



Considerations for Department of Defense Implementation of Zero-Emission Vehicles and Charging Infrastructure

Cabell Hodge,¹ Jesse Bennett,¹ Julian Bentley,² and Leidy Boyce¹

1 National Renewable Energy Laboratory

2 Bentley Energy Consulting

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Strategic Partnership Project Report
NREL/TP-5400-81925
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Executive Summary

In December 2021, the President issued [Executive Order \(EO\) 14057](#) on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability. The EO requires the Department of Defense (DoD) to transition its non-tactical vehicles to a 100% zero-emission vehicle (ZEV) fleet, including 100% of light-duty acquisitions by 2027 and 100% of medium- and heavy-duty acquisitions by 2035. This document provides considerations to comply with these requirements and transition to a ZEV fleet efficiently and quickly. It covers planning for ZEVs and electric vehicle supply equipment (EVSE), suggested roles and responsibilities of key stakeholders in designing EVSE, and execution issues including acquisition, installation, and ongoing fleet management (Table ES-1).

Table ES-1. Non-Tactical Fleet Electrification Implementation Checklist

PHASE	GOALS	ACTIONS
PLAN	 Train Team	<input type="checkbox"/> Review EV knowledge and training materials
	 Identify ZEV and EVSE Opportunities	<input type="checkbox"/> Complete ZPAC tool to identify ZEV replacements and EVSE sites <input type="checkbox"/> Complete DOE EVSE Planning Form to inform collaboration, site design, and project management. FEMP Fleet's EVSE Tiger Team can offer support.
DESIGN	 Meet with Key Stakeholders and Design EVSE	<input type="checkbox"/> Engage with priority site staff, including energy manager, fleet manager, site leadership, and facility owner <input type="checkbox"/> Call local electric utility or utility privatization partner <input type="checkbox"/> Work with leadership to secure funding and leverage other projects (e.g., ESPCs) <input type="checkbox"/> Determine installer (in-house or contractor)
EXECUTION	 Acquire EVs and Install EVSE	<input type="checkbox"/> Acquire EVSE from GSA's EVSE BPA , GSA Advantage , work with a charging-as-a-service contractor, or consider an alternative approach <input type="checkbox"/> Lease or purchase ZEVs (see GSA AFV Guide) <input type="checkbox"/> Install EVSE and set up accounts <input type="checkbox"/> Support operators, vehicles, and EVSE as ZEVs begin operation

Planning begins with understanding the technology, the requirements, and the identification of ZEV targets. To support that education, the Department of Energy (DOE) Federal Energy Management Program (FEMP) developed a list of [ZEV knowledge and training materials](#) with short videos on technology basics and detailed webinars for designing EVSE installation.

The Council on Environmental Quality (CEQ) and the DoD Services have negotiated targets for ZEV acquisitions in 2022. Targets for coming years will be determined annually until 2027, when all light-duty non-tactical vehicle acquisitions are expected to be ZEVs. For 2022, CEQ proposed an accompanying goal to install twice as many EVSE charging ports as ZEV acquisitions to prepare for future electrification. Service branches used the [ZEV Planning and Charging \(ZPAC\) tool](#) to target ZEV replacements and identify priority sites for EVSE installation, and they will be able to use the tool again in coming years.

Designing EVSE should involve several team members at the headquarters level, regions, and DoD installations, primarily Service fleet managers, vehicle oversight personnel, facility management staff, and installation master planners or energy managers. Contracting officers will likely be needed in the execution phase of acquiring EVSE and EVs as well. Service fleet managers are typically responsible for managing ZEV acquisitions and providing critical information to identify priority sites for EVSE installation in sufficient quantities to meet 2022 targets and ultimately full fleet electrification. Vehicle oversight personnel typically determine how many and what type of EVSE they need. Facility management and contracting staff are typically responsible for determining site electrical upgrades, coordinating with utilities or utility privatization contractors, and getting the EVSE installed. Finally, installation master planners typically ascertain the overall impact to the base. Electric utilities and utility privatization contractors should be involved as well because the added load from EVSE can impact distribution systems on bases and upstream. Utilities often offer programs to support EVSE installation too, including funding and technical support. Coordination is critical because the model for EVSE installation is more distributed than gasoline stations to provide charging where the vehicles dwell overnight.

There are several options for procuring and financing EVSE. The most straightforward option would seem to be use of appropriated funds programmed for this specific purpose; however, since this is a relatively new requirement, appropriated funds may not be immediately available. Another option would be to seek use of existing program funding that could potentially be applied for this purpose, such as the Energy Resilience and Conservation Investment Program (ERCIP), or potentially funding from energy savings accumulated under 10 USC 2912 programs. Due to the longer planning timeline and Congressional approval process required, use of ERCIP funding may be more appropriate for larger electrical system upgrades that support the deployment of EVSE. EVSE installations requiring distribution system upgrades could be candidates to apply for ERCIP funding. Alternative financing options include fleet-as-a-service, utility areawide contracts, enhanced use leases, the DOE Assisting Federal Facilities with Energy Conservation Technologies (AFPECT) grant program, energy savings performance contracts (ESPCs), utility areawide contracts, and utility energy service contracts (UESCs). Selection of an installation method and installer must be considered while evaluation of funding options is conducted.

ZEVs and EVSE units can also be acquired through the General Services Administration (GSA) or fleet-as-a-service providers. GSA is negotiating a new blanket purchase agreement (BPA) with expanded options for EVSE units that account for federal cybersecurity requirements; GSA Advantage includes several EVSE that are not available through the current BPA; and GSA has issued a request for quotations for design-build EVSE installers. Another acquisition approach, referred to as fleet-as-a-service shifts the responsibility for the design, construction, operation,

and maintenance responsibility to a third-party. As of the writing of this document, fleet-as-a-service has not been implemented within DoD. If this approach is pursued, service providers should be evaluated to offer ongoing EVSE maintenance and guarantee a high percentage of uptime (>98%). Contractors, utilities, and site staff can typically install EVSE with proper training.

Driving ZEVs and planning for third-party vehicle maintenance are not that different from the experiences with gasoline vehicles, although there are a few key considerations for drivers/vehicle operators and fleet management and servicing staff. Real-world driving range in BEVs is more sensitive to ambient temperatures, for example, ranging from 120% of rated range at 70°F to 50% at -2°F. Vehicle operators should be aware of the need to remain informed about public charging options if the vehicles will be taken off installation, or for long-distance drives. Mobile smartphone applications, such as DOE's Alternative Fuels Data Center Station Locator, can provide operators information about public charging options and locations.¹ Refueling/charging speeds for ZEVs are slower than for gasoline vehicles, even when using DC fast chargers. ZEVs cost less to maintain than gasoline equivalents, but on-site vehicle maintenance requires additional technician training. EVSE must be maintained as well. Networked EVSE that require user authentication can be prone to high failure rates (17-32% downtime according to Avista Corp. 2019), but simple EVSE units are highly reliable.

This document outlines a process to ensure stakeholders are appropriately engaged throughout the fleet electrification process and encourages each step to be thoroughly planned and properly executed.

¹ <https://afdc.energy.gov/stations>

List of Acronyms

AC	alternating current
AFFECT	Assisting Federal Facilities with Energy Conservation Technologies
BEV	battery electric vehicle
BPA	blanket purchase agreement
CEQ	Council on Environmental Quality
DC	direct current
DCFC	direct current fast chargers
DoD	Department of Defense
DOE	Department of Energy
EISA	Energy Independence and Security Act
EO	Executive Order
EPAct	Energy Policy Act
ERCIP	Energy Resilience and Conservation Investment Program
ESPC	energy saving performance contract
EV	electric vehicle
EVAULT	Electric Vehicle Assistant Utility Lookup Tool
EVSE	electric vehicle supply equipment
FAC	Facility Analysis Category
FAST	Fixing America's Surface Transportation
FEMP	Federal Energy Management Program
FMR	Federal Management Regulation
FY	fiscal year
GHG	greenhouse gas emission
GSA	General Services Administration
GOV	government-owned vehicle
HD	heavy duty
LD	light duty
MD	medium duty
NEC	National Electrical Code
NREL	National Renewable Energy Laboratory
O&M	operation and maintenance
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
PHEV	plug-in hybrid electric vehicle
POM	project objective memorandum
POV	privately owned vehicle
RFID	radio-frequency identification
RFQ	request for quotations
SIN	standard item number
UFC	Unified Facility Criteria
UFGS	Unified Facility Guide Specifications
USC	United States Code
VAM	vehicle allocation methodology
XFC	extreme fast charger
ZEV	zero-emission vehicle
ZPAC	Zero Emission Vehicle Planning and Charging tool

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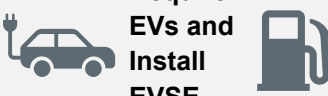
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Introduction

In December 2021, the President issued [Executive Order \(EO\) 14057](https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-Federal-sustainability/) on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability.² The EO requires the Department of Defense (DoD) to transition its non-tactical vehicles to a 100% zero-emission vehicle (ZEV) fleet, comprising 100% of light-duty acquisitions by 2027 and 100% of medium- and heavy-duty acquisitions by 2035. This document provides considerations for the DoD to comply with these requirements and efficiently and quickly transition to an all-ZEV fleet with sufficient electric vehicle supply equipment (EVSE). It was authored by the National Renewable Energy Laboratory (NREL) with support from the Office of Secretary of Defense (OSD) and DoD Service branch ZEV action officers and fleet managers. Table 1 outlines a high-level checklist with the implementation phases, goals, and suggested actions to electrify the DoD non-tactical vehicle fleet.

Table 1. Non-Tactical Fleet Electrification Implementation Checklist

PHASE	GOALS	ACTIONS
PLAN	 Train Team	<input type="checkbox"/> Review EV knowledge and training materials
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² <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-Federal-sustainability/>.

Suggested Roles and Responsibilities

The process of planning and installing EVSE relies on strong collaboration and partnerships with stakeholders, clearly distinguished roles and responsibilities, frequent and open communication, and methods for tracking deliverables and success throughout the project period. Early collaboration with the installation's electric and privatized utility is recommended to assess grid impacts and potential equipment upgrades, which are critical considerations when planning for EVSE. The facility and fleet managers are encouraged to work closely with electrical contractors with the proper expertise, information, tools, and training for installing EVSE to ensure a high-quality and efficient installation experience.

It is critical to determine who is responsible for the installation and maintenance of EVSE. Therefore, the following bullets and Table 2 provide considerations for the DoD on how to delineate roles and responsibilities. There are differences in naming conventions among the DoD Services; however, there should be personnel within each branch that fall under the five categories described below.

- **Service fleet managers and ZEV action officers** are best situated to determine how many ZEVs will be acquired, track acquisitions, and work with the agency energy team to determine which sites are priorities for the near-term installation of EVSE to support ZEVs because they can ascertain the entire scope of the fleet.
- **Vehicle oversight personnel (including installation or tenant fleet managers)** would typically then determine how many ZEVs, including both battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), should be acquired under their purview and in what parking areas. They should provide that information to the site facility manager and ensure that every ZEV has an EVSE connection plan.
- **Installation facility management and utility staff** (including electrical and civil engineers) are best able to plan the installation of EVSE and upgrades to the supporting electrical infrastructure as well as their ongoing maintenance. Plans should be informed by the installation or tenant fleet manager ZEV requirements. Facility management staff should coordinate with local utilities early in this process because many utilities offer support programs for EVSE.
- **Installation master planners (or energy managers)** should support facility managers with integrating EVSE into overall installation energy plans. This includes reviewing the location of the EVSE placement, considering how the EVSE will affect the installation energy plan, and revising the installation energy plan to account for EVSE. Master planners should also connect all installation tenants with the installation facility manager to ensure that tenants' needs are considered in the EVSE planning process.
- **Operators** should not have any responsibility for installing EVSE on bases. However, they will typically be responsible to charge the vehicles at installations or while in transit as directed by the local fleet managers or other vehicle oversight personnel. They can identify public charging stations using the desktop or mobile application version of the






Alternative Fueling Station Locator.³ DoD has not yet issued EVSE policy for home-to-work vehicles (defined as “Government passenger carrier to transport an employee between his/her home and place of work” in GSA Federal Management Regulation Part 102-5).

Table 2 offers suggested roles and responsibilities for key stakeholders during the fleet electrification process at a high level. However, there will likely be several other echelons of stakeholders involved in the fleet electrification effort. These would likely include personnel within the Office of the Secretary of Defense; program managers in charge of funding; policymakers within each of the Services; national and regional fleet, facility, and energy managers; base commanders; local utilities; and site engineers, electricians, and maintenance staff. All primary stakeholders would typically be responsible for determining whom they need to inform as part of their activities.

Additional team members could be involved in the fleet electrification process as well. Contracting officers would typically be involved in the execution phase of acquiring EVSE and EVs. Sections 4.5, 4.6, and 5.1 of this document contain considerations that are particularly relevant for contracting officers. Cybersecurity officers may be involved as well. Section 5.2 of this document addresses cybersecurity considerations.

³ <https://afdc.energy.gov/stations>

Table 2. Key Stakeholders and Suggested Roles and Responsibilities

SUGGESTED PRIMARY ROLES	STAKEHOLDER	SUGGESTED RESPONSIBILITIES
Program Development and Site Prioritization	<p>Service Fleet Manager / ZEV Action Officer</p> 	<ul style="list-style-type: none"> • Understand and convey ZEV goals and priorities. • Identify priority locations for EVSE installation. • Monitor and ensure fleet operations comply with Federal rules and regulations. • Train fleet managers on ZEVs and EVSE operations. • Develop a plan to maximize ZEVs and EVSE usage. • Develop policies to enable access to and use of electrical charging equipment. • Identify tenant command requirements for Installation Master Planner
Vehicle Selection and Determination of EVSE Needs	<p>Vehicle Oversight Personnel / Installation Fleet Manager</p> 	<ul style="list-style-type: none"> • Identify individual vehicles for replacement with ZEVs. • Determine the number and type of necessary EVSE and preferred locations for installation at facility. • Facilitate operator engagement and training. • Comply with data reporting requirements necessary for the Fixing America's Surface Transportation (FAST) Act • Develop EVSE operation and maintenance plans
EVSE Installation, Electrical Service Upgrades, and Maintenance	<p>Installation Facility / Utility Management Staff</p> 	<ul style="list-style-type: none"> • Design the installation of EVSE, including electrical upgrades. • Maintain EVSE, including the electrical infrastructure. • Identify the complete layout of existing parking spaces and proposed location of EVSE parking space(s) with respect to existing building and structures. • Assess if an existing electrical service will handle the extra load required to deploy the desired EVSE configuration in coordination with utility company or utility privatization contractor. • Meet reporting requirements including annual energy management report, installation energy plans. • Support mission assurance.
Master Planning	<p>Installation Master Planner / Energy Manager</p> 	<ul style="list-style-type: none"> • Connect installation tenants with the facility manager to ensure that all tenants are considered during EVSE design. • Integrate EVSE design with the installation energy plan.
Drive and Charge ZEVs	<p>Operator</p> 	<ul style="list-style-type: none"> • Charge the ZEV at EVSE as necessary. • Become familiar/competent with EVSE • Understand ZEV operational range • Understand ZEV charging need and schedule charging session accordingly. • Adhere to fleet requirements and standards. • Use Alternative Fueling Station Locator to find EVSE.

The icons in Table 2 are used in the margins throughout this guide to cue a focus for each suggested stakeholder. Because many of the concepts are important for all stakeholders, the icon in Figure 1 is used to indicate that all readers should take special consideration of a particular section, table, or figure.



Figure 1. Icon indicating suggested applicability to all readers



1 Planning for Electrification

The planning phase for fleet electrification should begin with education, followed by identification of ZEV opportunities, which in turn will lead to determination of priority sites for EVSE installation. Armed with an understanding of what ZEVs are, where they fit within the fleet, and what EVSE is required to support them, DoD Services can craft specific fleet electrification goals.

1.1 Education

There are dozens of resources available online to gain familiarity with the ZEVs and EVSE, ranging from primers on the differences between all-battery electric vehicles (or BEVs, where the drivetrain consists of typically one or more electric motors and a large battery) and plug-in hybrid electric vehicles (or PHEVs, where the vehicle has two drive trains that work in tandem—a conventional internal combustion engine with a fuel tank; and an electric motor with a smaller battery) to detailed cybersecurity considerations (Table 4).

Unlike conventional hybrid electric vehicles (or HEVs, where the vehicle has two drive trains, but where the electric drive train cannot be charged externally) such as the original Toyota Prius, PHEVs and BEVs can be charged externally from electrical sources through EVSE. PHEVs typically have relatively small batteries (~40 miles electric range) coupled with gasoline tanks, while BEVs have large batteries (~250–325 miles electric range) but no gasoline tanks (Figure 2). When driving long distances, PHEVs often refuel with gasoline when their batteries are depleted, while BEVs must refuel their batteries with electricity, typically at fast chargers. As explored in more detail in Section 6.1, real-world driving range is more sensitive to ambient temperatures, ranging from 120% of rated range at 70°F to 50% at -2°F.

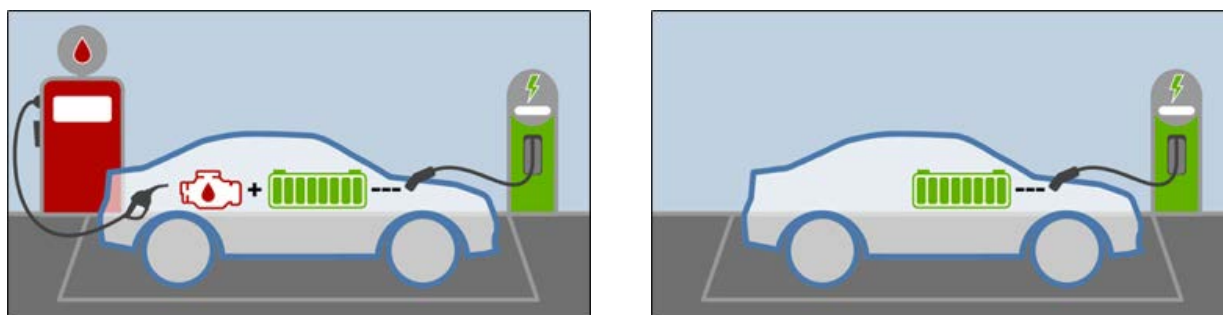


Figure 2. PHEVs (left) have relatively small batteries coupled with gasoline tanks, while BEVs (right) have large batteries but no gasoline tanks.

Illustration from Argonne National Laboratory⁴

⁴ <https://evolution.es.anl.gov/>

EVSE charging speeds are generally delineated by SAE International standard J1772 as alternating current (AC) Level 1, AC Level 2, direct current (DC) fast chargers (DCFC or DC Level 1), and extreme fast chargers (XFC or DC Level 2) (Table 3). AC Level 1 EVSE units are often portable charging cords that come with new EVs and can plug directly into 120-V wall outlets on dedicated circuits. AC Level 2 EVSE units are typically hardwired, standalone stations that charge about five times as quickly using 208 or 240 VAC single phase at 32 A. They are often installed in fleet parking lots and publicly available. DCFC and XFC can provide power much more quickly and are typically installed for public use. Figure 3 illustrates the amount of driving range charged per hour for a Chrysler Pacifica and a Ford Mach-E. The Pacifica PHEV can fully recharge its 32 mile range in about 9 hours with a Level 1 EVSE, and the base model 2022 Mach-E BEV 230 mile range in under 10 hours with a Level 2 EVSE.

Table 3. EVSE Types and Examples

EVSE Type	Typical Charging Power ^a (kW)	Chrysler Pacifica (PHEV)		Ford Mach-E (BEV)	
		Maximum Charging Rate (mi/hr)	Recharge Time (hours)	Maximum Rate (mile/hour)	Recharge Time (hours)
SAE AC Level 1	1.4	3	11	4	49
SAE AC Level 2	7.2	18	2	21	9
DCFC	50	N/A	N/A	147*	1.4*
XFC	150	N/A	N/A	441*	0.5*

^a DCFC and XFC example charging powers are maximum rates and not generally consistent throughout the charging cycle. Most DCFC and XFC ramp down power considerably at 80% state of charge to protect from battery overheating.

