ReadySet charge Fleets

ADDENDUM
Preparing for Mass Deployment of EVs
# Ready, Set, Charge Fleets! Addendum
Preparation for Mass Deployment of EVs

1. Acknowledgements 2
2. Introduction 6
   2.1 Previous Publications and Reference Materials 6
   2.2 Electric Vehicle Trends and Benefits for Fleets 6
   2.3 Who Should Read This Paper? 8
   2.4 Consider before reading - Who Pays the Bills? 8
   2.5 Consider before reading- Electricity Rates and EV Expansion 8
3. Determining the Costs of Fueling Your EV Fleet 9
   3.1 Determining the Cost of Electricity 9
   3.2 Calculating Cost of Operation 14
4. Strategies for Minimizing EV Fleet Fuel Costs 16
5. Experience from Alco Park: A Case Study 19
   5.1 The Problem: Energy Cost & Demand Charges 20
   5.2 Steps Taken to Reduce Demand Charges 22
6. More Strategies to Mitigate Demand Charges 27
   6.1 Add Stationary Battery Storage 27
   6.2 Add Solar with Net Metering 27
7. Additional Tools & Considerations 28
   7.1 EV “Fuel” Tracking for Fleet Managers 28
   7.2 Programs and Incentives 28
   7.3 EV Charging Efficiency Considerations 30
   7.4 Employee Adoption - Increasing employee confidence in EVs 32
8. Preparing Infrastructure for Mass Deployment 32
   8.1 A Wave of New EVs 32
   8.2 Developments in EV Chargers 33
   8.3 Scaling your electrical infrastructure 34
   8.4 Opportunities in New Facilities - EV Readiness 34
9. Appendix 37
1. Acknowledgements

Project Partners

*Ready, Set, Charge, Fleets!* Preparing for Mass Deployment of EVs is a collaborative project of the following organizations. It was made possible by funding from the California Energy Commission under the Electric Program Investment Charge.

**Prospect Silicon Valley**

ProspectSV is a non-profit cleantech innovation hub focused on solutions for sustainable, smarter communities. We bring government, corporations and academia together with start-ups, product teams and expert staff to accelerate commercial adoption of innovations in transportation, energy and the built environment. ProspectSV provides a full spectrum of support services including market and technical insight, connections to partners and investors, pilot opportunities as well as access to a $12 million, 23,000 sq. ft. Technology Demonstration Center with working and industrial space, lab facilities and specialized equipment. We have provided commercialization support to more than 25 startups that have raised over $153M in follow-on funding and created hundreds of jobs. In partnership with state and local governments, ProspectSV demonstrates and scales leading edge cleantech solutions. With projects in over 50 cities, leveraging over $80 million in funding and financing, and with industry leading corporate sponsors, ProspectSV is the only organization with the ability to both prove and apply solutions for next generation communities.

ProspectSV has worked extensively with fleets. This work includes facilitating the deployment of the two then largest EV fleets in the nation and the installation of 330 charge ports in the Bay Area. Currently, we are leading the first transit vehicle-grid integration project in the country. For more information visit www.prospectsv.org.

**Alameda County GSA**

Alameda County General Services Agency’s Motor Vehicle Division operates the County’s fleet, the main mechanism for business travel. The fleet includes shared pool vehicles that are available to employees and agency-specific vehicles that are utilized to provide social services, health inspections, and law enforcement. They continue to lead regional collaborative fleet management initiatives,
including serving as lead agency on the Local Government EV Fleet Demonstration Project.

Lawrence Berkeley National Lab

Lawrence Berkeley Lab’s Energy Technologies Area (ETA) performs analysis, research, and development leading to better energy technologies and reduction of adverse energy-related environmental impacts. ETA’s vision is to be a global innovation hub for science, technology, and policy solutions to the world’s most critical energy and environment challenges. The Energy Storage and Distributed Resources Division (ESDR) works on developing advanced batteries and fuel cells for transportation and stationary energy storage, grid-connected technologies for a cleaner, more reliable, resilient, and cost-effective future, and demand responsive and distributed energy technologies for a dynamic electric grid. The Grid Integration Group develops the technologies and tools that (1) facilitate dynamic interaction between grid operators and energy consumers; (2) support the grid integration of intermittent renewable sources; and (3) foster the participation of distributed energy resources.

Background on Authors

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Christian Hosler
Christian’s joined ProspectSV in October 2015 as a Climate Corps fellow and transitioned to a full-time staff member in June 2016. During his tenure notable
accomplishments have included coordinating ProspectSV’s annual symposiums and leading knowledge transfer activities on several CEC funded projects including two net zero buildings projects, an autonomous vehicles pilot, and this vehicle-to-grid integration project. Christian is also in charge of the daily operations for ProspectSV’s $12 million, 23,000 sq. ft. Technology Demonstration Center. Christian earned his bachelor’s degree in environmental studies from UC Santa Barbara. He is also a graduate of UCSB’s Technology Management Program, as well as a former intern for California State Senator Hannah-Beth Jackson.

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Edited by:
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DISCLAIMER

Prospect Silicon Valley and the Alameda County General Services Agency prepared this addendum to provide fleet managers with information about Plug-in Electric Vehicles and the related infrastructure required to support them in fleet deployments. These guidelines have been prepared at a time when PEV-related laws, regulations, and industry practices are undergoing rapid change. As a result, fleet managers must strive to continuously update their knowledge regarding industry, consumer, utility, and government expectations, as well as requirements for the deployment of PEVs and related infrastructure. These guidelines are intended to assist fleet managers to advance the adoption of PEVs in the fleets they manage. However, they do not represent a definitive legal framework for the adoption of PEVs nor the installation of charging infrastructure.

Neither the sponsoring organizations of the Ready, Set, Charge, Fleets! guide, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed within this document. Public and private fleets may or may not adopt similar methods of PEV and infrastructure planning, deployment, and operations. The views and opinions of authors expressed herein do not necessarily state or reflect those of the organizations that developed the document.

Funding Provided by......

Funding for this addendum was provided by the California Energy Commission through the Smart Charging of Plug-in Vehicles and Driver Engagement for Demand Management and Participation in Electricity Markets Project. CEC Agreement #EPC-14-057.

The objectives of the project are to demonstrate the following managed charging use electric cases:

1. Minimize operating costs for PEVs by leveraging time of use rates.

2. Minimize operating costs for PEVs and facilities by mitigating demand charges.

3. Generate new revenue and minimize grid impacts by responding to PG&E automated DR and wholesale market DR signals.
4. Generate new revenue and offer wholesale market ancillary services through the PG&E supply-side pilot program.

5. Coordinate PEV managed charging with existing systems, including integration with existing building energy systems, and provide grid support for distribution systems.

In addition, approaches will be developed to engage non-fleet PEV owners who charge their vehicles at Alameda County’s publicly available charging stations and manage their charging station loads to further reduce utility costs.

