5. EV CHARGING AT FLEET FACILITIES

Government, utility, and private fleets are currently the largest market for EVs. Federal and California clean air regulations specifically target fleets in their attempts to increase the number of clean air vehicles. PG&E has been a leader in introducing both EVs and natural gas vehicles into their fleet and can provide considerable assistance to other organizations attempting to meet clean air mandates.

The process of establishing EV charging infrastructure in fleet facilities is more complicated than in residential settings but many of the underlying issues are the same. This chapter outlines issues that are specific to fleet applications.

A. Site Planning

Many siting issues influence the successful planning of a charging facility:

1. Number of EVs and Chargers

Planners must be realistic when determining the number of EVs a fleet will include, because that number will determine each facility's charging requirements. Estimates must include the number of fleet vehicles to be added over the next three to five years, with special attention to meeting upcoming state and federal AFV mandates. The facility operator should also consider planned flexibility that allows the site to grow with developing technologies or changes in charging requirements. Planners should seriously consider installing extra circuits and additional electrical capacity during initial construction, when costs are minimal.

Fleet managers should analyze what the fleet's charging schedule will be by developing a charging curve for each vehicle in the fleet (see next page). The curve matches the time of day a vehicle is recharged with the amount of energy used. After developing a curve for each vehicle, they can be aggregated to get a facility-wide fueling curve. This calculation will determine the frequency of charging and the energy required to service the entire facility. It will also facilitate equipment scheduling by helping determine the amount of time needed to recharge each vehicle. Based on the information taken from the charging curve, a facility manager can plan: charging needs (number of chargers), facility energy needs, and the necessary mix of Level 2 and Level 3 charging. The vehicle manufacturer and EVSE supplier can provide fleet managers with sample charging time and electricity consumption figures in order to develop a charging curve.

Several factors must be considered when deciding between Level 2 or Level 3 charging. Because of the length of time necessary to complete Level 2 charging, a facility will most likely need one charger per vehicle, as charging will take place overnight. This scenario may require additional land, island construction, cabling, and transformers—and will require the installation of appropriate EVSE. These factors can increase capital costs significantly. Installing Level 3 charging will raise costs for cabling, transformers, and chargers, but possibly lower land and construction costs.

How a fleet uses its vehicles will determine the appropriate charging method. Vehicles requiring expanded range may require a fast mid-day charge, requiring rapid Level 3 charging. However, Level 3 charging will raise equipment and electricity costs. In addition, some EV manufacturers will void the vehicle's warranty if the owner uses Level 3 charging. Each facility manager must carefully assess their fleet use and weigh the cost differences before deciding on using one charging level or a combination of both.

As mentioned earlier in this section, the following table shows a sample aggregated charging curve for a fleet facility.

Time	Number of vehicles	Type of vehicle	Electricity dispensed (kWh)	Charge level	Total charge time per vehicle*
1:00					
2:00					
3:00					
4:00					
5:00					
6:00	2	Shuttle buses	200	3	1 hr. each
7:00					
8:00					
9:00					
10:00					
11:00					
12:00	2	Pass. cars	50	3	15 min. each
13:00					
14:00					
15:00					
16:00					
17:00					
18:00					
19:00					
20:00	4	Pickups	100	2	4.2 hrs. each
21:00					
22:00					
23:00	2	Pass. cars	50		4.2 hrs each
24:00					
Total			400 kWh		27.7 hrs.

** Charge time is determined by vehicle charging algorithm.*

2. Convenience

Locate the charging station so that it accommodates other activities within the fleet facility. It is advisable to locate the station in a low-traffic area of the facility, because EVs may be required to remain parked for several hours at a time and therefore could block the movement of other fleet vehicles.

3. Cable Management

Cords and cables associated with charging equipment should not cross sidewalks or pedestrian traffic patterns.

4. Ventilation Needs

As discussed in Chapter 2, most of today's advanced batteries do not require ventilation during charging. However, some earlier battery types do produce and emit gases during charging as a result of electrolysis. Due to the concerns related to these older battery types, the facility manager should ensure that adequate ventilation is in place when older battery types that do emit gases are included in their fleet.

The cost of ventilation equipment, including fans, ducts, and air handlers, ranges from $400 for a 320 cfm centrifugal roof exhauster to $2,550 for a 1000 cfm industrial exhauster. Equipment should be based on the specific enclosure and the number of chargers installed.

5. Battery Operating and Charging Temperature Limits

Some EV batteries have operating and charging temperature limits, so under some circumstances (such as cold climate conditions) it may be necessary to site the EVSE in an enclosed area.

6. Standing Water and Irrigation

Even though all EVSE have been designed for safe operation in wet areas, user comfort will be increased by not placing equipment in locations where water pools or within the spraying area of irrigation systems.

