience considerations	Sites with high demand charges, sites subject to frequent power outages	• High cost • Additional infrastructure required
Local Storage	Stores power generation to reduce EV load on the grid, improves resilience considerations, and may increase ability of infrastructure to serve vehicles	Sites with high demand charges, sites subject to frequent power outages, sites that require faster charging than their electrical infrastructure can support	• High cost • Additional infrastructure and significant construction required

The San Diego region is expected to follow national trends as EVs continue to build market share and adoption throughout the country. Sites along corridors are increasingly moving toward increasing driver convenience by providing high-powered charging (installations exceeding 100 kW); the NEVI program takes that a step further by incentivizing 150 kW minimum charging systems along corridors. As supplying this level of power can trigger significant additional cost to site hosts, many are examining battery storage support to buffer charging demand and reduce their electricity bills.

As more EVs appear on local roads and require additional charging, an alternative to re-striping or reconfiguring a parking lot may be to deploy mobile charging—devices that are able to move to vehicles and dispense a charge. This addresses the issue of internal combustion vehicles blocking charging stations and allows for a more flexible approach to deploying charging at a given site. To date, mobile charging technologies have primarily been deployed in semi-private locations such as workplace parking garages but may have wider applications.

Providing adequate power capacity to a parking area remains the most important step that jurisdictions can take to prepare their facilities for future charging technologies. Wireless charging will require similar power levels as conventional charging. Micromobility devices, such as e-bikes and scooters, do not currently have standardized charging systems. The availability of some additional electrical capacity equivalent to a single Level 2 port can ease the potential installation of charging systems in the future.

5. Conclusion

This report provides foundation-level education about best practices associated with charging. That background allows the reader to develop a broader perspective when considering public agency goals surrounding planning, operating, and potentially decommissioning public assets at the end of life.

SDG&E guidance will help site and size installations, set expectations for the installation process, and help select an appropriate rate for charging installations. Contact them early and maintain an open line of communication throughout your project.

EVs and EV charging are nascent when compared to the century-old combustion vehicle market. While California is a national and world leader in EV adoption, success is defined as increasing the number of EVs on the road by a significant factor. Achieving that goal will take time and well-thought-out, flexible plans for expanding charging stations into ubiquitous and convenient public amenities.

Public agencies are encouraged to use each of their EV charging installations as an opportunity to learn and evolve their thinking. The next 5 – 10 years will likely see increased EV charging needs that will require an iterative approach. The electrical infrastructure supporting EV charging has a long life and can support multiple generations of charging stations. Sites that install more electrical capacity than immediately necessary will be well-positioned to install additional charging stations quickly and inexpensively as EV adoption increases. Under ideal circumstances, charging stations will be maintained and expanded to provide benefits to many people representing differing needs for charging within the community. The hope is that EV charging becomes commonplace wherever people drive.

Strategies to accomplish to support the widespread deployment, sustainable operations, and eventual renewal of EV charging include:

- Start planning early and parallel process wherever possible.
- Understand your site's use case and select appropriate technologies to match driver dwell times.
- Consider equity aspects when selecting locations for EV charger deployment.
- Review funding sources to determine potential avenues to buy down upfront cost, or to find ownership models with reduced cost to the agency.
- Develop a plan for covering ongoing costs, including maintenance, electricity, and communications fees.
- Educate drivers on charging policies and enforce rules.
- Monitor charger usage and plan for the next generation based on feedback and utilization.
- Establish clear roles and responsibilities for asset ownership, maintenance, and operation to the end of asset life.

These strategies can help public agencies ensure that the type and scale of charging are appropriate for each venue, and remain reliable and accessible for all users. Ideally, agencies will locate charging in places that allow for and encourage usage during all hours of the day, such as public buildings or parks near MUD residences. Most importantly, agencies should find an operating model or partner to ensure all charging equipment can be maintained through end-of-life and upgraded over time to continue to provide a reliable charging network that meets the needs of its users.

List of Acronyms

- San Diego Association of Governments (SANDAG)
- California Department of Transportation (Caltrans)
- Electric Vehicle (EV)
- American with Disabilities Act (ADA)
- Electric Vehicle Supply Equipment (EVSE)
- California Electric Vehicle Infrastructure Project (CALeVIP)
- California Building Code (CBC)
- Local Coastal Program (LCP)
- California Green Building Standards (CALGreen)
- San Diego Gas and Electric (SDG&E)
- Direct Current (DC)
- Open Charge Point Protocol (OCPP)
- Low Carbon Fuel Standard (LCFS)
- Power Your Drive 2.0 program (PYD2.0)
- National Electric Vehicle Infrastructure (NEVI)
- Low Carbon Fuel Standard (LCFS)
- Emergency Load Reduction Program (ELRP)
- Per-kilowatt-hour (kWh)
- Leveraged procurement agreements (LPAs)
- Nationally Recognized Testing Laboratory (NRTL)
- Open automated demand response (Open ADR)
- San Diego Metropolitan Transit System (MTS)
- The University of California, San Diego (UCSD)
- Power Your Drive (PYD)
- Internet-of-things (IoT)
- WiFi Protected Access (WPA2)
- Vehicle-to-everything (V2X)