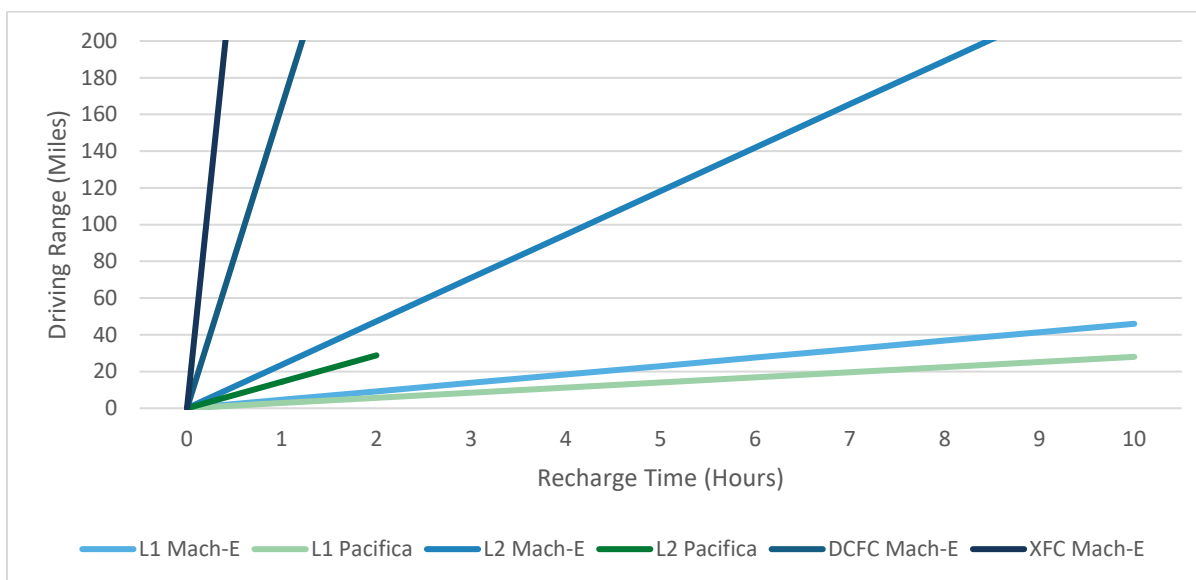


Figure 3. Driving range added per hour of peak charging time

While most EVSE units are connected to the local power distribution system, another option is to place portable charging stations on site which can stand alone without a grid connection. Instead of a grid connection, these portable EVSE units typically have a solar PV array, an energy storage system, and Level 2 charging ports. These portable chargers are typically a skid-mounted solution that can be moved, require no trenching or concrete work, and are not impacted by power distribution system outages (Figure 4).



Figure 4. Portable charging station solution with solar canopy and energy storage system

Image credit: Envision Solar International

The training materials listed in Table 4 can help DoD team members to develop the requisite technical knowledge to implement their roles and responsibilities, including EVSE installation planning, workplace charging program design, and vehicle cybersecurity awareness. The training materials are freely available at the links below, and team members can determine which subject areas and levels are appropriate for their involvement.

Table 4. Federal Fleet Training Materials

TRAINING	TYPE	DURATION	SUBJECT AREA AND LEVEL
<input type="checkbox"/> FEMP EV Technology Overview	Video	12 minutes	EV 101, EVSE 101
<input type="checkbox"/> FEMP EV Financial Considerations	Video	9 minutes	Financial 101
<input type="checkbox"/> FEMP Electric Vehicle Supply Equipment Infrastructure	Video	8 minutes	EVSE 101, Facility 101
<input type="checkbox"/> Charging GSA Fleet EVs Publicly	One Page	~5 minutes	EVSE 101
<input type="checkbox"/> GSA ZEV Fact Sheet and AFV Guide	Website	~30 minutes	EV 101
<input type="checkbox"/> EV Champion Training 1: Technology & Financials	CEU Webinar	91 minutes	EV 102, EVSE 102
<input type="checkbox"/> EV Champion Training 2: EVSE Power and Installation Requirements	CEU Webinar	68 minutes	EVSE 201, Facility 201
<input type="checkbox"/> EV Champion Training 3: EV Site Assessments	CEU Webinar	127 minutes	EVSE 202, Facility 202
<input type="checkbox"/> EV Champion Training 4: Advanced EV Solutions	CEU Webinar	121 minutes	Facility 301, Program 301
<input type="checkbox"/> EV Champion Worksheet 1: Technology & Financials	Worksheet	~30 minutes	EV 201, Financial 201
<input type="checkbox"/> EV Champion Worksheet 2: EVSE & Electric Utility	Worksheet	~30 minutes	EVSE 201, Facility 201
<input type="checkbox"/> EVSE Tiger Team Report: Army Site Assessments	Report	~45 minutes	EVSE 201, Facility 201
<input type="checkbox"/> Workplace Charging Program Guide	Report	~45 minutes	Program 201, Financial 201
<input type="checkbox"/> Workplace Charging Fee Calculator	Calculator	~10 minutes	Program 202, Financial 202
<input type="checkbox"/> Vehicle Cybersecurity Threats and Mitigation Techniques Report	Report	~45 minutes	EV 301, EVSE 301
<input type="checkbox"/> GSA Fleet Workshop: EVs and EVSE	Video	71 minutes	EV 101, EVSE 101
<input type="checkbox"/> Future GSA Fleet Workshop Trainings	Website	~60 minutes	Various
<input type="checkbox"/> Fed Fleet: Fleet Analysis for EV Suitability	Slide Deck	~30 minutes	EV 201
<input type="checkbox"/> Fed Fleet: EVs and EVSE	Slide Deck	~30 minutes	EV 201, EVSE 201
<input type="checkbox"/> ZPAC Training Series	Video	45 minutes	EV 202, EVSE 202



1.2 ZEV Acquisition Goals

ZEV goals for federal agencies were defined in EO 14057 (100% light-duty acquisitions in 2027 and 100% medium- and heavy-duty acquisitions in 2035) and a 2022 target-setting process was completed in December 2021 with the Council on Environmental Quality (CEQ). In the 2022 target-setting process, Army, Navy, Air Force, Marine Corps, and the other Defense Agencies came to agreements with CEQ on how many ZEVs they could feasibly acquire in 2022, provided sufficient funding was made available through Congressional appropriations, and where vehicles were produced by original equipment manufacturers. To prepare for future ZEV acquisitions, CEQ asked that each service install twice as many EVSE ports in 2022 as ZEV acquisitions with no more than 40% of those ports being Level 1 connectors. Every year until 2027, each of the services are expected to establish ZEV acquisition targets for the following year (EO 14057 Section 204).

To help visualize how the goals affect the DoD vehicle inventory, Figure 5 divides the targets among vehicle segments and stacks them into inventory goals through 2035. This figure is based on example targets and only includes domestic non-tactical vehicles.

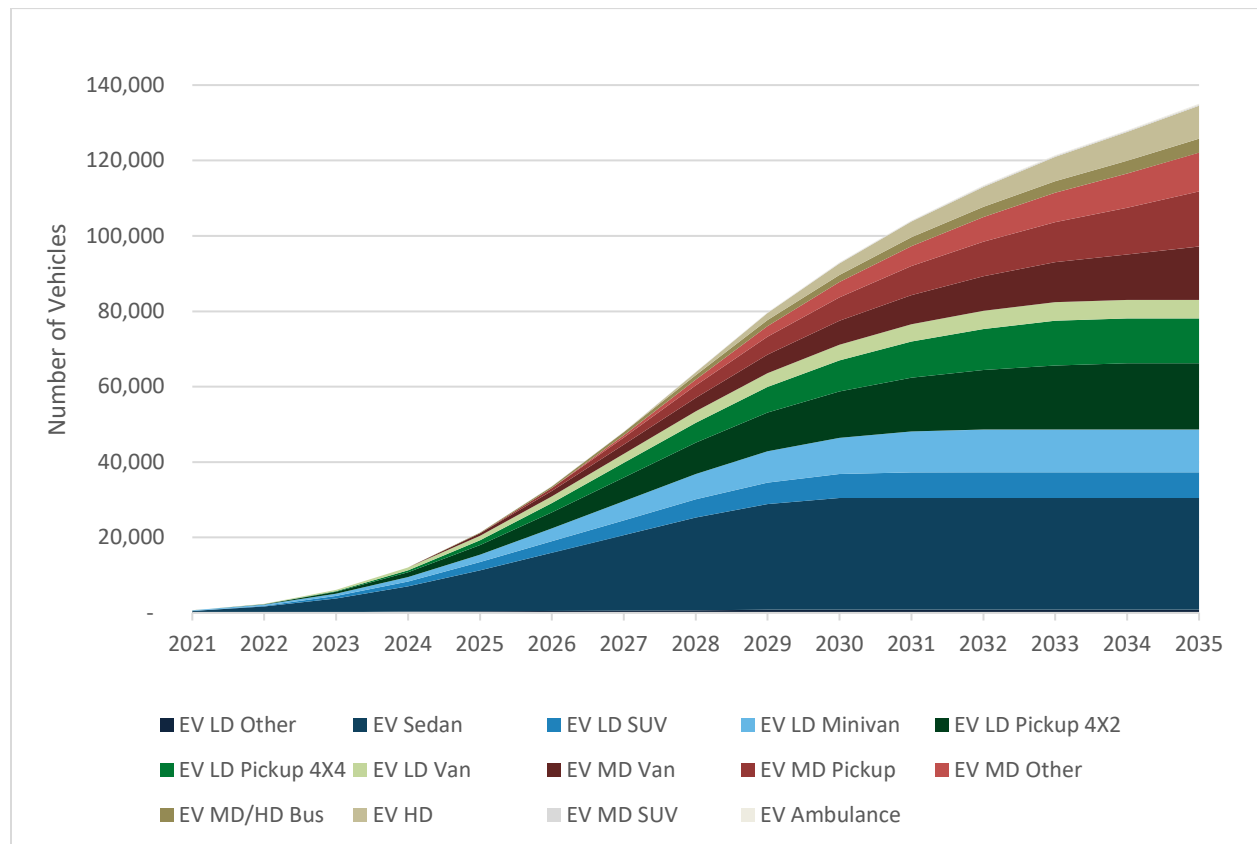


Figure 5. Example ZEV inventory scenario

1.3 Considerations for the Planning Process for Fleet Electrification

DoD can consider organizing its fleet electrification planning process around the framework shown in Figure 6.

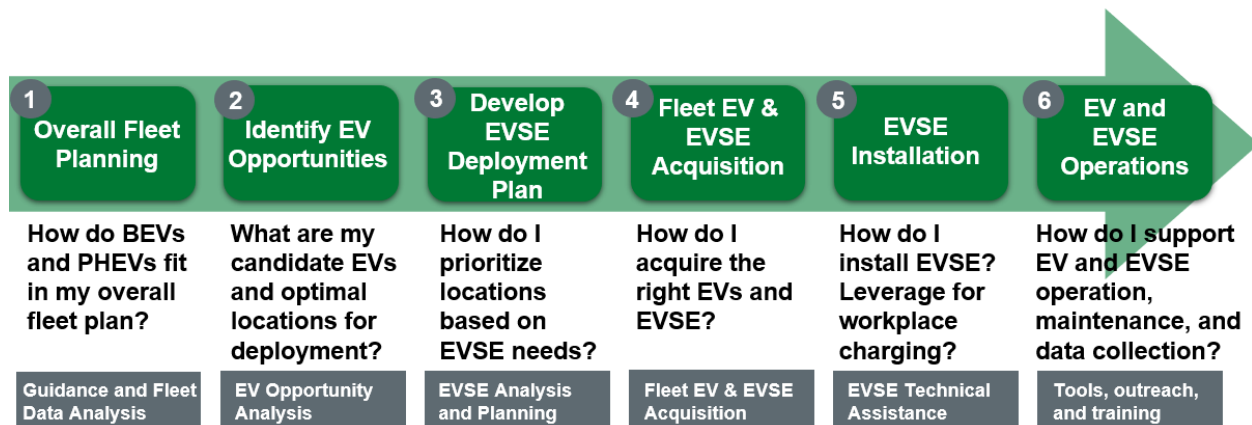


Figure 6. Suggested process for fleet electrification

The suggested electrification planning process includes the following six general steps:



1. **Overall fleet planning.** Fleet electrification planning begins with developing an overall fleet sustainability strategy, and determining how the acquisition of ZEVs, including BEVs and PHEVs, fits into the overall fleet plan. In this initial planning stage, Services and Defense Agencies assess how electrification integrates with other requirements (Section 2.1). The Services should also determine the budget available to support these efforts.



2. **Identify ZEV opportunities.** Local vehicle oversight personnel next should evaluate the existing fleet profile and determine which are possible candidates for electrification in coordination with the Service fleet manager. Based on that analysis, the potential number and type of ZEVs can be established for each location (installation) that has planned vehicle replacements. Agencies can consider using the ZEV Planning and Charging (ZPAC) tool to plan ZEV needs for current and future acquisition cycles, as described in Section 3.



3. **Develop EVSE deployment plan.** After identifying the acquisition outlook for ZEVs at the location (installation), the facility manager and local vehicle oversight personnel should develop an EVSE deployment plan based on vehicle parking locations and EVSE requirements as outlined in Section 4. The plan should identify and prioritize sites (e.g., parking areas and garages) that can provide the most cost-effective deployment of the EVSE needed to support ZEV acquisition plans. This may involve moving vehicle parking spots to sites with better access to power. Priority may be placed on sites with the greatest ZEV opportunities and those with existing charging stations.



4. **Ordering/acquiring ZEVs and EVSE.** Once the fleet managers have identified the vehicles that will be replaced with ZEVs in the next fiscal year, along with the EVSE required to support the deployment of those ZEVs, the fleet manager can place orders for ZEVs and EVSE. This typically occurs during the GSA ordering cycle. This process begins with the local vehicle oversight personnel but culminates in Service fleet manager approval. Key to executing this step is aligning GSA ZEV offerings with vehicle replacements, ensuring EVSE is acquired to support ZEV deployment. Another important

element of this step is contracting for EVSE installation—using, for example, the GSA blanket purchase agreement (BPA). An infrastructure-led strategy will help ensure EVSE is installed before ZEVs arrive. Installing additional EVSE for future years will also reduce long-term construction costs.



5. **Installing EVSE at site locations.** Once the fleet has firm commitments for ZEVs and EVSE, the facility manager would typically be responsible for executing the EVSE deployment plan, using either in-house or contractor installation services or the GSA BPA for EVSE installation.



6. **Support ongoing ZEV and EVSE operations.** Agencies sometimes overlook the ongoing support required for electric vehicle and charging station operations once they are deployed. This includes educating drivers about the use and charging of electric vehicles, vehicle and charging station maintenance, and streamlining the collection of data. These issues are explored in Section 6.

1.4 Using Fleet Data to Inform Electrification Strategies

Fleet managers can potentially use fleet data to: (1) identify potential candidate vehicles for replacement with electric vehicles, including analysis of electric vehicle suitability, availability, and alignment with vehicle operating characteristics and mission needs; (2) inform the selection, siting, and installation of EVSE at federal facilities; (3) assess current progress in fleet electrification both overall and at each fleet location; (4) evaluate the historical effectiveness of electrification strategies at each fleet location.

Services can use multiple systems to review ZEV acquisition, inventory, fuel use, mileage, and charging infrastructure data, including an agency fleet management information system, FAST, the Federal Motor Vehicle Registration System, and FleetDASH:

- The agency fleet management information system should be the primary repository for data on the entire agency fleet vehicle inventory, including electric vehicles, as well as the fuel use (including electricity) and mileage of each of those vehicles. Federal Management Regulation (FMR) §102-34.340 requires that each federal agency “must have a fleet management information system that: (1) identifies and collects accurate inventory, cost, and use data; (2) provides the information necessary to satisfy both internal and external reporting requirements; (3) collects all costs incurred in the operation, maintenance, acquisition, and disposition of motor vehicles used for official purposes; and (4) is capable of providing the data required for external reporting, such as FAST.”
- The Federal Motor Vehicle Registration System is a GSA-maintained system containing information on each electric vehicle registered to a federal government agency.
- Federal agencies are required to use FAST to collect and report accurate fuel consumption, mileage, cost, inventory, and acquisition data on each agency vehicle (including electric vehicles) for each fiscal year (FY)—the reporting period begins on the first of October and ends on approximately December 15 following each FY. Evaluating

inventory, fuel use, and mileage data in FAST allows agencies to identify potential candidates for electrification by analyzing vehicle and operating characteristics data.

- FleetDASH is an online tool that provides federal fleets the capacity to track agency fleet fuel consumption, greenhouse gas (GHG) emissions, vehicle usage patterns, and vehicle inventories at the asset level and at regular intervals. In evaluating fleet electrification, FleetDASH augments FAST by providing more detailed analysis of vehicle operating data to determine suitability for electrification.



2 Aligning Fleet Electrification with Fleet Requirements

The first step in a fleet electrification plan is developing an overarching vision and goals that align with federal fleet energy requirements. This section provides an overview of relevant EOs and statutory requirements (in effect at the time of writing), how ZEVs assist in meeting or exceeding those fleet requirements, and DoD policy for the acquisition, management, use, and reporting of nontactical vehicles, including ZEVs.

2.1 Federal Fleet Executive and Statutory Requirements

The statutory requirements in effect at the time of the writing of this document establish the Energy Independence and Security Act (EISA) Section 142 petroleum reduction goal as the overarching policy (42 U.S.C. § 6374e(a)(2)), which requires each fleet to reduce their annual petroleum consumption by at least 20% compared to a FY 2005 baseline by FY 2015 and continue at the lower levels for each year thereafter. Other energy and environmental statutory requirements support this overarching goal, including requirements to purchase alternative fuel and low-GHG emitting vehicles, increase alternative fuel use, use alternative fuel in dual-fueled vehicles, deploy alternative fuel infrastructure, and right-size the fleet using a vehicle allocation methodology study. At the same time, EO 14057 establishes net-zero GHG emissions as the Administration's overarching priority for the federal fleet. The statutory requirements as well as those of EO 14057 can be met by deploying ZEVs. Specifically, ZEVs assist in achieving the following fleet requirements:

- **Reduce petroleum consumption (EISA Section 142):** Electricity used in EVs displaces the petroleum that would have been used to support that transportation mission, assisting agencies in achieving their EISA Section 142 petroleum reduction goal. Replacing a conventional-fueled vehicle with a BEV or fuel cell vehicle provides a 100% reduction in that vehicle's petroleum use. Replacing a conventional-fueled vehicle with a PHEV provides substantial reductions in petroleum use, depending on the amount of electricity as well as the amount and type of conventional or alternative fuel used.
- **Increase alternative fuel (EISA Section 142):** Electricity is considered an alternative fuel under the Energy Policy Act (EPAct) of 1992, and use of electricity in EVs is counted towards meeting their EISA Section 142 goal to increase annual alternative fuel use by at least 10% relative to an FY 2005 baseline by FY 2015 and for each year thereafter.

- **Acquire AFVs (EPAct 1992):** Agencies receive one acquisition credit for each nonexempt BEV or PHEV they acquire each year in meeting the EPAct 1992 Section 303 (42 U.S.C. § 13212(b)) requirement that at least 75% of covered LD vehicle acquisitions by federal agencies be AFVs.
- **Acquire low-GHG emitting vehicles (EISA Section 141):** Almost all BEVs and PHEVs meet the definition of low-GHG emitting vehicles in compliance with the EISA Section 141 acquisition requirements.
- **Right-size fleets (GSA FMR Section 102-34.50):** Agencies should consider conducting a VAM to identify the optimal vehicle mix. This may include replacing inefficient vehicle or eliminating underutilized vehicles. Replacing inefficient vehicles yields greater environmental benefits, and higher utilization rates for ZEVs offer a better return on investment.
- **Use alternative fuel in dual-fueled AFVs (EPAct 2005 Section 701):** PHEVs are considered dual-fueled vehicles for Section 701 compliance. These vehicles are expected to use only alternative fuel (i.e., fully charge with electricity) at the garage location.



2.2 Executive Orders 14008 and 14057

The Biden Administration has issued two EOs —14008 and 14057—with the goal to “transform federal procurement and operations and secure a transition to clean, zero-emission technologies,”⁵ including acquisition of ZEVs and deployment of the charging infrastructure to support these vehicles.

2.2.1 Executive Order 14008

EO 14008, *Tackling the Climate Crisis at Home and Abroad* (signed on Jan. 27, 2021) establishes the policy of the Administration to “organize and deploy the full capacity of its agencies to combat the climate crisis.”⁶ Section 205 of the EO requires the CEQ, GSA, and the Office of Management and Budget (OMB) to develop a comprehensive plan to use federal procurement, including for the federal fleet, to support robust climate actions. Specifically, the EO 14008 plan calls on all agencies to procure federal fleet ZEVs to the maximum extent possible.