The lead organization on this project is Lawrence Berkeley National Laboratory, and project partners include Alameda County General Services Agency (GSA), ChargePoint, Kisensum, and Prospect Silicon Valley.

2. Introduction

2.1 Previous Publications and Reference Materials

The Ready, Set, Charge Fleets!: EV Fleet Deployment Strategies Guide was produced in May 2015 by the Bay Area Climate Collaborative, Metropolitan Transportation Commission, and Alameda County GSA to provide fleet managers with basic information about Plug-in Electric Vehicles and the related infrastructure required to support them in fleet deployment. It is highly recommended that fleet managers reading this guide first read the original guide. In addition, the Ready, Set Charge California: Linking EVs, Fast Chargers, and Storage to the California Grid Guidebook is recommended to fleet managers who are interested in incorporating a DC Fast Charger into their Electric Vehicle Supply Equipment (EVSE) or have the potential to implement battery storage on site.

2.2 Electric Vehicle Trends and Benefits for Fleets

A major trend in the vehicle fleet management area is the adoption of electric vehicles, or EVs for short. California has set a goal of putting 1.5 million electric vehicles on the roads in California by 2025, and public fleets are crucial to achieving that goal. EVs are divided into two categories: Battery electric vehicles (BEVs) and Plug-In Hybrid Electric Vehicles (PHEVs). BEVs run solely on electricity stored in an on-board battery, whereas PHEVs have both an electric motor and a gasoline engine. Both BEVs and PHEVs deliver significant benefits from lower fuel and operating costs and reduced emissions. For a more in depth discussion of EV categories and a detailed look at the benefits of electric vehicles for fleets, please take a look at Section 3: PEV Benefits and Section 3:
Developments in both technology and economics have led to significantly decreased battery costs over the past decade.

Due to these factors as well as shifting public sentiment about the contribution vehicle emissions make to climate change, electric vehicles are no longer a niche concept. Major automakers have been competitively pivoting toward near future business plans centered on EVs, with aggressive plans identified within the next half decade.

In 2017, GM announced plans for an “all-electric future”, including the launch of at least 20 new all-electric vehicles by 2023¹. Volkswagen said in November 2017 that it would spend $40 billion on electric cars, autonomous driving and new mobility services by the end of 2022. Ford is planning on investing up to $11 billion in electric vehicles by 2022 as well as having 40 hybrid and fully electric vehicles in its model lineup.² These developments toward an EV-centric future will be a boon for fleets looking to transition toward electrifying their vehicle stock, provided issues such as those presented in this guide can be addressed. One study shows that in all 50 US states it is cheaper to operate an EV than a traditional gas-powered vehicle, based on fuel costs³. In addition, maintenance costs for electric vehicles have been shown to be much cheaper than Internal

Combustion Engine (ICE) vehicles. This guide provides suggestions for fleet managers navigating this EV-centric future.

2.3 Who Should Read This Paper?
This guide is intended for fleet managers who are planning on expanding the number of electric vehicles in their fleets from a few to a few dozen. Using electrical energy is very different from using gasoline energy, and there are additional considerations that electric vehicle fleet operators should keep in mind.

2.4 Consider before reading - Who Pays the Bills?
As a fleet manager for a large organization, you may never see any of your facility's energy bills and in some cases, may not be directly responsible for bearing the energy costs. However, as you continue to fuel-switch from gas to electricity and your energy usage multiplies, this may not always be the case. If your organization has internal utility or energy managers, reach out to them with your plans for EV expansions. This guide will also help you understand the energy implications of growing to a substantial EV fleet and how to best manage your fuel.

2.5 Consider before reading - Electricity Rates and EV Expansion
This guide focuses on how to manage electrical costs once your electric vehicles and their infrastructure are deployed and in use. However, your facilities' rate structures should be used to inform numerous aspects of your deployment planning including evaluating the following:

1. Which facility may be most appropriate for initial EV deployments
2. Whether a facility can and should change its utility rate schedule to better manage overall facility electrical costs including the EV charging
3. Whether the EV charging can and should be on a separate meter

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4 More details on the price advantages of electric vehicles compared to traditional ICE gasoline vehicles can be found in section 7.1
3. Determining the Costs of Fueling Your EV Fleet

3.1 Determining the Cost of Electricity

Understanding Your Utility Bill

As a fleet manager, it is essential to understand the basics of commercial electric utility rates as you increase the number of electric vehicles in your fleet. Below are brief explanations of the important terms:

1. **Rate Schedule**: The tariff charged by the utility for electricity. In other words, it is the price of electricity. Utilities may have different rate schedules for different customers (residential vs. commercial), different rates based on the time of day (time of use rate, explained below) or time of year (seasonality, explained below) electricity is used, and many other factors. As one example, you can find the details on Pacific Gas & Electric’s (PG&E) electric rate schedules here: [https://www.pge.com/tariffs/index.page](https://www.pge.com/tariffs/index.page)

2. **Energy**: Energy bills charge (in part) on the amount of electricity used as measured by Kilowatt-hours (kWh). kWh is defined as a unit of work or energy equal to that done by 1 kilowatt acting for 1 hour. 1 kWh is equal to a thousand watt-hours. A kWh is also equivalent to approximately 1.34 horsepower. For example, on average, a typical EV in your fleet may consume 20 kWh per day.

3. **Power**: Energy bills may also have added fees for “demand charges” associated with maximum power used (discussed below). Power is measured in Kilowatts (kW) which is a measurement of energy release rate. 1 kW is equal to one thousand watts. For example, a building, say your fleet facility, may operate anywhere between 100-150 kW of power at any instant throughout the day, depending on how much equipment -- lighting, HVAC, EV charging etc. -- you are using at that time.

4. **Time of Use (TOU) Rates**: A utility rate plan that is billed based on what time of day electricity is used. A TOU rate might break a typical day into periods such as “on-peak, partial-peak, and off-peak” and encourages use of energy during non-peak periods to manage overall grid demand. For fleet managers, this means they can save a significant sum of money on their electricity bill by creating charging schedules for the EVs in their fleets that maximize charging at the time of day when rates are at the lowest price. Unlike gas or diesel, the price of which doesn’t vary throughout the day, fleet managers can take advantage of this variable pricing by getting the lowest cost fuel possible, during off-peak rates. Non-
peak electricity rates can be very substantially lower than the cost of gasoline.

5. **Seasonality**: Refers to the differing time of use rates for utility customers depending on the season of the year. Different rates are set because energy use is different depending on the season. As one example, you can find details on Pacific Gas and Electric time of use rates here: [https://www.pge.com/en_US/business/rate-plans/rate-plans/time-of-use/time-of-use.page](https://www.pge.com/en_US/business/rate-plans/rate-plans/time-of-use/time-of-use.page).