7. Curbs, Wheel Stops, and Setbacks

To avoid vehicles from inadvertently driving into the EVSE, provide curbs, wheel stops, and setbacks. Consider user access and mobility issues when installing this equipment (see section 10 in this chapter – Disabled Access).

8. Vandalism

Planners should site EVSE to avoid the risks of vandalism or tampering. Consider including motion detectors, security lighting, tamper alarms, locked enclosures, and fences. The level of protection required will depend on the location of the EVSE, whether access is public or private, and the overall security requirements of the facility.

9. Signs

Fleet operators may want signage to designate EV-only parking spaces. These should be positioned high enough to be seen over parked vehicles.

10. Disabled Access

ADA Compliance: Connector and receptacle heights, special curb cutouts, and disabled parking access are some of the measures that may be necessary to make a charging station fully accessible for the disabled. Each operator must assess their compliance with the federal Americans with Disabilities Act, as well as state and company policies regarding disabled access.

The State of California's Division of the State Architect has issued "Interim Disabled Access Guidelines for Electric Vehicle Charging Stations" (Policy #97-03). EV charging stations are required to be accessible because they offer a service to the general public. When EV charging is coupled with regular parking, the EV charging is considered the primary service. The following table should be used in determining the required number of accessible chargers:

Number of Chargers Provided at a Site	Number of Accessible Charger Spaces Required
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4

A 9-foot wide space by 18-foot deep space is required. An access aisle of 5 feet on the passenger side is also required. One in every eight accessible chargers, but not less than one, should be van accessible with an 8-foot access aisle. Accessible charging spaces are not reserved exclusively for people with disabilities. It is also recommended that accessible spaces be located in close proximity to the facility they serve. For new construction, an accessible path from the charger to the other services provided at the site is required.

B. Checklist for Fleet Facility EVSE Siting

Facility planners should answer the following facility planning questions before proceeding further:

- What level of charging will be used?
- What are the charger requirements?
- Is the existing electricity supply adequate for fleet needs?
- What is the location of the electrical service relative to the charging equipment siting?
- What will be the impact of electricity rates on choosing alternative approaches to fleet EV charging?
- What are the cost trade-offs between charging levels and equipment locations?
- Have I addressed all of the relevant federal, state, and local code requirements?

C. Engineering and Construction

Many pieces of equipment are unique to EV charging facilities, and fleet managers should be careful to select contractors familiar with their specifications. In addition to the standard civil engineering work required to construct any fueling facility, EV facilities will require considerably more electrical service and electrical equipment installation.

A primary consideration for the site designer and the facility manager is the condition and location of the existing electric utility equipment. These factors will govern the number and size of transformers, necessary trenching or overhead cabling, conduits, amount of cabling, and associated installation costs.

The key component in the interface between the existing electrical system and the EVSE is the transformer. To provide adequate power for Level 2 charging equipment, existing electrical service must be stepped down to a level that can work with Level 2 charging equipment: 208–240 volts. If not already available at the site, it will be necessary to install an isolation transformer capable of stepping electricity to 208–240 volts for Level 2 charging, or up to 480 volts for Level 3 charging. Isolation transformers can cost between $7,200 to $8,500.

D. Charging Equipment

As discussed in Chapter 2, charging equipment decisions depend on the EV charging designation: inductive or conductive, Level 2 or Level 3. Until the market determines which charging technology dominates, it is likely that both inductive and conductive charging will develop in parallel. Until a charger and connector standard evolves, some fleets may select a mix of inductive and conductive chargers, depending on what their fleet EVs require.

Presently, there are several different manufacturers supplying different types of connectors for conductive charging equipment. Facility managers should ascertain that the connector is compatible with the receptacle on the vehicle. Vehicle manufacturers can supply the proper connector specifications for their vehicles.

E. Fleet Recharge Management Systems

Another component of a charging facility will be its Fleet Recharge Management System (FRMS). An FRMS is an integrated, computerized charging system that is designed to eliminate the costly process of managing electric vehicle charging for fleet applications by automatically sequencing multiple chargers. These systems are designed to accomplish the following goals:

- Automate recharging of fleet vehicles, thereby reducing the need for human intervention in the process
- Eliminate redundant charging infrastructure at charging locations where more than one vehicle will be charged
- Reduce overall fleet management labor costs
- Reduce electric charging costs through load management
- Reduce electric utility infrastructure needs, thereby lowering the cost to serve the load
- Allow fleet operators to choose all charging parameters

The key to an FRMS is its ability to manage charger sequencing. This functionality will determine the ultimate value of any system that is developed. It is likely that any successful system will be computer-controlled and be able to communicate with the local utility to take advantage of time-of-use rates or real-time pricing. By managing the electrical load in this manner, the FRMS will use electricity economically and will optimize fleet energy use.