In July 2021, CEQ initiated the FY 2022 Federal Fleet Electrification Planning Effort to help agencies begin planning for electrification of their fleets in FY 2022 and facilitate the longer-term planning process. To assist the planning process, DOE, CEQ, GSA, and OMB developed the ZPAC tool to help agencies estimate (1) how many potential vehicles can be replaced with ZEVs in FY 2022 and (2) the potential charging infrastructure needed to support potential ZEV acquisitions in FY 2022 and additional ZEVs in coming years.

⁵ <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-Federal-sustainability/>

⁶ <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/>

2.2.2 Executive Order 14057

Section 102(i) of EO 14057, *Catalyzing America's Clean Energy Industries and Jobs through Federal Sustainability* (signed on Dec. 8, 2021) further details the EO 14008 policy by requiring each agency to ensure that **all light-duty vehicle acquisitions are ZEVs by the end of FY 2027, and all vehicle acquisitions are ZEVs by the end of FY 2035**. Coupled with the ZEV acquisition goal, the Administration is establishing the policy to ensure these ZEVs are powered with carbon pollution-free electricity. Specifically, Section 102(ii) establishes a goal to “achieve 100 percent carbon pollution-free electricity use by 2030, including 50 percent 24/7 carbon pollution-free electricity.”⁷

To support transition of the federal fleet to ZEVs, Section 201 of the EO requires agencies to work with the CEQ and OMB to propose and establish targets for the annual acquisition of ZEVs and deployment of charging infrastructure for FY 2022 and onward. Key to this effort is the **requirement to annually update a zero-emission fleet strategy** that includes “optimizing fleet size and composition; deploying [ZEV] re-fueling infrastructure; and maximizing acquisition and deployment of zero-emission light-, medium-, and heavy-duty vehicles where the GSA offers one or more zero-emission vehicle options for that vehicle class.”⁸ The fleet electrification planning process outlined in this document is designed to satisfy much of this planning requirement.

The EO ZEV requirements only apply to nontactical vehicles. Agencies may exempt “any vehicle, vessel, aircraft, or non-road equipment that is used in combat support, combat service support, military tactical or relief operations, or training for such operations or spaceflight.” (EO 14057 Section 602).

The CEQ and DoD leadership expect the transition to ZEVs to begin in FY 2022 with significant ZEV targets having been negotiated as of December 2021. The CEQ targets include goals to install twice as many EVSE ports in FY 2022 as ZEVs acquired. Up to 40% of the EVSE counted toward the goals may be Level 1, and the rest are expected to be mostly Level 2. DCFC is not generally the most cost effective option for installation light-duty vehicle charging. An exception would be where high vehicle utilization, quick turnaround times, and a lack of access to public fast chargers require on-site DCFC.



2.3 Select DoD Fleet and Facility Management Policies

The Office of the Deputy Assistant Secretary of Defense (Logistics) is responsible for the management of non-tactical vehicle fleets under the control of any DoD agency, activity, or component. DoD Manual 4500.36, Acquisition, Management, and Use of DoD Non-Tactical Vehicles (Dec. 20, 2018) establishes the policy, assigns responsibilities, and provides procedures for the operation of DoD owned, leased, and operated non-tactical vehicles.

⁷ <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-Federal-sustainability/>

⁸ Ibid.



2.3.1 Construction Practices

The DoD UFC program (prescribed by MIL-STD 3007) unifies all technical criteria (UFCs) and Unified Facility Guide Specifications (UFGS) related to the planning, design, construction, and operation and maintenance of real property facilities, in accordance with DoD Directive 4270.5, Military Construction. Section 11 11 37 of the UFGS (as described in Section 4.10) covers specifications for EVSE at DoD facilities.



3 Identifying ZEV Opportunities

Fleet managers should consider focusing on vehicle operating characteristics when selecting which ZEVs, but the vehicle acquisition process cannot expect to be undertaken without planning for EVSE as described in Section 4. Timing should focus on ensuring that the EVSE will be operational once the ZEV enters service at the fleet location. At a high level, these are the two steps to consider when identifying ZEV opportunities:

1. **Identify optimal ZEV candidates** based on fleet operational and location characteristics. Evaluate operating characteristics for each candidate vehicle, including average and maximum daily driving range, route, and driving cycle, to determine whether a ZEV can meet the vehicle mission needs. Determine availability of BEVs or PHEVs to replace conventional-fueled vehicles. Ensure that replacement options will serve the vehicle mission and charging requirements do not cause undue burden on fleet operations.
2. **Determine EVSE needs** as described in Section 4. The type of infrastructure needed depends on the types of EV procured and the vehicle's charging requirements (e.g., frequency, length). BEVs and PHEVs both require EVSE to charge. However, EVSE needs are different for each of these vehicle types. Some BEVs, which usually have larger batteries, may require higher-level EVSE (e.g., Level 2 [208/240-V charging stations]) compared to some PHEVs, which may only need lower-power charging (e.g., Level 1 [120-V electrical outlets]). Charging equipment can vary based on operating characteristics, size of batteries, and charging cycle.

3.1 Highlighting ZEV Opportunities Using ZPAC

Fleet vehicle data and fleet expertise should inform decisions on which vehicles to replace with ZEVs in the upcoming procurement cycle. The ZPAC tool was created to support and guide fleet managers in determining which individual vehicles should be replaced with ZEVs and how much EVSE is required to support the ZEV fleet.

3.1.1 Suggested Vehicle Selection Process

Figure 7 depicts six general steps that can be used to guide decisions when evaluating ZEV potential.

FY22 ZEV Selection Process



Figure 7. Suggested ZPAC FY 2022 ZEV selection process

Step 1: Vehicle Check

Start by verifying the list of vehicles provided in ZPAC column B in the “FY22 Selection” tab. If data inaccuracies are found, correct them as feasible.

Step 2: Quality of BEV Candidate and Quality of PHEV Candidate

FAST, FleetDASH, and GSA data are the primary sources of the prepopulated data presented in ZPAC. The list of LD vehicles, Quality of BEV Candidate, and Quality of PHEV Candidate columns are designed to serve as a starting point for ZEV consideration. Consider prioritizing vehicles with “Great,” “Good,” “Consider BEV,” or “Consider PHEV” labels. For more detailed information on the model consideration refer to the “flag definitions” tab in the ZPAC tool.

Step 3: Standard Item Number (SIN) Replacement Availability

Take a closer look at the “BEV Replacement-SIN” and “PHEV Replacement-SIN” columns. The SIN values presented in these columns were based on vehicles that were available in FY 2021 and some projections of what vehicles GSA believed would be available in FY 2022. When possible, contemplate vehicle replacement where “BEV Replacement-SIN” and “PHEV Replacement-SIN” occur.

As an example, in Table 5, an “Existing SIN” value of 21 shows 4 “Total Vehicles” were selected to be replaced with BEVs; however, the table shows that there are no direct “BEV” or “PHEV Replacement-SIN” available in FY22. A potential solution is to find a similar SIN to replace those vehicles without compromising the vehicle mission.

Table 5. Agency Decision vs. PHEV and BEV Replacement SIN

Agency Decision	Existing Vehicle Type	Existing SIN	PHEV Replacement-SIN	BEV Replacement-SIN	Total Vehicles
BEV	Sedan/Station Wagon Subcompact	8	8P	8E	14
	Sedan/Station Wagon Compact	9	8P	9E	36
	Sedan/Station Wagon Midsize	10	98P	10E	1
	LD Minivan 4x2 (Passenger)	20	20P	20P	6
	LD Van 4x2 (Passenger)	21	-	-	4
	LD Pickup 4x4	46	-	55E	2
	LD Pickup 4x4	55	-	55E	2
	LD SUV 4x2	91	98P	91E	1
	LD SUV 4X4	96	96P	96E	1
	LD SUV 4x2	98	98P	98E	2
	LD SUV 4x4	99	96P	96E	11
	LD Cargo Van	34	-	34E	5
PHEV	Sedan/Station Wagon Subcompact	8	8P	8E	1
	Sedan/Station Wagon Compact	9	8P	9E	4
	LD Minivan 4x2 (Passenger)	20	20P	20P	2
	LD SUV 4x2	98	98P	98E	1
	LD SUV 4x4	99	96P	96E	1

Step 4: GHG Emission Reduction Potential

Ideally, vehicles with “Very-High,” “High,” and “Moderate” labels will be the ones selected first to maximize the fuel reduction consumption and GHG emission reduction.

Step 5: Fleet Expertise

The model results in the ZPAC tool: “Quality of BEV Candidate,” “Quality of PHEV Candidate,” and “GHG Emission Reduction Potential” were derived using DOE and GSA data. The model is not aware if a vehicle is overseas or if a vehicle is used for home-to-work missions. Decisions regarding such vehicles should be made by the fleet manager for these situations. There may be other suitability factors unknown to the model that fleet managers should consider. This type of information should be captured in the “ZEV Unsuitability Special Circumstances” columns of the ZPAC tool.

Step 6: Decision Point

Use the dropdown menu to indicate a decision for each vehicle listed in column B of the ZPAC tool.

ZPAC Summary Result Example

Table 6 is an example of ZPAC results. It shows the number of each vehicle type selected by the agency (“Agency Decision” column) against the model predictions presented in the “Quality of BEV Candidate” columns. Of the 621 potential BEVs identified by the agency, 49% (or 304 vehicles) were originally predicted as “Great” and “Good” BEV candidates and 37% (or 228 vehicles) were specified as “Mediocre” and “Challenging” candidates. Moreover, the agency has opted to replace 990 vehicles that were “Great” and “Good” BEV candidates, 526 and 464 vehicles respectively, with another vehicle type (“Other” row). This ZPAC summary result illustrates that there is not a predetermined solution when evaluating the ZEV potential in each fleet. As mentioned above, the prepopulated data in the “FY22 Selection” tab of the ZPAC tool is there to offer guidance; ultimately, fleet managers control the decision point in this process.

Table 6. Example Agency Decision Point versus Quality of BEV Candidate

Agency Decision	Quality of BEV Candidate						TOTAL
	1–Great	2–Good	3–Mediocre	4–Challenging	5–Consider PHEV	6–No FY22 ZEV Option	
BEV	37	267	201	27	89	0	621
PHEV	33	145	168	82	244	0	672
OTHER	526	464	234	290	277	4810	6601
ELIMINATE	0	0	1	0	1	0	2
DELAY REPLACEMENT	101	1293	44	33	69	0	1540
NO RESPONSE	1	38	0	1	2	0	42

Finally, fleet vehicle data provide context related to driving patterns, energy consumption, fueling transitions, and driver behaviors. In the absence of these data, three considerations can help when looking for potential vehicles to replace:

1. Vehicles that take many short trips:

A high frequency of trips combined with small average trip distance is a clear indicator of a good fit for an electric replacement.

2. Vehicles with a daily usage of under 250 miles:

If typical daily vehicle mileage is within the 250-mile range, which is the rated range of most BEVs, consider replacing this vehicle with a BEV. Electric fleet vehicles performing this kind of work can be charged overnight, perform dependably each day, and save fuel. Charging away from the installation is manageable as well. There are public EVSE, including DCFC with relatively quick recharge times, available throughout the United States, as shown in the Alternative Fueling Station Locator in Figure 8. If BEVs operate 24/7, they will need to charge at DCFC or XFC.

3. More electric miles reduce more carbon dioxide emissions and save more on petroleum fuel costs:

If a BEV does not fit the fleet mobility needs, consider PHEVs. In electric mode, PHEVs create zero tailpipe emissions, and PHEVs can contribute to the achievement of fleet sustainability goals by reducing the amount of gasoline that is consumed.

Alternative Fueling Station Locator

Find alternative fueling stations in the United States and Canada. For U.S. stations, see [data by state](#). For Canadian stations in French, see [Natural Resources Canada](#).

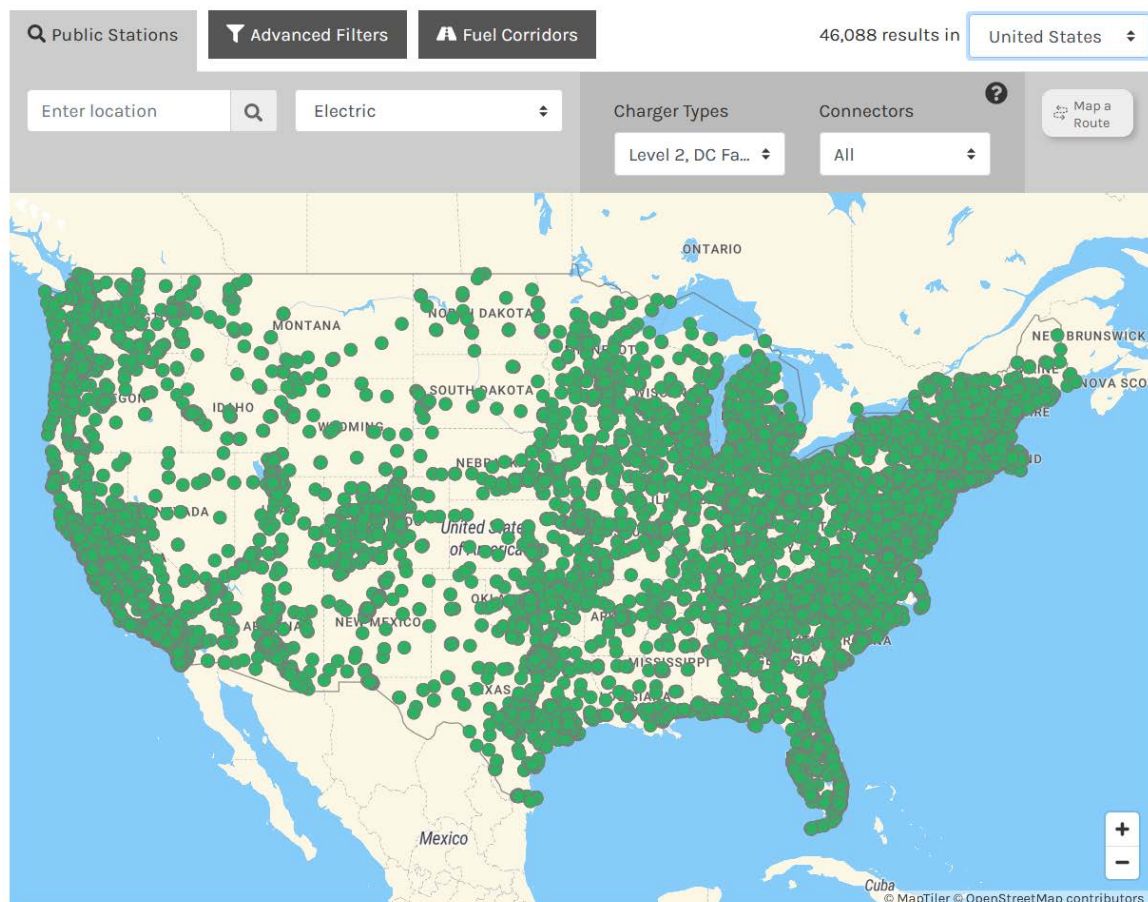


Figure 8. Alternative Fueling Station Locator

Image from <https://afdc.energy.gov/stations>.

3.2 Evaluating ZEV Candidates Without ZPAC

If ZPAC is unavailable, fleet managers can follow a similar process to assess the suitability of electrification for each vehicle at each fleet location. This is summarized in the following six steps.

1. **Complete a baseline profile.** Prior to selecting electrification strategies, agency fleet managers should create a baseline fleet profile. Typically, the first step in developing a fleet profile begins with reviewing fleet data in FAST and FleetDASH. The agency can begin to construct a database for each vehicle in the fleet that includes the vehicle, location, operations, and mission data elements necessary to evaluate suitability for electrification. FleetDASH contains an AFV Screening Tool with most of the necessary data for GSA-leased vehicles. Figure 9 is a screenshot from the FleetDASH tool.

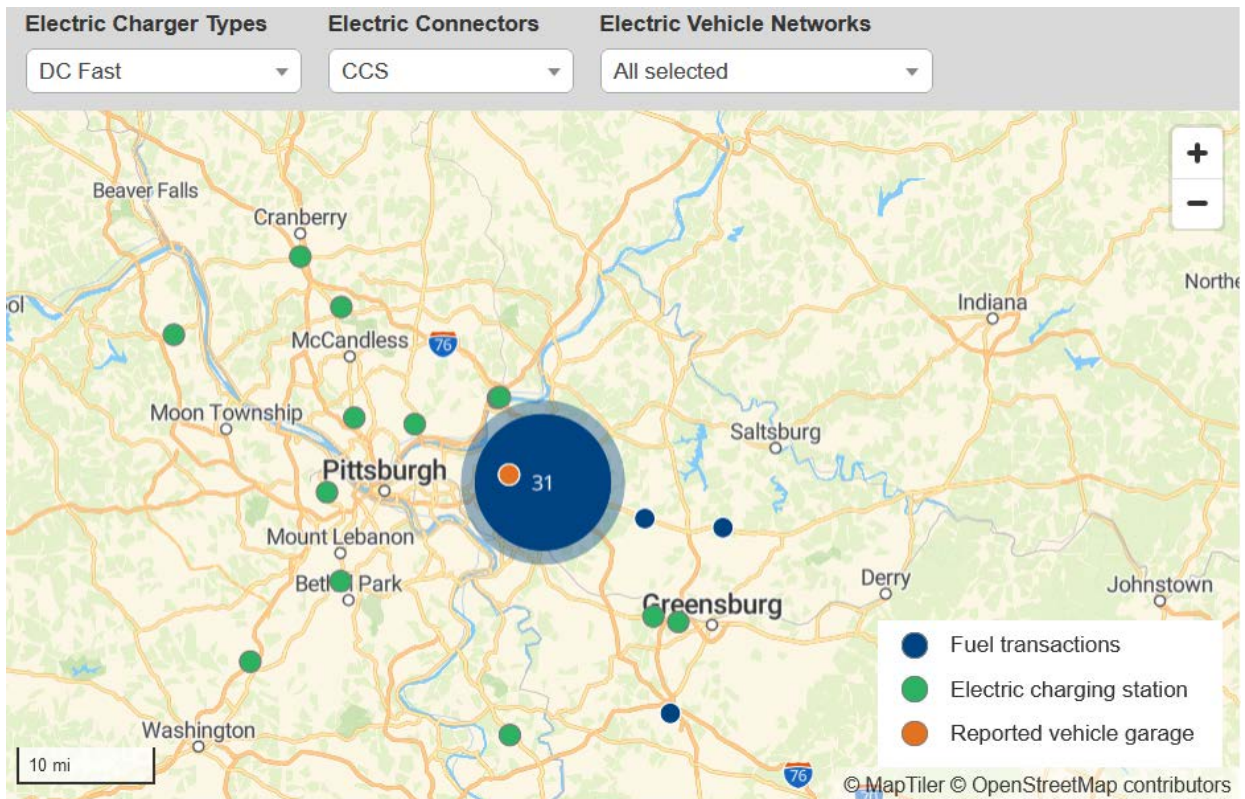


Figure 9. FleetDASH AFV Screening Tool

Image from <https://federalfleets.energy.gov/FleetDASH>.

2. **Identify potential candidate vehicles using basic criteria.** Agencies should review the age and use of all GSA-leased vehicles and agency-owned vehicles in the fleet to determine the fiscal year for expected replacement. For each vehicle with the potential to be replaced, the fleet should evaluate the vehicle specification requirements to assess the projected availability of BEVs and PHEVs to meet those requirements. Typically, this can be completed using GSA SINs that categorize available vehicles according to standardized criteria. These standards include vehicle size (wheelbase and passenger compartment volume), weight, engine, transmission, components (including safety devices), systems, devices, markings, and services.
3. **Assess suitability of EV capabilities for the vehicle's mission.** After reviewing the general vehicle specification requirements, the fleet manager should next assess whether a BEV or PHEV is suitable for the vehicle's operating mission. Some missions (e.g., unique upfitting requirements) may not be served by available BEVs and PHEVs.
4. **Evaluate the driving requirements of candidate fleet vehicles.** Fleet managers should evaluate the operating characteristics for each candidate vehicle, including average and maximum daily driving range, route, and driving cycle, to determine whether a BEV or PHEV can meet the vehicle mission needs.

5. **Prioritize ZEVs at fleet locations with existing or planned charging stations.**
Locations with existing or planned charging infrastructure may offer the most cost-effective opportunity to replace conventional vehicles with ZEVs.
6. **Determine whether suitable EVSE could be installed to support candidate fleet vehicles.** At some fleet locations, planning for installing charging infrastructure may not be feasible. Potential reasons may include the utility service, design, or ownership of locations where fleet vehicles are parked, or limitations on using charging infrastructure associated with some transportation missions.

After assessing and identifying potential candidate vehicles for electrification, the fleet manager should next refine that list to: (1) match candidates with the availability of ZEVs from GSA or other sources, (2) ensure candidate vehicles align with plans for deploying charging infrastructure, and (3) ensure that acquisition of electric vehicles aligns with fleet resources.

At least prior to FY 2024, the availability of ZEVs from manufacturers for the federal fleet may be limited due to either supply issues (e.g., battery availability or production limits) or demand issues (where consumer demand exceeds supply). If there are limits on available vehicles, fleet managers may have to eliminate some candidate ZEVs or choose vehicles from similar vehicle classes.

Fleet managers should ensure that charging infrastructure will be available to support BEVs at the fleet location once delivered. In FY 2022, there will be a long lag time (~270 days in some cases) between ordering and delivery. This will likely provide a great deal of time to install EVSE before vehicles arrive.



3.3 Using ZEV Plans to Inform EVSE Deployment



Planned acquisition results in the ZPAC “FY22 Selection” tab are designed to develop awareness of the potential priority sites when planning deployment of EVSE for fleet use. The list of primary considerations for installing EVSE are shown in Figure 10. Results of the “FY22 Selection” tab in the ZPAC tool support the identification of potential ZEVs based on the current fleet composition.

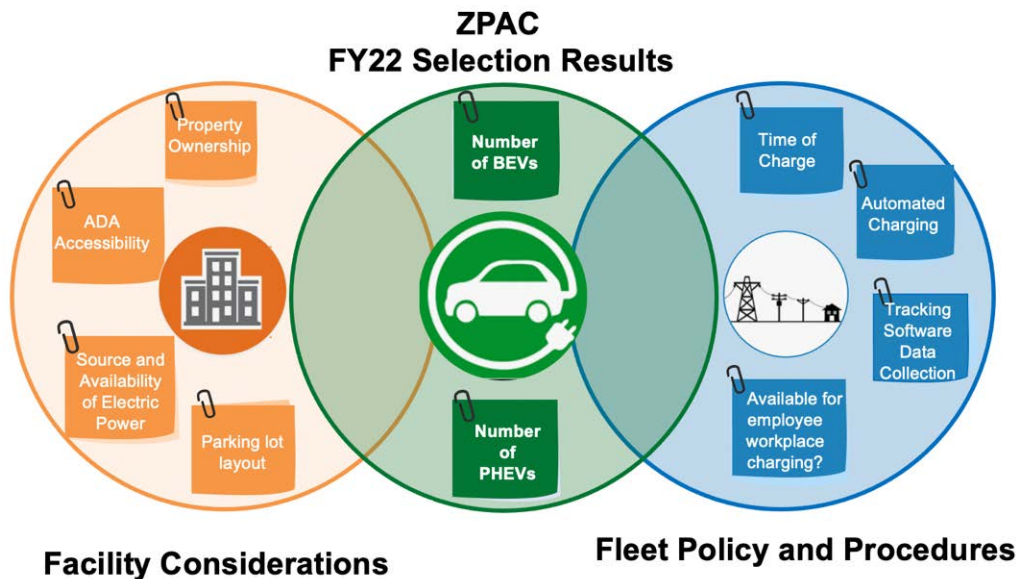


Figure 10. Considerations for installing EVSE

The types and quantities of ZEVs at site locations can be used to identify where to install EVSE to maximize the impact of the electrification. Figure 11 can be used to quickly identify priority sites based on the number of potential ZEVs identified in Section 3.1. Potential priority sites are listed from left to right based on total number of BEVs and PHEVs for potential acquisition. EVSE installations should be prioritized at sites where more future ZEVs will reside. However, fleet and facility managers should discuss relocating ZEV parking to areas with better access to power.

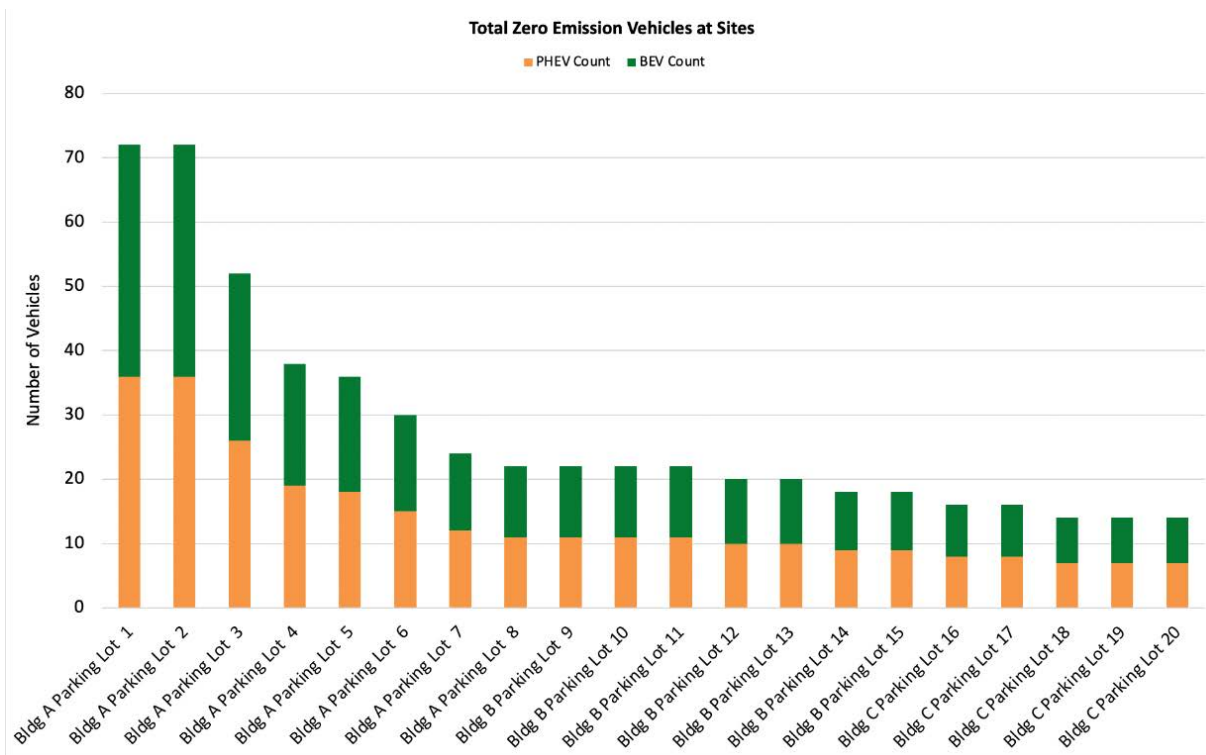


Figure 11. BEVs and PHEVs at site locations



4 Designing the EVSE

After completing the planning required to determine ZEV opportunities and resulting EVSE requirements, fleet managers should consider designing the specific solutions needed to support the electrification growth that will occur throughout the following year. This portion of the process is where agency-wide plans will translate into site-specific solutions. Therefore, it is important to begin this process with an understanding of ZEV opportunities and EVSE needs, as well as the current fleet of ZEVs and available EVSE at each site of interest. Fleet managers should work closely with installation facility staff to ensure that the EVSE will be operational once the ZEV enters service at the fleet location. This entire process requires coordination between fleet and facility staff as well as installation, regional, and headquarters personnel.

The type of infrastructure needed depends on the types of ZEV procured and the charging characteristics (e.g., overnight parking). BEVs and PHEVs both require EVSE to charge. However, EVSE needs are different for each of these vehicle types and operating characteristics. Some BEVs, which usually have larger batteries, may require Level 2 EVSE for overnight charging while many PHEVs can rely entirely on Level 1 EVSE (120-V electrical outlets on dedicated electrical circuits along with charging cord sets that are sold with all PHEVs). Some BEVs with lower daily usage may be served by Level 1 EVSE as well.

It is a best practice for drivers to have access to ZEV parking within about 100 yards of their office entrance. This differs from the centralized fueling model previously employed with gasoline vehicles and requires a more distributed deployment of EVSE as opposed to the more centralized installations common with gasoline fueling stations. Figure 12 illustrates the

difference between 3 centralized gasoline stations and 17 distributed EVSE clusters recommended to serve the energy needs of fleet ZEVs.

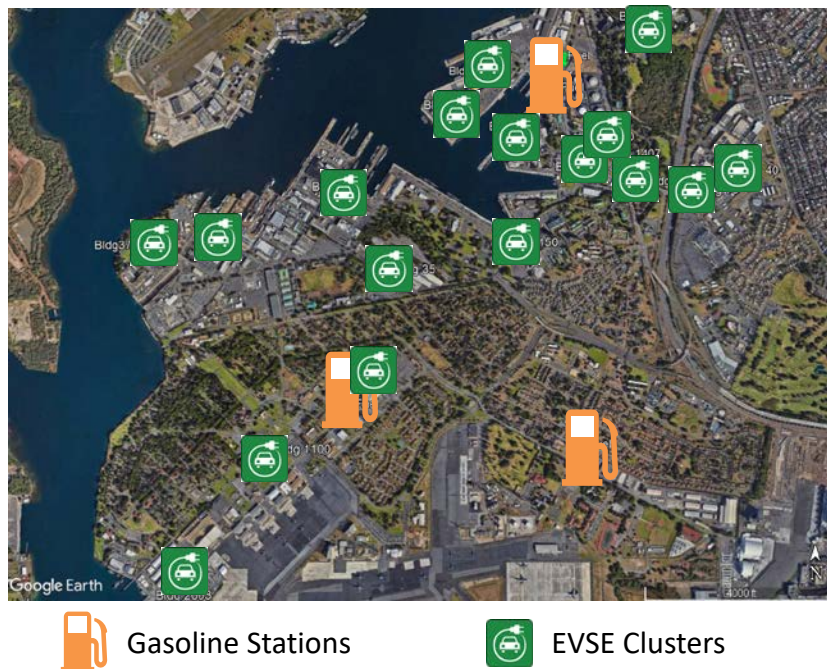


Figure 12. Existing gasoline fueling stations and distributed EVSE clusters recommended at Joint Base Pearl-Harbor Hickam

If overnight charging is not feasible for a BEV (e.g., vehicle operates 24/7) or the daily driving operations regularly exceed the rated range, then it will likely need to charge at a fast charger. BEVs can charge at publicly available fast chargers while operating on the road, but the installation may need to install fast chargers if operations are primarily on base.



4.1 Charging Situations

This document focuses on fleet ZEV acquisition and EVSE needs. However, multiple DoD Services have policies set up for workplace charging of privately owned vehicles (POVs), and there may be overlap in the planning process for charging POVs and government-owned vehicles (GOVs). Table 7 describes responsibility for charging by location.

Table 7. Suggested EV Charging Responsibility Matrix

Location Ownership	On Base	Off Base
Fleet GOV	DoD expected to bear full responsibility for installation and charging costs	DoD responsible for charging costs
Commuter POV	DoD required to bill for charging (FAST Act)	Personal responsibility for obtaining equipment and charging costs



4.2 Identifying EVSE Needs

Before procuring and installing EVSE, it is important to consider fleet needs and possible solutions. This will save time and help implement the best EVSE solution for each fleet. EVSE requirements will largely be determined by the makeup of the ZEVs procured for use at each facility. Table 8 describes questions and considerations for DoD for how to accommodate fleet needs and integrate EVSE into existing building and grid infrastructure.

Table 8. Key Questions Related to EVSE Electrification Priorities

Question	Investigate	Recommendation
How many EVSE ports should be located at one site?	How many ZEVs will be in the fleet in the next 5 years?	Install enough EVSE to support all ZEVs planned for the next 5 years. Consider how many EVSE are already available on site to support planned ZEVs.
What type of EVSE unit do I need?		Level 1 can support PHEVs; consider Level 2 charging units to increase BEV practicability.
Where does EVSE need to be installed?	What are the ZEV driving patterns that may guide EVSE locations?	Shorter distances from electrical service equipment to EVSE and minimizing hardscape trenching will minimize costs. Consider short relocations of ZEV parking spaces to minimize construction and power upgrades.
What electrical service upgrades are needed?	What is the remaining capacity (equipment capacity minus existing electrical load) on the service panels and transformers near the preferred ZEV parking location?	Consult with facility manager, staff electrician, on-site engineers, or contract support to complete a site assessment. EV plans are a pre-requisite to the site assessment. See Section 4.4.
Who will have access to the EVSE?	Will POVs have access to the EVSE?	POV charging requires recouping electricity expenses and typically other costs as well. Consult the Federal Workplace Charging Program Guide. ⁹
What type of parking restrictions and signage are appropriate?	Will the EVSE be parked in a dedicated fleet lot or open to the public at large?	Include “EV-Only” signs in any locations where POVs park. Consider enforcement action if combustion-engine POVs continue to park in “EV-Only” spots.

The number of EVSE ports required is determined by the number of ZEVs planned for the site and the anticipated ratio of EVSE to ZEVs needed to support fleet operations. As fleets begin the electrification process, EVSE deployment plans should be developed ahead of ZEV acquisition plans. Fleets should install enough EVSE to support the total ZEV acquisition plans as far as five years into the future. This will help to reduce the per port EVSE installation cost and avoid the burden of managing an excessive number of EVSE installation projects. Section 3 describes how

⁹ <https://www.energy.gov/eere/femp/articles/Federal-workplace-charging-program-guide>

to plan fleet ZEV acquisitions using ZPAC and other methods. **Fleet managers can plan for EVSE numbers equivalent to 50% of their LD fleet vehicles for those first five years, which coincides with the fleet electrification inventory that can be achieved by 2027 at aggressive ZEV acquisition rates.** Ultimately, a 2:1 ratio of ZEV:EVSE may be achievable at many fleet locations, fortifying this rule of thumb for a 100% electric fleet.

Consider plans for workplace POV charging using the FEMP Workplace Charging Program Guide. Appendix B of the guide includes a survey to determine employee interest in electric POVs on federal campuses.

PHEVs have relatively short electric ranges (~40 miles on average). To maximize electric miles traveled (which are less expensive and generate fewer GHG emissions than gasoline miles), PHEVs should charge any time they return to base after driving. Because PHEVs have smaller batteries, they do not require Level 2 EVSE. Level 1 EVSE is sufficient to charge PHEVs overnight, which typically only requires access to a 120 V receptacle. The vehicles are sold with 12-A charging cords that can plug into electrical outlets of 15-A or greater on dedicated circuits (i.e., no other devices should draw current from these outlets or circuits while PHEVs are charging). By leveraging the reliability of a receptacle and the provided Level 1 cordsets, PHEVs, as well as low-VMT BEVs can minimize infrastructure planning and costs.

BEVs have comparably larger electric ranges (most exceed 200 miles). To charge these larger batteries in a single night, Level 2 EVSE is recommended for most BEVs, although some BEVs that travel short distances – such as 50 miles per day or less – may only require the power capabilities of a Level 1 EVSE. There will be days when EVs do not need to charge, either because they were not driven at all or because they return to base with a nearly full battery after a short trip. **Fleet managers can minimize the number of EVSE installed by instructing drivers to park by EVSE and charge their vehicles only upon arriving with a battery state of charge below 80%** (unless they plan on driving a long distance the following day). In conjunction with this rule, **analysis of telematics data can be used to optimize the number of EVSE required to support a fleet of BEVs.** In many cases, this can result in BEV to EVSE port ratios of 2 or higher (e.g., 117 BEVs and 44 Level 2 EVSE ports) (Figure 13). This can save the fleet a significant amount of money and minimize electrical service upgrades, which often delay the installation of EVSE. This analysis is valuable for locations where three or more BEVs will park because the difference between installing a single or dual-port EVSE unit is normally minimal, and coincident charging is more likely with a smaller number of BEVs.

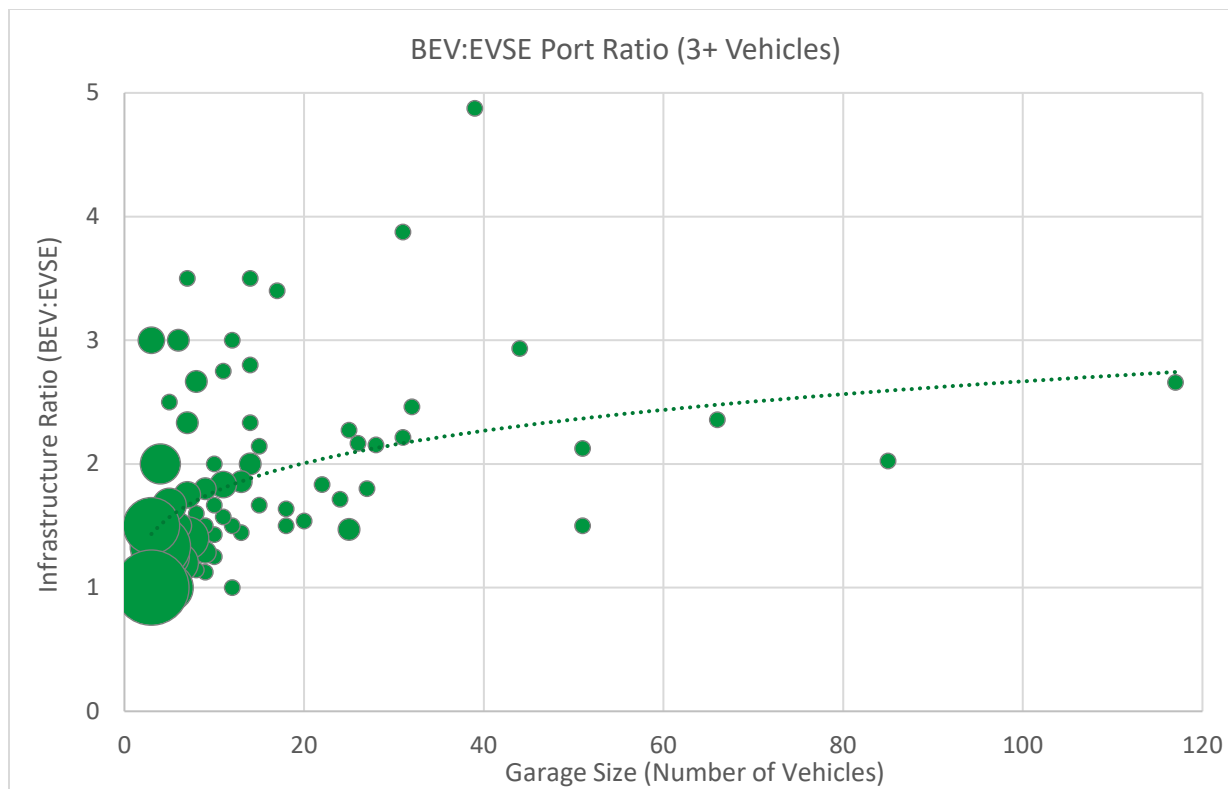


Figure 13. Optimal BEV to EVSE port ratio for 3+ vehicles

Figure Credit: Hodge et al. (2021)

Optimizing a site's BEV to EVSE ratio is a great way to mitigate the installation costs of EVSE. It is also a simple way to reduce peak demand to mitigate equipment upgrades as well as demand charges. However, many fleets may be planning for future expansion and therefore installing more EVSE than EVs for the time being.



4.3 Suggested Stakeholder Roles in EVSE Planning

It is a best practice for the Service fleet manager to contact the local fleet manager (see Table 2) at each location where new ZEV opportunities and EVSE needs have been identified for the upcoming year. During this time, both stakeholders should discuss the location's EVSE progress and ZEV acquisition plans for the following year. The local fleet manager should connect with the installation facility manager who will assume responsibility for the installation of charging equipment once the needs have been described, in collaboration with the community planner and local electric utility. The Service headquarters facility management staff should be informed of all EVSE projects. At any installation where the base infrastructure has been privatized, the installation facility manager should work closely with the utility privatization partner under the terms of the base's specific contract.

4.4 Suggested Priority of Work for EVSE Installation

CEQ has set targets in conjunction with the Services calling for the installation of twice as many charging stations in 2022 as ZEVs acquired in an effort to account for future fleet ZEVs. However, distribution system upgrades to support the larger EVSE installation sites could take

several years for planning, budgeting and contracting. Therefore, the following prioritization process is suggested with priorities 1 through 5 funded through Services and Defense Agency appropriations (smaller investments) and priority 6 projects funded primarily through the Energy Resilience and Conservation Investment Program (ERCIP) (larger investments).

1. Install EVSE in FY22 at locations where no construction or power upgrades are required. This includes any location with an existing EVSE stub previously installed for future expansion. It also includes any location where conduit was installed previously for wires to be pulled to EVSE later. Other priority locations may be identified as locations where multiple buildings only require a few EVSE at each, typically resulting in the need for fewer electrical service or distribution upgrades.
2. Plug Level 1 EVSE cordsets into available 120 V receptacles on dedicated circuits. This is particularly suitable for PHEVs, but it can suffice for BEVs when the vehicle's energy consumption does not exceed Level 1 power supply (approximately 60 miles per day if charged from 5:00 pm to 8:00 am).
3. At locations where Level 2 EVSE is required, identify buildings where existing service panels and service transformers provide sufficient physical and electrical capacity to support the new EVSE. This may include installing a subpanel off of a main distribution panel and running wires to the parking lot. Consider whether managed charging (Section 4.8) can avert transformer upgrades.
4. At locations where ZEV acquisitions are imminent and EVSE installation is delayed, procure portable/deployable charging infrastructure that leverage local generation and storage to provide rapid deployment of necessary charging infrastructure. Portable charging infrastructure is generally skid-mounted with a deployable solar array and integrated EVSE and battery storage unit. They can be moved from location to location and function regardless of the overall power distribution system. This solution addresses locations where the timing of ZEV deliveries and EVSE installations is misaligned. However, they do rely on solar power with a battery backup, and they cost around \$60,000-70,000 plus about \$15,000 to deliver in some cases.
5. Install EVSE where service transformers need to be replaced and/or parking lot construction is significant. This includes significant trenching. This process will require consultation with the distribution utility to ensure sufficient power capacity to the transformers and the development of engineering drawings. This analysis should begin as soon in tandem with the above priorities, but project execution will take longer.
6. Install EVSE where power distribution upgrades are required. This includes upgrades to distribution feeders and distribution substations. The likeliest source of funding for these power distribution upgrades is ERCIP (Section 4.5.2), which is on a longer project schedule than the operations and maintenance funding that is allocated for priorities 1 through 4 above.



4.5 Funding EVSE

Installation staff can either install and manage EVSE themselves or hire a contractor to do so. Installing the EVSE requires staff with the necessary electrical and construction expertise but can reduce costs. Contracting out the work is generally simpler but more expensive.

If a contractor is engaged, the contracting officer will need to either develop a new contract, acquire through GSA, or add a task order under the scope of an existing contract. In either case, the questions asked in Table 8 (Section 4.2) should serve as a reference when drafting the statement of work. The contract should also specify the role of the contractor in the ongoing maintenance and support of the EVSE.

4.5.1 Operation and Maintenance Funding

For most EVSE installation projects within the capacity of the existing power distribution system (Priorities 1-5 in Section 4.4), operation and maintenance (O&M) funding can be considered if a contract is available. O&M funds can typically be executed at the installation level but should be coordinated with EVSE leads at the Services Installation Management Offices. This may require a project objective memorandum (POM) and approval.

4.5.2 Energy Resilience and Conservation Investment Program

ERCIP funds projects that “improve energy resilience, contribute to mission assurance, save energy, and reduce DoD’s energy costs” (Office of the Assistant Secretary of Defense for Sustainment 2021a; 10 USC § 2914). In FY 2021, ERCIP funded over \$173 million in DoD projects, ranging in size from \$611,000 to \$32 million, none of which focused exclusively on EVSE. (Id). However, the **goals for future year funding specify infrastructure projects directly supporting EV charging stations** (Office of the Assistant Secretary of Defense for Sustainment 2021b).

The execution cycle for ERCIP funding requires the submission of proposals that include a quad chart, Form 1391, energy resilience assessment, life cycle cost analysis, measurement and verification plan, and DoD climate assessment tool results. A panel reviews the proposals and selects projects for execution in one of the following two years. Additional planning may be funded through the ERCIP process before the construction and power system upgrades can be complete. ERCIP projects have a five-year window for completion.

Due to the scale and planning requirements associated with ERCIP, the program is likely viewed as most suitable for larger scale EVSE projects that require more significant planning, integration, and funding.

4.5.3 Enhanced Use Leases

10 U.S.C. § 2667 allows defense agencies to accept “in-kind consideration” for underutilized or underperforming land controlled by the Department of Defense (NAVFAC n.d.). These considerations may include construction, maintenance, or equipment installation. For example, a developer might be able to install a shopping center on a DoD base in exchange for the installation of 100 Level 2 EVSE, a 500-kW PV array, and related infrastructure upgrades.

4.5.4 *AFFECT and ESPCs*

DOE manages the Assisting Federal Facilities with Energy Conservation Technologies (AFFECT) grant program for federal agencies. The 2020 guidance for AFFECT grants clarified that EVSE may be funded through the program. The Infrastructure Investment and Jobs Act of 2021 appropriated \$250 million to the AFFECT program, nearly 20 times the funding awarded by AFFECT in 2021.

AFFECT is designed to leverage energy savings performance contracts (ESPCs), which fund the “design, acquisition, installation, testing, measurement and verification, and, where appropriate, operation, maintenance, repair, and replacement, of an identified energy conservation measure [ECM], water conservation measure, [or a combination of both]” (DOE 2022a).

DOE released guidance in February 2022 allowing EVSE and components of EVs to qualify as ECMs in ESPCs in specific circumstances. The language below is quoted directly from DOE’s Frequently Asked Questions on ESPCs:

“Electric vehicle supply equipment (EVSE) may be incorporated into an ESPC if it is part of an energy conservation measure (ECM) or if it is demonstrated that the EVSE results in energy savings to a federal building. Three examples demonstrate permissible instances: (1) a power generation ECM, such as photovoltaics or cogeneration, that includes equipment such as EVSE to facilitate delivery of power to an end use; (2) an ECM that includes EVSE with charging capabilities employed for load management (e.g., kW savings and energy related cost savings), such as participation in a demand response program; or (3) an ECM that replaces existing EVSE with more efficient EVSE, where doing so results in energy savings to the federal building.

“Where EVSE is incorporated in an ESPC, the energy used by the EV (e.g., gasoline, electricity, or other) for non-building purposes would not be included in the ESPC building energy use calculations....

“The ESPC statute does not confer authority for agencies to procure electric vehicles (EVs) as part of an ESPC. In limited circumstances, however, there may be an opportunity for components of EVs to be included in an ESPC. For example, a load management ECM that incorporates bi-directional charging from an EV to provide power for building backup or load management (e.g., for the purpose of participating in a demand response program) could incorporate the EV components used for those purposes (e.g., the vehicle’s battery, charging unit, controls, related construction and/or supporting infrastructure, and related components) in an ESPC.

“Where EV components are incorporated in an ESPC, the energy used by the EV (e.g., gasoline, electricity, or other) for non-building purposes would not be included in the ESPC building energy use calculations.

“Because ESPC applications for EV components are limited, agencies should contact FEMP as they consider the incorporation of EV components in an ESPC.”

(DOE 2022a).

EVSE had been installed through ESPCs at federal facilities in the past, including Fort Buchanan in Puerto Rico. However, in that instance and others, the EVSE was only accounted for as an additional expense, and the overall project remained life cycle cost effective (Kiatreungwattana 2019). DOE's new Frequently Asked Questions language allows EVSE to qualify for bidirectional power generation, load management from managed charging, and improved EVSE efficiency. It also allows EV components to qualify when used for bidirectional charging.

4.5.5 Utility Areawide Contracts

Utility areawide contracts (Exhibit A) can be used to fund the upfront cost of charging infrastructure, including electrical upgrades. The costs must be repaid over 10 years through the utility bills (Hodge et al. 2021). Utilities determine what costs they will fund through areawide contracts. Therefore, this funding approach requires working closely with local utilities.

4.5.6 Utility Energy Service Contracts

Utility energy service contracts (UESCs) have been used by civilian agencies to install EVSE as part of larger projects. (Cantrell 2021). However, UESCs, like ESPCs, require that EVSE qualify as energy conservation measures with positive lifecycle cost impacts.

4.5.7 Fleet-as-a-Service

While far from being a well-established option, the concept of providing a fleet-as-a-service seems to be gaining traction with school districts and may be transferrable to DoD in some unique cases. Some providers, including ESCOs, utilities, and private vendors have expressed interest in using ESPCs, areawide contracts, UESCs, or other contractual instruments to install EVSE and/or procure ZEVs for DoD use as fleet vehicles. The fleet-as-a-service model typically involves the contractor planning, financing, building, and maintaining the EVSE and ZEVs, and it may include payment for electricity as well. In exchange, a DoD installation or Service would be contractually obligated for a monthly payment to the fleet-as-a-service provider. The full extent of this arrangement has not been completed for ZEVs in the federal government to the knowledge of the authors, but the State of Hawaii and several school districts elsewhere are operating ZEVs under fleet-as-a-service contracts, indicating that this approach is feasible in certain situations. Fleet-as-a-service providers should offer ongoing EVSE maintenance and guarantee a high percentage of uptime (>98%).

4.6 GSA EVSE Procurement Options

GSA currently offers EVSE units through its BPA.¹⁰ The BPA complies with federal procurement rules up to \$250,000 per order, thus simplifying procurement for agencies. The BPA in effect as of November 2021 includes several different Level 2 EVSE, two Level 1 units, and two DC fast chargers with both CHAdeMO and CCS connections. GSA provides a decision tree on which EVSE suits a particular need.¹¹ However, the BPA was developed in 2015 and focuses primarily on networked Level 2 EVSE, and there are additional EVSE options now available in the market.

¹⁰ Available at <https://www.gsa.gov/evse>.

¹¹ https://www.gsa.gov/cdnstatic/Which_Charging_Station_is_best_for_me_BPA_Decision_Tree.pdf.

In the interim, agencies can acquire EVSE units from GSA Advantage.¹² There are dozens of additional EVSE units and managed charging controllers for multiple units available through GSA Advantage. However, agencies must comply with contracting requirements for EVSE acquired through GSA Advantage.

GSA has two solicitations drafted as of October 2021: a “Source Sought Notice” for design-build contractors to install EVSE and a “Special Notice for GSA’s Draft EVSE and Ancillary Services RFQ” for the EVSE units themselves. The design-build contract will allow agencies to contract with private companies that can complete site assessments and install the units. The EVSE unit request for quotations (RFQ) will ultimately yield a new BPA.



4.7 Considerations for EVSE Site Analysis

Vehicle oversight personnel should consider beginning the design process by reaching out to installation facility managers and installation master planners or energy managers, who in turn should bring in electric utility representatives and eventually EVSE installers. In order to inform these conversations, FEMP developed the EVSE Installation Planning Form.¹³ The first section of the EVSE Installation Planning Form is displayed in Figure 14 (split to improve legibility). It should be filled out using information from the ZPAC summary table. Although conversations with these stakeholders will likely occur throughout the entire design process, it is critical to identify contacts as the first step in EVSE site design.



USE DATA SUMMARY FROM ZPAC TO INFORM STEP 1					
Step	Description	Total Parking Locations Throughout Facility	Total BEVs at Facility in FY21	PHEVs at Facility in FY21	BEV Opportunities in FY22
1	Anticipated ZEV Inventory				

PHEV Opportunities in FY22	Total LD Fleet Vehicles at Facility	Will GOVs & POVs have access to the same EVSE?	Will public have access to EVSE?	Is parking shared with any other agencies?

Figure 14. EVSE Installation Planning Form step one

4.7.1 Assessing Electrical Infrastructure and Logistics

Most fleet ZEVs will likely be charged from EVSE powered by electric infrastructure that currently supports buildings at each site. Therefore, site facility staff and utilities or privatization partners will play a critical role in verifying there is sufficient electrical infrastructure to supply electricity to new EVSE and supporting the electrical upgrades and construction projects that may be necessary to support new EVSE. In addition to the facility equipment considerations, site

¹² <https://www.gsaadvantage.gov/>.

¹³ <https://www.energy.gov/sites/default/files/2021-10/evse-installation-planning-form.xlsx>

facility managers may also be interested in fleet electrification to understand the increased electricity demand that may result from EVs to better inform their annual energy and sustainability reporting requirements.

EVSE installations will vary greatly from site to site; some will require a simple project with a wall-mounted EVSE inside a garage while others will require significant construction and system upgrades. Every project will require an EVSE installer, which can be any licensed electrician, while only some will include additional stakeholders such as construction firms or general contractors. The EVSE installer must be familiar with both national and local electrical code requirements and may need to be approved by the facility owner or local utility. At DoD installations, the Authority Having Jurisdiction is defined by UFC 1-200-01 as described in Section 4.10.2. There are civil engineering concerns to consider as well, such as protecting the EVSE as prescribed in UFGS 11 11 37 and allowing sufficient room around the vehicle for an EVSE cord to run to the vehicle's charging port.

Initial conversations with site facility managers should focus on existing EVSE capacity and possible EVSE needs, as well as installation requirements such as approved installers and construction guidelines. Facility managers will be key in determining the optimal EVSE locations and where existing electrical capacity may be present, as well as facility load considerations relating to peak demand. They will also be an important resource for information about which equipment is owned and managed by the facility or utility and will likely have the best contact for the electric utility representative. Throughout these conversations, step two of the EVSE Installation Planning Form, as displayed in Figure 15, should be completed.



SEEK SUPPORT FROM YOUR FACILITY MANAGER, OR ENERGY MANAGER TO COMPLETE STEP 2					
Step	Description	Parking Location Flexibility?	Parking Near a Wall?	Parking Near an Existing Outlet?	Number of Unused Level 2 EVSE Ports
2	ZEV Plans by Parking Location				

Number of Unused Wall Outlets (120V)	Parking Near a Wall?	Parking Near an Existing Outlet?	Number of Unused Level 2 EVSE Ports	Number of Unused Wall Outlets (120V)

Figure 15. EVSE Installation Planning Form step two

4.7.2 EVSE Electrical Needs

It is best to speak with a base electrical engineer and civil engineer after an initial site outline has been determined and an initial plan for EVSE quantity and locations has been established. This first conversation should cover the installation goals from a high level with an estimate of likely facility upgrades that will be needed. Unless the number of ZEV acquisitions has been finalized,

it is important to have some flexibility as to the number of EVSE units that will be installed. This is because certain quantities of EVSE may have more economical installation costs than others based on the equipment upgrades that will be required and their resulting new capacity. This design flexibility will ensure the best ZEV adoption plan is determined during the Refine Deployment Strategy phase. Throughout these conversations, step three of the EVSE Installation Planning Form, as displayed in Figure 16, should be completed.

SEEK SUPPORT FROM YOUR FACILITY MANAGER, ENERGY MANAGER, OR ELECTRICIAN TO COMPLETE STEP 3					
Step	Description	Parking Location Name	Distance: Parking Spaces to Service Panel (feet)	Service Panel Spare Breaker Positions	Service Panel Main Breaker Rating (Amps)
3	Electric Service Equipment by Parking Location				

Service Panel Peak Load (Amps)	Distance: Parking Spaces to Transformer (feet)	Transformer Rating (kVA)	Transformer Peak Load (kVA)

Figure 16. EVSE Installation Planning Form step three



4.7.3 Electric Utility and Privatization Partner Required Involvement and Incentive Programs

Electric utilities and privatization partners play a critical role in supplying the electricity necessary to charge ZEVs and therefore play a key role in the installation of EVSE. Although some smaller installations will have a lesser impact on the electric grid than large garage locations will, the site fleet manager should always contact their local electric utility representative early in the EVSE site design process. With privatized utility infrastructure, installations may be contractually obligated to work with the utility privatization partner. Regardless, the privatization partner will serve an important role in EVSE planning.

Utilities will play a key role in determining any grid or service upgrades that will be required as part of the new EVSE installations. These will likely be a result of facility equipment upgrades, such as a larger service panel or main breaker, required to support new EVSE, and will be determined by the EVSE installer. It is important to understand whether the installation of new EVSE will require a service upgrade, because that may also impact the rate structures for which the facility is eligible.

Many electric utilities offer incentive programs to reduce the purchase price of EVSE units, while some offer service options that simplify the EVSE installation process. It is critical to understand if there are EVSE incentive programs or EVSE make-ready service options early in

the design process. This will help to confirm which programs the fleet is eligible for and if program requirements will influence site design, such as a requirement for pedestal Level 2 EVSE or that all units must be publicly accessible. DOE FEMP developed the Electric Vehicle Utility Finder (EV U-Finder)¹⁴ (Figure 17) to help federal agencies identify utility EVSE incentives and contacts in their local ZIP code. EVAULT includes known EVSE funding incentives and advisory services by customer type (including government), a description of those services, and contact information for the utilities. It also specifies local Clean Cities Coalition representatives that can provide on-the-ground support and identify state incentives.

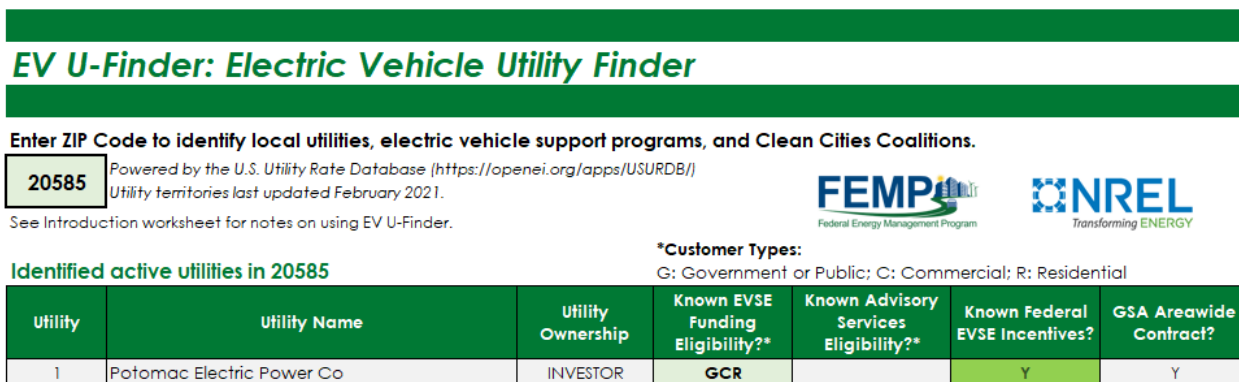


Figure 17. Electric Vehicle Utility Finder (EV U-Finder)

Electric rate structures are a critical element in determining the energy costs for charging an electric fleet. Most commercial rates will include both an energy charge and demand charge. Peak demand typically refers to the highest amount of energy consumed in a 15-minute period over the course of a month. Peak demand for a single day is illustrated in Figure 18. Demand charges have the potential to significantly increase electricity bills. Higher demand charges are typically a result of EV charging at the same time that facility loads are coincidentally operating at their highest levels. These coincident peaks will create a higher monthly peak demand and demand charges than before EVSE were installed. However, due to the long dwell periods of most vehicles, these impacts can be easily managed by opting to have EV charging occur at times when facility load is lower, which requires a conversation between both the facility and fleet managers. Section 4.8 provides additional details on managed charging.

¹⁴ <https://www.energy.gov/eere/femp/articles/electric-vehicle-utility-finder-ev-u-finder>.

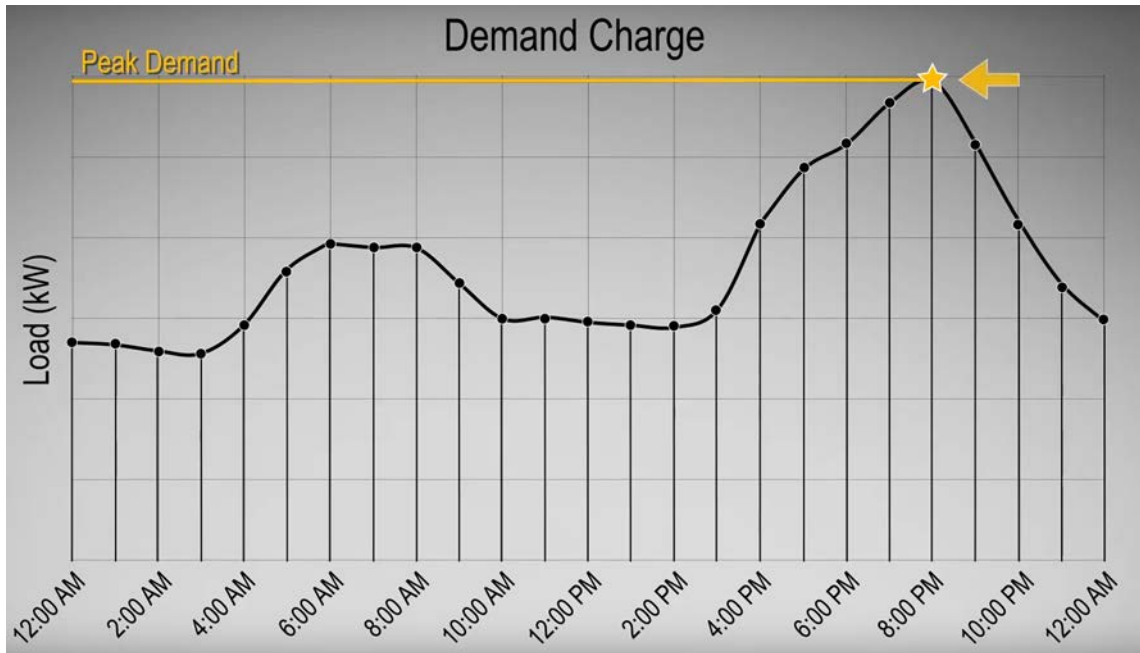


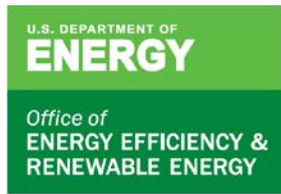
Figure 18. Peak demand illustration

Image from "Federal Fleet Training: Electric Vehicle Financial Consideration," NREL



4.7.4 EVSE Tiger Teams

The process of planning for fleet electrification requires the input from many stakeholders and covers a wide range of topics between fleet operations, facility management, electrical engineering, construction planning, and many more. In order to support the most ambitious fleet electrification plans, FEMP and NREL have developed the EVSE Tiger Team to offer technical support throughout this process by providing recommendations to federal agencies, including the DoD, on the installation of EVSE that minimize costs while accommodating the long-term charging needs of the fleet (Figure 19). This includes support with site layout plans, equipment upgrade considerations, plans for future growth, and advice on best practices to minimize costs and mitigate equipment upgrades through solutions such as managed charging, data analysis, or optimized EVSE deployment. Tiger Team engagement through federal_fleets@ee.doe.gov should include coordination with Agency fleet managers for awareness.



Supporting Electric Vehicle Supply Equipment Deployment

**Tiger Teams Offer Project
Assistance for Federal Fleets**



Figure 1. Workplace charging may be co-located with fleet EVSE or installed simultaneously to achieve cost savings. Here, an electric vehicle is plugged into a charging station in the NREL parking garage. Photo by Dennis Schroeder, NREL 26669.

Figure 19. EVSE Tiger Team flyer

Image from <https://www.energy.gov/eere/femp/articles/deploying-electric-vehicles-and-electric-vehicle-supply-equipment>

Tiger Teams begin this process through data collection with the use of the Federal Fleet EVSE Planning Form (Figure 14, Figure 15, and Figure 16). This form addresses all the information the Tiger Team needs to understand a fleet’s ZEV acquisition plans and EVSE needs. However, in addition to planning the EVSE needs in the near-term, consideration should also be made for long-term electrification goals. Planning for the future by installing additional charging capacity will reduce overall installation costs and mitigate the number of construction projects at each site. This extended capacity may be installed through either additional EVSE or just the wiring and conduit “stub-outs” to facilitate easy installations of EVSE in the future. The amount of additional capacity that should be installed at each site will depend on several factors, such as the level of demand that would require equipment upgrades or a new electrical service, and the Tiger Team will help determine the optimal level of EVSE deployment.

An Agency fleet’s EVSE deployment needs are best shared with installers and electricians through single-line diagrams and site outlines. The Tiger Team can work with fleet and facility managers to determine the optimal locations for EVSE deployment and outline the scope of work that will likely be required at each site. This includes the conduit raceway and circuit breakers, as well as service panel and possible transformer upgrades. Some of the costs associated with this work can be mitigated through solutions like managed charging as described in Section 4.8.



4.8 Managed Charging

Managed charging can have two distinct connotations:

1. **Networked or “smart” EVSE units** that can adjust power levels to limit infrastructure upgrades and power demand charges from utilities. This is the most common implication of the term “managed charging.”
2. **Human planning and scheduling to optimize charging**, which can be effective and less expensive. Human ingenuity is necessary in any networked or non-networked EVSE approach.

4.8.1 Networked EVSE

Networked charging solutions are a great way to mitigate demand charges and equipment upgrades. With the simplest solutions, fleets can leverage power sharing features to reduce the service equipment needed for each EVSE by having two to four charging ports share a single circuit, thereby reducing total installation costs and the peak demand across multiple vehicles. However, more sophisticated solutions can involve setting a power ceiling for a series of EVSE to mitigate transformer upgrades or integrate scheduled charging with facility management systems to shift EV charging away from a facility peak. Such a solution is employed in the NREL garage.¹⁵

Although many EVSE are designed to simply provide power to vehicles when they are plugged in, some are designed with more sophisticated features that often require a network connection. Common types of EVSE features are detailed in Figure 20. Most, if not all, networked EVSE units can set charging times to occur at a certain point in time. This is very useful with time-of-use rates. For example, if electricity costs \$0.20/kWh from 6:00 a.m. to 12:00 a.m., and \$0.05/kWh from 12:00 a.m. to 6:00 a.m., the EVSE should be set to charge starting at 12:00 a.m.

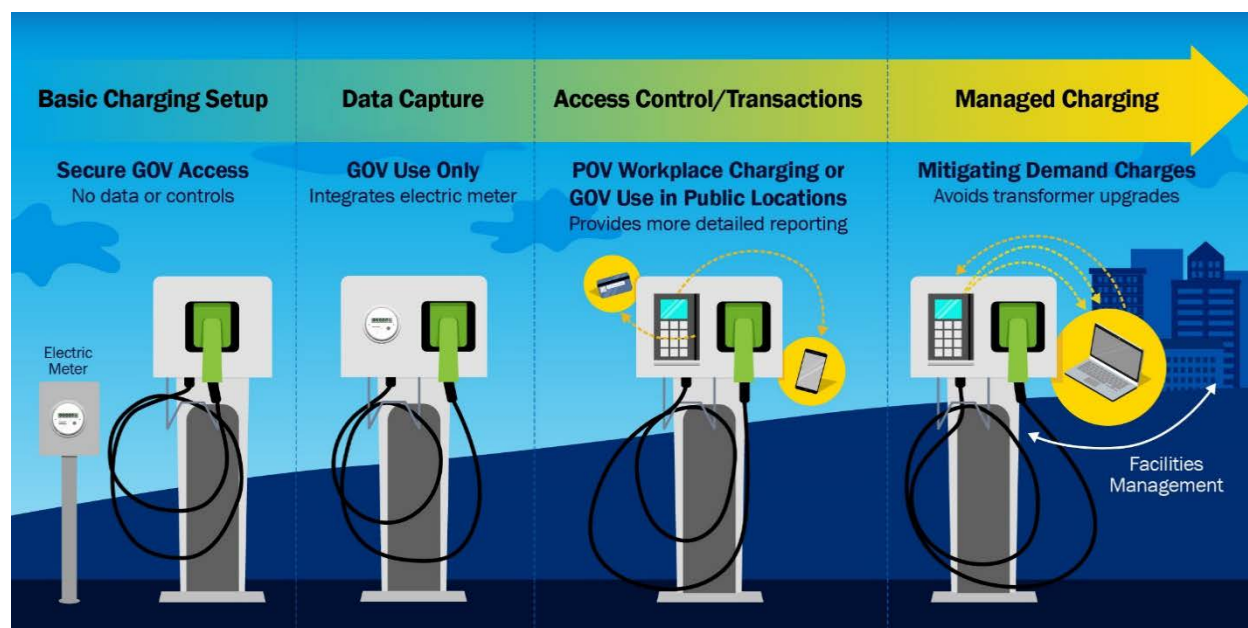


Figure 20. Network connected EVSE features and types

Figure Credit: (Bennett et. al., 2019)

Networked units can also be configured to stagger charging so that they do not set a high peak level. Most utilities charge a demand rate for the most energy consumed in a 15-minute period over the course of a month. To avoid all vehicles charging at the same time, networked chargers can set EVs to start charging at different points in time (e.g., 1/3 of the EVSE units begin charging at 5:00 p.m., 1/3 begin at 10:00 p.m., and 1/3 begin at 3:00 a.m.). Actual optimal timing

¹⁵ <https://www.energy.gov/eere/femp/evse-upgrades-nrels-parking-garage-generate-financial-benefits>

will depend on other facility loads and fleet needs. Fleet managers should work with facility managers to set charging times.

Certain EVSE can also divide power from a single circuit to two different EVSE. If both heads of a dual-port EVSE can charge at 32-A when charging a single vehicle, they can be configured to simultaneously charge two vehicles at 16-A each. In this case, the EVSE that would have otherwise required capacity for 64-A only requires access to 32-A. This strategy can reduce the need for service panel replacements and other electrical upgrades. The National Electrical Code (NEC) requires that continuous loads such as EVSE be protected at 125% of their rated capacity (i.e., 32-A EVSE requires a 40-A circuit breaker).

Some networked EVSE can react dynamically to various situations. This includes power sharing across dozens of EVSE units as opposed to the simple two-unit power share described above. Large-scale power sharing can be completed through software that controls when EVSE are actively charging and sometimes the power level of the EVSE. For example, dynamic charging can follow instructions to charge one vehicle at full power because it must return to mission shortly while it charges a second vehicle at 25% power because the second vehicle does not need to be fully charged until the next day.

EV charging can be controlled by a separate controller or at the service panel in conjunction with smart, solid-state breakers that do not need to be manually reengaged. These solutions can convert the simplest EVSE units into a smart charging solution.

Networked EVSE serve other uses as well, such as reporting energy consumption and billing POVs for workplace charging.

DOE, GSA, OMB, and CEQ do not require that energy consumption be tracked at the EVSE, but rather at the vehicle itself. GSA has standardized its telematics solution with Geotab for the leased vehicles, and all newly leased vehicles will include telematics unless the fleet manager opts out. Telematics should capture energy consumption from EVs. If not, energy consumption (kilowatt-hours) can be estimated by tracking the electric miles traveled multiplied by the vehicle efficiency in kilowatt-hours/mile (available from fueleconomy.gov or estimated for light-duty vehicles at 0.28 kWh/mile) (Bennett 2021).

$$kWh = \text{electric miles} * \frac{kWh}{\text{mile}}$$

Equation 1. Energy Consumption

For workplace charging, networked EVSE can be very valuable by tracking the electricity consumed in each transaction and billing the employee for that transaction. EVSE network providers can then remit the funds to the federal government (Bennett and Hodge 2020).

Networked EVSE require ongoing sustainment, including paying the charging service provider an annual network fee. There are firmware and software updates that must occur as well. Because of these complexities, a study found that nonresidential networked EVSE in its sample size performed at 68% to 83% uptime, while simple EVSE performed above 99% uptime during the study period (Avista Corp. 2019). The study authors noted that this was because

nonresidential networked EVSE would not charge vehicles without user authentication through a mobile application or RFID card, and that could not take place if the network was disturbed. It is critical that a sustainment plan be included for networked EVSE and preferable that the units function for fleet GOVs without a requirement for authentication.

4.8.2 Human Planning

None of this technology is valuable without human planning. Informed vehicle oversight personnel and installation facility managers should decide whether a simple EVSE unit is sufficient, or whether to pursue a specific networked solution. There are a few rules of thumb that can support the personnel responsible for these decisions.

1. Level 1 EVSE provides sufficient overnight charging power levels (~1.4 kW) for PHEVs (typically <20 kWh batteries).
2. Level 1 units do not require networked solutions for power management because their power levels are so low. Access control and payment can be arranged for Level 1 units through an external controller.
3. Level 2 EVSE are generally recommended for overnight charging of BEVs (often >60 kWh batteries) because of their higher power levels (~7.2 kW).
4. Level 2 EVSE units can benefit from networked charging management solutions to minimize coincident charging peaks and electrical service upgrades. There are many options for networked chargers.
5. Defaulting networked solutions for GOV EVSE to functionality without authentication if the cellular network fails would maximize uptime. Consider the risks of requiring user authentication (17% to 32% downtime per Avista Corp. 2019) to the risk of POVs using GOV-only units.
6. Consider installing more EVSE than required for the coming year. Plan approximately five years out. Upgrade electrical service or trenching through parking lots on multiple occasions is not preferred. While every vehicle may not require a dedicated EVSE port because most EVs will not require nightly charging, it is likely that more EVSE ports will be required ultimately than the number of EV acquisitions in the coming year to support full fleet electrification.



4.9 Electrical Service Upgrades

Installing EVSE, as with the addition of any large electrical load, will likely require the consideration of possible equipment upgrades. Increasing electrical loads as a result of the installation of new energy consuming devices could, at times, exceed the power limitations of electrical service equipment such as service panels, wires, and transformers. The first step in understanding these impacts is to perform an energy audit to determine the nature of a facility's existing loads and the remaining equipment capacity. Following this, consideration of both facility and utility owned equipment is necessary to determine the remaining capacity after the installation of EVSE and predict any equipment upgrades that may be needed. As noted in Section 4.8, the NEC requires that continuous loads such as EVSE be protected at 125% of their

rated capacity (i.e., 32-A EVSE requires a 40-A circuit breaker). Consider whether certain locations on base have more excess power capacity to minimize installation costs.

4.9.1 Power Needs

The scale of EVSE power requirements is determined by charging speed and the number of charging ports. For example, a single 250-kW XFC can provide 100 miles of charge in 6 minutes with the same power capacity requirements as 179 Level 1 EVSE ports (Table 9). Therefore, it is worth considering what power level is truly appropriate for the use case. Rather than oversizing service equipment to meet an unlikely future scenario, it is appropriate to base EVSE power levels and upstream electrical service needs on the use case of existing vehicle driving patterns as they would function if transitioned to EVs. In a simple use case, if a vehicle never drives more than 50 miles in a day on gasoline and always parks overnight, a Level 1 charger will suffice. Level 1 EVSE therefore suffice for PHEVs, with typical 25–50 mile electric ranges. Comparing these figures to gas station dwell times (8 minutes per station plus 12 minutes driving off-course for fleets (Geotab 2020) indicates that the 250-kW XFCs are similar to the gas station experience.

Table 9. EVSE Power Capacity Equivalents

Charger Type	XFC (DC Level 2)	DCFC (DC Level 1)	AC Level 2 at 240-V	AC Level 1
Power Level (kW)	250	50	7.2	1.4
Time to Charge 100 Miles of Electric Driving Range (hours) ^a	0.1	0.6	3.9	20.1
Equivalent Number of Chargers Installed at 250 kW Available Power (ports)	1	5	35	179

^a Time to charge 100 miles is based on 3.6 miles/kWh, a sales weighted average calculated using data from Argonne National Laboratory (2019).

4.9.2 Power Capacity

Every piece of electrical service equipment (EVSE, service conductors, circuit breakers, service panels, meters, transformers, feeder lines, etc.) is rated for an appropriate power level. If exceeded, that equipment will fail and may become unsafe. Therefore, it is critical to assess each element in the chain, at least up through the service transformer, which is typically protected by a main distribution panel.

The main distribution panel shown in Figure 21 has an open breaker position (red oval) where an appropriately sized circuit breaker could be installed, a 400-A 208-Y enclosure rating, and a three-phase 400-A main breaker, indicating 144 kW of three-phase power capacity. For context, this panel is served by a 150-kVA transformer.

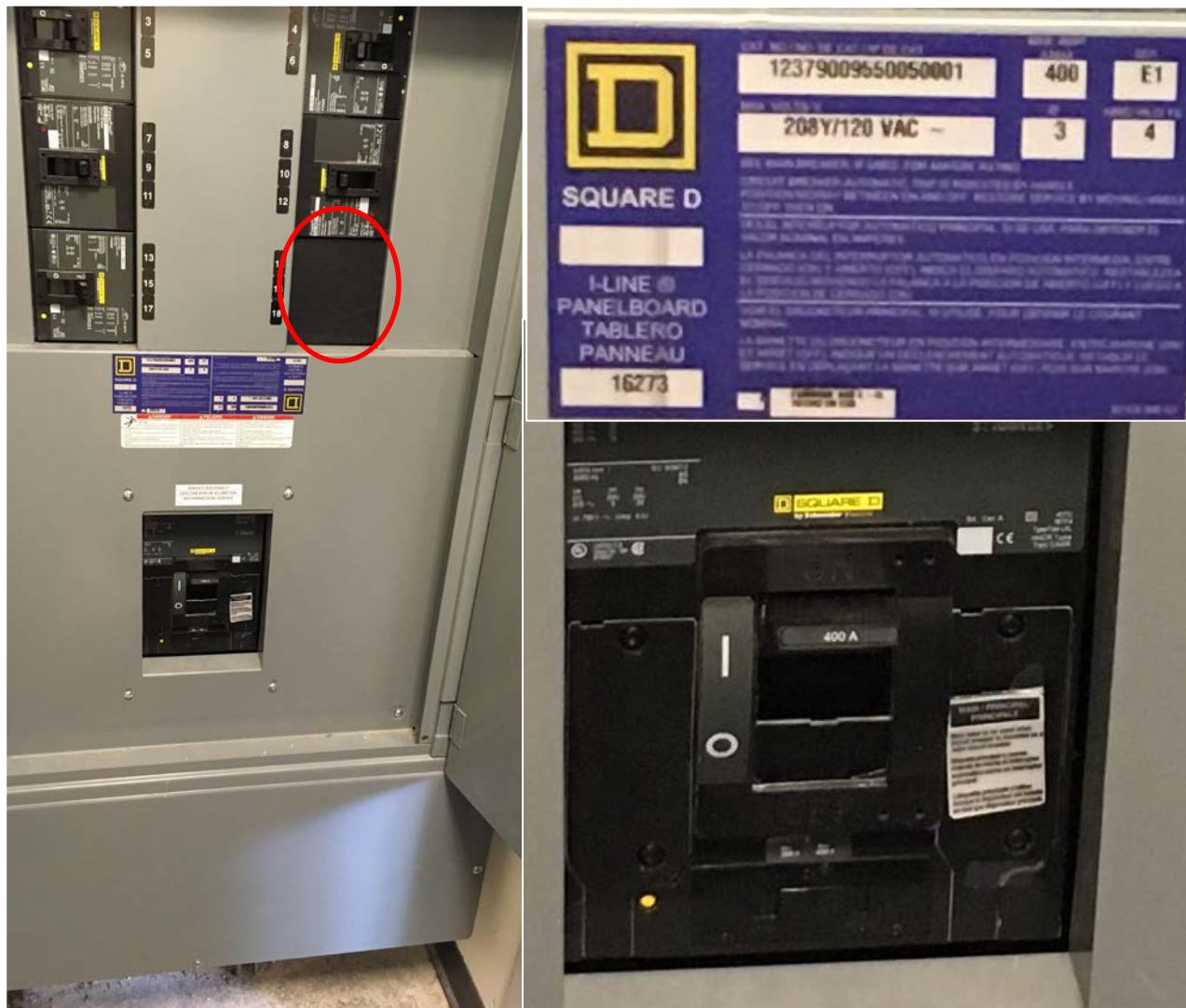


Figure 21. Main distribution panel from an Army garrison building

Photos by Cabell Hodge

4.9.3 Power Load at the Parking Lot Level

Electrical loads are sometimes measured (such as with a demand meter) and sometimes must be estimated. Energy management information systems often store power load data over time, which is useful when assessing the inconsistent nature of these loads and sizing equipment correctly. Figure 22 shows the maximum monthly peak demand for the main distribution panel in Figure 21, indicating that no more than 67 kW is ever required at this location. Therefore, 77 kW of capacity is available from the service panel out of the 144 kW detailed above.

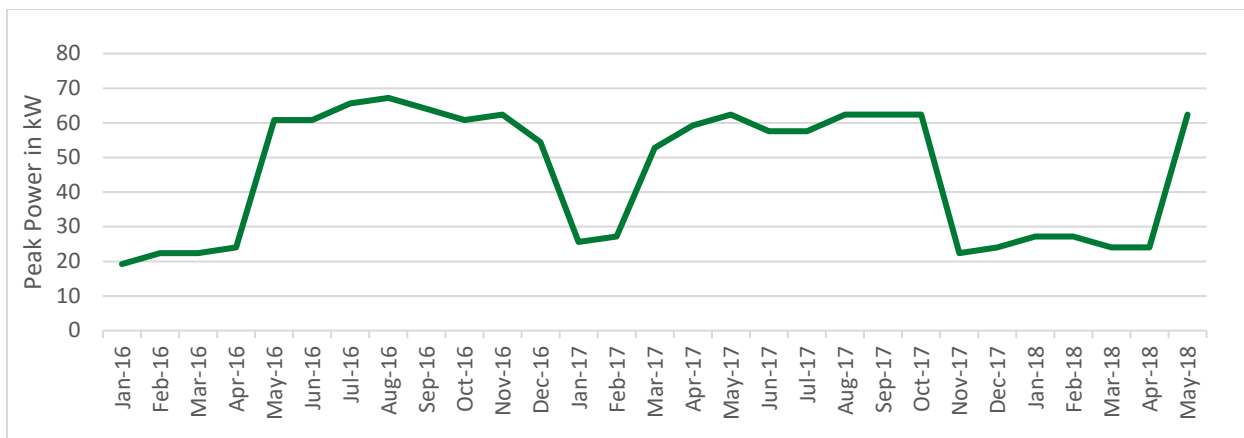


Figure 22. Monthly power demand for an Army garrison building

This information allows an EVSE site assessment team to determine how many EVSE ports at a particular power level could draw power from this panel. Nine Level 2 EVSE at 208 V (6.7 kW) could be installed (after accounting for NEC requirements to oversize protective equipment for continuous loads). This may be sufficient for a relatively small transportation motor pool, but a managed charging solution as described in Section 4.8 or a new main distribution panel and transformer may be necessary for larger numbers of EVSE or higher power equipment.

4.9.4 Power Load at the Base Level

Total electricity consumption at a base can reach much higher levels. An example Army base has an on-peak maximum demand of 54,379 kW, the equivalent of 8,116 Level 2 EVSE charging vehicles at the exact same time. That same base reported an inventory of 682 light-duty vehicles and 648 medium- or heavy-duty vehicles in 2020. If all were electric with 50% of those vehicles charging on Level 2 chargers simultaneously to the existing peak, they would increase the maximum power demand by 4,459 kW or 8%. This could require new feeder lines and upgrades to substations under the purview of the base itself or the utility.

Issues at a base-level tend to become more significant for larger vehicles and BEVs because they require higher power EVSE even to recharge overnight. For example, buses often use 65-kW DCFC for depot charging, providing approximately 10 times more power than Level 2 EVSE. Therefore, controlling bus loads is more significant for demand charges and system upgrades than cars and SUVs on a vehicle-by-vehicle basis. Distributing EVSE across the base reduces the demand on low voltage transformers.

4.9.5 Facility Equipment Upgrades

All EVSE require the installation of new circuit breakers and wiring from the service panel to the EVSE. However, when installing a large number of EVSE, such as five or more at one location, additional upgrades are often required. Site fleet managers should coordinate with site facility managers to determine which equipment is at risk of becoming overloaded. This will require the consideration of existing loads, as informed by the energy audit, in conjunction with anticipated EV charging loads. This will generally include service panel and main breaker ratings that could be overloaded during a coincident peak of facility and EV charging loads.

The best planning practices in response to these equipment considerations are very location-specific. However, there are some general rules that will apply in most situations. The most general consideration is to always plan for the future. If additional EVSE will be needed in the future, it is best to include those future loads in equipment capacity considerations. This will be most relevant when a service panel upgrade, new transformer, or distribution feeder line is required. When installing new equipment such as a service panel, it is best to account for the extra capacity needs of future EVSE. However, there may be situations where the EVSE plans for a particular site are just barely exceeding the capacity limitations of the service equipment. In these circumstances, it could be most practical to slightly reduce the current plans for EVSE to delay equipment upgrades and expedite the construction process.

4.9.6 Utility Equipment Considerations

The same considerations made for facility electrical equipment capacity should also be made for utility service equipment. The most important consideration here is to determine which equipment is owned by the facility and which is owned by the utility or utility privatization contractor. Figure 23 outlines a typical electric distribution system, including facility equipment and EVSE. Discussions between the site facility manager and local utility representative will better inform where the ownership divide lies. However, in almost all circumstances, the facility will own and operate equipment to the right of the meter in Figure 23. As building loads and overall facility size increases, this line of ownership tends to shift more to the left, leaving the facility responsible for a wider scope of equipment.

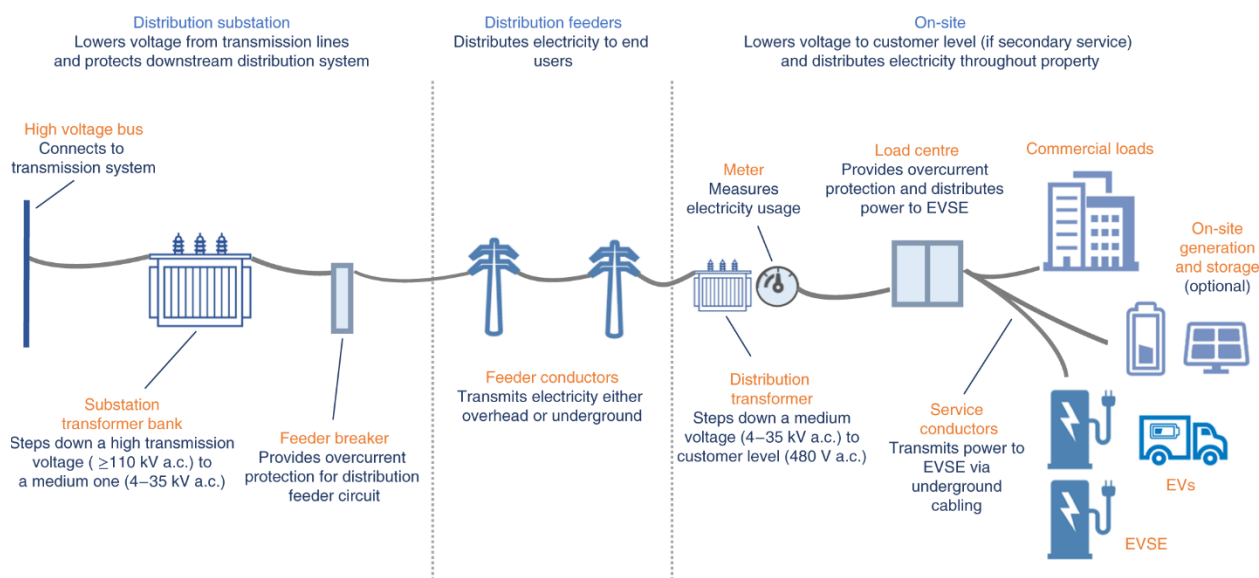


Figure 23. Typical electric distribution system with EV charging

Illustration Credit (Borlaug et. al.)

The ownership divide line is important because everything the facility owns and maintains must be updated and completely paid for by the facility. These upgrades will most often include increased service drop—the wire between either the feeder conductors or distribution transformers and the meter or load center—or distribution transformer capacity. However, these upgrades should only be necessary if an additional service panel or larger main circuit breaker

are installed. For the rest of the situations where upgrades may be required on electric utility owned equipment, the responsibility of installing and paying for these upgrades will be different depending on local utility practices.

4.9.7 Load Planning

Planning for EVSE generally begins at the parking lot level and focuses on proximate equipment such as service panels and transformers; however, master planners or energy managers at bases should be involved in every EVSE installation, at least to track the load added. While a dozen EVs in a single lot is unlikely to impact distributions feeders or substations, they will add up over time. Minimizing charging load with lower power EVSE as appropriate, managed charging, or time delays to off-peak hours can reduce project costs and major system upgrades over time. At the same time, the purpose of installing EVSE is to ensure EVs have sufficient energy to complete their mission, and that should be the driving priority.



4.10 Select Facilities Guide Specifications and Criteria

In addition to the design constraints outlined above, consideration should also be made to the United Facilities Guide Specifications (UFGS) and United Facilities Criteria (UFC) that apply to EVSE installations. The following sections outline a few select UFGS and UFC sections of interest and summarize their content and value when planning for an electric fleet.

4.10.1 UFGS 11 11 37 EVSE

The specifications in UFGS 11 11 37 deal with EVSE and cover a wide range of unit and installation requirements that should be considered. These include the definitions of Level 1, Level 2, and DCFC stations as defined by SAE J1772. In addition to these definitions, Level 1 and Level 2 AC charging could be supported from 120-V or 240-V receptacles, respectively. Each of these EVSE may also require or benefit from the addition of either spare parts or accessories such as spare cords, back-lit displays, or energy management controls.

The design of EVSE including shop drawings, product data, and other information must be submitted through the process described in UFGS 01 33 00, Submittal Procedures. In addition to the design constraints throughout the following UFC sections, the UFGS outlines specific requirements for wheel stops, bollards, signage, and concrete pedestal foundations. These designs must also be installed in accordance with the NFPA 70 National Electric Code Section 625 and by an installer either certified by the EVSE OEM or a recognized certified training agency. Upon completion of the installation, testing and verification of the EVSE should be performed, as well as consideration for personnel training on EVSE maintenance or the acquisition of a maintenance plan.

4.10.2 UFC 1-200-01 DoD Building Code

UFC 1-200-01 provides general building requirements, codes, and implementation rules for military construction. It refers heavily to the international building code with specific modifications noted, and it defines the authority having jurisdiction for DoD sites: “The Building Official/Authority Having Jurisdiction represents the DoD design and construction agent responsible for accomplishing the project, and exercises authority to interpret and apply criteria to work in progress, evaluate compliance with criteria, and accept finished work that is in compliance.”

4.10.3 UFC 3-120-01 Signage

Chapter 3-4 of UFC 3-120-01 details the signage requirements for traffic control devices. Although not required to identify EVSE, 3-4.5 outlines the details for reserved parking signs. Reserving parking spaces near EVSE may be of interest to ensure EVs always have access to their primary energy source. In the event these signs are installed, they should conform to the requirements in Chapter 2 and 3-1.

4.10.4 UFC 3-201-1 Site Appurtenances

Section 2-10 of UFC 3-201-1 outlines site appurtenances for parking structures. Of specific interest is section 2-10.4.1 regarding bollards around structures. These bollards must be a minimum of 4-feet high and 4 inches in diameter. Bollards or wheel stops can be used to protect pedestal EVSE from damage due to contact with a vehicle. UFGS 11 11 37.

4.10.5 UFC 3-501 and 3-520 – Spare Capacity Requirements

In addition to electrical engineering and interior electrical systems requirements, UFC 3-501 and 3-520 contain requirements for spare capacity regarding newly built building service panels and distribution service equipment. Section 3-2.1 in UFC 3-501 states a requirement for all service equipment to be designed with a minimum of 15% capacity for future expansion. This service equipment includes, but is not limited to, distribution service transformers, service drop wires, and step-down transformers. Additionally, section 3-2.3.3 in UFC 3-520 states a requirement for all service panels to be designed with 15% electrical capacity and physical space for future growth. This refers to the remaining capacity in the main circuit breaker in comparison to the anticipated peak load (in Amps), as well as the physical remaining breaker positions throughout the service panel enclosure. These capacity requirements should be considered when designing a new building and should be accounted for after including EVSE needs. However, this requirement also means that EVSE installation in new buildings may be supported by the initially overbuilt electrical capacity.

4.10.6 UFC 3-530-01 Lighting

Chapter 4 and 5 of UFC 3-530-1 outline the controls and applications for exterior lighting. Specifically, Chapter 5-3.1 outlines the requirements for lighting at parking lots, which will be of particular interest when installing EVSE. The primary considerations for parking lot lighting cover controls, lighting distribution, and fixture specifications. The outline of controls in the Equipment Requirements details the periods of the day when lighting fixtures should be on and when dimming is required. The distribution of light outlined in the Performance requirements specify light distribution with fixture spacing requirements to ensure sufficient illuminance. Finally, the Critical Design Issues also detail fixture specifications such as a U rating of 1 or 0 to mitigate glare and type V distributions for use in parking areas and Type III or IV for parking perimeters.

4.10.7 UFC 3-550-01 Electrical Distribution

UFC 3-550-01 addresses requirements for distribution systems on military bases, including primary and secondary substations, distribution feeders, primary and secondary transformers, switchgear, capacitors, and integrated power equipment. It is designed as high-level guidance with several external reference for electrical engineers and design/build proposals.



4.11 Assess Public Charging

Although most fleet EVs will receive much of their energy from agency-owned EVSE, some longer trips will require the use of public EVSE for mid-day charging needs. To determine the availability of public charging, DOE developed an Alternative Fueling Station Locator tool to help identify the location, charger type, and power rating of public EVSE.¹⁶ The tool is also helpful in mapping nearby stations with CCS DC fast charging capabilities, like in Figure 24, as well as display the designated alternative fuel corridors as designated by the Federal Highway Administration.

Alternative Fueling Station Locator

Find alternative fueling stations in the United States and Canada. For U.S. stations, see [data by state](#). For Canadian stations in French, see [Natural Resources Canada](#).

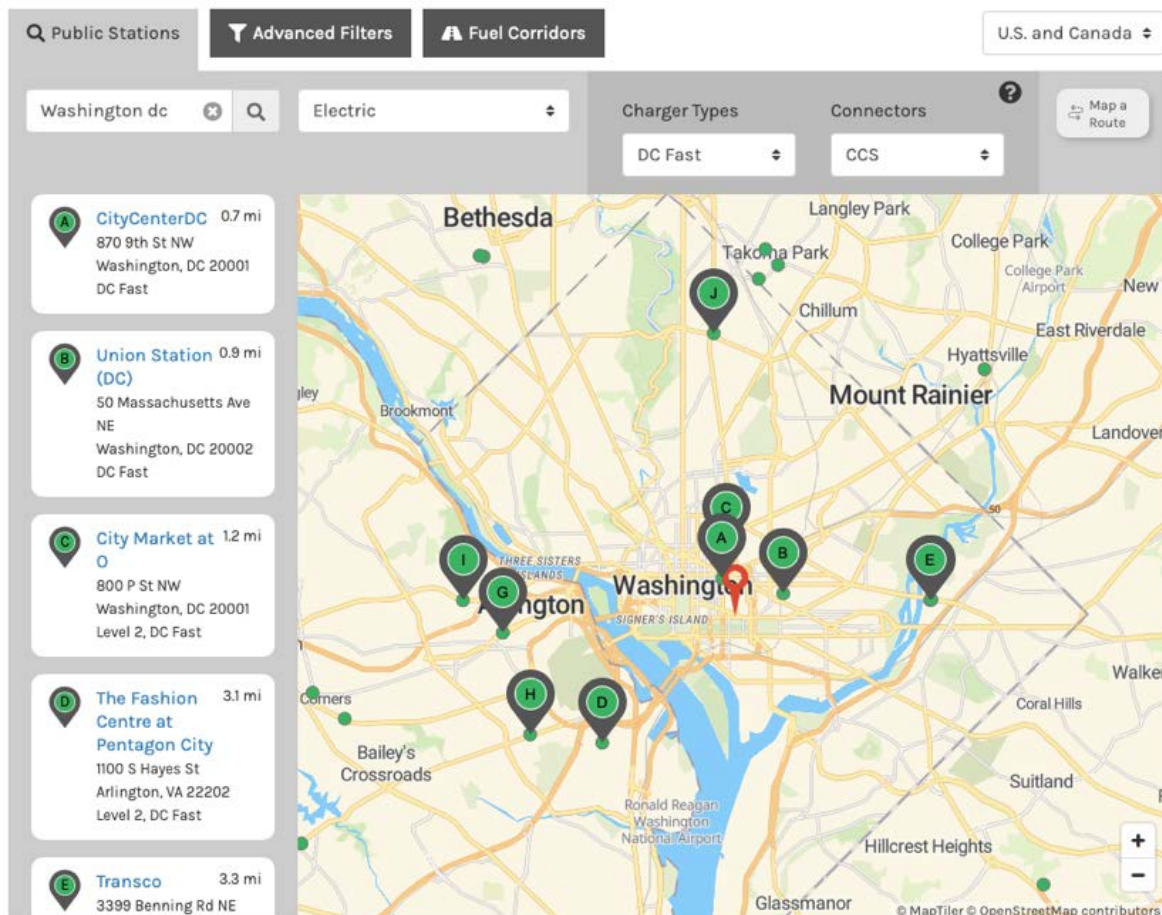


Figure 24. Alternative Fueling Station Locator

¹⁶ <https://afdc.energy.gov/stations/>.

5 Acquisition and Execution



5.1 ZEV Acquisition



Federal fleet managers can consider purchasing ZEVs through GSA, leasing from GSA, or leasing commercially, including through GSA's Schedule 751.¹⁷ Acquisition through GSA reduces the risk and difficulty of acquiring ZEVs, as GSA already has the necessary procurement and support contracts in place with major ZEV manufacturers. ZEV availability as of December 2021 is listed in Table 10, although some variations are excluded for brevity. The number of ZEVs available through GSA will continue to expand as the market grows and matures. Consult with local GSA fleet service representatives to discuss timelines, model closures, and expectations for model reopenings.¹⁸

¹⁷ www.gsa.gov/afv.

¹⁸ <https://www.gsa.gov/buying-selling/products-services/transportation-logistics-services/fleet-management/vehicle-leasing/find-a-fleet-service-representative>.

Table 10. FY22 GSA ZEV Offerings (December 2021)

Make	Model	Range	Fuel Type	Vehicle Type	SIN	FY22 Selling Price
Nissan	Leaf	149 miles	BEV	Sedan	8E	\$22,293
Nissan	Leaf Extended Range	226 miles	BEV	Sedan	8E	\$27,388
Toyota	Prius Prime	25 electric / 640 total	PHEV	Sedan	8P	\$28,641
Chevrolet	Bolt	259 miles	BEV	Sedan	8E	\$28,910
Hyundai	Niro	26 electric / 547 total	PHEV	SUV (4x2)	98P	\$28,994
Hyundai	Kona	258 miles	BEV	SUV (4x2)	98E	\$31,694
Chevrolet	Bolt EUV	247 miles	BEV	SUV (4x2)	98E	\$32,025
Mitsubishi	Outlander	24 electric / 320 total	PHEV	SUV (4x4)	96P	\$34,435
Chrysler	Pacifica	32 electric / 520 total	PHEV	Minivan	20P	\$42,825
Ford	Mach-E	230 miles	BEV	SUV (4x2)	91E	\$43,315
Ford	Mach-E 4x4	210 miles	BEV	SUV (4x4)	96E	\$45,959
Ford	Trans350 EV	150 miles	BEV	Cargo Van	34E	\$46,931
Tesla	Model 3	262 miles	BEV	Sedan	9E	\$48,223
Ford	Trans350 EV	150 miles	BEV	Cargo Van	162E	\$49,870
Ford	Mach-E Ext. Range 4x2	300 miles	BEV	SUV (4x2)	91E	\$51,047
Ford	Mach-E Ext. Range 4x4	270 miles	BEV	SUV (4x4)	96E	\$53,691
Ford	F150 Lightning	230/300 miles	BEV	Pickup (4x4)	55E	\$56,250
Ford	Tran350 EV	100-150 miles	BEV	Cargo Van	95E	\$57,248
Tesla	Model 3	353 miles	BEV	Sedan	9E	\$58,423
Tesla	Model Y	326 miles	BEV	SUV (4x4)	96E	\$59,093
GM	Hummer	350 miles	BEV	Pickup (4x4)	55E	\$116,173
Sonny Merryman	Starcraft	105 miles	BEV	Bus	342	\$200,354
Creative Bus Sales	Glaval Universal	105 miles	BEV	Bus	341	\$201,957
Transportation Equipment Sales	Turtle Top Terra Transit	105 miles	BEV	Bus	341	\$242,369



5.2 Cybersecurity Considerations



As with most new technology, fleet electrification introduces new equipment capable of digital communications over both local and international networks. Both EVs and EVSE have certain cybersecurity vulnerabilities that should be considered and, if possible, mitigated. Many of these concerns are common among all modern vehicles, as outlined in the FEMP Cybersecurity Report (Hodge et. al. 2019) and displayed in Figure 25.

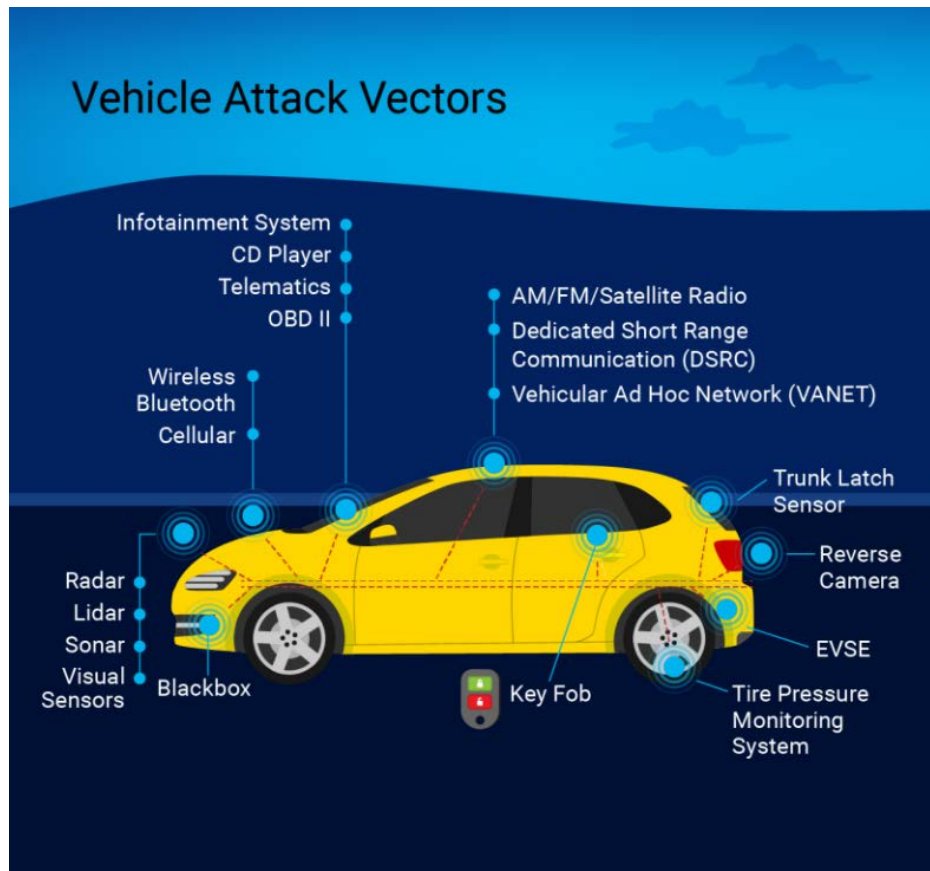


Figure 25. Common cybersecurity vulnerabilities

Figure Source: Hodge et al. (2019)

Level 1 and Level 2 EVSE have minimal input signals and connection to electric vehicles. They verify that a connection is active, the EVSE is grounded, and the EV is ready to accept charge. Level 1 and Level 2 cannot transmit malicious code to EVs. DCFC units are more complex, as are the cybersecurity issues. Network connections and payment streams have been compromised, including account and credit card information. This information should be encrypted at rest, over the air, and on the charging service provider's servers.

The majority of concerns, for both EVs and EVSE, can be characterized as either physical or remote threats resulting in either compromised data or equipment operations. However, the three key elements to consider are related to physical access, data encryption, and secure communication. All physical control board access, such as USB ports, should be concealed and/or lockable. Communication within each device, as well as all messages sent to and from the device should be encrypted. All remote access capabilities should be secure and cloud servers storing operational data should be FedRAMP approved. More details about the specific threats possible for this new equipment, as well as the best mitigation techniques and necessary procurement language can be found within the report (Hodge et. al. 2019).

GSA is requiring several protective measures to be taken by all awardees of its BPA, currently under negotiation. GSA is developing a security framework aligned with NIST 800-171 for protecting the confidentiality of controlled unclassified information in non-federal information

systems. They will align security and privacy requirements with NIST 171, NIST 172, and select NIST 800-53, as well as FedRAMP in any cases involving cloud-as-a-service (Toth 2021).



6 Managing the Program



Ongoing management is required for a successful fleet electrification program. This includes operator education on EV range and public charging, vehicle maintenance, and a plan to manage EVSE loads and sustain the units, especially networked EVSE.



Fleet vehicle operators should be trained on how to operate ZEVs and use EVSE. The authors recommend training before personnel can use ZEVs or EVSE. Instruction needs to focus on the following topics:

- Introduction to ZEVs and EVSE
- Components of the charger
- Connecting to the EV
- Turning on the charger
- Safety
- Usage policies.

FEMP offers EV training for fleet and facility managers, including the EV Champion Training Series.¹⁹

6.1 Driving the Vehicles

Driving EVs is not very different from driving gasoline vehicles. They generally feature push-to-start technology like other modern vehicles, they include the same air conditioning and heating systems as gasoline vehicles, and the accelerator, brake, and steering function in a similar way from a user perspective. There are a few key distinctions, however.

EVs recapture energy from braking that can later be used for propulsion. While there are some mechanical losses from the braking process and software to enable a smoother ride, regenerative braking is a major factor of an EV's improved efficiency (returning 17% of energy to the battery and ultimately to the road) (EPA and DOE 1 n.d.). An even larger factor is motor efficiency—internal combustion engine losses total 68–72%, while EVs lose about 20% (EPA and DOE 2 n.d.). This process of regenerative braking can be surprising to new EV operators, but it can allow more experienced EV operators to improve ride quality by slowing the car more smoothly.

EVs typically allow for different modes of operation, such as an eco-mode to extend range, a strong regenerative braking mode to recapture as much energy as possible, and a single-pedal driving mode that can bring the vehicle to a complete stop in some models. It is important to understand the capabilities and limitations of each vehicle model's driving modes (e.g., determining whether the vehicle will come to a complete stop and stay that way at a traffic light).

¹⁹ <https://www.energy.gov/eere/femp/electric-vehicles-Federal-fleets>.

Fully electric BEVs exclusively use electricity as fuel. BEVs on the 2021 GSA schedule store between 150–350 miles of electrical energy in on-board lithium-ion batteries. Energy storage capacity varies based on ambient temperature, especially if heating or air conditioning are in use. As an example, at optimal temperatures (between 51 and 90 degrees Fahrenheit), 2021 Chevrolet Bolts outperform their 259-mile rated range. However, that can fall to less than 50% of rated range at extreme cold or hot temperatures (less than -2 degrees Fahrenheit or greater than 123 degrees Fahrenheit). These estimates and Figure 26 were developed based on average real-world driving range data from Geotab telematics (Argue 2020).

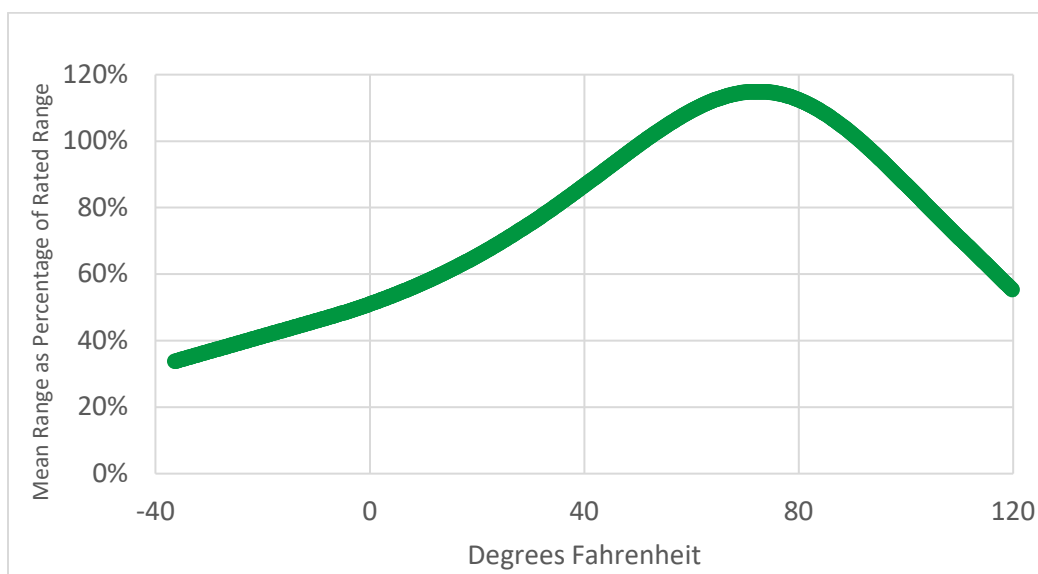


Figure 26. Chevrolet Bolt real-world driving range

Data from Argue 2020

Driving patterns and conditions affect EV range as well. EVs are more efficient at lower speeds and recapture energy from braking, resulting in higher efficiencies in city driving (94–100% power to wheels) compared to highway driving (77–79%) (EPA and DOE 1 n.d.).

Plug-in hybrid electric vehicles (PHEVs) can switch between electricity and gasoline as fuel sources. Therefore, they can be charged with EVSE or at gasoline stations. Electric range is less than 40 miles on PHEVs offered in the FY 2022 GSA 2022 AFV Guide,²⁰ and gasoline extends that range to 500+ miles for most of the options.



6.2 Maintaining the Vehicles

Fleet managers should expect less frequent (i.e., less downtime) and less costly maintenance for ZEVs compared to traditional internal combustion engine vehicles. Typically for BEVs, the only maintenance that is required is to rotate the tires twice a year and replace the brake fluid and

²⁰ <https://www.gsa.gov/buying-selling/products-services/transportation-logistics-services/fleet-management/vehicle-leasing/alternative-fuel-vehicles/electric-vehicle-charging-stations>.

wipers every few years. Additionally, battery technology has improved to the point where the useful life is similar or longer to that of an internal combustion engine.

PHEV engines are used less frequently and at lower loads, reducing wear and tear on the engine. And for all ZEVs, regenerative braking results in a lower impact on use of the braking system and the pad, extending the operational lifetime of brake pads and shoes.

The high-voltage systems in EVs should be maintained by certified EV mechanics. The simplest approach in many cases is to work with a local vehicle dealership on EV diagnostics and maintenance. There are options to develop on-site mechanics into certified EV technicians. For example, courses lasting from 12–16 weeks are available through various organizations (Clean Tech Institute n.d.; Tesla 2021).

EVs generally cost less for maintenance compared to internal combustion engine vehicles according to Consumer Reports and Argonne National Laboratory (Table 11) (Harto, C. 2020; Argonne National Laboratory 2021). EVs have fewer moving parts, they do not require oil changes, and their brakes last longer due to heat recapture in regenerative braking. Consumer Reports estimates average BEV lifetime maintenance at \$0.031/mile, PHEVs at \$0.030/mile, and internal combustion engine vehicles at \$0.061/mile. Argonne National Laboratory estimates average light-duty BEV maintenance at \$0.061/mile, PHEV maintenance at \$0.090/mile, and internal combustion engine vehicles at \$0.101/mile.

Table 11. Maintenance Costs for Electric Vehicles and Internal Combustion Engine Vehicles

Source	Internal Combustion Engine Vehicle	Battery Electric Vehicle		Plug-in Hybrid Electric Vehicle	
	Cost/Mile	Cost/Mile	Savings	Cost/Mile	Savings
Consumer Reports (Harto, C.):	\$ 0.061	\$ 0.031	49%	\$ 0.030	51%
Argonne National Laboratory:	\$ 0.101	\$ 0.061	40%	\$ 0.090	11%

Federal light-duty vehicles leased from GSA are replaced within 5–7 years on average in the federal fleet, while many EV manufacturers offer an 8 year/100,000 mile warranty on the lithium-ion battery, although shorter warranties are often standard on powertrains (e.g., Chevrolet n.d., Nissan 2021, Ford n.d.).



6.3 Maintaining the EVSE

EVSE requires ongoing support, in the form of inspections, routine preventive maintenance, and unscheduled maintenance. Facility managers need to consider how to establish EVSE management and maintenance after installation. Generally, this arrangement consists of on-site personnel taking responsibility for low-level inspections and routine checks, and, if necessary, contractors taking responsibility for preventive and unscheduled maintenance. Facility managers should determine what arrangement is best for each situation and develop the necessary contracts.

Most EVSE or charging stations require some maintenance over their lifetime, including potential for individual components to malfunction. For non-networked EVSE, factors that may increase maintenance include EVSE utilization, climate, and exposure to the elements. Networked EVSE tend to have higher operational and maintenance requirements. These charging stations typically include payment processing and data collection services that include additional components such as card readers and touchscreens. Networked EVSE likely require more maintenance compared to a non-networked unit; if authorization is required to charge, EVSE downtime increases significantly (Avista Corp. 2019). Ongoing maintenance costs should be factored into EVSE acquisition to avoid extensive downtime. The Alternative Fuel Data Center recommends budgeting up to \$400 annually per charger (DOE 2022b).



6.4 Capturing and Reporting Data

There are multiple reporting requirements pertaining to EVs and EVSE as described below:

- Vehicle-level data (VLD) report in FAST
- EVSE report in FAST
- Annual Energy Management Report
- Installation Energy Plans.

All DOD agencies are required to report both VLD and EVSE installation information to DOE and GSA through FAST. VLD is used to inform the OMB Sustainability Scorecards. Primary metrics on those scorecards from 2016 to 2020 centered around petroleum consumption and alternative fuel. While petroleum has fallen consistently for DoD since the 2005 baseline, alternative fuel has been less consistent. Alternative fuel consumption rose through 2015 and has since fallen to less than the 2005 baseline level (Figure 27). Electricity consumption in EVs factors heavily into both metrics. Electricity is also captured separately in the VLD report along with vehicle acquisitions. Alternative fuel vehicle acquisitions (including EVs) are reported to Congress annually by DOE to comply with EAct 1992, EAct 2005, and EISA 2007, and GSA posts the Federal Fleet Report²¹ for the public as well. It is likely that EV acquisition and utilization will be key metrics for OMB and CEQ to consider moving forward, and FAST will be the system of record.

²¹ <https://www.gsa.gov/policy-regulations/policy/vehicle-management-policy/Federal-fleet-report>.

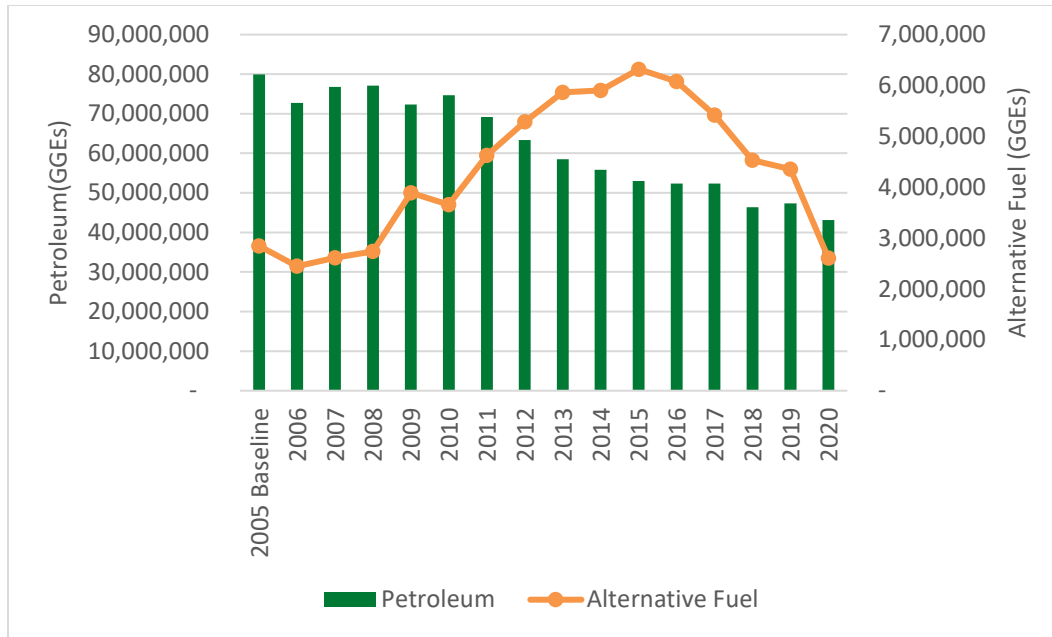


Figure 27. DoD fleet performance metrics

Fleet managers are responsible for the accurate measurement and reporting of electricity used in EVs in coordination with Service fleet managers. EV electricity consumption data is typically managed using the following sources:

1. Telematics data that captures electricity used by each vehicle. This is the easiest and most accurate method.
2. Estimates of EV electricity using vehicle mileage in conjunction with a calibrated vendor-provided vehicle efficiency factor (such as 3.6 miles/kWh) to calculate electricity consumption.
3. On-site EVSE with built-in data collection and management systems that capture electricity transaction data for each EV charging session
4. Credit card transaction data for charging sessions at public and non-agency charging stations.

DoD will need to consider how to balance the efficiency with the costs of data collection in determining the best method for its vehicles and facilities. If DoD chooses to rely on (3) on-site EVSE with built-in data collection, it should complement that information with data from (4) public EVSE in order to provide a complete picture of electricity consumption.

Agencies are also required to report the number of EVSE installed. As of 2020, Navy had installed more Level 2 and Level 1 EVSE units than any other agency in the federal government (Figure 28). However, the combined total of 1,308 DoD EVSE units reported in 2020 will not be nearly sufficient to accommodate the predicted amount of demand from the 174,297 vehicles in the DoD nontactical fleet.

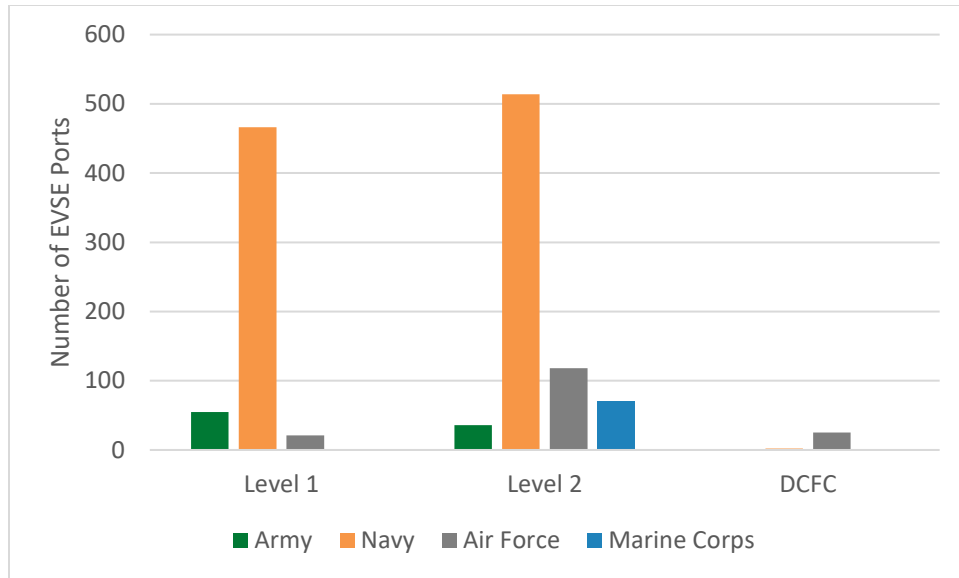


Figure 28. EVSE units by DoD branch through 2020

DoD Services are also required to include EV utilization in their annual energy management report. They should further include EVSE planning and utilization in installation energy plans.



7 Conclusion

The transition to a ZEV fleet will require coordination among all key stakeholders described in this document as well as electric utilities, EVSE installers, and other external partners. In order to support recently established fleet electrification goals, policies will need to be reformed, funding identified, vehicles replaced, and EVSE installations planned. This document outlines many processes and considerations to ensure each of these stakeholders is appropriately engaged throughout this process and each step is thoroughly planned for and properly executed.

As the EV industry evolves, the process for fleet electrification should evolve as well. The steps and processes outlined in this document are intended to provide considerations for DoD to accelerate the adoption of electric vehicles in the federal fleet, but as the adoption of this technology grows, the approach to fleet electrification should expand as well. The result envisioned in EO 14057 is a zero-emission fleet that will require a new understanding of vehicle applications and transportation energy supply. This document will inform DoD personnel of the best approaches and considerations to finding the necessary fleet solutions for this transition and prepare agencies to serve as a model for other governments while catalyzing American investment in ZEVs.

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