It is important to note that the payment structure for electricity costs varies across organizations and governments, and many fleet managers may not pay for these costs directly from their fleet budgets. Electricity costs may be split evenly amongst agencies and departments or paid from a general fund. In either case, your organization or government will see increased electrical costs from increased charging. Even if the fleet budget is not directly affected by increased electrical costs, these costs should be considered for the organization as a whole.

### Translating electric costs to fuel cost per mile

It is helpful to put the electrical costs seen on a utility bill in the context of vehicle cost per mile. Typical electric vehicles (LEAF, Bolt) get 4 miles/kwh. Taking the 11 cent “Partial Peak” Energy Charge detailed in the above utility bill we can do the following math:

\[
11 \text{ cents/kwh} \quad = \quad 2.75 \text{ cents/mi.}
\]

\[
4 \text{ mi./kwh}
\]

Note: This is a very simplified calculation, but it is important to keep this relationship in mind as you read through the rest of this guide. To calculate actual fuel cost for your EV fleet it is necessary to isolate the energy used by charging stations from that of the rest of the building, as well as to consider locational and TOU factors discussed below.

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**Historical Increase of Electricity Rates and Future Utility Rate Changes**

In most cases, electricity rates will change over time. For one example of this, please see the below table, which examines the increase in electricity rates
across all California users (commercial, residential, and industrial) from 1990-2014. The costs referenced throughout this report are all from 2017. All dollar amounts analyzed is nominal (not adjusted for inflation).

<table>
<thead>
<tr>
<th>Increase in electricity rates across all California users from 1990-2014.</th>
<th>Annual % Increase</th>
<th>Net % Increase</th>
<th>Net Increase ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Year Increase (1995-2014)</td>
<td>2.14%</td>
<td>52.88%</td>
<td>0.052</td>
</tr>
<tr>
<td>10 Year Increase (2005-2014)</td>
<td>2.98%</td>
<td>30.27%</td>
<td>0.035</td>
</tr>
<tr>
<td>5 Year Increase (2010-2014)</td>
<td>3.88%</td>
<td>16.45%</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Fleet managers should keep a watchful eye on changes to electric rates. Though in most years, changes to rates will not be significant (in 2018, energy rates for Alameda County’s AlCo Park facility will raise by an average of .63% from 2017 levels, while demand charges saw a .06% increase), in others, they may experience a more dramatic shift.

In addition to the steady historical increase of electricity costs, there are significant changes coming to the TOU periods throughout California. The CPUC directed the California utilities to examine current rate structures. These changes are being driven by the significant penetration of renewable energy such wind and solar power into California’s energy system, which creates a significant gap between electrical supply and demand in the late-afternoon and early evening, as solar resources stop producing and electrical demand increases as people return home. In Southern California, SoCal Edison has already begun instituting TOU pricing in the residential market with a peak period of 4pm-9pm, in order to address this new period of strain on the grid. This mirrors changes to the commercial peak periods from 12pm-6pm to 4pm-9pm, which are also on the horizon.

Fleet managers should monitor these changes, possibly working with energy managers in their organizations for assistance. SoCal Edison has already begun

to shift their peak periods and PG&E is expected to have new TOU periods introduced by November 2020.

Many of the strategies in this guide revolve around taking advantage of part or off-peak TOU periods for charging, so it is clearly important to monitor what these changes mean for a specific facility and adjust any charging strategies accordingly.

**Peak Power and Demand Charges**

Utilities maintain the distribution grid to deliver power to customers. The distribution grid must be built to accommodate the maximum amount of power that may be required to be delivered at any given point in time. A demand charge is a billing mechanism used by some utilities, including PG&E, to recover the cost of providing that distribution capacity. This charge is in addition to the usage rate and is applied to customers whose consumption reaches a predetermined maximum threshold, as defined by a facility’s rate tariff. Typically, energy use is monitored during the monthly billing period and the demand charge is based on the highest use during any 15-minute period. Demand charge rates may vary based on time-of-use as well as the season (seasonality).

Some utilities, like Pacific Gas & Electric (PG&E), charge three separate demand charges for the highest power demand during different parts of the day (a similar structure, though distinct, from the time of use rates). The "Max Peak" demand charge is a levy based on the highest power demand during peak hours. The "Max Part Peak" is based on the highest power demand during part peak hours. The "Max Demand" demand charge is based on the facility’s overall highest power demand during the billing period.

An analogy to traditional vehicles would be if a fuel provider were to charge for fuel and then charge an additional large fee for turning on the fuel dispenser at a faster rate or at the wrong time, or both.
An example of demand charges on a utility bill. An important distinction to make is that TOU rates are measured in kWh (energy), whereas demand charges are kW (power).

It is crucial to note that a single spike in demand can cause a demand charge to be incurred.

As a result of these factors, demand charges can make up a significant portion - even a majority - of a commercial facility’s electricity bill. In the summer of 2016, for example, demand charges made up 52% of Alameda County’s main parking facility’s (known as AlcoPark) energy bill.

**Demand Charges and EV Fleet Charging**

Calculating a fleet’s contribution to demand charges can be tricky, as it depends on whether EVs are charging at the exact time that the rest of your facility had its highest power demand. If you can avoid charging during those times, then your fleet will not incur any additional demand charges, but if your cars are charging at the same time as your facility's highest power demand, then EV charging can exacerbate those demand charges.

If multiple cars are charging at once, then a facility’s demand charges can add up quickly. Fortunately, there are many things that fleet managers can do to reduce their demand charges. This document will describe some of the strategies that fleet managers can use.

**One general rule is that charging should be planned to avoid demand charges and take advantage of beneficial TOU rates.**
3.2 Calculating Cost of Operation

Before you can determine how to minimize energy costs incurred by your fleet, you must have an understanding of what current costs of operation are. For facilities that have a simple volumetric rate for electricity, calculating cost of operation can be as simple, or simpler, than with gas-powered cars. For fleets charging at multiple sites, it may be more complex. Alameda County has multiple sites with charging stations, which have different rate tariffs. In addition, the price of electricity varies by time of day and by time of year.

Figure: As Alameda County increased the number of EVs in their fleet, costly demand charges rose as well.
Managing Energy Prices: Example

The following table shows how average energy prices vary by location even within the same county (Alameda), and how the cost of operating a 2015 Nissan Leaf can depend on where it is charged. These calculations are based on an average Nissan Leaf in Alameda County’s fleet with an annual consumption of 1,507 kWh and an annual distance traveled of 5,659 miles, as well as the TOU energy price and an estimate of the cost of demand charges incurred during charging at a 6.6 kW level (also assumes that the vehicle charging contributes to the monthly demand peak).

<table>
<thead>
<tr>
<th>Facility</th>
<th>Location</th>
<th>Rate Tariff</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>AlcoPark</td>
<td>Oakland</td>
<td>PG&amp;E E19</td>
<td>$275.29</td>
</tr>
<tr>
<td>Amador Garage</td>
<td>Hayward</td>
<td>PG&amp;E A1</td>
<td>$343.20</td>
</tr>
<tr>
<td>Elmhurst</td>
<td>Hayward</td>
<td>PG&amp;E A6</td>
<td>$295.33</td>
</tr>
<tr>
<td>Harbor Bay</td>
<td>Alameda</td>
<td>AMP A2</td>
<td>$242.15</td>
</tr>
</tbody>
</table>

This creates challenges when calculating cost operation.

The Importance of Telematics

The use of vehicle telematics is crucial in calculating operating costs of your EV Fleet. Alameda County GSA uses GPS devices designed specifically for EVs that track a vehicle’s data including its location, state of charge, and when it charges. To estimate the cost of operating its electric vehicle fleet, GSA used the location specific charging data provided by the GPS.

GSA multiplied the quantity of energy that was used in each location by the electricity rate at the time of day that the charging session occurred and location. To accurately assess cost, charging data has to have an attached location, because the cost of electricity varies based on location. Additionally, data from these charging sessions must be gathered from the car and not from the charger because GSA did not have access to data from non-County owned chargers that may be used. Without telematics, these calculations would not have been possible.

Telematics are also important in managing your energy fuel. With a telematic system fleet managers can track:
- Where and when EVs are charging and analyze if off-peak charging can be further maximized
- What the average battery levels are when vehicles are returning from the field to identify if EVs could be utilized in higher-mileage applications
● What the real-time battery levels are for EVs at a dispatch location

![Fleet Pool Dispatch](image)

**Figure:** The telematic software portal displaying real-time SOC of cars located in AlCo Park at the time.

Telematics are also useful for utilization metrics and analyses that allow fleet managers to track how employees are using EVs. For example, all of the analysis used to complete the employee adoption and usage pattern sections in this report used data from GPS installed in the car.

Investing in telematics in order to achieve an accurate assessment of your EV fleet’s operating cost will also yield many valuable co-benefits that help with EV fleet management.

## 4. Strategies for Minimizing EV Fleet Fuel Costs

### Overview

When a fleet is comprised of many electric vehicles, it becomes important to set up a fleet charging strategy so that the vehicles take advantage of the best electric rates, avoid demand charges, and are still fully charged when they are needed by drivers. This becomes more important if these vehicles are housed at a single, or a few, central fleet facilities, which is commonly the case. This section describes easy strategies for fleet managers to consider in order to achieve this goal.
Information Required to Determine EV Charging Strategy
In order to define a fleet charging strategy, the following information will be required:

1. Electric utility rate schedule to determine electric power rates and demand charges. Your rate schedule can be identified on your facility’s utility bill.
2. Electric vehicle type(s) in the fleet to determine battery capacity and charging rate.
3. Quantity of each vehicle type in the fleet.
4. Estimate of the number of miles each car will be driven on a daily basis.
5. Number and type of charging stations available for charging the EV batteries.

Minimizing Demand Charges
As described previously, utility demand charges can be as much or more than the energy costs on the facility electric bill. However, additional demand charges can be minimized or even completely avoided by sequencing vehicle charging. Since demand charges are based on the maximum peak for any 15-minute interval during the billing period there are several scenarios to avoid strategies to use:

- Charge as few vehicles simultaneously as possible. By sequencing charging, demand peaks are avoided.
- Curtail charging when other power demands in the facility are high. In other words, schedule EV charging when other systems such as air conditioning are inactive.
- In order to do this, it is necessary to know the state of charge (SOC) for each vehicle in the fleet before charging starts. Subtracting the SOC from the total battery capacity of the vehicle will provide the amount of energy necessary to re-charge each battery to 100%.
  - Example: If a vehicle has a 60-kWh battery capacity and is at 50% SOC at the end of the day, the battery will need 30 kWh to fully recharge it. If the charging station provides 6 kW of power, charging will take about 5 hours. Assuming the vehicle will need to be ready for service at 8:00AM, it could start charging as late as 3:00AM. If there were four vehicles needing the same amount of power, charging could be sequenced as follows:

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6 This word is really important. If your rate schedule includes demand charges, they will never be completely avoided. Only ADDITIONAL ones will be.
**Simple Example** (each green cell = 6kWh charge)

<table>
<thead>
<tr>
<th></th>
<th>PM</th>
<th>AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>6 7 8 9 10 11 12</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Car 1</td>
<td>6 6 6 6 6</td>
<td></td>
</tr>
<tr>
<td>Car 2</td>
<td></td>
<td>6 6 6 6 6</td>
</tr>
<tr>
<td>Car 3</td>
<td></td>
<td>6 6 6 6 6</td>
</tr>
<tr>
<td>Car 4</td>
<td></td>
<td>6 6 6 6 6</td>
</tr>
<tr>
<td>Total</td>
<td>6 6 6 12 12 12</td>
<td>12 12 6 6 6</td>
</tr>
</tbody>
</table>

In this example, 4 cars receive 30 kWh of energy each and the demand is 6kW (6PM-9PM), 12kW (9PM-4AM), and 6kW (4AM-7AM). Compare this to charging all 4 cars simultaneously with a peak of 24kW for 5 hours.

This charging schedule can be easily modified to account for when electric rates are the lowest, peak demand charges are lowest, and when base peak loads are lowest.

**A more complex example:**

“P” represents peak hours, and “O” represents off hours.

<table>
<thead>
<tr>
<th></th>
<th>PM</th>
<th>AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>6 7 8 9 10 11 12</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Demand Rates</td>
<td>P P O O O O O O O O O O O O P P</td>
<td>P P</td>
</tr>
<tr>
<td>Base Load (kW)</td>
<td>20 15 10 5 5 5 5 5 5 5 10 15 20</td>
<td>20 15 10 5 5 5 5 5 5 5 10 15 20</td>
</tr>
<tr>
<td>Car 1</td>
<td></td>
<td>6 6 6 6 6</td>
</tr>
<tr>
<td>Car 2</td>
<td></td>
<td>6 6 6 6 6</td>
</tr>
<tr>
<td>Car 3</td>
<td></td>
<td>6 6 6 6 6</td>
</tr>
<tr>
<td>Car 4</td>
<td></td>
<td>3 6 6 6 6 6 3</td>
</tr>
<tr>
<td>Total</td>
<td>20 15 10 11 17 22</td>
<td>23 26 23 17 11 10 15 22</td>
</tr>
</tbody>
</table>
In this example the prime car charging times are from 10PM to 5AM, when energy rates are the lowest, peak demand charges are lowest, and base load is lowest. So, car charging in this example is scheduled to be mostly in those hours. Remember that both of these examples are simplified but the general concepts still apply:

1. Collect information for how much charge each car needs each night. This may be difficult to do without sophisticated technology, so the next best thing is to make a conservative estimate for each car based on historic daily mileage.

2. Determine the time periods for peak energy rates and peak demand charge rates. Remember that the time periods and charges vary by the season, so you may need a different strategy for each season.

3. Get a historic record of the base load for the electric meter to which the charging stations will be connected and establish the base peak load periods that should be avoided.

4. The basic goal is to smooth out the overall peaks and shift them to off-peak hours through sequencing of the charging sessions.

Implementing Charging Strategies

Many EVSE providers and software companies have developed, or are currently developing, technological solutions to assist with charger scheduling and energy cost management. When choosing an EVSE provider, fleet managers should consider what smart charging features are included in a given vendor’s chargers and software platform. These features may be sufficient. If necessary, such as if there is a need to manage public facing charging stations, more advanced tools are being developed and will soon be available from vendors, focusing specifically in this arena.

5. Experience from Alco Park: A Case Study

AlcoPark is a parking garage in Downtown Oakland that is owned and operated by the Alameda County GSA. The basement of AlcoPark is the main facility for GSA’s fleet of electric cars. AlcoPark has sixteen publicly accessible charging stations on the upper floors, twenty fleet-only charging stations in the basement and a DC Fast charger that is also publicly accessible.
5.1 The Problem: Energy Cost & Demand Charges

Demand charges at AlCoPark account for a significant percentage of the County’s utility bills from that location. During summer months, the PG&E demand charges at this facility are $18.74/kW for AlcoPark’s “Max Peak Demand” and $17.33/kW for the facility’s overall “Max Demand” (see Section 3: Peak Power & Demand Charges for an explanation of the different types of demand charges). This means that if the facility’s maximum power demand during a given billing cycle occurs during peak hours, then each kilowatt of power demand costs $36.07, the combination of the demand charge rate for both maximum peak demand and maximum overall demand. For context, AlCo Park’s DC Fast Charger dispenses 45 kW, and a regular level 2 charging station can dispense up to 7 kW. In a worst-case scenario, these stations would incur $1,623.15 and $252.49 in demand fees (in addition to fees from the building’s baseload) during a billing cycle, respectively.
During the summer months, demand charges constituted more than half of the energy bills at AlcoPark. This graph shows demand charges at AlcoPark between 2015 and 2016, as well those charges as a percentage of the facility’s overall energy bill. While overall energy amounts are relatively stable, the significantly higher demand fees show the impact of uncontrolled EV charging.

When this is translated to electric cost per mile, a similar trend arises. From November 2015 through November 2016, electric cost per mile across Alameda County’s EV fleet was 3.6 cents, excluding demand charges. When demand charges are considered, however, this cost jumps to 7.8 cents/mile. Isolate AlCoPark, the facility in question, from other County facilities, and demand charges increase the cost to 9.8 cents per mile. This weakens the economic argument for EVs and thus should be an area of focus for fleet managers.
5.2 Steps Taken to Reduce Demand Charges

**Decreasing Overall Building Load From Other Uses**
The first step to reducing energy cost and demand charges at a fleet facility is considering the overall building load and looking for energy efficiency measures to reduce this load. Strategies to reduce impact of EV charging on a facility’s utility bill may not be effective if there are other large electrical loads. For example, replacing the fluorescent lighting in AlCoPark with high-efficiency LED bulbs would save more than $13,000 per year from the facility’s energy bills, and reduce its peak demand by more than 6.5 kW. The process of implementing these measures is underway during the writing of this report. Large scale energy efficiency projects may be out of a fleet manager’s purview, but they are important to consider and worth advocating for.

**Scheduled Charging of Fleet Vehicles**
Lawrence Berkeley Lab, received a grant from the California Energy Commission to work with Alameda County, Kisensum and ChargePoint to explore “smart charging” strategies that shift the times that fleet vehicles charge to periods of lower power demand, avoid demand charges and take advantage of lower TOU rates.

The initial strategy that Alameda County and its project partners tried to decrease peak power demand at AlcoPark was by shifting the fleet charging operations to nighttime off-peak hours. However, the first iteration of this strategy caused many charging stations to turn on exactly at 9:30 p.m., causing a new spike in power demand. Thus, while these stations were taking advantage of lower energy charges, they were still increasing the risk of an increased demand charge.

In Phase 2 of this project, this problem was solved by simply staggering the hours when charging begins. Some stations turn on at 9:30 p.m., some turn on at 11:30 p.m., and the rest turn on at 1:30 a.m.
The following graph shows the load profile of the ChargePoint stations in AlcoPark before and after the implementation of smart charging, as well as in the middle of the implementation showing the artificial spike. The yellow line shows the load profile before scheduled charging was implemented. There was an afternoon spike in charging when several vehicles were plugged in to charge after arriving at AlcoPark. The red line shows the load profile during the first phase of scheduled charging, when the managers had set the charging stations to start charging at 9:30 p.m., to take advantage of off-peak energy. The green line shows the load profile after the improved scheduled charging system was implemented, greatly reducing the spikes in power demand.

Power shedding: Power Throttling & Smart Charging

Reconfiguring charger output

Another strategy to reduce demand charges is to decrease the power dispensed by the charging stations. At AlcoPark, this strategy was successful in decreasing GSA’s demand charges and improving customer satisfaction.

During the summer of 2016, GSA decided to decrease the power output on five of the publicly accessible charging stations at AlCo Park from roughly 7 kW to 1.65 kW, effectively converting them into level 1 charging stations. This enabled it to decrease overall power demand from EVSE in Alco Park by approximately 20 kW (see above diagram), saving around $685 per month in demand charges.
Figure: This graph shows the peak demand at AlCoPark before and after power shedding was implemented.

The assumption that allowed for this change is that many of the drivers utilizing the public chargers are employees parking for an 8-hour day, thus giving them enough time to receive a significant charge, just at a slower rate. For drivers who do not have this time, several Level 2 chargers remain accessible. Alameda County instituted a 4-hour time limit on these stations to ensure turnover and increase access for everyone who needs them.

It may seem counterintuitive to provide charging at a Level 1 rate via a charging station, as Level 1 charging is usually done with a simple outlet in a residential setting. While energy-reduced charging stations do represent underutilized assets and Alameda County is exploring ways to return them to full operating capacity, there are still two benefits to providing Level 1 charging via a Level 2 capable station, in addition to the cost savings on demand charges referenced earlier. These benefits are collecting session data from charging stations and retaining the ability to charge drivers for electricity, thus recovering the cost of energy. This is necessary because ChargePoint and other EVSE manufacturers do not sell Level 1 chargers, let alone ones that have data collection and fee collection capabilities for commercial (non-residential) use. If your facility is power-constrained, these are additional reasons to use any existing Level 2 charging stations as Level 1 charging stations, instead of simply providing outlets for drivers.
One of the “converted” level 2-to-1 charging stations at AlCo Park

Smart Charging
In addition to power throttling, Alameda County is working with its project partners to design and implement more advanced smart charging strategies. The project includes three advanced strategies:

- Delayed charging commencement on certain fleet stations (discussed under ‘Scheduled Charging of Fleet Vehicles’)
- DC Fast Charger communication protocol & override
- Adaptive Load Management for public facing stations

DC Fast Charger Override
Alameda County purchased a DC fast charger that became operational in August 2017. Along with the hardware, the project team implemented software that allows the DC fast charger to override active fleet chargers, reducing the chance of negative outcomes.
This charger operates at 50 kW and allows GSA to maximize utilization of its EV assets by recharging vehicles in 15-20 minutes for redeployment. However, given the power level of the DC fast charger, extra measures had to be implemented in order to prevent expensive demand charges. The DC fast charger is public facing so its usage is somewhat unpredictable. This meant a smart solution was necessary, separate from simple behavior change by fleet technicians.

To tackle these challenges, the project team implemented a cloud-based communication protocol whereby the DC fast charger will communicate with active chargers just before it turns on. Any active fleet chargers will turn off while the DC fast is used and turn back on when the charger returns to inactivity.

These delays do not affect other charging sessions significantly, but they create “space” for the DC Fast Charger to operate. The average charging session on a DC fast charger is only 12 minutes. Given the time available for EVs to charge (see Section 5, “Usage Patterns”), one or two 12-minute delays does not prevent EVs plugged into fleet chargers reaching a sufficient charge.

**Public Facing Level 2 Charging - Adaptive Load Management**

Implementing smart charging programs at public facing chargers is only relevant to fleet managers who have public facing chargers at their fleet facility, but it does require a few additional considerations. Delayed charging is not sufficient because of the chance a vehicle may not receive sufficient charge, or the amount of charge the owner expected, in the requisite time. Employees or members of the public charging their personal vehicles are paying for the electricity and thus cannot have their charge limited, with no regard to the amount of charge expected.

To avoid any change in the user experience, the project team piloted a solution called adaptive load management. For this solution to function, drivers must submit how much charge they need and how long they will be parked. This data is fed into algorithms that calculate the optimal charging schedule that keeps total demand as low as possible while ensuring that all drivers get the charge they need, by the time they are ready to leave. If plans change, drivers can update their submission and the schedule will change accordingly.

Electricity demand, energy, and cost savings that resulted from the smart charging methods described above and demonstrated at the AlCoPark Garage will be presented in the project’s final report, “Smart Charging of Electric Vehicles and Driver Engagement for Demand Management and Participation in Electricity Markets” that will be available from the California Energy Commission in the Fall of 2018.
6. More Strategies to Mitigate Demand Charges

6.1 Add Stationary Battery Storage
A stationary battery storage system is the best way you can actively ensure savings via demand charge management, instead of only mitigating against the risk of higher charges. Simply, a battery system, managed by its associated software, will charge at off-peak times and discharge during peak demand events, thereby “cutting off the top” of the demand peak and ensuring that peak demand stays below a certain level. This results in lower demand charges and savings.

Fleet managers should work with their organization’s energy managers or an outside consultant to carry out a viability analysis. This analysis should consider factors such as the health and current state of a facility’s electrical infrastructure, current demand assessment and future demand modeling assessing the viability of future charging scenarios, and a financial assessment of a possible battery storage system based upon predicted energy bill savings and the cost of a system, including installation.

Alameda County has also found working with a consultant to be quite useful when assessing project proposals from battery vendors. Increasing your understanding of how batteries will help a specific site will allow for a more critical assessment of which specific offering will ensure that a long-term investment in a battery system will be successful.

6.2 Add Solar with Net Metering
Integrating solar into a facility where you will be doing EV fleet charging can have substantial benefits. Solar systems are often a good fit at preexisting fleet locations, as they can be located onsite on rooftops or carport charging stations.\(^7\)

Incorporating solar and other renewables into your facility not only offers the benefit of reducing your facility’s need for electricity from the grid, it can also change the tariff you operate under from your utility, therefore changing your TOU pricing structure.

In PG&E territory, a solar development can prompt a voluntary tariff switch from your current tariff to the A-6 schedule. The A-6 schedule does not include demand charges, thus removing a significant cost center from your electrical bill. In the case of the aforementioned case study, AlCo Park, this tariff switch would result in over 30,000 $/year in savings.

\(^7\) See this useful case study for the US Dept. of Energy related to solar options for workplace EVSE
Alameda County takes advantage of this, as well as the many other benefits of solar, at the Elmhurst Park facility where it has a 308-kW solar array.

7. Additional Tools & Considerations

7.1 EV “Fuel” Tracking for Fleet Managers
As covered in Section 3, it is very important for fleet managers to know the cost of operating electric vehicles in their fleet, and to understand how they compare to ICE vehicles. To better understand this dynamic, fleet managers should be familiar with the Total Cost of Ownership of their vehicles. Total Cost of Ownership is defined as the overall cost for a particular vehicle, including acquiring and operating the vehicle over an estimated useful term, based upon mileage or age of vehicle. Alameda County GSA has developed a tool that allows fleet managers to calculate the total cost of ownership (TCO) of electric vehicles (EVs). By plugging in data from their fleet facility’s energy bill, they can learn how, through energy management, they can save significantly through the use of EVs, compared to a traditional ICE fleet. You can access the tool here: http://bitly.com/evfleets

7.2 Programs and Incentives
Many programs and incentives exist to aid fleet managers with the procurement and management of electric vehicles. Below are high level overviews of a few existing programs that fleet managers may consider doing additional research on and potentially participating in.

**EV Smart Fleets**
A project team of CALSTART, Atlas Public Policy, California Department of General Services, Georgetown Climate Center, NESCAUM and Ross Strategic have developed an aggregate purchasing model for EVs. By developing a new type of buying system that could lower costs and expand product availability for EVs, this project supports the U.S. DOE’s Clean Cities program and the work they do with nearly 100 local coalitions to decrease the use of petroleum in transportation. http://evsmartfleets.com/

**Fleets for the Future**
This national partnership of regional councils, Clean Cities coalitions, and industry experts is charged with coordinating five regional procurement initiatives, and one national scale procurement initiative, designed to consolidate bulk orders of alternative fuel vehicles and related infrastructure. http://www.fleetsforthefuture.org/

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8 EV Fleet Deployment Strategies Guide, pg.16
Accelerating Electrification through Municipal Demand Aggregation
Led by City of Los Angeles, this is the first step in a formal bidding process, inviting automakers to describe their plans for meeting a potentially record-breaking order of EVs. The cities of Los Angeles, Portland, Seattle and San Francisco could buy or lease up to 24,000 EVs for their fleets, if manufacturers are able to meet the demand and provide appropriate pricing. About 30 different manufacturers submitted information. For more information please see: https://electrek.co/2017/03/15/electric-vehicle-order-114000-vehicles-40-companies-competing/

Low Carbon Fuel Standard
The Low Carbon Fuel Standard (LCFS) is a program managed by the California Air Resources Board (CARB) to reduce greenhouse gas emissions from California’s transportation sector by incentivizing a switch toward cleaner automotive fuels. Since electric cars do not have tailpipe emissions, operators of electric fleets are eligible for LCFS credits. This enables fleet operators to earn money by selling credits for operating a clean fleet.

If a charging station is operated by a third party such as ChargePoint, it is necessary for fleet managers to ensure that this third party has not already received LCFS credits. After verifying this, then managers can submit an application for LCFS credits to the CARB. The application form can be downloaded at this website: https://ssl.arb.ca.gov/LCFSRT/Anonymous/Account%20Registration%20Form.pdf

After registration, the California Air Resources Board will give the agency access to the LCFS data portal where it can upload charging session data and receive credits. After receiving credits, operators of EV fleets can sell their LCFS credits to a corporation that is required to buy them. In order to sell credits, a fleet operator can either enter into a contract with a corporation that will buy them on a repeating basis, hire a brokerage firm to sell credits on the open market or sell credits themselves if the amount is large enough and there is a desire to avoid broker fees. If possible, it may be useful for a fleet manager to work with an in-house partner that has energy brokerage experience. The SFMTA, for example, partnered with the SFPUC to sell their LCFS credits and keep all of the revenue in the city family.

EV fleet operators can receive between 4 and 12 cents of credit for every kWh of electricity you use as fuel. As more entities join the program, CARB sees the market stabilizing and this range decreasing.
Other Revenues & Incentives

For a comprehensive listing of updated state and federal incentives, please refer to this interactive map created by PlugIn America.

7.3 EV Charging Efficiency Considerations

The energy lost due to various charging inefficiencies is another issue to consider as a fleet grows beyond a few EVs to tens and eventually hundreds of vehicles. This issue, which is initially negligible from a cost perspective, increases as fleets grow because more charging means more energy lost.

An analysis of charger power loss between ChargePoint chargers and vehicles stored at AlCo Park revealed that, in 2016, energy lost was between 8-10% of the energy used by those vehicles. Additionally, it should be noted that DC Fast Charging is far less efficient than Level 1 and Level 2 charging. The amount of energy lost during charging is not directly dependent on the amount of miles driven or energy used while driving, but rather this percentage is given to contextualize the scale of the loss.

As all energy costs do, the cost of charger loss depends on the energy tariff at the charging facility and on time of use. The same amount of charger loss in

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9 AlCo Park did not have a Fast Charger at this time, but it is important to note nonetheless.
kWh will have a different cost, depending on where and when that loss occurred. Assuming charging occurs relatively evenly throughout the year, and that smart charging and charge management successfully reduces some charging during peak hours each day, charger loss across the twenty vehicles cost about $200 in 2016. Expanding that out to the full EV fleet, costs rise to a total of around $700 per year.

A secondary consideration is the rate of charge and depth of charge for each charging session. Higher charging rates, especially DC Fast Charging are substantially less efficient than lower charging rates such as Level 2 charging. Also, EV manufacturers recommend minimizing the frequency of DC Fast Charging to ensure maximum battery life. Along the same lines, it is recommended to charge EVs to 80% of capacity rather than 100%. This is for two reasons: 1) the final 20% of charging is very slow due to battery chemistry limitations; 2) charging to 100%, like DC Fast Charging, has a deleterious effect on battery life.

Given the relatively low cost of charger loss, especially compared to demand charges and other aspects of a fleet’s budget, there is no immediate action necessary. However, as EV fleets grow, this issue is something to be aware of and to be included in budgeting when considering fleet-wide fuel costs. As EV adoption increases, this cost could rise to as much as $10,000 per year for Alameda County, assuming there is no improvement in charger technology that increases efficiency.
7.4 Employee Adoption - Increasing Employee Confidence in EVs

EVs cannot become the foundation of fleets and remain sound investments if employee adoption lags.

While the EV sector is seeing rapid growth in sales and adoption, the overall adoption numbers are still small\(^\text{10}\), and fleet managers cannot expect decisions that employees make in their personal driving habits to be significantly different from ones they make driving fleet vehicles. Employees need support and training to change their habits and become comfortable with EVs.

An effective strategy for employee education that increases adoption are ‘Ride & Drive Events’. These events give employees a chance to interact with an EV, ask questions and test drive in a controlled setting. ‘A Ride & Drive Event’ at the County’s garage in Hayward, CA increased the utilization of the two Ford Focus EVs located there significantly. In the months after the event, the County saw an average 11% increase in total number of rides and 33% increase in total distance of rides. This translated to a daily average increase of 9% and 25%, respectively.

Adding EVs to shared motorpools with other (non-EV) options are a way for employees to more easily transition and possibly experience driving an all-electric vehicle for the first time. These training strategies should accompany the roll-out of EVs at any new location.

8. Preparing Infrastructure for Mass Deployment

8.1 A Wave of New EVs

As technology progresses, and the cost of batteries decrease, OEMs will be able to offer EVs with farther range, allowing fleet managers to deploy EVs into more unpredictable and variable applications. As mentioned before, starting in motorpools or fixed-route applications are a more predictable way of beginning transition to EVs. As range continues to extend and recharge times decrease

to match that of traditional refueling, EVs can be added to more variable applications.

As of 2018, 4 EV models had a range of over 200 miles, a significant increase over the last few years.

To see a comprehensive and updated list of the latest Electric Vehicle models that have been released, please visit https://pluginamerica.org/vehicles/.

8.2 Developments in EV Chargers

Another important aspect to consider as we examine the future of electric vehicles in fleets is the technological advancement of electric vehicle chargers, known as electric vehicle supply equipment (EVSE). For baseline information on EVSE, including tools for picking what EVSE may be best for your facility and fleet, please refer to the EV Fleet Deployment Strategies Guide.

To recap, there are currently 3 levels of EV charging available to fleets in the US:

- Level 1, 120V AC, up to 1.9kW, 2 to 5 miles of range per 1 hour of charging
- Level 2, 208-240V AC, up to 19.2kW, 10 to 20 miles of range per 1 hour of charging
- DC Fast Charger, 200-500V DC, up to 50kW, 60 to 80 miles of range per 20 minutes of charging

Over the last 5 years, the number of publicly accessible EV charging stations has grown significantly, and Navigant Research expects the global market for EV supply equipment (EVSE) to grow from around 425,000 units in 2016 to 2.5 million in 2025. For fleets, this will likely drive down the cost of EVSE installations, as well as increase the likelihood of having agreeable policies from their utility and more consistent options for EVSE install contractors.

Newer fast chargers such as the 480V DC Tesla Supercharger will also become more widely available. With a charging rate of 120kW, these Superchargers are able to provide up to 170 miles of range on just 30 minutes of charging.

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11 As previously noted, DC Fast Charging is substantially less efficient than L1/L2. Also, repeated DC Fast Charging can be detrimental to EV battery life.
12 https://www.afdc.energy.gov/data/10332
13 https://www.navigantresearch.com/research/electric-vehicle-charging-services
Even more advanced DC Ultra-Fast chargers, such as ChargePoint’s Express Plus station, can offer charging rates of up to 350kW or higher. These chargers can theoretically provide up to 1,590 miles of range on a 1 hr. charge and are therefore not only suitable for light duty EVs but also for electric medium and heavy-duty vehicles (such as dump trucks and buses) as well.

The availability of public charging may be of value in high mileage fleet scenarios, allowing vehicles to extend their range in the field.

8.3 Scaling Your Electrical Infrastructure

At first glance, these significant advancements in range and charging speed may seem like a boon for fleet managers looking to increase the number of electric vehicles in their fleet. But it is important to note that these improvements bring along with them the same issues that any transition to an EV brings (risk of costly demand charges). The infrastructure selected should be defined based on the vehicle duty cycle requirements. Short duty cycles and long dwell times make slower charging rates feasible and allow demand charges to be more easily managed. Long duty cycles and short dwell times may necessitate not only higher capacity batteries but faster charge rates which create more exposure to significant demand charges. In short, a faster charge for a bigger battery may not always be the best option for your fleet.

8.4 Opportunities in New Facilities - EV Readiness

As detailed above, EV technology is developing rapidly. As EV fleets grow, range stretches and chargers increase in power, the only way for fleet managers and their organizations to cost effectively future-proof their facilities is by planning for future EV adoption and charging.

Additionally, it is significantly more expensive to install EV charging as a retrofit than it is to install it during new construction. Transitioning to mass deployment of EVs will require fleet managers to move beyond retrofitting older facilities and present them with the opportunity to add significant charging infrastructure in a new facility. This section provides suggestions on EV Readiness that should be implemented in new fleet facilities or during significant renovations.

EV Readiness is often discussed as having two levels, EV Ready parking spots/facilities and EV Capable parking spots/facilities. EV Ready refers to a parking facility and parking spots equipped with “make-ready” infrastructure to support the immediate and convenient installation of an EVSE, including electrical panels, conduit/raceways, overprotection devices, wires and pull boxes. EV Capable refers to a parking facility that has the electrical panel
capacity to provide EV charging but not necessarily the complete supporting infrastructure connecting the panels to the parking spots.

EV Ready spots and EV Capable spots/facilities provide different benefits. Each EV Ready spot requires a branch circuit and pull-box near the spot. A 40-Amp 208 or 240-volt branch circuit, for example, provides the ability to install a Level 2 charging station during or immediately after construction. Installing that circuit, however, is more expensive than simply leaving space in the electrical panels. EV Capable spots provide the panel capacity to install charging stations, while maintaining the flexibility to install EVSE that meets a fleet’s changing needs, such as installing one DC Fast charger in place of multiple Level 2 stations. The cost of that flexibility, however, is that the circuitry required to move from EV Capable to installing a charging station will be more expensive than if it was added during construction, as in the case of an EV Ready spot.

Establishing an internal policy to require EV Readiness during new construction or significant renovations will ensure that your organization can deploy EVs efficiently and cost-effectively. A sample summary EV Readiness policy is provided below.

Summary of EV Readiness Guidelines

• Require that all new buildings and any significant alterations, at locations with parking, be 100% EV capable and 10% EV Ready.
• Provide an outline to allow full Level 2 charging (6.6 kW) at 20% of parking spaces or to utilize power management systems to provide lower Level 2 charging (1.6-6.6 kW) at 100% of parking spaces.

For each EV-Ready spot provide: A 40-Amp 208 or 240-volt branch circuit, including raceway/conduit, electrical panel capacity, overprotection devices, wire, and pull boxes. Pull boxes should be located at or near the location of future charging stations. Conduit shall be a minimum 1-inch inside diameter. A clearance of at least 20in should be provided between the end of the parking spot and the wall/other barrier to allow space for charger installation.

For EV Capable Spots: Electrical panel capacity for additional 40-Amp 208 or 240-volts branch circuits multiplied by minimum of 20% of the number of parking spaces. This will ensure that Level 2 EVSE operating at full capacity on a 40-amp circuit can charge at a minimum of 20% of the total number of EV Spaces simultaneously, or that EVSE operating at 8-amps can charge at 100% of the spots simultaneously. Depending on the needs at a specific site, this excess panel capacity can be used to create a charging scenario with EVSE operating at or anywhere in between the two scenarios outlined above.
Power management systems are required to execute the 8-amps at 100% scenario. Give the requirements above, no power management system will be needed for capacity reasons until 20% of the parking spaces have installed EVSE. To ensure ease of future planning and installation, electrical and design plans shall indicate that the service capacity of the electrical system, including any on-site distribution transformer(s), meet the requirements detailed above.

Please note that this policy is far from exhaustive and is merely intended to demonstrate the outline of a potential policy. Many local governments (e.g. San Francisco, Sacramento) are adopting EV Readiness policies for their jurisdictions which will provide a more complete example for interested fleet managers.

Depending on vehicle duty cycle and dwell times, power management systems can be used to maintain “oversubscription ratios”, thereby allowing a building owner to save on electrical panel upgrades. An oversubscription ratio refers to the ratio of installed charging stations to rated panel capacity. Longer dwell times allow for a higher oversubscription ratio because charging can be spread out over a longer period of time. Shorter duty cycles may also allow for a higher ratio. This can be extremely useful when installing charging at existing locations, while EV Readiness policies will ensure that electrical infrastructure is not a constraint at new fleet facilities.
9. Appendix

- Plug-In America- Vehicles  [https://pluginamerica.org/vehicles/](https://pluginamerica.org/vehicles/).
- AlCo TCO Tool  [http://bitly.com/evfleets](http://bitly.com/evfleets)
- LCFS Credit Application [https://ssl.arb.ca.gov/LCFSRT/Anonymous/Account%20Registration%20Form.pdf](https://ssl.arb.ca.gov/LCFSRT/Anonymous/Account%20Registration%20Form.pdf)
- Fuel Economy data for each make and model of gas or electric car [www.fueleconomy.gov](http://www.fueleconomy.gov)
- Interactive map with state and local incentives for electric cars [https://pluginamerica.org/why-go-plug-in/state-federal-incentives/?location=ca](https://pluginamerica.org/why-go-plug-in/state-federal-incentives/?location=ca)
- Data on EV resale value [https://www.kbb.com/](https://www.kbb.com/)

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Preparation for Mass Deployment of EVs  March 2018 | 37