One FRMS is currently under development by Southern California Edison and has been demonstrated using existing hardware. The goal of this pilot is to study the feasibility of the system, determine its strengths and weaknesses, determine fleet operator needs, and transform those needs into algorithms that can be improved in the future. This knowledge will be used to develop hardware that can be easily mass-produced to lower overall system costs.

The key component of this FRMS is the charge controller that automates the charging process. Through a PC-compatible computer, the controller distributes enough charge to maintain low overall peak electricity costs, while keeping connected vehicles in a state of full charge. It acts by interfacing with individual charging meters to perform the following tasks:

- Report on the required charge of each vehicle
- Determine the initial charge level of each plugged-in vehicle
- Determine the energy flow through the system
- Receive synchronization commands from the local utility through a communications device
- Display historical and real-time information
- Provide diagnostics

Other utilities are investigating different load management devices. The Electric Vehicle Research Network has sponsored a study of charge management systems in conjunction with Norvik. This system is a charge sequencer for fast chargers and does not have some of the enhanced features mentioned above.

The full costs of FRMS have yet to be determined but could be minimized by the use of existing computers, meters, communication devices, and kiosks. It is estimated that costs for a complete FRMS will range from $4,000 to $10,000 depending on the number and level of chargers. For more information on the SCE system, please contact Sam Katagi at (626-302-9515).

F. Metering and Billing Systems

While metering/billing systems are most often associated with public refueling systems, fleets may also want to investigate their use. Along with the FRMS, these systems can be very helpful in matching electricity consumption to individual vehicles. A typical system could incorporate advanced billing capabilities to help generate detailed monthly statements, including tracking by vehicle identification number. This system would allow fleet managers to track EV use, charging times, and associated energy costs. Several system options are available to fleet operators and are designed to accommodate individual access and reporting policies, including direct utility billing or point-of-sale billing. Metering and billing system prices vary, depending on which features are included. Prices range from $800 for a debit card system to $2,700 for a cashless voucher system to $14,000 for a TECH-21 proprietary card system. Fleet managers should assess their needs in this area to choose the appropriate system. Because the current billing systems are most compatible with gasoline and diesel fuels, charging equipment manufacturers would have to modify their systems for EV use. Recently, EVSE manufacturers have begun to make their equipment compatible with existing metering and billing systems.

G. Electrical Service

Generally, one charger will be required for each EV for overnight recharge (Level 2). The typical electrical demand for original equipment manufacturer vehicles using 240V single-phase service is 7 kW while charging for buses and fast chargers (using 480V three-phase service) can have demand levels of 50 kW or more. Actual kW demand is determined by the individual charging algorithm required by the vehicle. PG&E can help the fleet manager determine electricity requirements and compare them to existing service. If the feeder line must be upgraded and new transformers added, the organization should add sufficient capacity to meet the site's EV charging needs for several years. If the fleet manager plans to install Level 3 fast chargers, the electrical service requirements should also meet this load. When evaluating electrical service, managers should examine the following issues:

- **Service Level.** Determine the location, capacity and types of service panels and on-site transformers.
- **Distances Between Equipment.** Determine the distance between service entrance, transformers, panels, subpanels, and parking locations.
- **Identification of Potential Hazards.** Ensure that EV charging spaces are not located near potentially hazardous sites such as gasoline fueling areas.

When determining electrical needs for recharging, the fleet manager should contact PG&E to determine if existing feeder lines and equipment can provide the service, or if they must be upgraded.

Other factors to be considered include the costs of running three-phase power to the site and stepping it down to single phase, or using high-voltage single phase and a step-down transformer to the appropriate voltage. Again, local utilities will be able to assist facility planners in determining what service changes or upgrades will be necessary.

H. Electric Rates

The additional electrical demand for each EV charging during peak-demand periods may move a customer into a higher rate category. Charging multiple EVs may also trigger a surcharge for the reactive component of energy consumed. Fleet managers should discuss the impact of EV charging on rates with a PG&E representative. During the planning process, it is also important to discuss potential loads so that PG&E can assess their impact on PG&E’s overall system. Fleet charging may have some effect on peak power demand, especially when Level 3 charging is used. The integration of an FRMS at the fleet site can manage and minimize demand by scheduling charging at off-peak times whenever possible.

I. Site Installation Plan

Many municipalities require EV fleets to develop and submit an installation plan for engineering review and approval. Fleet managers may want to hire an electrical contractor for this task. A site plan typically describes:

- Location of the main electrical panel, branch circuits, and conduits
- Location of hazardous materials
- Location of charging stations
- Lighting
- Traffic flow
- Ventilation (if necessary)
- Description and locations of signs
- Curbing, wheel stops, cutouts, setbacks, and bumper guards
- Parking spaces, striping, driveways, and walkways
- Landscaping

J. Building Permits

Building and electrical permits are required for EVSE installations (see Chapter 3). Some utilities will not energize new charging circuits until they have passed inspection and the city or county notifies the utility. The cost of the permit and installation varies by municipality and depends on the scale of the upgrade.

K. Costs

The cost of installing fleet charging facilities can vary dramatically depending on the following factors:

- The number of circuits and chargers installed
- Whether the facility is indoors or outdoors
- The need to upgrade electrical service to the charging facility
- Whether ventilation is or is not required
- Whether Level 3 fast charge equipment is used or not
- Availability of discounts, tax deductions, and rebates from air districts and others.

In general, the cost to its fleet customers of installing EVSE range from $500 per vehicle per site to more than $5,000 per vehicle per site. The average cost per vehicle is $2,000.

For reference only, the following table lists some sample costs for specific components. Actual costs will vary and all costs may not apply to all installations. The costs quoted are applicable for fleet, public access, and multifamily charging installations.

Sample EV Charging Installation Costs for Public, Fleet, or Multifamily Buildings (all estimates are for installed costs)

Item	Cost
Power Distribution Sub-Panel -200A, 120/240 VAC single phase; three wires with main circuit breaker; six 40A/2P branch circuit breakers	**$1,435 ***
Transformer 50 kVA, 480/277 VAC primary, 120/240 VAC; 3 wires secondary; dry type NEMA 1 enclosure If power comes directly from utility distribution system: transformer pad; NEMA 3R, 200A, 120/240 VAC; 3 wires combination meter/main service and panelboard; ground rod (PG&E can furnish and install the transformer.)	**$ 3,975 *** **$ 5,300**
Cables/Conduits a) 40A branch circuit - Above ground installation - Underground installation b) 200A feeder circuit - Above ground installation - Underground installation	 **$3.85/linear ft **** **$6.85/linear ft **** **$13.25/linear ft **** **$21.00/linear ft ****
Lighting 250 watt, metal halide, parking lot lighting a) Wall or ceiling mounting b) On 16 ft galvanized steel pole, concrete base	 **$640 each *** **$2,750 each ***
Concrete Island In-place concrete island 6 in thick reinforced	**$7.20/ft^2 ****
Concrete Steel Pipe (Transformer or EVSE protection) Concrete fill steel pipe, 8 ft high, set 4 ft in ground, rounded top, painted	**$155 each ***
Concrete Bumper (EVSE protection) 4 ft long precast concrete bumper	**$88 each ***
Paving a) Demolition b) Asphalt paving composite	 **$1.95/ft^2 **** **$33.00/ft^2 ****
Signs 24 in x 24 in reflective signs; 2 in galvanized steel pole	**$200 each ***
Landscaping Soil preparation, irrigation system, sod (excludes trees and shrubs)	**$6.10/ft^2 ****

* Sample costs only. Actual cost may differ significantly depending on location, site requirements, installation, and equipment specification.

** Sample costs provided by Ocampo Esta Corporation. Actual cost may differ significantly.

L. Checklist for Vehicle Fleet Charging

1. Estimate 3–5 year EV purchase plans.

. Determine recharging locations.

3. Estimate the electrical load at those locations.
   - Determine whether to use Level 2 or 3 charging and type of charging to be used: inductive and/or conductive
   - Obtain charger requirements from vehicle and charger suppliers
   - Develop charging curves
   - Determine the appropriate number of chargers

4. Contact vehicle and charger suppliers.
   - Confirm charging needs and types
   - Identify any special ventilation requirements
   - Identify any other special considerations for the specific equipment

5. Contact PG&E.
   - Assess existing electricity supply
   - Determine necessary electrical service upgrades
   - Review metering requirements
   - Determine the impacts of rates on choosing alternative charging methods
   - Determine if any other special requirements exist

6. Develop a detailed facility site plan.
   - Develop and review wiring diagrams
   - Develop and review ventilation diagrams
   - Determine if there are hazardous material locations at site
   - Review traffic, pedestrian flow, parking requirements, and ADA compliance issues
   - Determine additional retrofit needs, including landscaping

7. Contact pertinent permitting agencies.
   - Identify special local fire, construction, environmental, or building requirements
   - Obtain all applications
   - Determine additional permitting costs
   - Determine site plan requirements

8. Hire the prime contractor and verify contractor subcontractor credentials.

9. Obtain all pertinent building and use permits.

10. Perform any necessary electrical upgrades, install EVSE, and complete all site preparations.

11. Have the site inspected by pertinent building, fire, environmental, and electrical authorities.

- Comply with any change order, if necessary
- Notify PG&E that site has passed all inspections

12. Begin charging operations.

The following flowchart illustrates the process of installing EVSE infrastructure at a fleet facility: